TEK User's Reference Manual

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Product Group 47

11401 and 11402
Digitizing Oscilloscopes
User's Reference Manual

Please check for *CHANGE INFORMATION* at the rear of this manual.

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Artek Media
1042 Plummer Cir. SW
Rochester, MN 55902

Manuals@artekmedia.com

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INSTRUMENT SERIAL NUMBERS

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

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

Key to Manuals

Operating Manuals

These manuals are provided with your instrument:

Introducing the 11401 and 11402

11401 and 11402 User's Reference

11401 and 11402 Incoming Inspection

11401 and 11402 Programmers Quick Reference

Service Reference Manual

The service reference manual is an optional accessory. To order, use the service reference manual request card in the front of this manual.

11401 and 11402 Service Reference

Note:

For further information, refer to Instrument Documentation on the next page.

5791-125b

How to Use This Manual

The 11401 and 11402 User's Reference Manual describes all 11401 and 11402 features from the user's point of view. After the Introduction presents an overview of the 11401 and 11402, the manual is organized to provide detailed information in the order you will need it.

Reference Aids

To quickly locate information, use the following reference aids:

- The Contents at the beginning of this manual lists subjects covered in the five sections and three appendixes.
- The Contents at the beginning of each section lists the subjects covered in that section.
- The Errors, Warnings, and Messages explain the meaning of various messages displayed on the screen.
- The appendixes provide summaries of useful information, as follows:
  Appendix A–Accessory List
  Appendix B–Algorithms
  Appendix C–Glossary

Instrument Documentation

Three Operator manuals provide operating information about the 11401 and 11402 Digitizing Oscilloscope.

1. Introducing the 11401 and 11402 Digitizing Oscilloscopes presents the concepts and methods of operating the instrument. As a training aid, Introducing the 11401 and 11402 Digitizing Oscilloscope helps a new user learn the concepts of the 11401/11402 and their operation.
2. The 11401 and 11402 Digitizing Oscilloscope User's Reference Manual is the reference document for the user/operator. This manual gives detailed information about how to perform measurements with the 11401/11402, their specifications and options, and how to use GPIB and RS-232-C interfaces.
3. The 11401 and 11402 Programmers Quick Reference contains all the syntax, headers, links, and arguments for the command set; as well as listing the appropriate event codes for the command set.

The 11401 and 11402 Service Reference Manual is available as an optional accessory. Refer to Appendix A, "Accessory List", for further information. To order this manaual, use the Service Reference Manual Request card in the front of this manual.

The Incoming Inspection Procedure provides a set of procedures to functionally checkout the instrument. For a Performance Verification procedure, refer to the Service Reference Manual.

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Safety Summary

The following general safety information applies to all operators and service personnel.

Terms

In Manuals

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

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

As Marked On Equipment

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

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

Symbols

In Manuals

Static-Sensitive Devices.

As Marked On Equipment

DANGER—High Voltage.

Protective ground (earth) terminal.

ATTENTION—refer to manual.

Warnings

Power Source

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

Grounding the Product

The 11401 and 11402 are grounded through the grounding conductor of the power cord. To avoid electric shock, plug the power cord into a properly wired receptacle before connecting to the product's input or output terminals. A protective-ground connection, by way of the grounding conductor in the power cord, is essential for safe operation.

Danger Arising from Loss of Ground

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

Do Not Operate in Explosive Atmospheres

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

Do Not Service Alone

Do not perform internal service or adjustment to this product unless another person capable of rendering first aid and resuscitation is present.

Use Care When Servicing with Power On

Dangerous voltages exist at several points in this product. To avoid personal injury, do not touch exposed connections and components while power is on.

Disconnect power before removing protective panels, soldering, or replacing components.

Crt Handling

Use care when handling a crt. Breakage of the crt causes a high-velocity scattering of glass fragments (implosion). Protective clothing and safety glasses should be worn. Avoid striking the crt on any object which might cause it to crack or im plode. When storing a crt, place it in a protective carton or set it face down in a protected location on a smooth surface with a soft mat under the faceplate.

Use the Proper Fuse

To avoid fire hazard, use only the fuse specified in the parts list for your product, and which is identical in type, voltage rating, and current rating.

Introduction

The 11401/11402 Digitizing Oscilloscope is a state-of-the-art instrument that can display or store waveforms and make measurements on either continuously acquired or stored waveforms. The 11401 and 11402 instruments function exactly alike except for their bandwidths. The 11401/11402 uses a system of menus that lets the operator call a menu that suits the purpose at hand, and then achieve the desired result by selecting items from the menu.

The menus are displayed on the crt screen, which has an infrared touch panel. Items are selected from a menu by simply touching the desired menu item with a fingertip or similar pointer.

The menu system and the touch panel on the screen gives the operator control of a larger number of functions than would normally be possible with a reasonably sized front panel. In other words, the menu system and the touch panel permit a dramatically smaller front panel (and instrument) than would be possible with hardware controls.

The oscilloscopes also provide both RS-232-C and IEEE-488 General Purpose Interface Bus (GPIB) interfaces. These interfaces and a comprehensive command set let you remotely access all the instrument's waveform setup and measurement facilities. Some of the 11401 and 11402's more important capabilities are:

- Up to 1 GHz bandwidth with the 11402 and up to 500 MHz bandwidth with the 11401, depending on the plug-ins installed. Refer to the "Vertical System Specifications", in Section 4 for specific information.
- Up to eight signal-input channels, acquired and displayed simultaneously.
- Ten-bit vertical resolution.
- Vertical accuracy of 1.0% of the volts/division setting; time-base accuracy of 0.01% of the time/division setting, +100 ps.
- On-board pulse parameter measurements and waveform processing.
- Single-button automatic setup with AUTOSET.
- Record lengths to 10k points; storage to 200k points.
- Built-in, dual time-bases with 10 psec resolution.
- High-resolution time A→B measurements.
- GPIB and RS-232-C industry-standard remote-control interfaces.
- Command set provides full remote access to all waveform setup and measurement features.
- Enhanced Accuracy and extensive internal diagnostics.

Oscilloscope System Architecture

This section introduces the hardware architecture of the 11401 and 11402 Digitizing Oscilloscopes.

The 11401/11402 are organized around three main operations:

- Digitizing signals and storing the waveform samples in memory;
- Executive control of the instrument and waveform processing (i.e., performing measurements, averaging, etc.); and
- Displaying waveforms, icons, control menus and sensing Touch Panel input.

Figure 1 shows these operational blocks as the Digitizer, the Executive Processor, and the Display and Touch Panel.

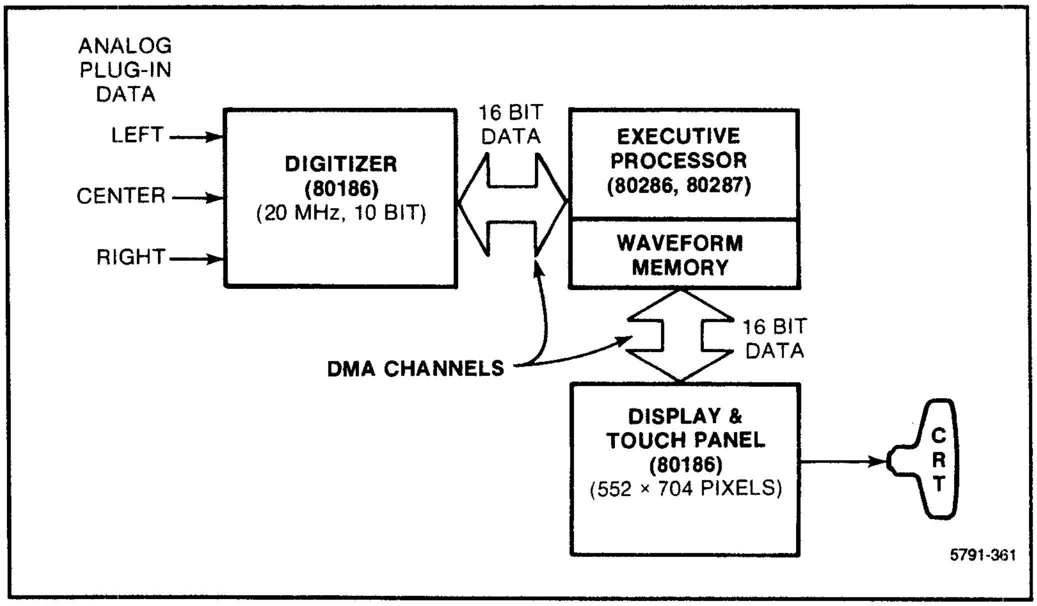


Figure 1. Diagram of Main Operational Blocks.

When you initiate an operation, such as acquiring and displaying a waveform, the Executive Processor responds by sending instructions to the Digitizer to begin acquiring the signal with a specific length of waveform record and time/div. Digitized waveform samples taken during each sweep are sent to acquisition memory. The samples are then transferred by a high-speed direct memory access (DMA) channel to the memory management unit (MMU), which puts the record in a reserved Waveform Memory block. The waveform record is sent by the MMU over a DMA channel from Waveform Memory to the Display, which processes it to produce a waveform display. If you specify a measurement or a waveform processing function, such as waveform Averaging, the Executive Processor performs the function on the waveform record before sending it to the Display.

Each operational block will be discussed separately, starting with the Executive Processor. Implementation details that can affect instrument accuracy are covered in greater depth under the last topic "Improving Accuracy". The following discussions assume the use of generic plug-ins (i.e., 11A32, 11A34).

The Executive Processor

The Executive Processor (EXP) is designed around the Intel 80286 microprocessor and its coprocessor, the 80287 Numeric Processor Extension. Together they coordinate instrument operations and process waveforms (i.e., perform measurements or waveform inversion, averaging, etc.). The EXP receives Touch Panel, pushbutton, or external interface commands and directs the appropriate subsystems to perform the requested operations. Under EXP control, the MMU stores and transfers waveform records and provides communication channels to the Display and Digitizer. The EXP controls the Digitizer and Display by placing instruction messages in Waveform Memory and instructing the MMU to transfer the message to the appropriate subsystem. Likewise, the MMU and Waveform Memory are used to pass status information from the subsystems to the EXP.

Three separate serial communications channels give the EXP full control over the installed plug-ins. These serial links are used to send setup instructions to or read status information from the plug-ins.

The EXP controls Touch-Panel operation by generating the items for display and reacting to touches. All icons and menu items and all waveform related features, such as graticules and axis scale indicators, are sent to the Display through one of the MMU's DMA channels. When the Touch Panel detects a touch, it interrupts the EXP and gives it the location of the touch. The EXP correlates this location with its current "map" of the items that are selectable. When a function is selected, the EXP directs instrument subsystems to perform the operation and sends function status information to the Display.

Two other important functions controlled by the EXP are running an extensive set of instrument diagnostic tests and ensuring that the instrument reaches Enhanced

Accuracy. Both these functions are performed at power-up. The diagnostics can also be invoked from the Utility major menu. Enhanced Accuracy mode is entered by pushing its front panel button after at least a 20-minute warmup to thermally stabilize the instrument. The instrument can be set to automatically invoke the Self-Tests when a temperature or configuration changes occurs.

The Digitizer sends waveform records from acquisition memory into Waveform Memory over a 16-bit, DMA channel (see Fig. 1). Once in Waveform Memory, measurements and other processes are performed on the waveform records by the EXP. The 80287 accelerates the arithmetic operations used to manipulate waveform data. In addition, the EXP generates measurement results and limit indicators (e.g., Measurement Zone Limits and Mesial level) for display.

After waveform records are processed for display, they are moved from Waveform Memory to the Display by a another 16-bit DMA channel. The EXP sends instructions to the Display, telling it whether to size and position the waveform for a one graticule or two graticules display. It also sends all necessary information to display the touch panel menus, labels, icons, etc. These are sent as messages through the DMA channel to the Display.

In addition to the previously mentioned functions, the Executive Processor also performs or controls a number of utility functions. They include:

Time of Day Clock

Provides the current time and date, which is kept current with a back-up battery supply.

IEEE-488 (GPIB)

Provides external access to control 100% of the system's functions, and a way to move waveform records and measurement results to and from an external system.

RS-232-C

Performs the same functions as the IEEE-488 and provides an alternate way to control diagnostics.

Storing waveforms

Stores or recalls waveform records from volatile memory.

Storing front-panel settings

Complete front-panel setups can be stored or recalled from permanent memory.

The Digitizer

The Digitizer converts analog signals into precisely timed sequences of 10-bit digital values. Up to eight signals can be acquired at a time. Digital samples of a plug-in channel signal are stored in local memory. At the end of a time base sweep, the waveform record is transferred to Waveform Memory by a high-speed DMA channel. (See Fig. 1.) The DMA channel is contained within the Intel 80186 microprocessor that controls the Digitizer hardware. Following configuration instructions from the EXP, the 80186 controls these main Digitizer components:

- High-speed analog-to-digital flash converter;
- Two time bases; Main and Window;
- Two trigger circuits, one for each time base;
- High precision (10 ps resolution) time interpolator;
- 16k points of acquisition memory.

Signals are sampled by a sophisticated 20 megasample/second analog to digital converter (ADC). Each plug-in compartment has a 50 ohm signal path to one of three sample and hold (S/H) amplifiers on the front end of the ADC. Active plug-in channels are sequentially connected (chopped) to their plug-in compartment's 50Ω ADC channel (see Fig. 2). The one megahertz chop signal is generated by the Digitizer and shared by the plug-ins. Voltage levels held by the three S/H amplifiers are converted sequentially by the ADC. These digital values are simultaneous in real time to within 100 ps. Refer to "Improving Accuracy", following the Display discussion for more information.

Sampling is performed in the Real or Equivalent time mode. In the Real Time Sampling Mode, enough signal samples are taken during each triggered sweep of a time base to produce a complete waveform record. A nonrepetitive signal can be captured with Real time sampling by setting the time base to acquire a single triggered sweep. Real time sampling is guaranteed only when the current setting is for a single channel with no Windows and a time/point greater than 50 ns.

Any other setup may cause the instrument to switch to the Equivalent Time Sampling Mode. In the Equivalent time mode, random samples are taken on successive triggered sweeps of a time base until the desired number of waveform record points have been acquired. The time interpolator determines the time between a sample and the trigger point with great precision. This precision allows Equivalent time sampling to produce effective sample intervals down to 10 ps.

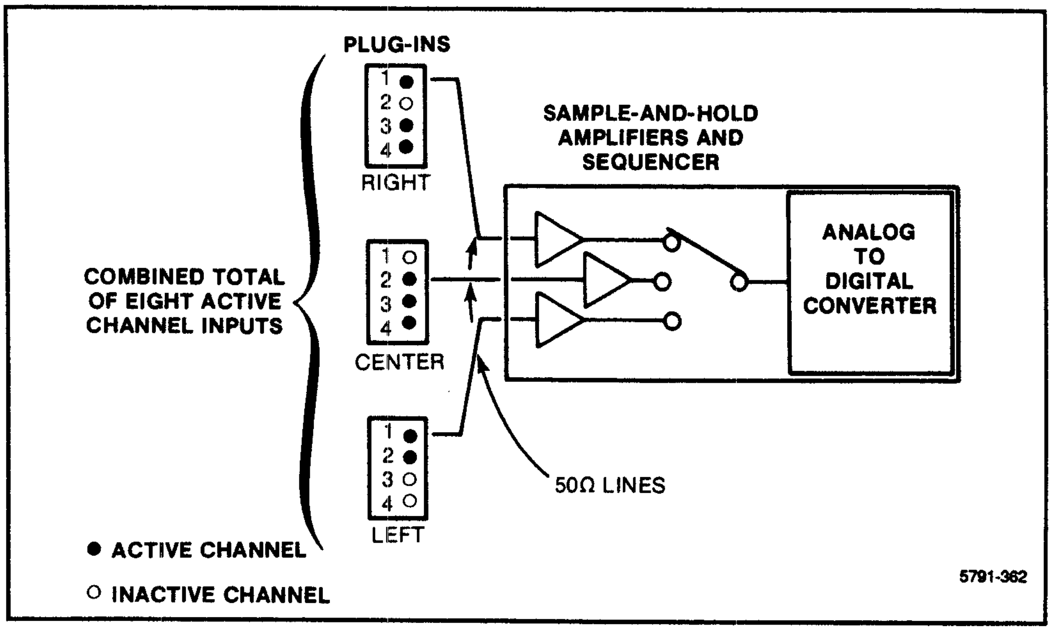


Figure 2. Plug-in and Digitizer Channel Sequencing

The two mainframe time bases, Main and Window, and their associated trigger circuits provide versatile signal acquisition. The Main and Window trigger circuits can use signals from different inputs or from a shared one. Because waveform samples are taken continuously, the trigger may occur anywhere within a waveform record. Thus, pre-trigger acquisition is possible; limited only by the duration of the Main time base record. The Window time base can be set to a lesser time/div than that of the Main time base to acquire two segments (Window1 and Window2) of a Main time base record. The two Windows can be positioned anywhere within the duration of a Main time base record or off either end so long as they coincide with the Main record at one or more points. The Window trigger can be held off by setting the time or the number of Window trigger events after the occurrence of the Main trigger.

The DISPLAY and TOUCH PANEL

The Display generates a vectored waveform display from a waveform record and positions it on the screen. It also displays touch panel function selections, user prompts, status information, and measurement indicators (such as cursors, peak points, etc.) from its bit-mapped display memory.

The Display subsystem uses a vertical-raster-scanned crt with a resolution of 552 horizontal by 704 vertical pixels. Waveforms are displayed with 512 pixels (or data points) across the graticule with either one 512 vertical pixel graticule or two 256 pixel vertical graticule. Four trace intensities are used to convey item status on the screen: off, low, medium and high. A two plane, bit-mapped memory enables the multiple intensity display. An Intel 80186 microprocessor controls the Display circuitry based on instructions from the Executive Processor.

Data compression and vertical scaling circuits size and position waveforms for single and dual graticule displays. They process longer waveform records to display 512 data points by generating a series of min-max data points that show the vertical range for groups of waveform record points. The maximum horizontal compression factor of 20 is used for 10240 point records. The Pan/Zoom function allows the compression factor to be adjusted so that any 512-point segment of a full waveform record can be viewed without affecting signal acquisition.

The Display processor uses the vertical min-max pairs to draw the vectors necessary to provide coherent waveform displays. Normally, adjacent data points are connected to form a smooth waveform. But a nonvectored mode can be invoked (from the Utility menu) to produce a waveform display using unconnected data points. The result is a waveform of unconnected dots and short vertical lines that is similar to the display seen on some sampling oscilloscopes.

The Touch Panel interface is read and controlled by the EXP as though it were a keyboard input device. In this case, the keys are replaced by a 22 row by 11 column matrix of infrared emitters and sensors. The EXP correlates selectable items on the screen with the location of a screen touch to determine the desired operation. The functions of the touch sense areas of the screen are changed to facilitate the current operations of the instrument. When the TOUCH PANEL ON/OFF button is toggled off, the EXP ignores screen touches.

Improving Accuracy

Instrument accuracy directly affects the accuracy of measurements. Enhanced Accuracy, acquisition mode, and system configuration can all affect instrument accuracy and the usefulness of a waveform record for measurements. Instrument functions and hardware that directly affect operating accuracy will be discussed here.

Enhanced Accuracy Mode

Upon power-up, the mainframe runs Self-Tests. After a 20-minute warmup, the system can perform further Self-Tests to achieve the Enhanced Accuracy state. The first step to improving the system accuracy is to connect the probes to be used and calibrate them. The probes can be calibrated with the **Probes** function located in the Utilities major menu. Each probe is connected to the front-panel CALIBRATOR output and vertically calibrated, deskewed (compensates for differences in propagation delay), and compensated (probe adjustment) with the **Probes** pop-up menu. This brings the instrument to its highest state of vertical accuracy.

Signals acquired in the Enhanced Accuracy state with calibrated probes allow the most precise measurement results.

Data Used for Measurements

The Standard Measurements (e.g., Rise time, Frequency, etc.) are performed on waveform record points, not on the compressed waveform points of the display. Custom Measurements (using the **Cursors** function) with the Dot Cursors also use the waveform record points. However, Bar Cursors are based on the screen scale factors so they are less accurate than Dot Cursors for Custom Measurements.

For guaranteed accuracy of standard and custom measurements, only waveform records completely filled with valid data points should be used. If the **%Fill** function is used to acquire a waveform record with less than 100% of the waveform record points filled, then the record will contain a number of null data points. Such null waveform record points can produce inexact or erroneous measurement results for some types of measurements (e.g., delta time, peak, etc). Questionable measurement results are displayed with a qualifier such as ≤ or ≥.

The quality of data used by the measurements can be improved by waveform averaging. Averaging reduces the effect of signal jitter (unstable trigger edge timing) and random noise on waveform record data. The accuracy of waveform record data is determined by the plug-in input circuitry and the Digitizer linearity. Averaging improves resolution by reducing the effect of random noise on the signal. A reduction in noise implies an improvement in the signal to noise ratio. Generally, noise decreases by the square root of the number of averages. For example, 100 averages will decrease the noise to 1/10 the unaveraged noise level. A decrease in noise results in an increase in resolution according to the relationship, 1/2 noise = 1 bit increase. So 100 averages will result in a resolution improvement of just over three bits. A four bit increase in resolution would require about 256 averages. Waveform samples are stored as 16 bit values, which set the upper limit on improving resolution. For details on averaging algorithms, refer to Appendix B "Algorithms".

Common Mode Rejection

The three S/H amplifiers in the Digitizer provide for simultaneous sampling of three channels (one from each plug-in). For example, L1, C1, and R1 (from left, center, and right generic plug-ins) can be acquired at the same time with simultaneous vertical values for each sample point. These digitized vertical values are simultaneous to within 100 ps and can be used for accurate signal comparison (left 1 minus center 1) with good common mode rejection (CMR). This CMR advantage over a comparison of two channels from the same plug-in (left 1 minus left 2) is greatest for signals with high frequency components. The 1 MHz chop frequency for the plug-in channels sets the frequency at which a CMR advantage is noticed. When using the S/H amplifiers for simultaneous sampling, the lowest numbered active channel of each plug-in will be sampled simultaneously. Of course, when comparing two signals, the best CMR can be obtained with a differential plug-in.

Installation

This section contains operator oriented installation information for the 11401/11402 Digitizing Oscilloscopes.

An electrical inspection of the 11401/11402 may be performed by the operator using the procedure given in the 11401 and 11402 Incoming Inspection Procedure.

Contents

Installation

The 11401/11402 Digitizing Oscilloscope has been inspected both mechanically and electrically before shipment. It should be free of mars or scratches and should meet all electrical specifications. First, inspect the instrument for physical damage incurred in transit. Then confirm that the instrument is operating properly by performing the procedures in the 11401 and 11402 Incoming Inspection Procedure.

Operating Power Information

This instrument can be operated from either a 115-volt or 230-volt nominal supply source, 48 to 440 hertz. The 6-ampere, 250-volt line fuse is used for both 115-volt and 230-volt operation.

WARNING

AC POWER SOURCE AND CONNECTION. The 11401/11402 operates from a single-phase power source. It has a three-wire power cord and two-pole, three-terminal grounding -type plug. The voltage to ground (earth) from either pole of the power source must not exceed the maximum rated operating voltage, 250 volts.

Before making connection to the power source, check that the 11401/11402 LINE VOLTAGE SELECTOR is set to match the voltage of the power source, and has a suitable two-pole, three-terminal grounding-type plug. Refer any changes to qualified service personnel.

GROUNDING. This instrument is safety Class 1 equipment (IEC designation). All accessible conductive parts are directly connected through the grounding conductor of the power cord to the grounded (earthing) contact of the power plug.

The power input plug must be inserted only in a mating receptacle with a grounding contact where earth ground has been verified by a qualified service person. Do not defeat the grounding connection. Any interruption of the grounding connection can create an electric shock hazard.

For electric shock protection, the grounding connection must be made before making connection to the instrument's input or output terminals.

TABLE 1-1
Power-Cord Conductor Identification

Conductor	Color	Alternate Color
Ungrounded (Line)	Brown	Black
Grounded (Neutral)	Light Blue	White
Grounded (Earthing)	Green/Yellow	Green

Power Cord Information

A power cord with appropriate plug configuration is supplied with each 11401/11402. Table 1-1 gives the color-coding of the conductors in the power cord. If you require a power cord other than the one supplied, refer to Table 1-2, Power-Cord and Plug Identification.

Operating Voltage

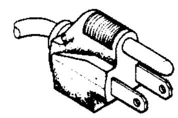
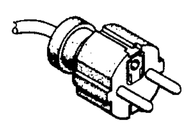
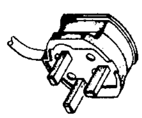
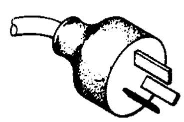
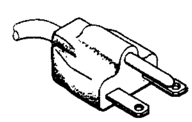
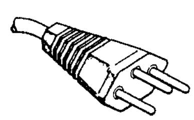
The LINE VOLTAGE SELECTOR (located on the rear panel) allows you to select 115-volt or 230-volt nominal line-voltage operation. The same line fuse is used for both 115-volt and 230-volt operation. If you have any questions on voltage conversion, contact a qualified service person.

Memory Back-up Power

A self-contained power source within the 11401/11402 allows the retention of volatile memory upon loss of the ac power source. The self-contained power source provides memory back-up power which stores the last selected front- and crt touch-panel settings of the mainframe and plug-ins. Waveforms stored in memory are not retained. The self-contained power source also supplies power to the IC that generates the Time/Date parameters, and records the hours of instrument on-time and the number of power-up sequences.

The self-contained power-source has a nominal shelf life of approximately five years. Partial or total loss of stored settings upon power-up may indicate that the power source needs to be replaced.

TABLE 1-2
Power-Cord and Plug Identification

Plug Configuration	Usage (Max Rating)	Reference Standards & Certification	Option #
	North American 125V/6A	[1]ANSI C73.11 [2]NEMA 5-15-P [3]IEC 83 [10]UL [11]CSA	Standard
	European 220V/6A	[4]CEE (7), II,IV,VII [3]IEC 83 [8]VDE [9]SEMKO	A1
	United Kingdom 240V/6A	[5]BSI 1363 [3]IEC 83	A2
	Australian 240 V/6A	[6]AS C112 [12]ETSA	A3
	North American 250V/10A	[1]ANSI C73.20 [2]NEMA 6-15-P [3]IEC 83 [10]UL [11]CSA	A4
	Switzerland 240V/6A	[7]SEV	A5

[1]*ANSI—American National Standards Institute*
[2]*NEMA—National Electrical Manufacturer's Association*
[3]*IEC—International Electrotechnical Commission*
[4]*CEE—International Commission on Rules for the Approval of Electrical Equipment*
[5]*BSI—British Standards Institution*
[6]*AS—Standards Association of Australia*
[7]*SEV—Schweizevischer Elektrotechischer Verein*
[8]*VDE—Verband Deutscher Elektrotechniker*
[9]*SEMKO—Swedish Institute for Testing and Approval of Electrical Equipment*
[10]*UL—Underwriters Laboratories*
[11]*CSA—Canadian Standards Association*
[12]*ETSA—Electricity Trust of South Australia*

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Operating Environment

The following environmental requirements are provided to ensure proper operation and long instrument life .

Operating Temperature

The 11401/11402 can be operated where the ambient air temperature is between 0° and +50°C and can be stored in ambient temperatures from –40°to +75° C. After storage at temperatures outside the operating limits, allow the chassis to reach the safe operating temperature before applying power.

Enhanced Accuracy is available after a 20-minute warmup period. After entry into Enhanced Accuracy, the instrument will revert to Not-enhanced accuracy if the internal mainframe temperature changes more than ±5° C.

Ventilation Requirements

The 11401/11402 is cooled by air drawn in through the side panels of the instrument by the fan and blown out through the rear. To ensure proper cooling of the instrument, allow at least two inches clearance on both sides and the rear of the instrument. The top and bottom of the instrument does not require ventilation clearance.

CAUTION

If air flow is restricted, the instrument's power supply may temporarily shut down.

Plug-in Operating Information

CAUTION

Before installing or removing plug-ins set the front-panel ON/STANDBY pushbutton to STANDBY. The mainframe and plug-in may be damaged if you install or remove a plug-in with the power on.

Do not attempt to remove or reinstall plug-ins if the ON/STANDBY switch is disabled (locked-on). Damage to the plug-ins or the mainframe could result.

If the green light indicator remains lit after the ON/STANDBY switch is moved to STANDBY, the power has been internally locked ON. To remove or replace plug-ins, use the PRINCIPAL POWER SWITCH (rear panel) to shut OFF the power.

To once again enable the ON/STANDBY switch, refer the instrument to qualified service personnel.

To install a plug-in in the mainframe, align the grooves in the top and bottom of the plug-in with the guides at the top and bottom of the mainframe's plug-in compartment. Then push the plug-in in until its front panel is flush with the front panel of the mainframe. (See Fig. 1-1.) To remove a plug-in, pull out on the release latch.

It is not necessary that all plug-in compartments be filled to operate the instrument. The only plug-ins needed are those required for the measurement at hand.

Blank plug-in panels may be inserted in unused compartments whenever the instrument is operated for extended periods. Refer to the "Accessory List" in Appendix A, for ordering information.

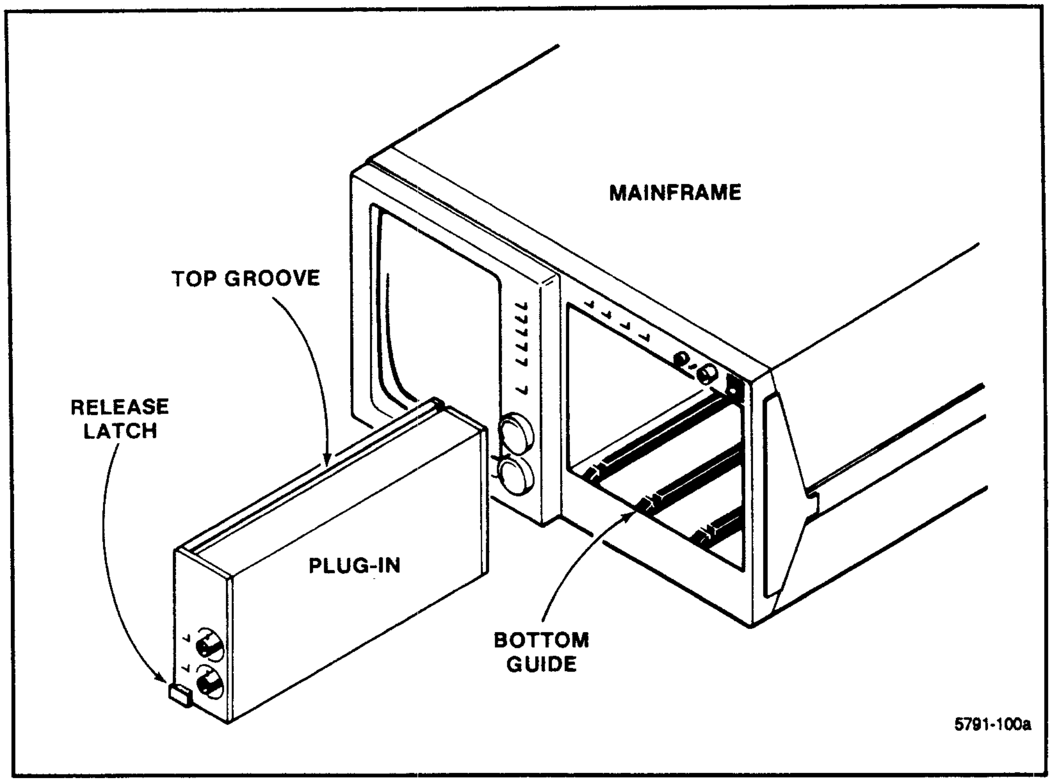


Figure 1-1. Installing a plug-in in the mainframe.

External Interface Connection

The 11401/11402 Digitizing Oscilloscope has three rear-panel external interface connectors; the RS-232-C (Data Communications Equipment), GPIB (IEEE STD 488 PORT), and the PRINTER. Refer to Section 3 for detailed information on the GPIB and RS-232-C interfaces.

Printer Connection

The PRINTER port uses a standard Centronics parallel printer interface. The printer must be an Epson compatible dot-matrix type such as the FX-80 or Tektronix 4644. The printer should be set for an input buffer, No Auto LF, and No skip over the perforation. Appendix A, "Accessory List" gives a recommended printer type and the Centronics interconnection cable.

Printer Setup

The 11401/11402 outputs directly over its Centronics interface to certain printers. Any printer that supports the Epson graphics character set as implemented in the Epson FX80 series printers is included.

Some printers require setup before they will operate correctly with the 11401/11402. Some things to look for in the printer operator's manual are:

Input buffer = on (if available)
Skip perforations = off
Auto 1f = off

The printer may have several options for interconnect cabling. The 11401/11402 supports the Centronics interface exclusively. You must specify this when ordering the printer.

Table 1-3 shows the PRINT connector contact assignments.

TABLE 1-3
PRINT Connector Contact Assignments

Pin No.	Signal Name	Pin No.	Signal Name
1	/DATA STROBE	19	/STB RET
2	DATA 1	20	DATA 1 RET
3	DATA 2	21	DATA 2 RET
4	DATA 3	22	DATA 3 RET
5	DATA 4	23	DATA 4 RET
6	DATA 5	24	DATA 5 RET
7	DATA 6	25	DATA 6 RET
8	DATA 7	26	DATA 7 RET
9	DATA 8	27	DATA 8 RET
10	/ACKNLG	28	/ACKNLG RET
11	BUSY	29	BUSY RET
12	PE (Paper End)	30	PE RET
13	SLCT	31	/INPUT PRIME
14	/AUTO LF	32	/FAULT
15	(NC)	33	(NC)
16	GND (OV)	34	(NC)
17	PG (Protective Ground)	35	(NC)
18	(NC)	36	/SLCT IN

Rackmounting

A special option (Option 1R) is available to convert the standard benchtop 11401/11402 mainframe to a rackmount version. Option 1R allows the 11401/11402 to be mounted in a standard 19-inch rack with universal hole spacing. Refer to Section 5 "Instrument Options", for additional information.

Packaging for Shipment

If the 11401/11402 is to be shipped for long distances by commercial transportation, we recommend that it be packaged in the original manner. The carton and packaging material in which your instrument was shipped should be saved and used for this purpose.

Also, if the 11401/11402 is to be shipped to a Tektronix Service Center for service or repair, attach a tag to the instrument showing the following:

- Owner of the instrument (with address);
- Name of person to contact at your firm;
- Complete instrument type and serial number;
- If possible, furnish complete system firmware versions as displayed in the **Instrument Options** popup menu selected from the Utility major menu.
- Describe the service required, or the symptoms of trouble the instrument exhibited.

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

1. Obtain a corrugated cardboard shipping carton with a 375-pound test strength and having inside dimensions at least six inches greater than the instrument dimensions. This allows for cushioning.
2. Wrap the instrument with polyethylene sheeting or equivalent material to protect the finish.
3. Cushion the instrument on all sides by tightly packing dunnage or urethane foam between the carton and the instrument, allowing three inches on each side.
4. Seal the carton with shipping tape or with an industrial stapler.
5. Mark the address of the Tektronix Service Center and your return address on the carton in one or more prominent locations.

Operating Information

Oscilloscope Familiarization

This material discribes the fundamental operation of the front-panel, touch-panel panel, and screen displays.

Waveform Control

This material discribes the operation of the touch-panel controls and associated menus which provide a display.

Triggering

This material describesthe trigger parameters: mode, source, coupling, slope, level, and holdoff.

Measuring Waveforms

This material describes how to measure waveforms, and discusses standard and custom measurement functions.

Storing and Recalling Waveforms

This material describes the display of stored and recalled waveforms and their respective settings.

Utilities

This material discusses setting the various parameters used in communicating, via the GPIB or RS-232-C interfaces, with external instruments. This material also discusses probe calibration and ID, the 11401/11402 options, the Self -Tests, diagnostics, time and date control, and initializing the 11401/11402.

Contents

Operating Information

This section is intended as a reference to all functions available for front-panel instrument control. The first topic covers front- and rear-panel features which are briefly described with references to detailed information when necessary. Each subsequent topic provides complete information for a specific oscilloscope operation, such as Triggering or Measuring Waveforms.

Oscilloscope Familiarization

Front Panel

The power switches, pushbuttons, Top and Bottom Control knobs, and the Calibrator are described here. Also see Figure 2-1, Front-panel controls, connectors, and indicators.

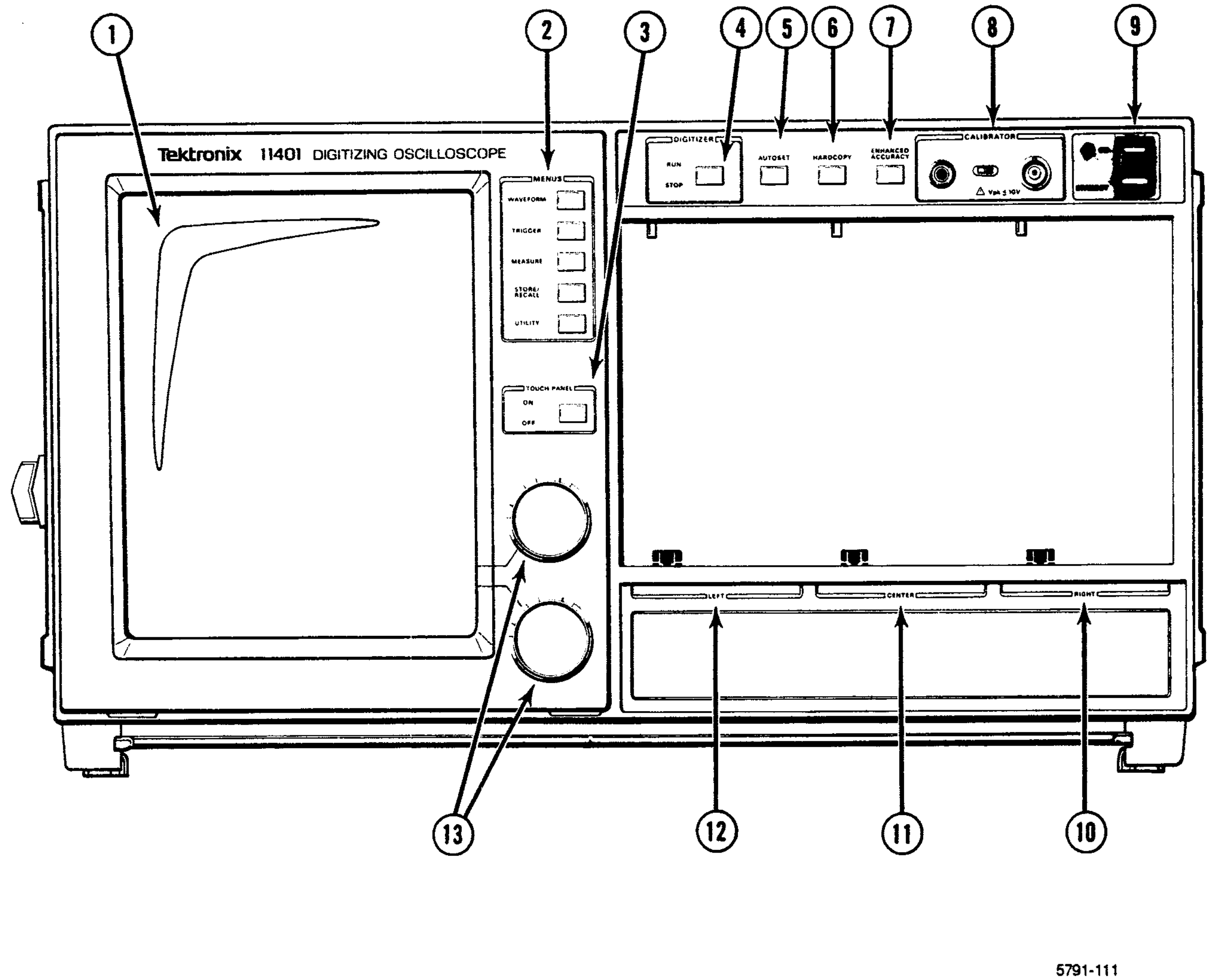


Figure 2-1. Front-panel controls, connectors, and indicators.

Front-Panel Controls, Connectors, and Indicators

(1) Crt screen touch-panel display. Refer to Figure 2-3 for detailed a description.

(2) MENUS buttons

- WAVEFORM–Provides access to selectable characteristics of displayed waveforms from MENUS. Displays the Waveform major menu in the menu/status area. Refer to "Waveform Menu Function Selections".
- TRIGGER–Selectable triggering characteristics are available on the screen. Displays the Trigger major menu in the menu/status area. Refer to "Triggering" in this section.
- MEASURE–Provides a list of measurements that can be performed. Displays the Measure major menu in the menu/status area. Refer to "Measuring Waveforms" in this section.
- STORE/RECALL–Waveforms and settings can be stored, recalled, deleted, or cleared. Displays the Store/Recall major menu in the menu/status area. Refer to "Storing and Recalling Waveforms" in this section.
- UTILITY–Functions that are not used to acquire, display, or measure waveforms are available through this menu. Displays the Utility major menu in the menu/status area. Refer to "Utilities" in this section.

(3) TOUCH PANEL ON/OFF–Activates or deactivates the touch panel. Refer to "Touch Panel Operation" in this section.

(4) DIGITIZER RUN/STOP–Starts or stops the process of acquiring waveforms from the plug-ins. Refer to "Waveform Control" in this section.

(5) AUTOSET–Sizes and positions the input signal for a stable display on the screen. Refer to "Displaying a Waveform Using Autoset" in this section.

(6) HARDCOPY–Sends data to a hardcopy unit (through the rear-panel PRINTER connector) to produce a permanent record of the display. Refer to "Instrument Configurations and Display Options" in this section.

(7) ENHANCED ACCURACY–Increases the measurement accuracy. Refer to "Waveform Menu Funcuion Selections" in this section for specific information.

(8) CALIBRATOR–Provides an accurate square wave for use as a reference for voltage calibration, frequency compensation, and time deskewing of oscilloscope probes. The Calibrator signal is active only when the Probes pop-up menu is used to calibrate probes.

(9) ON/STANDBY–Sets instrument from a ready-to-operate state to an operational state.

(10) RIGHT
(11) CENTER
(12) LEFT

Plug-in compartments for amplifiers and special purpose units.

(13) Control Knobs–Functions are assigned to Control knobs by selecting an icon or by selections made from various menus. Refer to "Control Knobs and Numeric Keypad Functions" in this section for detailed information.

Power-Up Information

The 11401/11402 has two power switches. The rear-panel PRINCIPAL POWER SWITCH controls ac power to the instrument; the ON/STANDBY switch located on the front panel, controls the dc power supply.

To operate the 11401/11402, first set the rear-panel PRINCIPAL POWER SWITCH to ON, then set the front-panel ON/STANDBY switch to ON. Set the ON/STANDBY switch to STANDBY to turn the 11401/11402 off.

CAUTION

Before installing or removing plug-ins set the front-panel ON/STANDBY push-button to STANDBY. The mainframe and plug-in may be damaged if you install or remove a plug-in with the power on.

Do not attempt to remove or reinstall plug-ins if the ON/STANDBY switch is disabled (locked-on). Damage to the plug-ins or the mainframe could result.

If the green light indicator remains lit after the ON/STANDBY switch is moved to STANDBY, the power has been internally locked ON. To remove or replace plug-ins, use the PRINCIPLE POWER SWITCH to shut OFF the power.

To once again enable the ON/STANDBY switch, refer the instrument to qualified service personnel.

For further operating power information refer to Section 1, "Installation".

Self-Test

Self-test of the 11401/11402 internal circuitry is performed each time the ON/STANDBY switch is set to ON.

During Self-test, the following events will occur:

1. The screen will display:

Diagnostics In Progress
Comm Test In Progress

NOTE

This message will normally not be observed before the next routine starts because of crt heater warmup time.

In the event these routines find a failure, one of the following will occur:

- In the Display subsystem, a message will be displayed such as:

Dsy Kernel Failure
RAM Data Bit

- In the Executive or if the Display system has a fatal problem, the MENUS button lights to indicate the error and a single beep will be heard.

2. Next, the screen will display:

Self Test In Progress

No operator action is required for the 11401/11402 to perform its Self-Test. Do not touch the pushbuttons or the crt touch-screen while either is being tested; a Self-Test failure may result.

If the Self-Test finds no failure the 11401/11402 will perform its power-up initialize sequence and then display the graticule.

In the event that the second part of the Self-Test finds a failure, the following events occur:

1. The 11401/11402 will activate and display an **Extended Diagnostics** menu when the Self-Test ends;
2. The UTILITY and TOUCH PANEL-ON button label will be lit;
3. Two beeps will sound, which indicate that the Self-Test found at least one fault.

Extended Diagnostics is a troubleshooting tool. For a description of Extended Diagnostics and how to use them, qualified service personnel can refer to the 11401 and 11402 Service Manual.

Self-test can also be invoked through the Utilities major menu. For details of the Utility major menu and what you can accomplish with it, refer to Utilities, later in this section.

Restoring Control Settings

When first turned on, the 11401/11402 sets its controls as they were when the instrument was turned off.

The **Plug-In Channels** selections and the **Displayed Waveforms** descriptions are stored, so that when the 11401/11402 is turned on, channels whose waveforms were being continuously acquired will start continuous acquisition. Only waveform setup information is stored in nonvolatile memory at power-down; waveform data is not stored.

The operator can initialize the control settings to a preset state after power-on. Refer to "Initialize Function" under "Utilities", later in this section, for more detailed

Display Intensity

Upon power-up, the display intensity will return to its previous setting. Display intensity can be set with the **Instr Options** function in the Utility major menu.

Power-Down Information

To turn the 11401/11402 off, set the ON/STANDBY switch to the STANDBY position.

Internally Stored Control Settings

The 11401 stores its control settings in nonvolatile RAM (NVRAM). When the instrument is turned off (ON/STANDBY switch set to STANDBY or principal power disconnected), NVRAM maintains its record of the control settings. The settings of the 11401 and its plug-ins are retained, however all stored waveforms and their descriptions will be lost.

When the 11401/11402 is turned on, it will again continuously acquire waveforms that were being continuously acquired when the instrument was turned off.

In other words, when it is turned off and subsequently turned on, the 11401/11402 will remember what it was doing and proceed as before. But it will not remember the waveforms it had previously stored.

Touch-Panel Operation

The 11401/11402 Oscilloscope employs a touch-screen to display information, and as the primary means for instrument control. In addition to displaying waveforms, the screen also shows the currently valid options and functions either as rectangular (highlighted background) labels or as icons. The rectangular labels contain the names of functions, pop-up menus or objects (such as waveforms). The icons represent display functions with adjustable parameters. Icon functions are indicated by their shape and placement on the screen. Detailed explanations of icons and the layout of the display are given elsewhere in this section and in other portions of this manual (refer to the Contents).

Valid selectable options are displayed with a low-intensity background and medium intensity letters or icons. Briefly touching a valid label, waveform, or icon on the screen causes the system to take the indicated action. **The selection is invoked when the touch is withdrawn.**

Making Selections

To select an item: Touch a waveform, a label, or an icon with your finger or some other soft, blunt pointer. When making a selection, you will hear a click from the 11401/11402 just before your finger contacts the screen. If your selection is valid, a solid line box will be drawn around that selection. If your finger is then moved directly away from the screen, the action associated with the touch will be performed, and a second click occurs. If the touch is moved to another valid function area without removing it from the screen, the drawn box will follow the touch. Invalid touches within a menu will be indicated with a dashed line box.

Selecting Waveforms

A waveform that was previously displayed but not selected will change from low to medium intensity when selected. When two or more waveforms are under the pointer, repeated touches will select each waveform in succession. No selection will be made if an unselectable item is under the pointer when the pointer leaves the screen.

TOUCH PANEL ON/OFF

The touch-screen sensing can be turned on or off with the TOUCH PANEL ON/OFF pushbutton, located just above the two knobs on the right side of the screen. The TOUCH PANEL OFF feature can be useful when the instrument is set for a particular task that you want to retain, or to allow touching the screen for purposes of discussion without activating a command. The instrument setup and operating functions do not change when the TOUCH PANEL ON/OFF switch is pressed.

Keyclick Control

The audible click, heard when using the touch screen or pushbuttons, may be turned on or off with the **Audio Feedback** option. The **Instrument Options** pop-up menu in the UTILITY major menu provides this feature. A detailed explanation of this procedure is given in the "Utilities" discussion at the end of this section.

Displaying a Waveform Using AUTOSET

When the AUTOSET button is pressed, the selected waveform is automatically scaled (vertically and horizontally), a trigger point on the selected waveform is chosen, and the waveform is positioned on the crt. If no signal is displayed, the first ac or dc signal found on a plug-in channel will be scaled and displayed.

Each time the AUTOSET button is pressed, the oscilloscope display parameters are automatically selected to provide a nominal waveform display. The steps in the Autoset function are as follows:

1. The signal amplitude from the plug-in channel input is tested and the vertical scaling for the waveform is adjusted. Vertical scaling follows the coarse scale factor convention.

2. A vertical offset is selected that will place the ac component of the waveform at the center of the screen graticule.

3. The selected waveform may become the trigger source for the Main and Window time bases.

4. The Main time base size (time/division) is chosen to display at least three cycles. The sizes (time/division) of Window 1 and Window 2 are set to the size of the first and second pulse width, respectively.

5. The Main timebase position is set so that the Main trigger point occurs two divisions to the right of the vertical axis labels. The Window 1 and Window 2 positions are adjusted to zero and three divisions from the Window trigger point' respectively.

6. Main holdoff by time is set to minimum if it is greater than 1 ms. Window time and events holdoff are also set to their minimum values when their current settings are too large.

If the results of AUTOSET are undesirable, the previous settings can be restored with the **Undo Last AutoSet** function in the **Instrument Options** pop-up menu. The **Instr Options** label is located in the Utility major menu.

The probe ID buttons can be assigned with the **Probes** pop-up menu (in the Utility major menu) to automatically invoke AUTOSET for the probe's signal.

The parameters that AUTOSET adjusts can be selected from the **Instrument Options** pop-up menu discussed under "Utilities". These AutoSet Options allow you to configure the function to fit the application or to reduce the time required to scale and size a waveform. Note in particular that when the **Amplitude Autoset Option** is set to **OFF**, a new trigger level is not calculated, and the horizontal AUTOSET algorithm will fail if the waveform is not already triggered.

Control Knobs and Numeric Keypad Operation

Overview

The Top and Bottom Control knobs allow the operator to set the numeric parameters for any selected function that requires numeric input. Numeric values are assigned to the controls when you select specific icons, major menus, or pop-up menus.

The numeric keypad in the **Numeric Entry and Knob Res** pop-up menu provides an alternative to adjusting values with the Control knobs.

Functions assigned to the Top and Bottom Control knobs are determined either by the mainframe or plug-ins. Further, the plug-ins determine the range of some functions (i.e., Vert Size, Position, etc.).

Control Knob Assignments

The Control knobs can each be assigned separate functions. That is, the knobs offer control of two related functions (e.g., trigger level and trigger holdoff) for improved efficiency. Some applications suited to two-function control are trigger level and trigger holdoff, vertical and horizontal control of a cursor, simultaneous control of two cursors, etc.

The Top and Bottom Control knobs have "soft" labels. These soft labels are displayed on the screen adjacent to their associated control knob and indicate which function each knob controls.

The amount of change in a function's setting is directly proportional to the amount of knob movement. Knob resolution can be set by the user. Refer to "Knob Resolution Control" later in this topic.

Generally, clockwise knob rotation increases the controlled value; counterclockwise rotation decreases the controlled value.

The Top and Bottom Control knobs can change any function that has one of the following characteristics:

1. A numeric entry is needed to completely specify the command.

2. A graphic indicator on the display must be moved (i.e., waveform cursor, measurement parameter, etc.).

The instrument remembers the last selected Control knob assignment for each major menu. This allows you to shift among major menus without reassigning the Top and Bottom Control knob functions each time.

Numeric Entry and Knob Res Pop-up Menu

When selected, some functions require a numeric value to be entered or they allow a numeric parameter to be modified. When a numeric-controlled function is selected, the Top and Bottom Control knobs are assigned to that numeric function's parameters, and labeled accordingly. The labels are placed on the right side of the screen beside the knobs.

Touching one of the knob labels calls up the **Numeric Entry and Knob Res** pop-up menu, which is then associated with that knob's function. The knob function, for which the pop-up menu was invoked, is highlighted beside the other Control knob's function label at the top of the pop-up menu. The **Numeric Entry and Knob Res** pop-up menu displays the minimum and maximum values for the knob's assigned parameter, and the resolution of the knob's adjustment (i.e., coarse or fine). In addition, a numeric keypad is displayed which allows the value for the knob controlled parameter to be entered directly. The other Control knob function can be controlled by touching its label at the top of the pop-up menu. When the **Enter** key is touched, the function is executed, using the value entered. Figure 2-2 shows the features of the **Numeric Entry and Knob Res** pop-up menu.

While using the **Numeric Entry** keypad, the entries you make will be shown at the top of the pop-up menu. After the numbers have been entered by touching a scaling key, if necessary, and the **Enter** key, the new value will be displayed directly below the knob's function label in the menu/status area. Selecting the **Enter** key terminates the numeric entry and immediately invokes the selected function using the new value. The value entered must be within the valid range of the function; otherwise an error message will be generated. If the value entered has greater resolution than the function can accept, the value will be rounded or truncated depending on the function. If the entered value is outside the limits of the function, the value of the nearest limit (maximum or minimum) will be used. A warning message will be displayed in the message area to inform the user that the limit was used. In some cases, such as setting the record length, the closest acceptable value to the value entered will be used.

Description of Keys

The soft keys for the keypad are labeled with medium-intensity symbols on a low-intensity background. The scaling factor keys displayed will vary depending on the parameter being set. The various scale-factor keys displayed result from the choice of scaling factors needed for some functions. The soft keys provided are:

CHS	Invert the sign of the value.
Backspace	Erases the previous number or sign
Enter	Terminates the numeric entry and executes the value selected.
p	Pico (1 EE –12) scaling.
n	Nano (1 EE –9) scaling.
u	Micro (1 EE –6) scaling.
m	Milli (1 EE –3) scaling.
0-9	Numeric keys.
.	Decimal point.

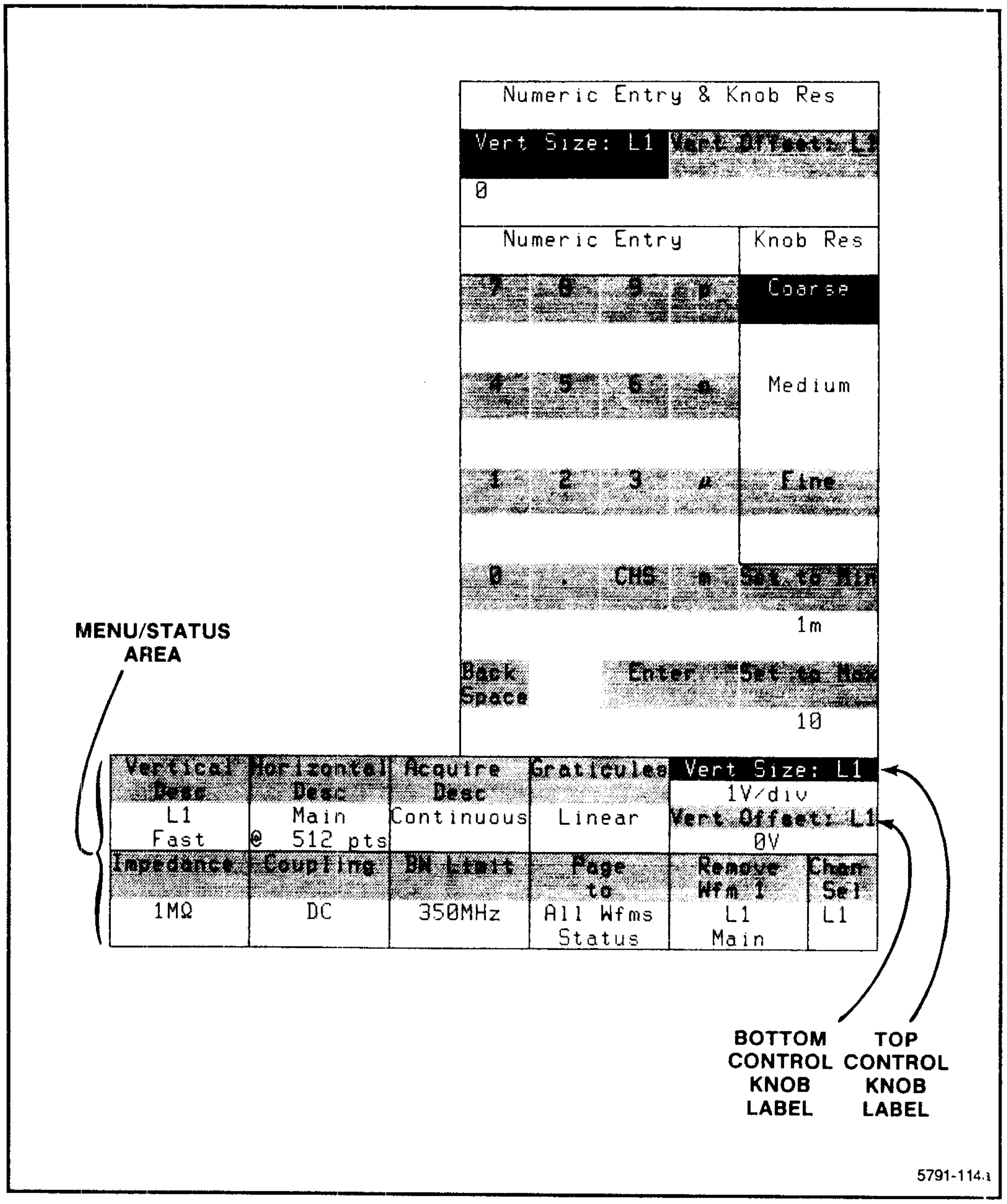


Figure 2-2. Numeric Entry & Knob Res pop-up menu.

Minimum and Maximum Function Limits

Two function labels, **Set to Min** and **Set to Max**, are displayed in the **Numeric Entry and Knob Res** pop-up menu. Touching the functions **Set to Min** or **Set to Max** sets the knob function to its minimum or maximum value, respectively, then invokes the knob's function. The actual minimum and maximum values allowed for the function assigned to the knob are located below the **Set to Min** and **Set to Max** labels. The selected Control knob or the **Numeric Entry** keypad can set the function value anywhere between the minimum and maximum values.

Knob Resolution Control

The **Numeric Entry and Knob Res** pop-up menu provides the means to change the resolution of the knobs from **Coarse**, the initial setting, to **Medium** or **Fine**. Generally, only **Coarse** and **Fine** settings are provided as they will cover a function's range. When the dynamic range of a function is very large, the **Medium** setting will be provided. The value of one detent, or step, of the knob is shown below each resolution label for most functions.

Display Information

The 11401/11402 Oscilloscope uses a nine-inch (23 cm) vertical raster-scanned crt for its display. The screen display has a touch-panel that provides an efficient user interface to the instrument. The screen appears as a dark background overlaid with green waveforms, text, and graphics. The information is displayed with four intensity levels which are defined as: **off**, **low**, **medium**, and **high**. These four levels are used to portray information graphically in an easily used form. For information on the touch sense capability of the screen, refer to Touch Panel Operation earlier in this section.

The screen, which has 44 horizontal lines and 55 vertical columns, is organized into three main sections. The upper 36 lines are the waveform display area. Messages are displayed in the top two lines of the display area. The eight lines beneath the waveform display area are the menu and status area. Error and warning messages are displayed in the message area at the top of the screen. Figure 2-3 shows the main areas of the screen and some of their common display features.

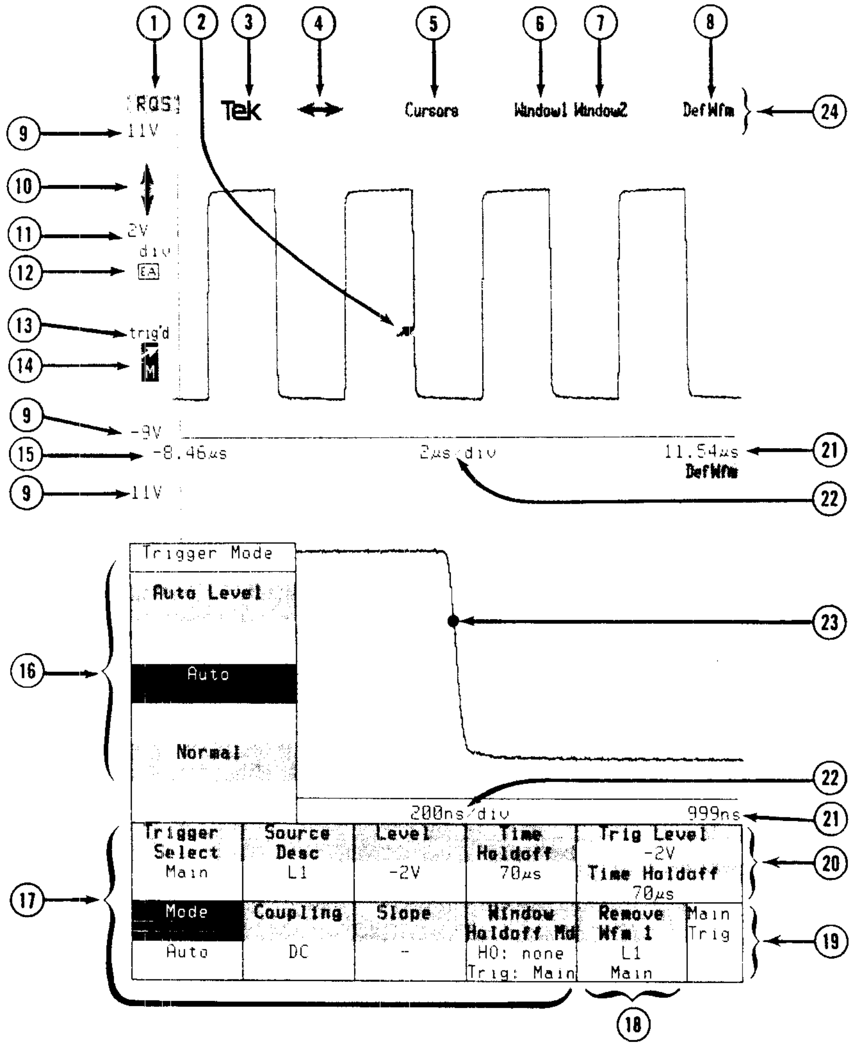


Figure 2-3. Screen area components with two-graticule display.

Crt Display

(1) **RQS** Label–This label will be displayed when enabled from the GPIB or RS-232-C ports.

(2) Trigger Point–Indicates the point on the waveform where the time base trigger occurs. The trigger point occurs only on dc coupled waveforms.

(3) Tektronix logo.

(4) Horizontal Size and Position Icon–Touching this icon assigns control of the horizontal size and position to the Top and Bottom Control knobs, respectively.

(5) **Cursors** Label–Touching this label will display cursors on the last selected waveform. Also, displays the Cursor major menu in the menu/status area.

(6) **Window1** Label–Touching this label creates a window record waveform on a main record waveform.

(7) **Window2** Label–Touching this label creates a second window record waveform on a main record waveform.

(8) **DefWfm** Label–DefWfm means Define Waveform. Touching the DefWfm label allows you to display up to eight waveforms on the screen through the Vertical Description pop-up menu. Normal use is for calculated or complex waveforms.

(9) Vertical DC offset voltage–Readout display showing the upper and lower dc offset voltage limits of graticule.

(10) Vertical Size and Position Icon–Touching this icon assigns control of the vertical size and position to the Top and Bottom Control knobs, respectively.

(11) Vertical scale factor readout–Readout display showing the main graticule vertical scale factor for the selected waveform of the axis.

(12) Enhanced Accuracy symbol (**EA**) indicates that the DC vertical accuracy of the selected waveform is within one percent (when invoked after a 20-minute warmup).

(13) **Trig'd** Label–This label will be displayed when the time base is triggered. When not triggered, **!not! trig'd** will be displayed.

(14) Trigger Level and Holdoff Icon–Touching this icon assigns control of the triggering level and holdoff to the Top and Bottom Control knobs, respectively. The letter displayed below the arrow designates the controlled time base M (main), W (window).

(15) First Vertical Graticule line–Readout display showing the time value of the first (farthest left) graticule line. with respect to the trigger

(16) Pop-up Menu–Pop-up menus are selected and displayed through a major menu in the menu/status area .

(17) Major Menu–Displays a major menu as selected from one of the front-panel MENUS pushbuttons, or the **Cursors** label.

(18) Remove Waveform-Produces pop-up menus that allows for removing the currently selected waveform whose description is displayed below the label.

(19) Icon Associated Functions:

- Trigger—Names the trigger source of the selected waveform (e.g., Main or Window).
- Horizontal—Assigns the Pan/Zoom function to the Control knobs.
- Vertical—The Chan Sel function allows each waveform component of a complex trace description to be individually adjusted.

(20) Control Knob Function Labels—Displays the currently selected Control knob assignments. The numeric value for each Control knob setting is displayed below its assignment label.

(21) Last Vertical Graticule line–Readout showing the time value of the last (farthest right) graticule line.

(22) Horizontal scale (time per division)–Readout display showing the horizontal time per division

(23) Waveform Cursor–Cursors will appear on the selected trace when the **Cursors** label is touched.

(24) Message Area–This area is used to display general purpose , error, and warning messages.

Waveform Display Area

The waveform display area is used both for displaying waveforms, and for other purposes. The types of information shown in the waveform display area are shown in Figure 2-3.

Display features will be described in detail in this section, but their usage is described elsewhere in this manual. Refer to the Contents.

Message Area

The top two lines of the waveform display area comprise the message area. This area either displays information or requests action from the user. The message can be removed by either selecting another function or by touching the message area. The message area is used primarily to display these error and warning messages:

- Errors (The 11401/11402 will not perform the requested operation, and may suggest alternatives.)
- Warnings (The 11401/11402 performs the requested operation, but the results may not be valid; alternatives may be suggested).

Refer to Errors, Warnings and Messages.

Waveforms

Waveforms are displayed in the waveform display area on scaled axes with a graticule overlay. Up to eight waveforms can be displayed concurrently, but only one may be selected at a time. The selected waveform, which is displayed in medium intensity, is the main waveform on which system measurements are made. All other waveforms are displayed in low intensity. In a dual-axes display (split-graticule screen) the window trace (expanded portion of a trace) will also be medium intensity. A waveform is selected either by touching a displayed waveform, touching a waveform's label in the **All Wfms Status** display, or by defining a new waveform. The waveforms may all be displayed on one graticule or they may be distributed on two graticules. A waveform can be a vertical displacement versus time (YT) or an X versus Y axes (XY) plot. For more information on these procedures refer to "Operating the Display" later in this section.

Another type of waveform display is invoked with the window labels at the top of the screen. The window labels, **Window1** and **Window2**, provide functions similar to the delayed sweep on conventional dual time base oscilloscopes. "Windowing" provides an expanded display of a part of the selected waveform, on a second graticule at the bottom of the waveform display area. The part of the selected waveform that is to be expanded is displayed in high intensity while the remainder of the waveform remains in medium intensity. The expanded part on the lower graticule is displayed in medium intensity. Figure 2-4 shows a waveform displayed on the upper graticule with Window 1 and 2 segments highlighted. The lower graticule displays the expanded window 1 and window 2 segments. For a detailed explanation of **Window1** and **Window2** label functions refer to "Waveform Segment Expansion", under "Waveform Control".

Graticules

Either one or two axes and associated graticule(s) may be displayed at any given time. Each waveform is associated with a graticule and a set of axes, with horizontal and vertical axis scaling factors. The graticule has 10 horizontal divisions and 10 vertical divisions of equal size. When dual graticules are selected, the vertical divisions are shortened to make room for two complete graticules. Figure 2-4 shows a two-graticule waveform display.

For more information, refer to "Selecting Graticules" under "Waveform Control" later in this section.

Pop-up Menus

Many items in the major menus, when selected, call pop-up menus. These pop-up menus offer further choices of items and functions in the category selected from the major menu. A currently selected item will appear as a high-intensity symbol on a medium intensity background. The pop-up menu will have a title block at the top. Each subdivision or category within the displayed pop-up menu will also be titled (See Fig. 2-5).

Selecting the highlighted label in the menu/status corresponding to the pop-up menu toggles the display of the menu.

The pop-up menu display will be removed when:

- Any front-panel MENUS button is pressed;
- Any menu/status function is selected;
- A pop-up menu **Exit** is selected;
- A complete and valid selection is made from a pop-up menu;
- A waveform is selected;
- Any displayed icon is selected;
- A plug-in channel button or probe button is pressed; or
- Any area outside the pop-up menu is touched.

Some pop-up menus will offer the user additional command functions at the bottom of the menu. For example, in Figure 2-5 the **Measurements** pop-up menu has an **Exit Menu** label, and a **Clear All** label.

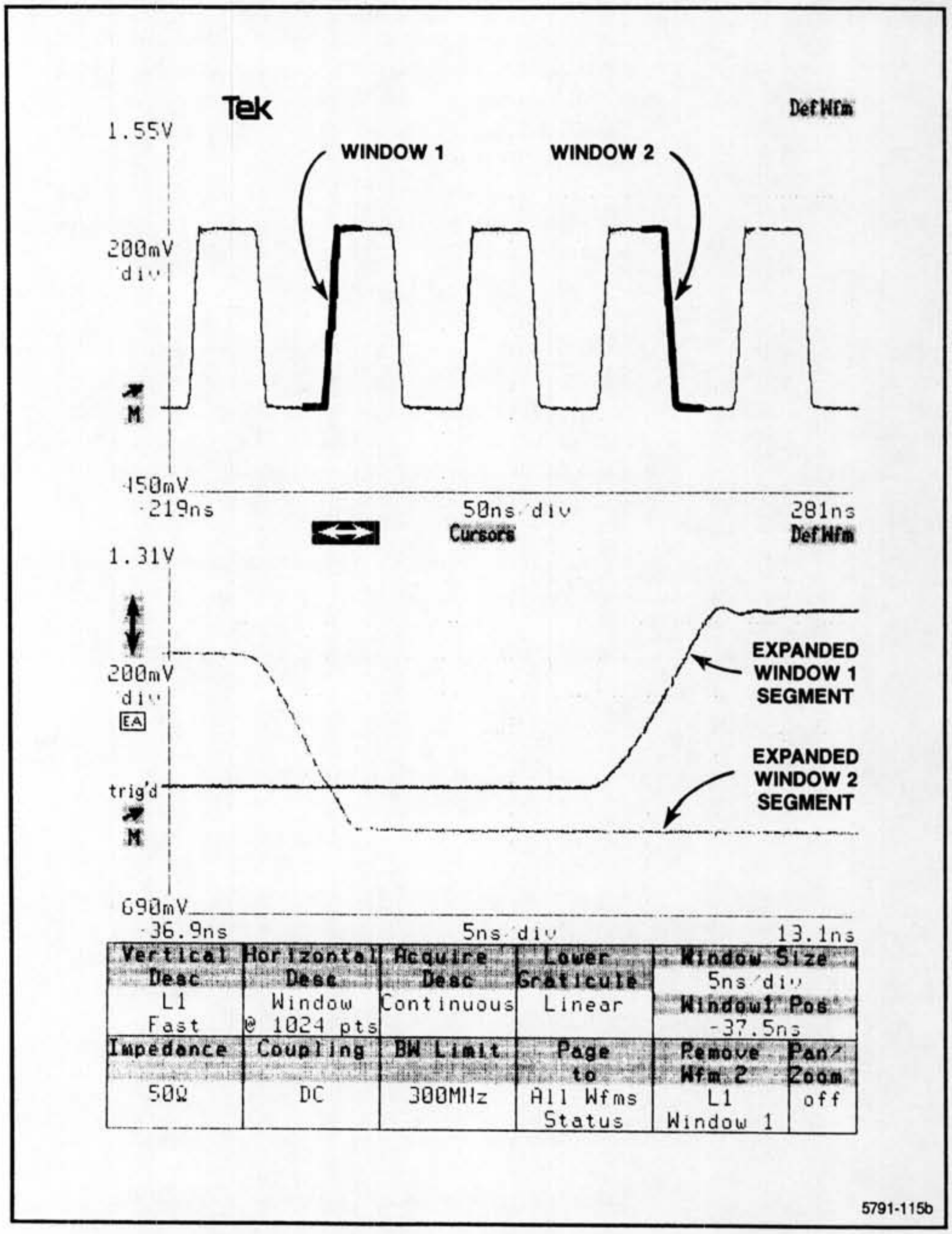


Figure 2-4. Waveform Display with Windows 1 and 2 on Lower Graticule.

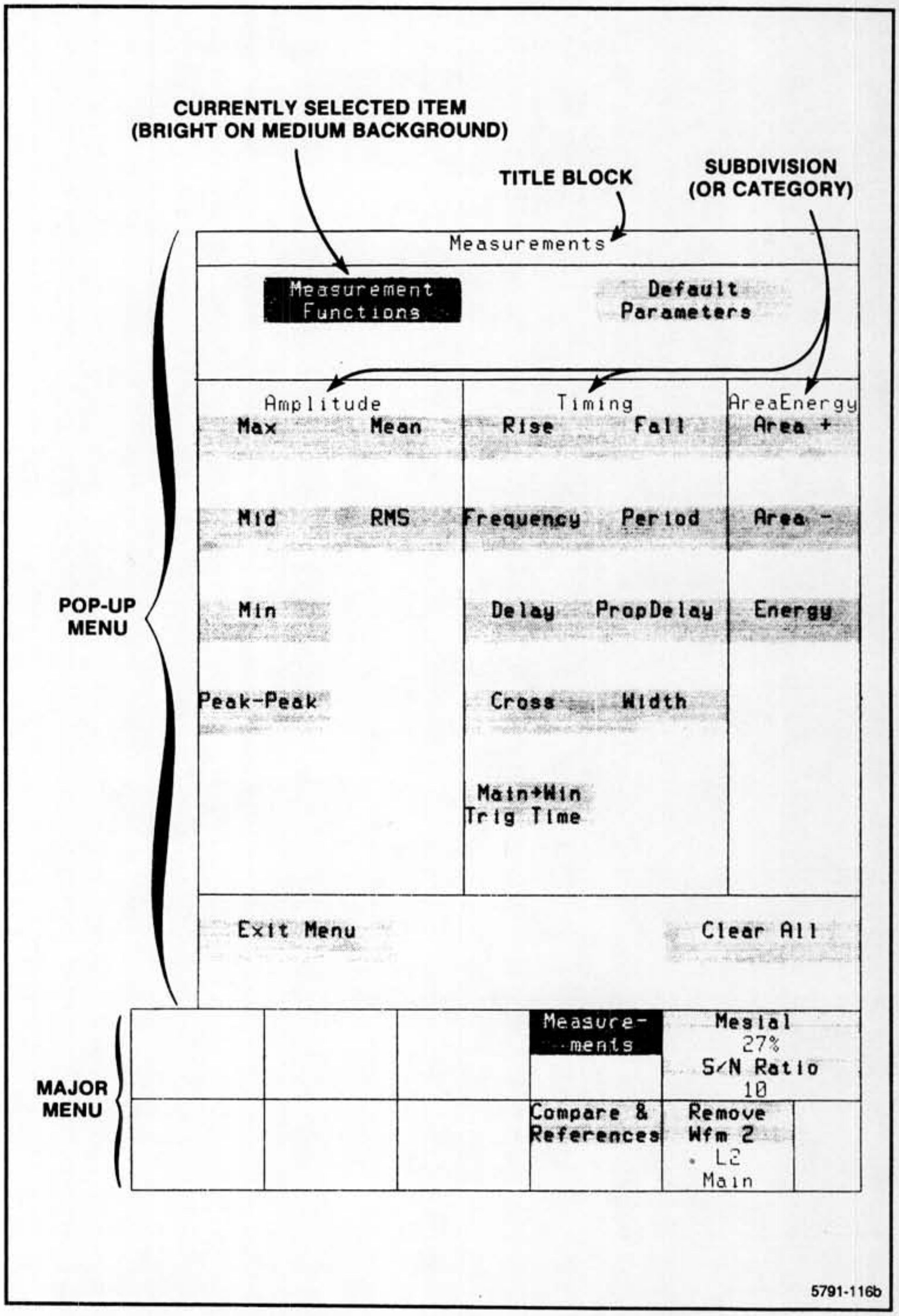


Figure 2-5. Typical pop-up menu configuration.

Icons and Labels

Functions that control the waveform display are accessed through icons and labels. Icons represent waveform display parameters and usually indicate their function with their shape and placement on the screen. For instance, the Vertical Size and Position icon is located beside the left vertical axis. The upper and lower graticules have identical icons.

The icon and label functions displayed for each last selected waveform graticule are:

Icons—

- Trigger Level and Holdoff
- Vertical Size and Position
- Horizontal Size and Position

Labels—

- **Cursors**—Cursors Position and Readout
- **Window1**—Waveform Window 1
- **Window2**—Waveform Window 2
- **DefWfm**—Define Waveform (to define and display a new waveform)
- **RQS**—Request Service (for use with GPIB).

Icons and labels initially appear in medium intensity with a low intensity background. When selected, they change to high intensity on a medium intensity background. The selected icon or label will remain in this state until another selection is made. The system associates some selected icon functions (such as Horizontal Size and Position) with the knobs to the right of the screen, to allow their numeric parameters to be changed. While the knobs are assigned to a functional icon, a label will appear on the screen beside each knob to indicate the parameter it will adjust. For more information on the Top and Bottom Control knobs, refer to "Control Knobs and Numeric Keypad Operation" earlier in this section. The RQS label is discussed in section 3, "GPIB and RS-232-C Interfaces." Figure 2-3 shows the locations and shapes of all the icons and labels for a dual-graticule waveform display.

Waveform Annotation

When the system invokes user-chosen measurements on the currently selected waveform, the various parameters that define the measurements can be shown on the waveform. For example, a notation for the Rise Time measurement would show the lower and upper levels (proximal and distal) on the waveform that were used to measure the rise time. Most default measurement parameters displayed can be changed to suit your needs. The measurement procedures are explained in detail in "Measuring Waveforms" in this section.

Cursors

Cursors are used to define parameters for custom waveform measurements. Each waveform has a set of cursors that may be used only when it is the selected waveform. The cursors are invoked by touching the **Cursor** label at the top of the waveform's graticule. You can change the cursor type by touching the **Cursor Type** label in the menu/status area. Selections can then be made from the **Cursor Type** pop-up menu displayed on the screen. The cursor types and their appearance are as follows:

- **Paired Dots**—The cursors appear as bright dots positioned on the selected waveform.
- **Split Dots**—The cursors appear as bright dots with Cursor 1 positioned on the selected waveform and Cursor 2 positioned on a different displayed waveform.
- **Vertical Bars**—The cursors appear as bright vertical bars the full height of the vertical axis. These are useful for making timing measurements.
- **Horizontal Bars**—The cursors appear as bright horizontal bars the full width of the horizontal axis when selected. These are useful for making amplitude measurements.

The cursors are controlled with the Top and Bottom Control knobs on the front panel or, alternately, with the softkey **Numeric Entry** keypad. The usage of cursors is covered in "Custom Measurement Functions" under "Measuring Waveforms" later in this section.

Cursor Off-Screen Indicators

If the currently selected waveform is expanded so that it takes the cursor off screen, a small triangle will appear at the edge of the screen. These triangle symbols indicate the direction of the cursors:

(▲) Above
(▼) Below
(◀) Left
(▶) Right

Trigger Indicator

The trigger indicator appears on the screen as a small, high-intensity arrow with a low-intensity background, when the trigger source signal is displayed as the selected waveform. The trigger indicator will be positioned at the actual trigger point on that waveform. The trigger indicator will be displayed at a low intensity when the trigger source waveform is displayed, but not selected.

The trigger indicator can be displayed only when the trigger source is a displayed waveform and dc coupled.

Window Indicators

The part of a waveform that is displayed in a Window 1 or Window 2 function will be highlighted on the main displayed waveform. For the selected waveform, the windowed section will be shown in high intensity on a medium-intensity waveform. For nonselected waveforms, the windowed region will appear in medium intensity on a low-intensity waveform.

Enhanced Accuracy System

The 11401/11402 oscilloscope system (mainframe and plug-ins) has two major levels of accuracy; Enhanced, and not-Enhanced. For the first 20 minutes after power-up the instrument accuracy is not specified. Enhanced Accuracy is available after the 20-minute warmup period. Refer to the Enhanced Accuracy System Functional Block Diagram in Figure 2-6.

The Enhanced Accuracy state provides the highest level of vertical accuracy that can be achieved with the instrument systems, not including the probes. The probes must be compensated and deskewed separately. Refer to the "Probe Calibration and ID Function" under "Utilities" in this section.

The Enhanced Accuracy state can be invoked by pressing the ENHANCED ACCURACY button on the front panel. This will cause the oscilloscope system to Self-Test its input sensitivity and note the temperature. Enhanced Accuracy is indicated by the symbol **EA** displayed on the left side of the screen.

The system will remain in the Enhanced Accuracy state as long as the ambient temperature does not change more than ±5 degrees centigrade.

When a waveform is stored, the accuracy state (**EA** symbol for Enhanced Accuracy or no symbol for not-Enhanced Accuracy) will be stored with the waveform. Recalled stored waveforms will be displayed using the accuracy state with which they were stored, regardless of the instrument's current accuracy state.

For further information, refer to section 4, "Specification".

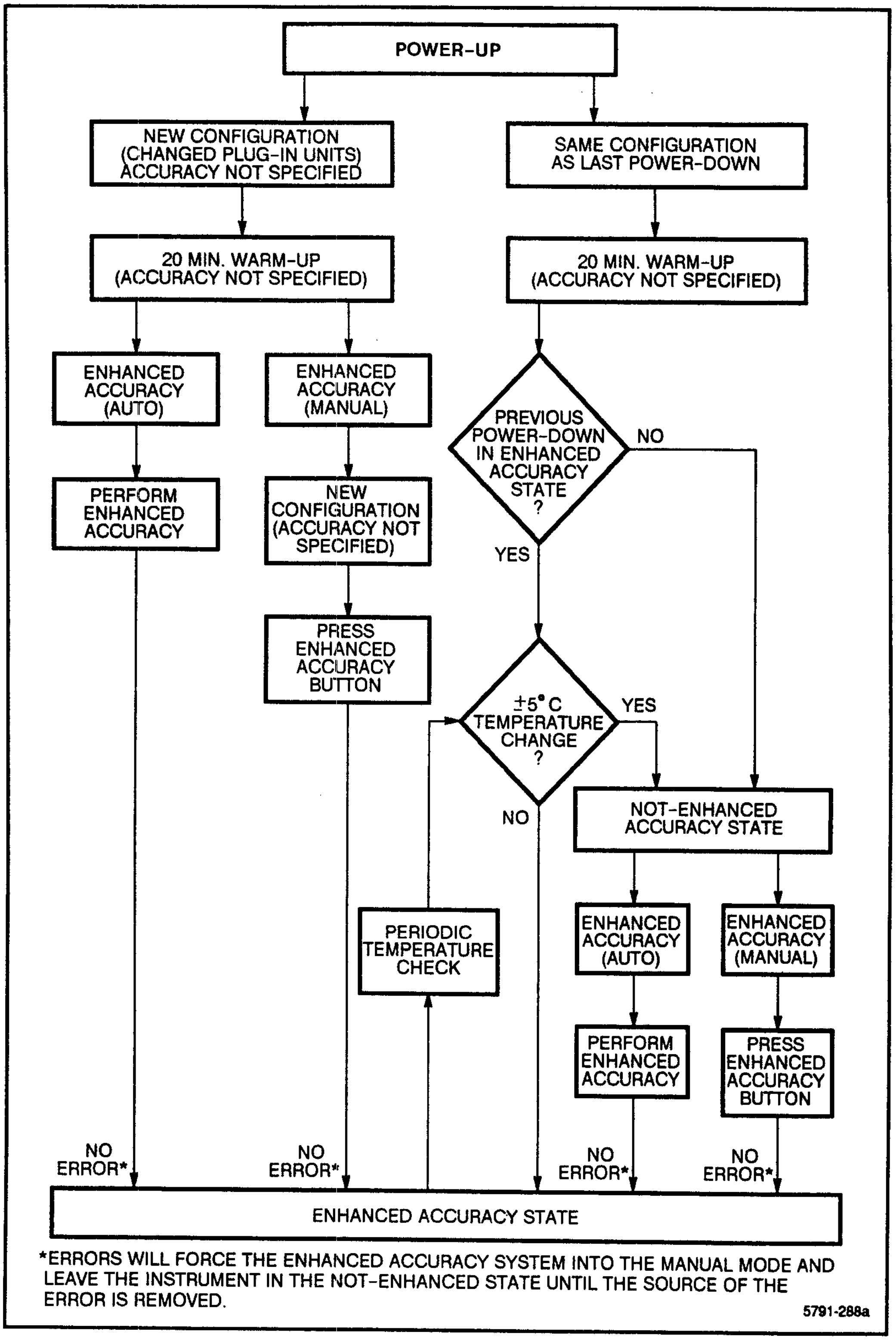


Figure 2-6. Enhanced Accuracy System Functional Block Diagram.

Menu and Status Area

The menu/status area occupies the last eight lines of the screen below the waveform display area. After any MENUS button on the front panel is pushed, or the **Cursor** label is touched, the selectable items will be displayed in the menu/status area. Successive pushes on any MENUS button will alternately remove and restore the major menu display. This provides a less cluttered display, when desired. The system's operating status and any measurement results will also be displayed in the menu/status area. The types of information displayed in the menu/status area are:

- Waveform major menu and status.
- Trigger major menu and status.
- Measure major menu and results.
- Store/Recall major menu and status.
- Utility major menu and status.
- Cursor major menu and status.
- Top and Bottom Control knob labels.
- Remove Waveform.
- Pan/Zoom (with Horizontal Size/Position Icon).
- Channel Select (with Vertical Size/Position Icon).

Menu/Status Area Display Conventions

The menu/status area follows certain conventions in displaying menu items, status and command functions. The information is displayed with four intensity levels, which are: off, low, medium, and high. Figure 2-7 shows the display conventions for major menus and status, with the Trigger major menu as an example.

The display conventions shown in Figure 2-7 operate as described below:

- **Nonselectable**—Nonselectable menu items are shown with off background and dim-intensity symbols.
- **Selectable**—Selectable menu functions are shown with low-intensity backgrounds and medium-intensity symbols.
- **Selected**—The currently selected menu function is displayed with medium-intensity background and high-intensity symbols.
- **Status**—The text immediately below a menu function label shows the present status of that function.

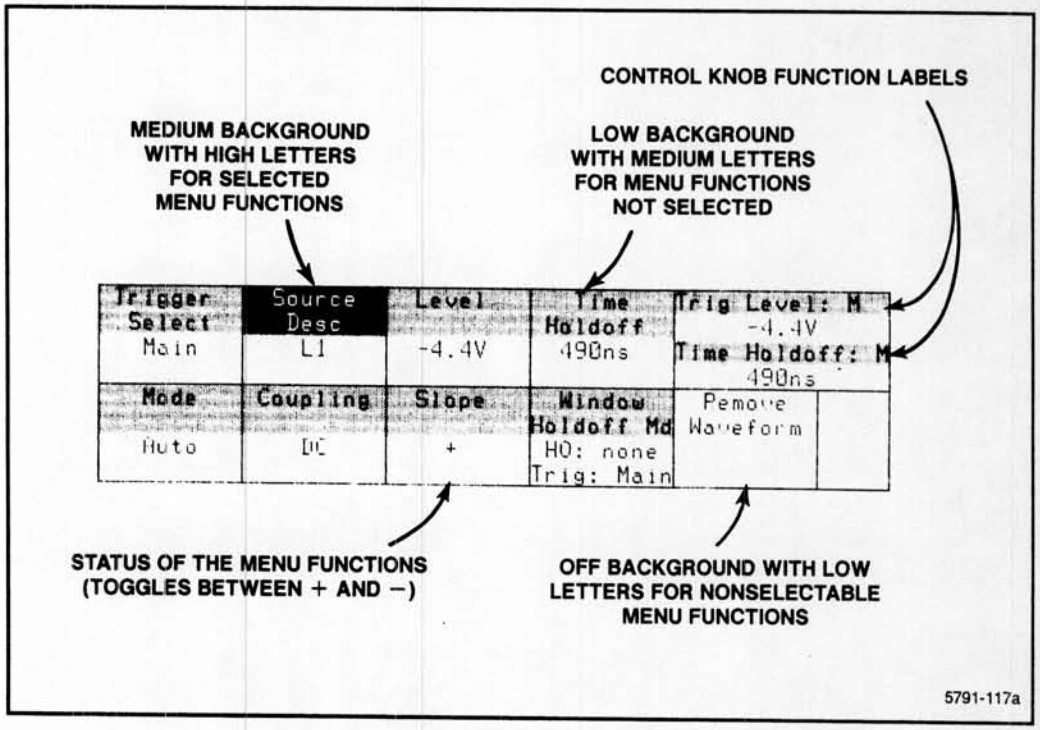


Figure 2-7. Menu/Status area display conventions.

- **Toggle**—Functions that have only two settings change to the other value when the function is selected (e.g., the **Slope** label toggles between + and –).

- **Control Knob Function Labels**—Functions that require entry of numerical values will have the Control knobs assigned to them, so that values can be changed. Their functions are indicated by labels adjacent to the knobs.

- **Paging**—If there is insufficient space to display all the pertinent menu items and their status, the menu and status area must be paged to bring the additional menu items into view. The paging label is not shown in Figure 2-7.

- **Status Overflow**—When the status information for any function has more characters than the allotted space allows, an ellipsis (...) is used to indicate that not all the status information is displayed. The status overflow is not shown in Figure 2-7.

Rear Panel

The rear-panel switches and connectors are briefly discussed here. Also, refer to Figure 2-8, Rear-panel controls, connectors, and indicators.

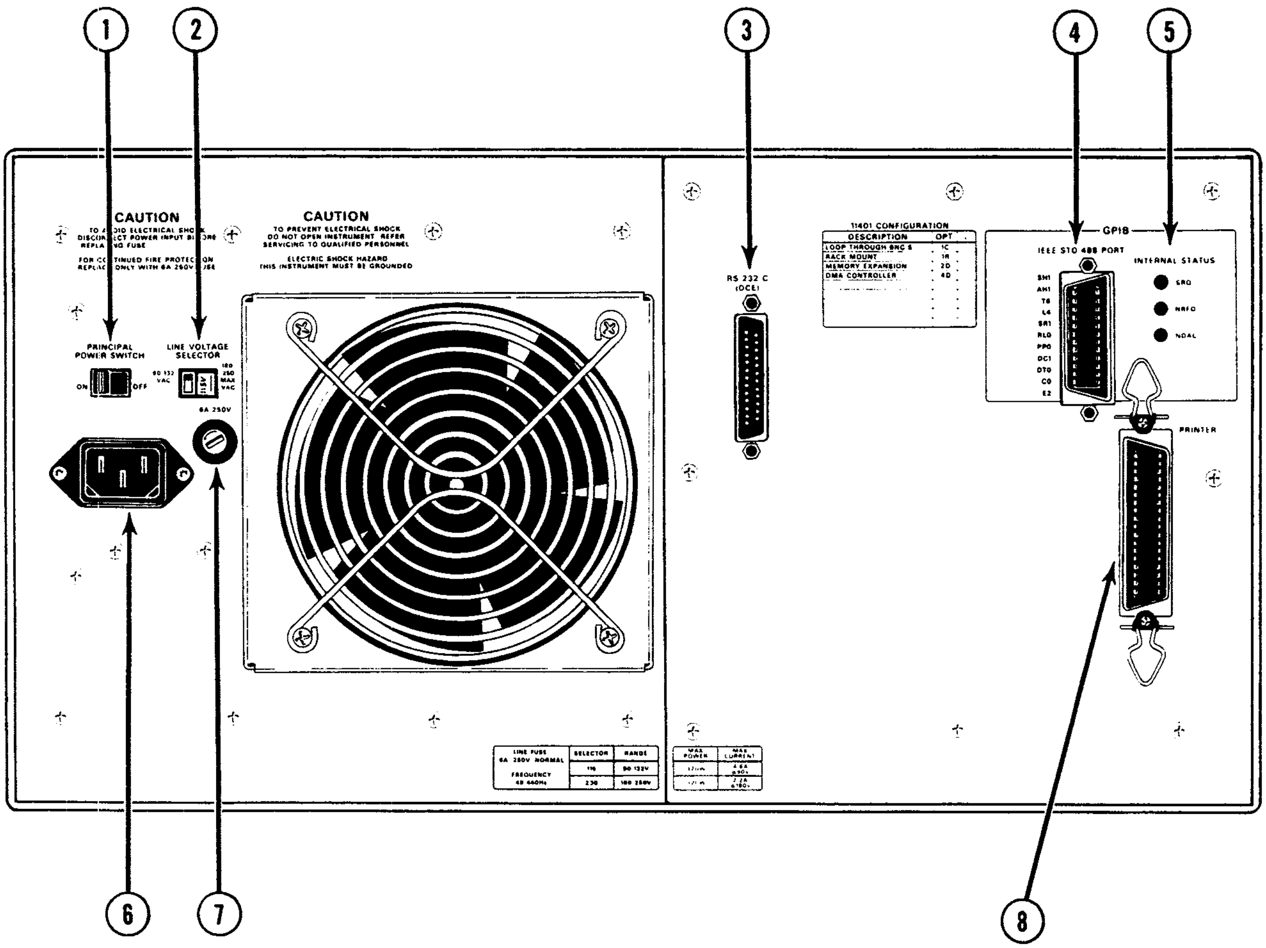


Figure 2-8. Rear-panel controls, connectors, and indicators.

Rear-Panel Controls, Connectors, Indicators, and Fuse

1. PRINCIPAL POWER SWITCH–Controls line power to the 11401/11402.
2. LINE VOLTAGE SELECTOR–Sets the 11401/11402 to accept either 115- or 230-volt nominal line voltage.
3. RS-232-C Connector–Provides a serial data port to communicate with peripheral devices.
4. GPIB Connector–Provides a parallel data port to communicate with peripheral devices for instrument control.
5. INTERNAL STATUS Indicators–LEDs light to indicate present status of GPIB interface.

   SRQ–(Service ReQuest)
   NRFD–(Not Ready For Data)
   NDAC–(Not Data ACcepted)

6. Power Input Connector–Provides a means to connect the 11401/11402 to a line power source.
7. Fuse–6 ampere, 250 volt normal blow.
8. PRINTER Connector–Provides a means to transfer data from the 11401/11402 to a line printer unit for hardcopy.

PRINCIPAL POWER SWITCH

The rear-panel PRINCIPAL POWER SWITCH controls ac power to the instrument. For detailed information refer to "Power-Up Information" earlier in this section.

LINE VOLTAGE SELECTOR SWITCH

The LINE VOLTAGE SELECTOR switch allows you to select 115-volt or 230-volt nominal line-voltage operation. For further information, refer to "Operating Voltage" in Section 1, Installation.

RS-232-C Connector

The RS-232-C connector provides a means of connecting an external serial interface to the 11401 Oscilloscope.

For specifics about controlling the 11401 via an external serial interface, see the following:

- "Utilities" in this section and;
- Section 3, "GPIB and RS-232-C Interfaces" in this manual.

GPIB Connector & Status Indicators

The GPIB Interface connector lets you connect the 11401/11402 into a GPIB system.

For specifics about using the 11401/1402 in GPIB mode, see:

- "Utilities" in this section and;
- Section 3, "GPIB and RS-232-C Interfaces", in this manual.

PRINTER Connector

The rear-panel PRINTER connector provides a means of transmitting hard-copy data to a hard-copy unit.

For specific information about obtaining hard copies of the screen display, see "How to Obtain a Hardcopy of the Screen Display" in "Waveform Control" of this section. Printer connection information is located in Section 1, "Installation".

Associated Equipment

Probes

In addition to the standard Tektronix probes (e.g., variable bias/offset and current probes) four types of voltage probes are available in our new probe format for this instrument:

1. A passive voltage probe,
2. A differential active voltage probe,
3. A 450 Ω offset probe for ECL and other circuits, and
4. Two optical probes.

Coaxial Cables

Coaxial cables used with this instrument must have bnc connectors and should be terminated correctly for minimum signal loss.

Plug-ins

Refer to Section 1, "Installation" for specific data concerning plug-ins.

CAUTION

Before installing or removing plug-ins set the front-panel ON/STANDBY pushbutton to STANDBY. The mainframe or the plug-ins may be damaged if you install or remove a plug-in with the power on.

Anytime a plug-in is replaced with a different type of plug-in the 11401/11402 will initialize the settings of the newly installed plug-in. If the plug-in is replaced with another plug-in of the same type, the settings will remain the same.

Waveform Control

The primary set of Waveform functions is accessed by pressing the WAVEFORM MENUS button on the front panel, which displays the Waveform functions at the bottom of the screen. Vertical and horizontal waveform positions and scale factors are adjusted with the Control knobs after touching the Vertical or Horizontal size and position icons.

This discussion provides information on the facilities and techniques for displaying waveforms and adjusting their appearance.

Displaying Waveforms

A waveform or trace can be displayed in several ways:

1. Pressing the channel button for the plug-in channel connected to a signal.

2. Pressing the probe ID button (when assigned to new waveform selection). The probe ID button performs the same function as the plug-in channel button.

3. Touching the **DefWfm** (define waveform) label (see Fig. 2-9) at the top right corner of the graticule and selecting a plug-in channel or stored waveform from the **Vertical Description** pop-up menu. Touching the **Enter Desc** label completes the selection and displays the waveform.

   The new selected waveform is displayed at medium intensity level, while any other waveforms are displayed at a low intensity level.

   The new waveform's, icons, and labels, and scale factors are displayed on the graticule associated with the **DefWfm** label.

   Pressing the AUTOSET button on the front panel will scale and position the waveform on the screen if pre-assigned to these functions.

4. **Window1**, and **Window2**

   Selecting the **Window1** or **Window2** label creates a new trace showing an expanded segment of the last selected waveform. Refer to "Waveform Segment Expansion" later in this section.

   If the **Window1** or **Window2** label is touched, the new waveform is displayed on the lower graticule.

5. Selecting a stored waveform with the **Recall Waveform** function label in the Store/Recall major menu. Waveforms can be stored from the display and recalled to the display. These functions reside in the Store/Recall major menu.

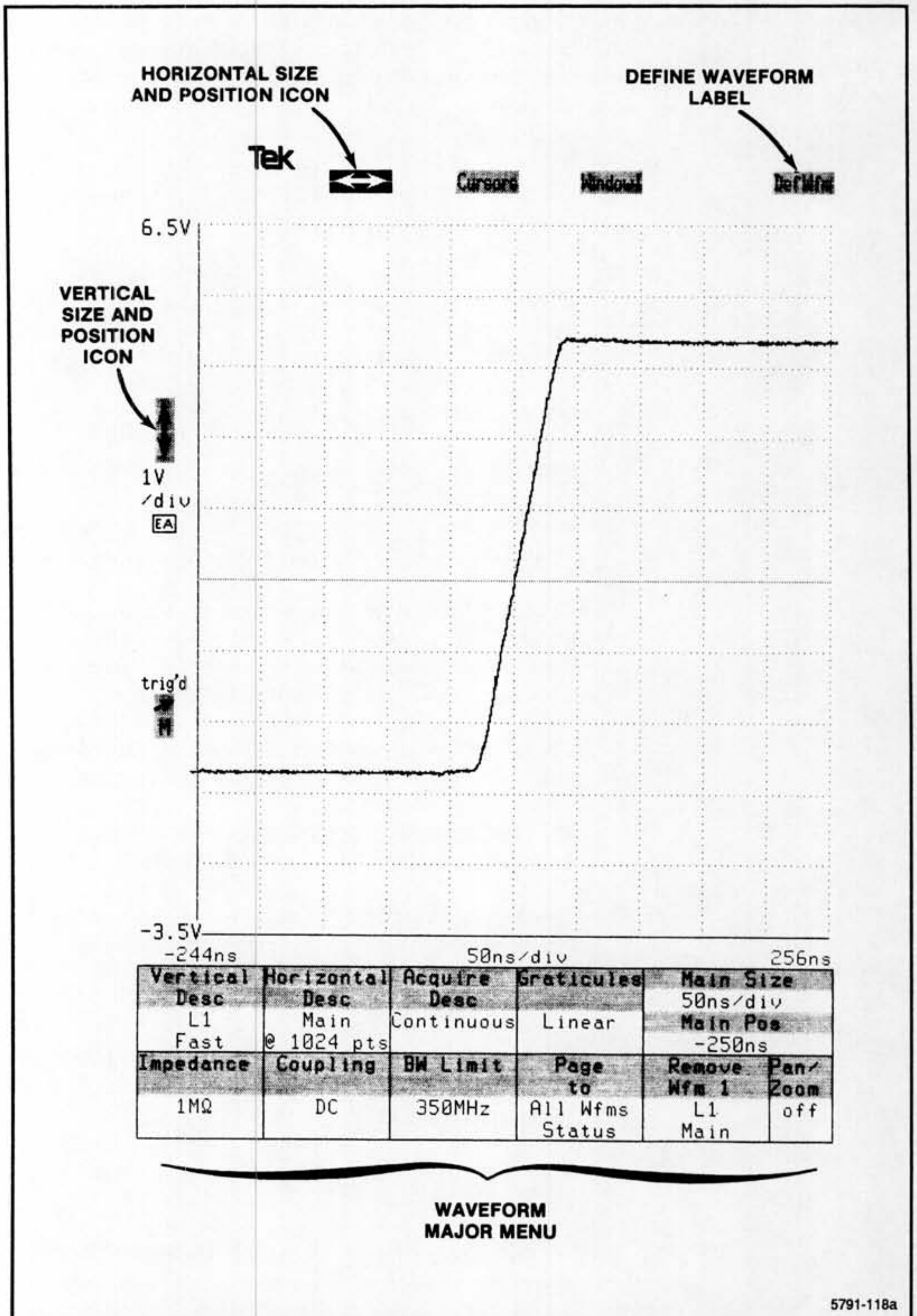


Figure 2-9. Location of **DefWfm** label for one graticule display.

Waveform Menu Function Selections

When you press the front-panel WAVEFORM button, the 11401/11402 displays the Waveform major menu in the menu/status area at the bottom of the screen. Refer to Figure 2-9. The selected waveform's status is displayed under each of the menu items listed below. Selection of the **Page to All Wfm's Status** label displays the scale factors for all displayed waveforms in the menu/status area.

Functions that can be performed through the Waveform major menu are listed in Table 2-1. A detailed description of each function listed in the table is discussed in the text following the table.

TABLE 2-1
Waveform Major Menu Functions

Function	Operation Performed
Vertical Desc	A source description (e.g., L1, for Left plug-in compartment, channel 1) for the vertical component of a displayed waveform.
Horizontal Desc	Main or Window time base (description) and record length for YT display, or one of the previously defined waveforms (either stored or continuously acquired) for XY displays.
Graticules	Selects the number of graticules and the graticule on which the selected waveform resides.
Acquire Desc	The plug-in channel waveform acquisition can be stopped upon completion of a chosen requirement, and both Averaging and Enveloping can be started.
Impedance	The input impedance for the selected plug-in channel.
Coupling	The input coupling for the selected plug-in channel.
BW Limit	The bandwidth limit for the selected plug-in channel.
Page to	Displays the waveform name, time base and scale factor for each displayed waveform. Refer to "Status of All Displayed Waveforms" later in this section.
Pan/Zoom	Allows control of waveform expansion when the Horizontal Size and Position icon is selected. Refer to Horizontal Size and Position in this subsection for a detailed discussion.

Table 2-1 (cont)
Waveform Major Menu Functions

Function	Operation Performed
Control Knobs	Allows control of individual components of the Control Knobs when the Main Size and Position icon is selected.
Remove Waveform	Allows removal of the currently selected waveform from the display and its description from the **Vertical Desc** label. If several waveforms are displayed, the instrument will choose another waveform to be the selected waveform. The description for that waveform will appear below the **Vertical Desc** label. In this way, all displayed waveforms may be removed from the screen. Note: when the Remove Waveform function is touched, the selected waveform is not immediately removed. Instead, a Verify Wfm Removal pop-up is displayed. If this popup's "Remove" label is touched, the selected waveform is removed. Any other touch location cancels the removal request.

Vertical Description

The vertical description specifies the source of the vertical (Y-axis) amplitude or displacement for a waveform display. Vertical sources are signals being acquired with plug-in units or reference waveforms stored in memory. Touching the **Vertical Desc** label causes the **Vertical Description** pop-up menu to be displayed in the waveform display area. (See Fig. 2-10). The Vertical Description entry is shown at the top of the pop-up menu.

Vertical sources may be combined using the arithmetic operators and math functions in the **Vertical Description** pop-up menu. For instance, choosing L1 + Ln(C2) means that the selected waveform's vertical component will be comprised of the signal from the number one channel of the Left plug-in added to the natural logarithm of the number two channel of the Center plug-in. The result of the expression evaluation provides the vertical information displayed on the Y-axis. This complex trace can be manipulated as if it were a stored trace.

These waveform expressions are evaluated in the following order:

1. Expressions within paired parentheses.

2. Waveform Functions

3. Multiplication (*) and division (/)

4. Addition (+) and subtraction (–) or inversion (–)

A waveform can be inverted on the display by prefixing its description with a minus sign (e.g., –L1, –(L1+Ln(C2)), –Sto3, etc.).

Waveform expressions must follow certain syntax rules. Syntax rules are enforced by permitting selection of valid items only . If the syntax of a description is incorrect the **Enter Desc** label will not be selectable.

Touching the **Enter Desc** label in the **Vertical Description** pop-up menu completes the waveform description process and displays the requested waveform.

Functions **Average** and **Envelope** can be performed with either integer or floating point arithmetic. The integer mode is performed quicker but produces only four digit measurement results. Floating point results have six digit measurement resolution. To select one of these Waveform Scaling modes refer to "Instrument Configuration and Display Options" under "Utilities" later in this section.

Selections made from the **Vertical Description** pop-up menu are shown below the **Vertical Desc** label in the menu/status area. The name or the mathematical expression (at least the part that fits within the area allotted) associated with the waveform will be displayed to identify the waveform (i.e., L1+Ln(C2)).

Vertical Description Pop-up Menu

When the **Vertical Desc** label in the Waveform major menu is selected, the pop-up menu is displayed in the waveform display area and its label is highlighted (see Figure 2-10).

Menu Items

The **Vertical Description** pop-up menu is divided into five functional areas which define the vertical components of a waveform or trace. They are:

- **Plug-in channels**—Lists the channel inputs for all plug-ins installed in the LEFT, CENTER, and RIGHT compartments (e.g., L1 "Left plug-in channel 1", or R3 "Right plug-in channel 3").

- **Keypad and Operators**—Math symbols (i.e., +, –, *, and /), numeric keypad, and scientific notation (i.e., EEX).

  These operators allow channels and waveforms to be added, subtracted, inverted, multiplied, and divided.

  Only highlighted operators can be selected. To chain operators, parentheses must be used (e.g., L1+(–C2)).

  Operators EEX and minus allow a number such as .05 to be entered as 5 EEX –2 (5 times 10 to the minus 2 power).

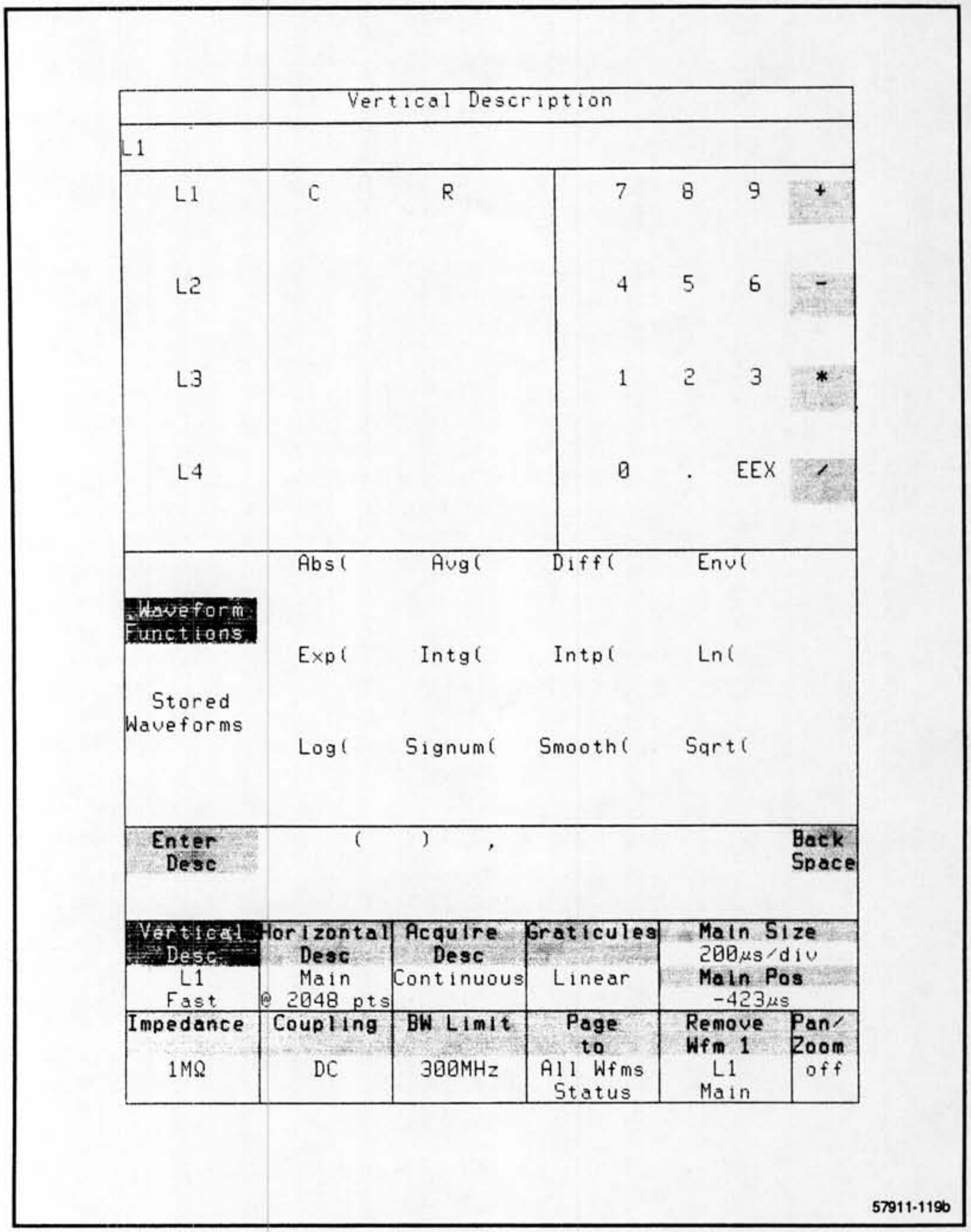


Figure 2-10. Vertical Description pop-up menu.

- **Waveform Functions**—Math functions (i.e., Average, Ln, Square Root, etc.). If the functions are not visible, touch the **Waveform Functions** label.

- **Stored Waveforms**—There is an entry for each internally stored waveform. Touch the **Stored Waveforms** label to view and select a previously stored waveform.

  Page to—These entries are used to page the Stored Waveforms area up and down to display all available entries.

- **Common Menu Items**—The following menu selections are common to all functions within the **Vertical Description** pop-up menu:

  Enter Desc—Touching this label exits the **Vertical Description** pop-up menu and executes the commands selected.

  Backspace—Touching this label backspaces and deletes entered items (for error corrections) displayed in the message area at the top of the screen.

  (and)—Parentheses provide the proper order for evaluating waveform expressions.

  , —Comma separates terms for functions requiring more than one term for proper evaluation. Some functions require a comma, then a value for the number of repetitions of the function. For example, Smooth(ST01,21) means average each point of stored waveform number one with twenty-one adjacent points.

When you exit the **Vertical Description** pop-up menu by touching **Enter Desc**, the new waveform expression is evaluated. Then, the resultant trace is displayed on the screen.

A quick way to cancel all selections while still in the **Vertical Description** pop-up menu is to simply touch any function label in the menu/status area or to press any MENUS button. This action ignores all selections and removes the pop-up menu from the display.

The terms "Fast" and "High Precision" appearing in the Vertical Descriptions of traces refer to differences in internal processing of waveform data. Single-channel and simple Vertical Descriptions, such as "L1", are processed as integer arrays, resulting in rapid updating of the displayed trace. These have the word "Fast" in the Vertical Description.

Calculated waveforms, stored waveforms, and scaled Average and Envelope waveforms are termed "High Precision". They are processed as floating-point arrays and update more slowly allowing waveform scaling and increased precision. Some Vertical Descriptions examples are: Log(L1) and (L1+1).

Selecting Waveform Functions

Waveform Functions share an area of the pop-up menu with the list of Stored Waveforms. If the Stored Waveforms are displayed, touch the **Waveform Functions** label and the Waveform Functions will return to the shared display area.

All Waveform Functions appear with a left parentheses (e.g., **Avg(**, **Env(**). After a Waveform Function has been selected, a waveform name (i.e., plug-in channel or stored) or an expression must be entered followed by a right parentheses. Only valid choices are selectable.

Functions are executed continuously for any expression that has a plug-in channel component. Functions are executed only once for stored waveforms. The result of a Waveform Function is another waveform, not a single scalar value.

The **Waveform Functions** category of the **Vertical Description** pop-up menu contains all the available arithmetic functions (see Fig. 2-10).

The following functions are available from the **Waveform Functions** category of the **Vertical Description** pop-up menu:

Average

The Average function can be used to remove random noise from a signal and present a better picture of the actual waveform. Averaging more waveform acquisitions removes more noise. Also, an averaged waveform produces averaged measurement results that have greater accuracy.

After selecting the **Avg(** label from the Waveform Functions category, the name of a continuously acquired waveform or a waveform expression must be entered. The next entry should be a closing parenthesis. By default, 32 waveform acquisitions are averaged.

The number of averages can be set in the **Acquire Description** pop-up menu. Averaging can also be invoked or halted on the selected waveform from the **Acquire Description** pop-up menu.

Waveform Scaling is optional. When **Waveform Scaling** is set to Optional, averaging will be fast; when set to Forced, averaging will be slower but with higher precision. Refer to "Instrument Configuration and Display Options" in "Utilities" later in this section

Algorithms for all waveform functions are defined in Appendix B.

Envelope

The Envelope function provides a method of capturing amplitude variations occurring during consecutive cycles of a signal. The envelope shows how the signal has varied over a period of time. This is done by storing both the maximum and minimum values for each data point of the acquired waveform. These values are then used to construct a display of the signal envelope. By default, 32 waveform acquisitions are used.

After selecting the **ENV(** label from the **Waveform Functions** category, the name of a continuously acquired waveform or a waveform expression must be entered. The next entry should be a closing parenthesis.

The number of waveform acquisitions included in the envelope can be set in the **Acquire Description** pop-up menu. Enveloping can also be invoked or halted on the selected waveform from the **Acquire Description** pop-up menu. **Waveform Scaling** is optional.

Algorithms for all waveform functions are defined in Appendix B.

Smooth

When selected, **Smooth(** replaces each point of a stored waveform with the average value of the waveform points within a specified distance about that point.

Selecting **Smooth(** allows you to choose a single stored waveform and set the number of points (N) to be averaged. N can be any odd integer value between 3 and 999 except when the waveform record is 512 points in which case the upper limit is 511. **Smooth(** must be followed by a comma before the number, N, is entered. A closing parenthesis is required. **Waveform Scaling** will be Forced.

Algorithms for all waveform functions are defined in Appendix B.

Natural Logarithm

Ln(takes the natural logarithm (base e) of the vertical value of each waveform data point. The natural logarithm results provide the vertical plot data for a waveform. The horizontal scale is not changed. Ln works on plug-in channels, stored waveforms, or both combined. **Waveform Scaling** will be Forced.

Algorithms for all waveform functions are defined in Appendix B.

Exponential

The natural logarithm base e is raised to an exponent equal to the vertical value of a waveform data point. **Exp(** exponentiates each point of the waveform. The results provide the vertical plot data for a waveform. The horizontal scale is not changed. Exp works on plug-in channels, stored waveforms, or both combined. **Waveform Scaling** will be Forced.

Algorithms for all waveform functions are defined in Appendix B.

Logarithm

The Logarithm function converts the absolute vertical values in the waveform record to common logarithms of base 10. The results provide the vertical plot data for a waveform. The horizontal scale is not changed. **Log(** works on plug-in channels, stored waveforms, or both combined. **Waveform Scaling** will be Forced.

Algorithms for all waveform functions are defined in Appendix B.

Square Root

The Square Root function calculates the square root of the absolute vertical value of each waveform data point. The results provide the vertical plot data for a waveform. The horizontal scale is not changed. **Sqrt(** works on plug-in channels, stored waveforms, or both combined. **Waveform Scaling** will be Forced.

Algorithms for all waveform functions are defined in Appendix B.

Integrate

The Integrate function calculates the integral of the vertical values of the waveform data points. The results provide the vertical plot data for a waveform. The horizontal scale is not changed. **Intg(** works on plug-in channels, stored waveforms, or both combined. **Waveform Scaling** will be Forced.

Algorithms for all waveform functions are defined in Appendix B.

Differentiate

The Differentiate function calculates the differential vertical value of the waveform data points and returns the resulting differentiated waveform. The horizontal scale is not changed. **Diff(** works on plug-in channels or stored waveforms, or both combined. **Waveform Scaling** will be Forced.

Algorithms for all waveform functions are defined in Appendix B.

Absolute Value

The Absolute Value function makes positive all vertical values of the waveform data points. The results provide the vertical plot data for a waveform. The horizontal scale is not changed. **Abs(** works on plug-in channels, stored waveforms, or both combined. **Waveform Scaling** will be Forced.

Algorithms for all waveform functions are defined in Appendix B.

Signum

The **Signum(** (sign of a number) function converts vertical waveform data points to 1 when greater than zero, and to –1 when less than zero. Out of range and zero vertical values are not changed. The results provide the vertical plot data for a waveform. The horizontal scale is not changed. Signum works on plug-in channels, stored waveforms, or both combined. **Waveform Scaling** will be Forced.

Algorithms for all waveform functions are defined in Appendix B.

Interpolate

The Interpolate function replaces null points within a stored waveform record with vertical values equal to the average of the next valid value on each side of the null point. The stored waveform is displayed with the interpolated vertical values substituted for the null points. The horizontal scale is not changed. **Intp(** works only on single stored waveforms. **Waveform Scaling** will be Forced.

Algorithms for all waveform functions are defined in Appendix B.

Horizontal Description

The **Horizontal Description** pop-up menu lets the user choose the horizontal component of the display.

Two basic display modes are available: YT and XY.

Both Normal and Point Accumulate YT displays can be presented; Normal YT is a conventional display, and Point Accumulate YT produces the effect of infinite persistence.

An XY display waveform can be produced from either the signals being acquired, or stored waveforms.

When you press the front-panel WAVEFORM button, the **Horizontal Desc** label appears in the menu/status area. Touching the **Horizontal Desc** label will display the **Horizontal Description** pop-up menu (see Fig. 2-11).

Horizontal Description Pop-up Menu

When the **Horizontal Desc** label in the Waveform major menu is selected, the pop-up menu is displayed in the waveform display area and its label is highlighted (See Fig. 2-11).

Menu Items

The following items are entries in the **Horizontal Description** pop-up menu:

- **Acquiring Timebase**—indicates the selected waveforms time base; either **Main** or **Window.**
- **Main & Window Sample Interval**—reads t/point, where t = time. Sample Interval can be indirectly controlled by varying the record length or horizontal size.
- **Main & Window Record Length**—separate entries permit individual control of **Main** and **Window** time bases. When selected, record length may be varied with the Control knobs. The range is 512 to 10,240 points.
- **YT Display Mode**

  Normal—in Normal YT mode, only the current vertical value is displayed for each horizontal point.

  Point Accumulate—in Point Accumulate YT mode, vertical values are allowed to accumulate for each horizontal point on the display. Such accumulation produces the effect of infinite persistence. The maximum record length of the selected waveform is 2048 points in this display mode.

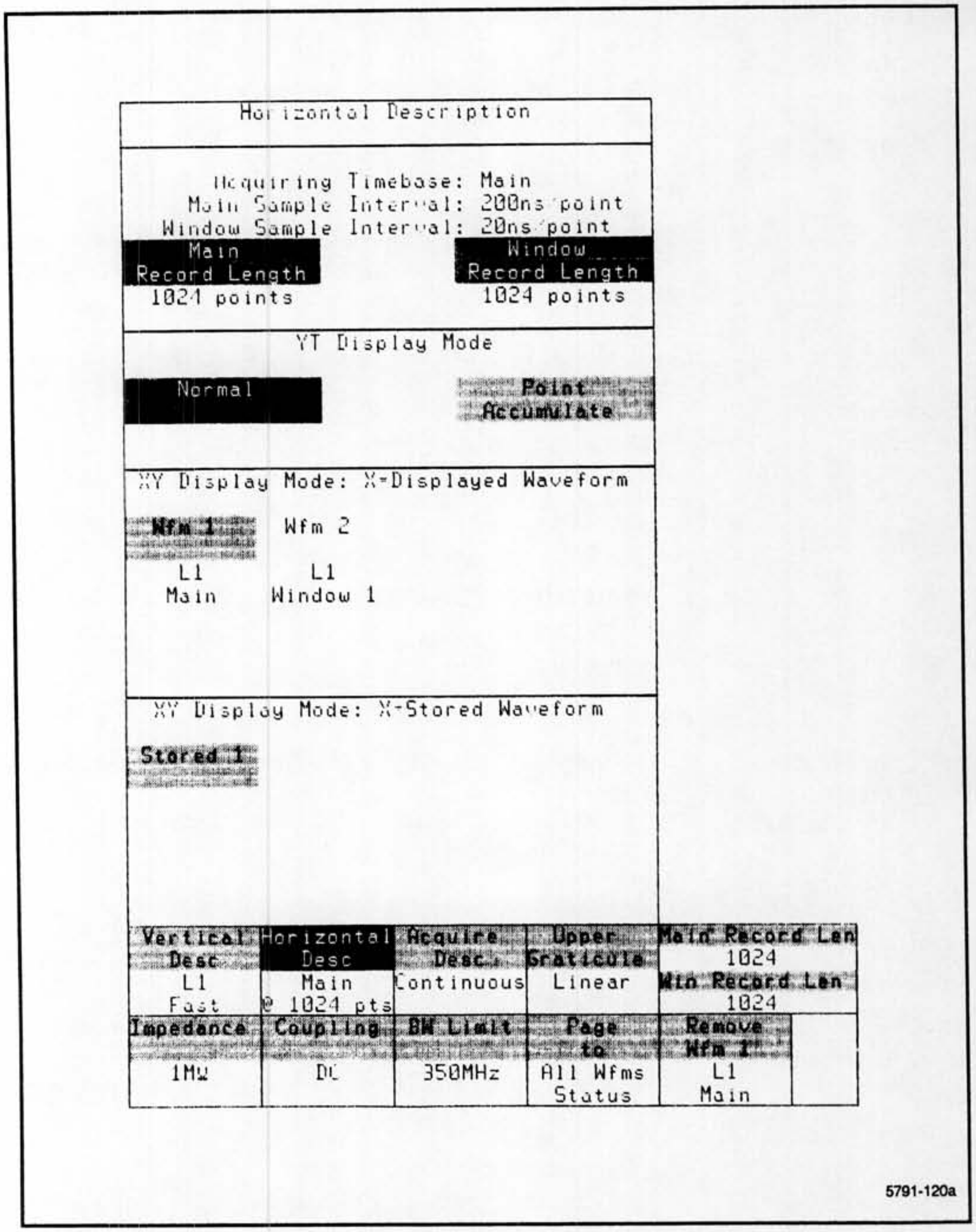


Figure 2-11. Horizontal Description pop-up menu.

- **XY Display Mode**

  X=Displayed Waveform (plug-in channel waveform or waveform expression)—previously defined YT waveforms that are being displayed may be selected to create an XY waveform.

  X=Stored Waveform—this category lists each internally stored waveform.

  The currently selected waveform is used for the Vertical display. The waveform selected in the **XY Display Mode** menu is used for the horizontal display.

- **Page to**—if many waveforms have been stored, touching the **Page to** label will display additional waveforms. When an end of the list of waveforms is reached, or if the entire waveform list is displayed, the corresponding Page label will dim.

YT Waveform Display by Point Accumulation

The **Point Accumulate YT** display differs from the Normal YT display mode in that it does not erase old trace data when new data is acquired. The **Point Accumulate YT** display is intended for displaying infrequent, but repetitive, events by gradually building a picture of the waveform.

YT waveforms are displayed in **Point Accumulate YT** only when they are the selected waveform. If a **Point Accumulate YT** waveform becomes unselected its display mode is changed to **Normal YT**. The display mode will revert to **Point Accumulate YT** when it again becomes the selected waveform. Two waveforms can be in **Point Accumulate Mode** by using two graticules, where each graticule will have a selected waveform to use **Point Accumulate Mode** on. The maximum waveform record length is 2048 points. Point Accumulate is not selectable for longer record lengths.

When a pop-up menu is displayed, Point Accumulate acquisition halts. Removal of a pop-up menu clears the screen and acquisition continues.

To select Point Accumulate mode, touch the **Point Accumulate** entry under the **YT Display Mode** label in the **Horizontal Description** pop-up menu.

Displaying XY Waveforms

The XY display mode allows the user to plot two YT traces against each other. XY waveforms are divided into two classes: actively acquired XY traces, which are updated as new data is acquired, and stored XY traces (i.e., those whose data is static). The two XY display modes are mutually exclusive, although an acquired signal can be combined with a stored signal for an XY waveform.

XY waveforms can be constructed from records of any length. They may have no intensified zones (i.e., no windows). XY waveforms are displayed only on a one graticule display.

To create a XY display, touch the waveform label of the waveform desired for the X axis of the XY display. The currently selected waveform as shown in the Vertical Description box will be used for the Y axis of the XY display.

Time base parameters are not directly controllable when in XY display. To adjust the horizontal time base, the Normal YT Display mode must be chosen, or you may adjust the horizontal magnitude of another displayed YT waveform that uses the Main time base.

The status entry below the **Horizontal Desc** label in the menu/status area shows the description of the horizontal source.

XY Waveform Restrictions

- Only one XY waveform may be actively acquired at a time. A maximum of two XY waveforms may be displayed in the stored XY mode.
- When an XY waveform is created, the scaling modes of its two YT components must agree ("scaling" refers to whether or not YT waveform data is computed with floating point or integer arithmetic). Refer to the waveform scaling description in the instrument options pop-up menu for more details. The following examples illustrate this restriction:

XY Waveform			Comments		
L1	plotted against	C4	Valid,	integer	—integer
ST01	plotted against	ST03	Valid,	float. pt.	—float. pt.
ST01	plotted against	L2	Invalid,	float. pt.	—integer
R1	plotted against	R1/R2	Invalid,	integer	—float. pt.

Selecting Graticules

The **Graticules** function allows the user to simultaneously display two graticules.

X-axis and Y-axis trace parameters are displayed on both graticules. If a graticule displays more than one trace, the displayed parameters pertain to the last-selected waveform (medium intensity). Only displayed parameters are affected by the Control knobs.

Figure 2-18 later in the text shows where the vertical and horizontal scale factors and limits are located on the screen.

Both single and dual graticules have 10 vertical and horizontal divisions. However, dual graticules have shortened vertical divisions.

Graticules Pop-up Menu

Selecting the **Graticules** label will display the **Graticules** pop-up menu in the waveform display area and highlight its label in the menu/status area. The **Graticules** pop-up menu is shown in Figure 2-12.

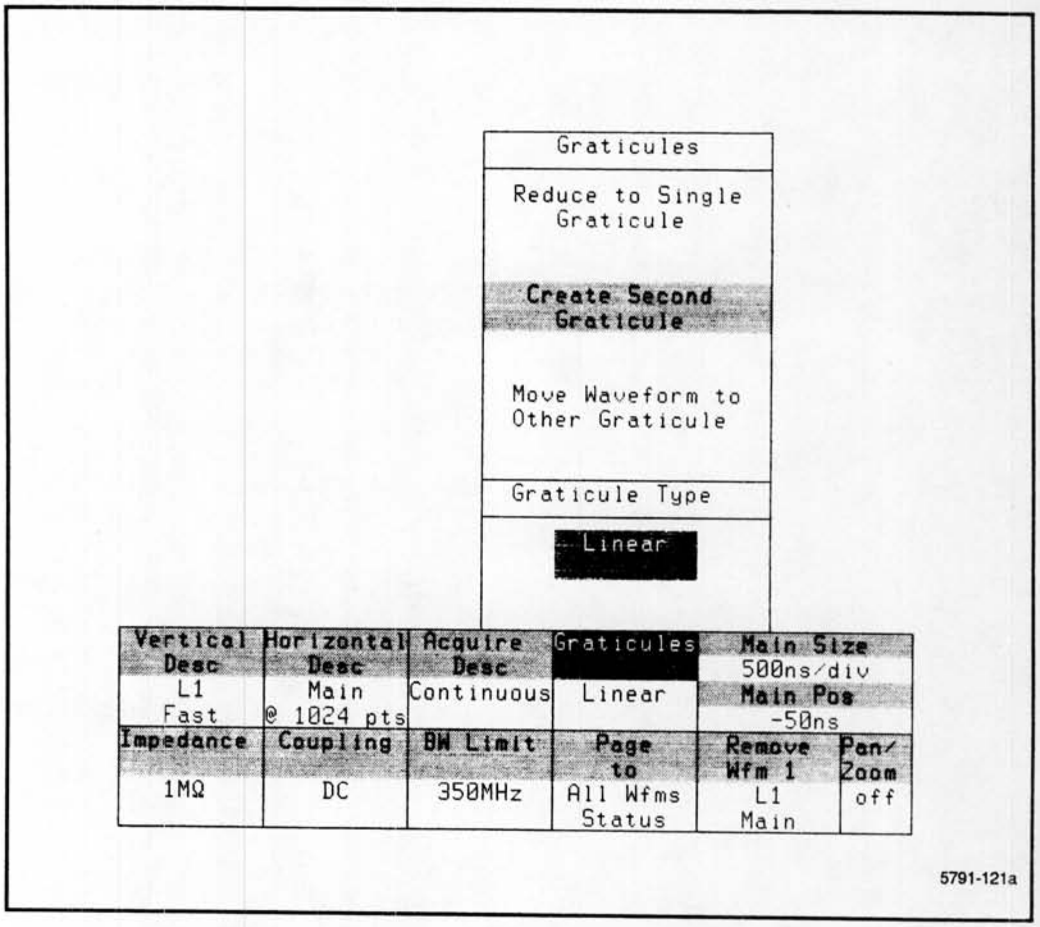


Figure 2-12. Graticules pop-up menu.

Menu Items

The following items are entries in the **Graticules** pop-up menu:

- **Graticules**

  Reduce to Single Graticule—Places all waveforms displayed with a two graticule display onto a single graticule (full screen) display.

  Create Second Graticule—Places the selected waveform displayed in a single full screen graticule onto the lower graticule of a dual-graticule display. The menu/status area label and the pop-up menu name change to **Lower Graticule** (where the selected waveform now resides).

Move Waveform to Other Graticule—Moves selected waveform to the other graticule of a dual-graticule display. The menu/status area label and the pop-up menu name change to reflect the location of the selected waveform (e.g., **Upper Graticule** or **Lower Graticule**).

- **Graticule Type**

Linear—Only linear graticules may be selected at this time.

Acquire Description

The Acquire Desc function allows control of the Average and Envelope Waveform functions and selection of criteria for stopping acquisition. Averaging combines (averages) a specified number of waveform acquisitions while displaying the waveform. This reduces the effect of random noise on a waveform display and its record data. Enveloping captures amplitude variations for a specified number of waveform acquisitions and displays the waveform envelope.

The Acquire Description function is selectable only when waveforms from plug-in channels are displayed.

The **Stop Acquisition On** Selections proceeds in the following sequence:

1. Stops the acquisition, if in process;
2. Clears all waveform record data from acquired channels;
3. Restarts the acquisition process with the user-selected acquisition stopping criteria; and
4. Terminates the acquisition process automatically upon satisfaction of the specified completion condition.

These actions take place regardless of the DIGITIZER RUN/STOP button setting, and regardless of any progress in a previous Stop Acquisition on function.

The following acquisition stop criteria apply to the Acquire Description function:

- Stop when all waveform records have reached the selected percentage of data point fill.
- Stop when all waveforms being averaged reach the user-specified number of averages. Acquisition does not stop for any waveform until all waveforms reach the specified number of averages.
- Stop when all waveforms being enveloped reach the user-specified number of envelopes. Acquisition does not stop for any waveform until all waveforms reach the specified number of envelopes.

- Stop when both envelope and average conditions are satisfied.
- Stop when a single trigger has occurred.

The status conditions are shown below the **Acquire Desc** label in the menu/status area.

Acquire Description Pop-up Menu

When the **Acquire Desc** label in the Waveform major menu is selected, the pop-up menu is displayed in the waveform display area and its label is highlighted (see Fig. 2-13).

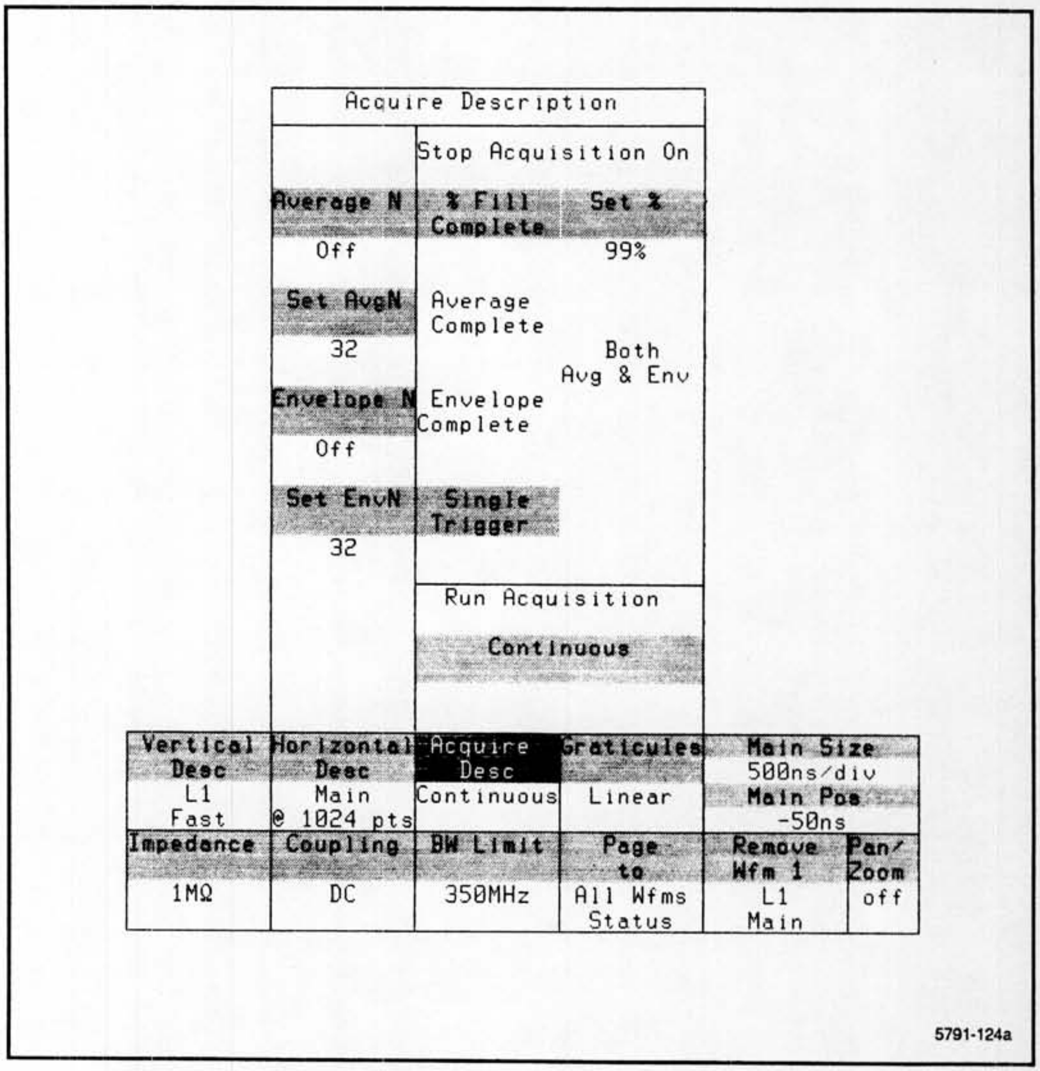


Figure 2-13. Acquire Description pop-up menu.

Menu Items

The following items and categories are entries in the **Acquire Description** pop-up menu:

- **Average and Envelope**

  Average N—The selected waveform is acquired and averaged the number of times indicated below the **Set AvgN** label. This is a convenient alternative to making the selection from the Vertical Description pop-up menu. Successive selection of the **Average N** label toggles the function on and off. See "Selecting Waveform Functions" in this section under "Waveform Control". The algorithm is defined in Appendix B.

  Set AvgN—Assigns the Control knobs to adjust the number of averages. The number of averages selected is displayed below the **Set AvgN** label. The number of averages must be an integer between 2 and 4096.

  Envelope N—The selected waveform is enveloped the number of times indicated below the **Set EnvN** label. This is a convenient alternative to making the selection from the Vertical Description pop-up menu. Successive selection of the **Envelope N** label toggles the function on and off. Refer to "Selecting Waveform Functions" in this section under "Waveform Control". The algorithm is defined in Appendix B.

  Set EnvN—Assigns the Control knobs to adjust the number of envelopes. The number of envelopes selected is displayed below the **Set EnvN** label. The number of envelopes must be an integer between 2 and 4096.

- Stop Acquisition On

  % Fill Complete—Waveform acquisition stops when all records reach the user-set percentage of fill requirement.

  Set %—Assigns the Control knobs to adjust the percentage of fill parameter.

  Average Complete—Waveform acquisition stops when all records reach their average requirements, as set in the Acquire Description.

  Envelope Complete—Waveform acquisition stops when all records reach their envelope requirements, as set in the Acquire Description.

  Both Ave & Env—Waveform acquisition stops when all records reach their average and envelope requirements, as set in the Acquire Description.

  Single Trigger—Waveform acquisition stops when a single Main trigger is detected and the time base duration has expired.

- **Run Acquisition**

  Continuous—Suspends all operations selected in the **Stop Acquisition** category and allows the digitizer to run continuously.

If no waveforms are being acquired with the Envelope function invoked, then neither **Envelope Complete** nor **Both Ave & Env** is selectable.

If no waveforms are being acquired with the Average function invoked, neither **Average Complete** nor **Both Ave & Env** is selectable.

The record fill percentage value can be set by using the Control knobs, or the **Numeric Entry and Knob Res** pop-up menu. Refer to "Control Knobs and Numeric Keypad Operation" in this section for a detailed discussion of their operation.

Selecting Channel Input Impedance

Selecting the **Impedance** label in the menu/status area allows you to choose the input impedance for each plug-in channel. The impedance value for the selected channel is displayed below the **Impedance** label in the menu/status area.

Channel Impedance Pop-up Menu

Selecting **Impedance** causes the **Channel Impedance** pop-up menu to appear in the waveform display area and highlights its label in the menu/status area (see Fig. 2-14). The selectable impedance values will depend on the type of plug-ins and probes installed.

Menu Items

The following items are the entries found in the **Channel Impedance** pop-up menu for generic plug-ins (e.g., 11A32, 11A34, etc.):

- **Channel Select**—Selects the channel for impedance assignment.
- **50Ω**—Assigns 50 Ω input impedance to the selected channel.
- **1 MΩ**—Assigns 1 MΩ input impedance to the selected channel.

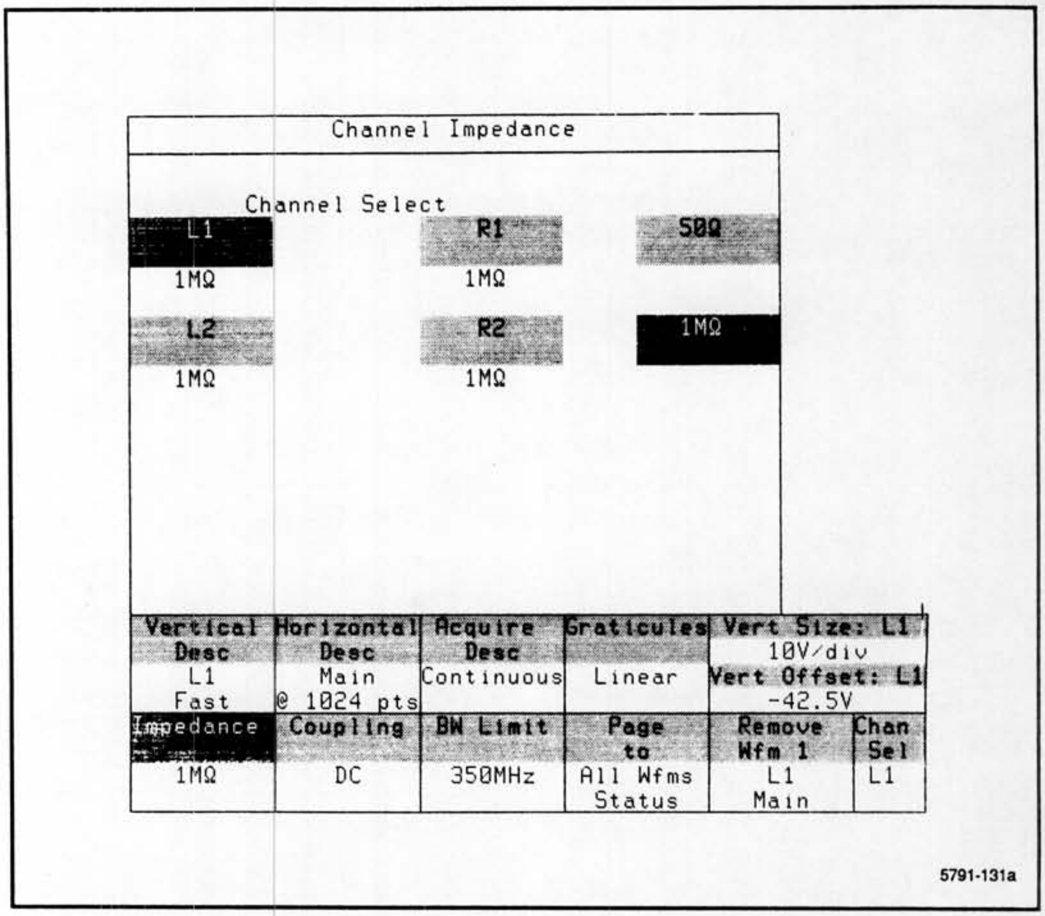


Figure 2-14. Channel Impedance pop-up menu.

Selecting Channel Coupling

Selecting the **Coupling** label in the menu/status area allows you to choose the signal coupling for any plug-in channel. Once selected, the coupling value for that channel is displayed below its pop-up menu label.

Channel Coupling Pop-up Menu

Selecting **Coupling** causes the **Channel Coupling** pop-up menu to appear in the waveform display area and highlights its label in the menu/status area (see Fig. 2-15).

Menu Items

The following items are entries in the **Channel Coupling** pop-up menu for a single-ended channel (see Fig. 2-15A.):

- **Channel Select**—Selects the channel for coupling assignment.
- **DC**—Allows the dc signal voltage to be displayed on the screen.
- **AC**—Blocks the dc signal and allows only the ac signal to be displayed on the screen.
- **Off**—Disconnects the selected channel signal before the amplifier and presents an infinite impedance at the input.

For Differential channel coupling the following items and the individual coupling selections are displayed for plus and minus (refer to Fig. 2-15B.).

- **VC**—Allows Control knob adjustment of an internally generated dc offset voltage coupled to a selected differential input for comparison with the other differential input signal.

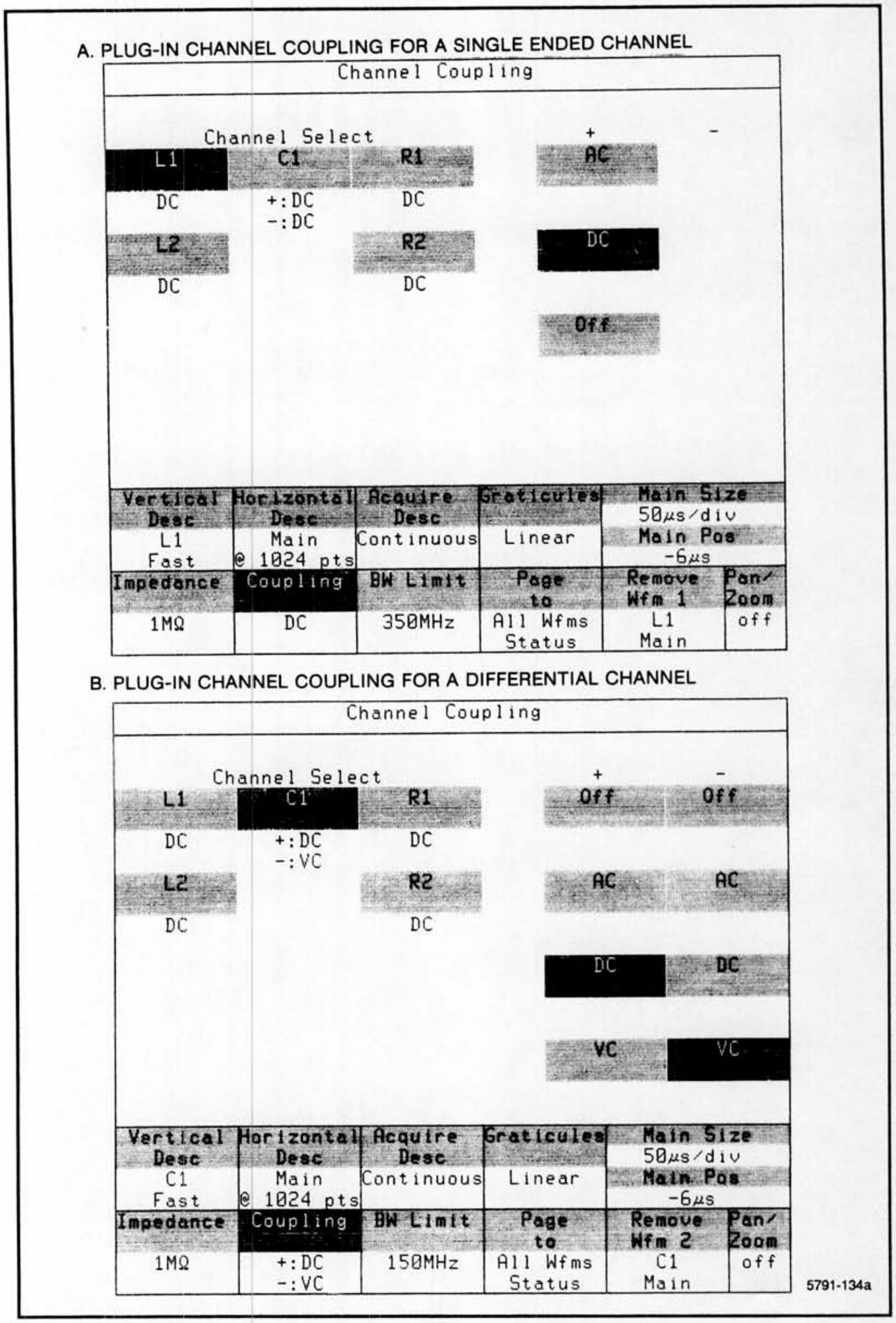


Figure 2-15. Channel Coupling pop-up menu.

Selecting Channel Bandwidth Limit

Selecting the **BW Limit** label in the menu/status area allows you to limit the system bandwidth for any plug-in channel. Once selected, the bandwidth value for that channel is displayed below its pop-up menu label.

Channel Bandwidth Limit Pop-up Menu

Selecting **BW Limit** causes the **Channel Bandwidth Limit** pop-up menu to appear in the waveform display area and highlights its label in the menu/status area (see Fig. 2-16).

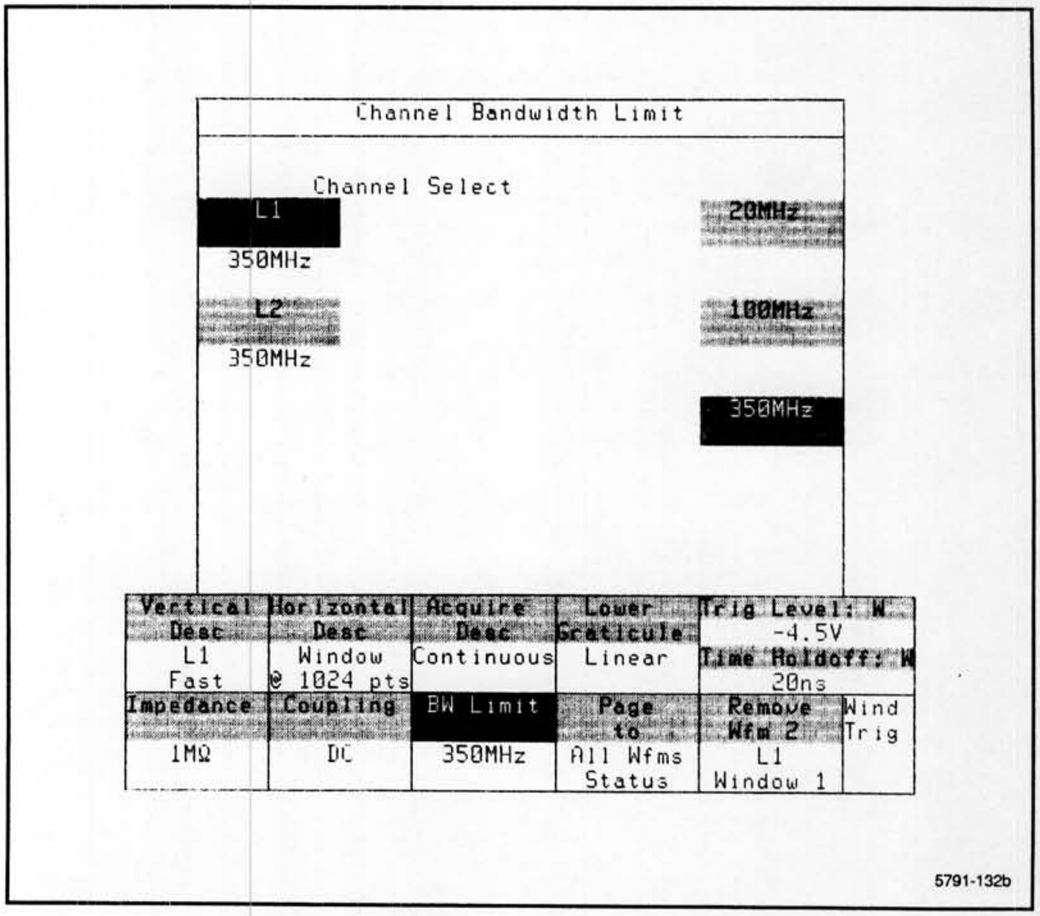


Figure 2-16. **Channel Bandwidth Limit** pop-up menu.

Menu Items

The following items are entries in the **Channel Bandwidth Limit** pop-up menu:

- **Channel Select**—Selects the channel for bandwidth assignment.
- **Bandwidth**—Allows selection of the available bandwidth limits for the channel selected. Some plug-ins allow control of the upper and lower bandwidth limits.

Status of All Displayed Waveforms

When touched, the **Page to All Wfms Status** label changes the menu/status area of the Waveform major menu to display a limited status display for all waveforms which are presently being displayed.

The **Page to All Wfms Status** is an exception to the other waveform menus; there is no pop-up menu for **Page to All Wfms Status** label.

The status information listed below is displayed in the menu/status area:

1. For YT waveforms, the Vertical Description and a time-base indicator (i.e., Main, Window1 or Window2).
2. For XY waveforms, the Vertical Description and Horizontal Description.
3. The vertical scale factor for each waveform.
4. The horizontal scale factor for each waveform.
5. The label for the currently selected waveform is highlighted.

Menu Items

Waveforms can be selected from the menu/status area by touching the appropriate waveform name (label). The selected waveform is displayed brighter than the other displayed waveforms.

Touching the **Page to Single Waveform** label will return the single waveform menu/ status area to the Waveform menu.

Figure 2-17 shows the status area of the Waveform major menu after the **Page to All Wfms Status** label has been selected.

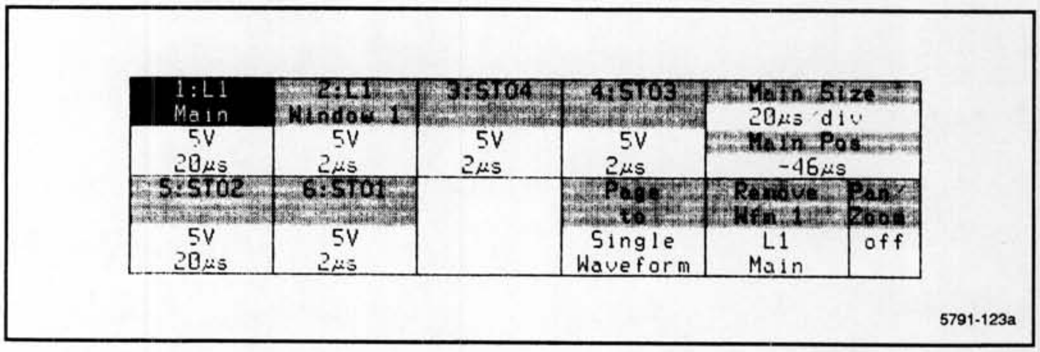


Figure 2-17. All Wfm's Status menu displayed in the menu/status area.

Vertical Size and Position

Vertical size and position may be set automatically by the 11401/11402 or manually by the user.

Pressing the AUTOSET button automatically selects settings for vertical size and position of the selected (medium intensity) Main waveform and any associated Window waveforms.

To manually set Size and Position for the selected waveform, simply touch the Vertical Size and Position icon (see Fig. 2-9). The Size and Position icon is selectable from single- and dual-graticule displays.

Touching the Vertical Size and Position icon (see Fig. 2-9) assigns the Top and Bottom Controls to vary vertical size (amplitude) and position (dc offset), respectively, of the selected Main record waveform. For Window waveforms, only trace separation is controlled when the Vertical Size and Position icon is selected. Windows are sized by controlling the Main waveform size. See "Control Knobs and Numeric Keypad Operation," earlier in this section. When sizing and positioning stored waveforms the top knob is assigned to vertical magnification.

Vertical size and position are performed on the selected waveform (the waveform on which all operations are performed). When more than one waveform is displayed, a waveform can be selected by simply touching the trace. The selected trace changes from low to medium intensity. If traces are superimposed, repeated touching of the complex display will select each waveform in turn.

Vertical Size

Vertical size is adjusted in a 1, 2, 5 sequence or is continuously variable; its normal mode is 1, 2, 5. Continuously variable sizing is available by touching the Control knob label, then selecting **Fine** from the **Numeric Entry and Knob Res** pop-up menu. To return to 1, 2, 5 mode, select **Coarse**.

Waveforms may be vertically sized independently in both graticules of a split-screen display.

Whenever the AUTOSET button is pressed, the signal ground reference (signal zero voltage level) automatically determines the displayed scaling reference values.

Acquired Waveforms

XY or YT Waveforms acquired with the Main time base or the Window time base are vertically sized by changing the plug-in channel's sensitivity (volts/div). Vertical sizing is limited by the sensitivity range of the plug-ins.

Moving a waveform out of the display area will clip part of the waveform that leaves the display area.When the waveform is returned to the display area it will remain clipped until new data is required.

When Vertically sizing and positioning a complex waveform (that is, a calculated waveform made up of more than one channel), the **Chan Sel** function will be available in the menu/status area. The **Chan Sel** function allows each waveform component of a complex trace description to be individually adjusted. Each touch of the **Chan Sel** label selects the next component of the trace description. Size limitations of the individual components are as described in this Vertical Size section. When **Chan Sel** is set to Calculated Waveform (Calcd Wfm), which is available only in high precision mode, the whole complex trace is sized as a whole.

Stored Waveforms

Stored XY or YT waveforms are mainframe dependent and can be sized within the limits of the mainframe processor. Expansion or compression is performed about the center screen. Waveform clipping will occur only when the amplitude exceeds the display area.

Vertical Position

Touching the Vertical Size and Position icon (see Fig. 2-9) assigns the Top and Bottom Controls to control vertical size (amplitude) and vertical position (dc offset), respectively, of the selected waveform. When so assigned, the Bottom Control will change the vertical position. See "Control Knobs and Numeric Keypad Operation" earlier in this section.

Waveforms may be positioned independently in both graticules areas of a split screen display.

Whenever the AUTOSET button is pressed, the ground reference (signal zero voltage level) is automatically determined and used for waveform scaling and positioning. The ground reference will be at center screen for an ac coupled waveform and may be off screen for a dc coupled waveform.

Acquired Waveforms

Waveforms acquired with the Main time base are vertically positioned by changing the plug-in channel's dc offset. Vertical positioning is limited by the offset range of the plug-ins.

Waveforms acquired with the Window time base are mainframe dependent and may be positioned off the top or bottom of the graticule area. Acquisition is unaffected. The Control knobs are labeled **Trace Sep** when Windows are being vertically positioned.

When Vertical sizing and positioning a complex waveform (that is, a calculated waveform made up of more than one channel), the **Chan Sel** function will be available in the menu/status area. The **Chan Sel** function allows each waveform component of a complex trace description to be individually adjusted. Each touch of the **Chan Sel** label selects the next waveform component of the trace description. Position limitations of the individual components are as described in this Vertical Position section. When **Chan Sel** is set to Calcd Wfm, which is available only in high precision vertical mode, the whole complex trace is positioned as a whole.

Stored Waveforms

Stored waveforms are mainframe dependent and can be positioned off the top or bottom of the graticule area and returned to graticule center without clipping.

Horizontal Size and Position

The Horizontal Size and Position function provides control of the horizontal scale (time/div) and relative position used to display waveforms. Acquired signals are horizontally sized by adjusting their time base setting. All waveforms acquired with the same time base are sized together. Stored waveform records are sized by changing the magnification setting to display anywhere from a 512 point segment up to the whole waveform record.

Signals acquired with the Main time base are horizontally positioned by changing the ratio of pre-trigger to post-trigger record duration that is acquired and displayed. Similarly, Window waveforms are positioned relative to the Window time base trigger, although different limitations apply. (See Figs. 2-24, 2-25, and 2-26 under Window Holdoff Mode in "Triggering" later in this section for examples of Main and Window record positioning.) Stored waveforms are graphically positioned by changing which segment of record points is displayed from a previously expanded (horizontally sized) waveform.

Horizontal Size and Position may be set automatically with the AUTOSET function or manually by adjusting the Top and Bottom Control knobs. Selecting the AUTOSET function (front-panel pushbutton) causes the oscilloscope to select horizontal size and position settings to display the selected trace on the screen.

To manually set Horizontal Size and Position, simply touch the Horizontal Size and Position icon. Doing so dedicates the Top Control knob to Horizontal Size and the Bottom Control knob to Horizontal Position (see Fig. 2-9). When sizing and positioning stored waveforms, the Control knobs are labeled **Horz Mag** and **Horz Pos Gr** for horizontal magnification and graphical position, respectively. This labeling is also used when Pan/Zoom is invoked on acquired Main or Window waveforms. **Pan/Zoom** allows temporary expansion of acquired waveform records longer than 512 points without affecting the time base setting. **Pan/Zoom** must be toggled off before normal time base sizing can be controlled. The Size and Position icons apply to both single- and dual-graticule displays.

Size and Position may also be changed with the Numeric Entry keypad by touching a knob label. For details refer to "Control Knobs and Numeric Keypad Operation" earlier in this section.

When more than one waveform is displayed, a waveform can be selected by simply touching the trace. The selected trace changes from low to medium intensity. If traces are superimposed, repeated touching of the complex display will select each waveform in turn.

Horizontal Size

Touching the Horizontal Size and Position icon (see Fig. 2-9) assigns the Top and Bottom Controls to control horizontal size and position, respectively, of the selected (highlighted) waveform. When so assigned, the Top Control will change the horizontal size for acquired waveforms or horizontal magnification for stored waveforms.

Horizontal size may be adjusted in a 1, 2, 5 sequence for YT and XY waveforms or may be set to continuously variable for XY waveforms only. Continuously variable sizing is available by selecting the knob label and selecting FINE from the **Numeric Entry and Knob Res** pop-up menu. See "Control Knobs and Numeric Keypad Operation", earlier in this section.

Waveforms may be sized independently in either graticule area of a split-screen display.

When adjusting the horizontal size of acquired waveforms, the Main and Window time bases interact. One important case occurs when you attempt to reduce the Main horizontal scale factor to a value lower than that of the Window. In this case the Window's scale factor will be reduced a like amount. Increasing the Main horizontal scale factor causes the Window scale factor to track until the initial Window scale factor is reached. Further increases in the Main's scale factor will not affect the Window scale factor. This is a result of the instrument constraint that the Main horizontal scale factor setting must be greater than that of the Window.

An apparent exception to this rule is when the Pan/Zoom function is invoked. Pan/Zoom replaces the whole Main record display with an expanded segment display. The scale factor of this expanded segment may be set to a value less than the Window scale factor; however, the scale value of the whole Main record still remains equal to, or greater than, that of the Window.

Three other important constraints on Main and Window interaction are:

- The Main record duration must be greater than or equal to the Window record duration.
- The Main sample interval must be greater than or equal to the Window sample interval.
- The Ratio of Main to Window sample interval must not exceed about 16 million.

One result of these constraints is that to get the Main horizontal scale factor to 500 ps, both the Main and Window record lengths must be 512 points.

Important interactions between the record length and Horizontal Size limits, which result from the above constraints, are discussed next under "Record Length vs Horizontal Size".

Record Length vs Horizontal Size

The record length limits the horizontal size range (time/division) when using 10 ns, 5 ns, 2 ns, 1 ns, and 500 ps per division. Increasing the Main or Window record length at time/div settings below 10 ns/div will cause an automatic increase in the displayed time/division. The scale factor changes because the minimum time between sample points is 10 ps in the Equivalent Time mode. As the number of points in a waveform record increases, the total duration of the record also increases. The only way to display the complete record with the increased duration is to increase the displayed time per division.

For example:

> A 512 point record has a minimum duration of 5.120 ns. With 10 graticule divisions across the screen, the time/div must be 500 ps/div. The additional 12 points (120 ps duration) extend beyond the graticule on the left and right. Increasing the record length to 2048 points increases the duration of the waveform record to 20.480 ns. To display the entire record, the horizontal scale factor must be 2 ns/div.

Table 2-2 gives the relationship between the available record lengths and the allowed horizontal size ranges for Main and Window records, respectively. The Main and Window record lengths are changed by selecting either Main or Window Record Length from the Horizontal Description pop-up menu and adjusting the appropriate Control knob.

TABLE 2-2
Horizontal Scaling vs Record Length

Record Length[1] (Points)	Horizontal Scale Range (Time/division) Main[2,3] Upper Limit	Main[2,3] Lower Limit	Window Upper Limit	Window Lower Limit
512	500 ps	100 s	500 ps	Main Time Base Setting
1024	1 ns	100 s	1 ns	
2048	2 ns	100 s	2 ns	
4096	5 ns	100 s	5 ns	
5120	5 ns	100 s	5 ns	
8192	10 ns	100 s	10 ns	
10240	10 ns	100 s	10 ns	

[1]Main and Window can have different Record Lengths.

[2]The Pan/Zoom function permits a horizontal scale range of 500 ps/division (the Main record length must be greater than the Window record length).

[3]The Main horizontal scale cannot be less than the Window horizontal scale except when using Pan Zoom.

Acquired YT Waveforms

Rotating the Top Control knob horizontally sizes acquired waveforms in a 1, 2, 5 sequence by changing the time/division of the appropriate mainframe time base. Changing the horizontal size of the 11401/11402 display is analogous to changing the time/division setting (sweep rate) of a real-time oscilloscope.

When controlling the time base, its size limits are:

- For Main records—When controlling the Main time base record, its size per division is limited at the low end by the minimum 10 ps sample interval. A shorter record length will allow a shorter time/div (the Pan/Zoom function allows long waveform records to be expanded to 0.5 ns/div). For example, a 512 point record can have 0.5 ns/div setting while a 10,240 point record can have a minimum 10 ns/div setting.

  The maximum Main time base setting is 100 s/div.

- For Window records—Window records can be 0.5 ns/div up to the Main record Horizontal Size with the same 10 ps sample interval limitations. A Window record that is shorter in length than the Main record can not be set to the Main Horizontal size.

Pan/Zoom allows you to temporarily expand and search the entire acquired record without affecting any acquisition parameters (e.g., time base settings, size and position). Pan/Zoom expansion is restricted to the record length/512. For example, a 1024 point waveform can be expanded only two times, while a 10240 point waveform allows a twenty-fold expansion.

Pan/Zoom is selected from the menu/status area. **Zoom** is dedicated to the Top Control, labeled **Horz Mag**, which controls waveform expansion. **Pan** is dedicated to the Bottom Control, labeled **Horz Pos Gr**, which controls the segment of the record to be expanded. The graphical position in the waveform record is given, below the knob label, as the left most point displayed.

Stored YT Waveforms

Horizontal Size (Magnification) determines the amount of the stored record displayed in the 512-point graticule area. All of a stored waveform record, up to the 10,240-point maximum length, can be compressed and displayed. Displaying a part of a longer-record waveform in the 512 display points effectively expands that part of the waveform. Size can be varied in a stepped sequence which is based on the record length. Coarse resolution only is available.

When you use the **Horz Mag** Control knob to expand part of the record, the **Horz Pos Gr** Control knob selects the part of the record to be displayed. Any part of the record can be expanded.

Acquired XY Waveforms

Acquired XY waveforms are composed of two waveforms acquired with either the Main time base or with the Window time base.

The horizontal size of an XY waveform being acquired with the Main time base is controlled by changing the Vertical sensitivity of the horizontal source plug-in amplifier. Moving a waveform out of the display area will clip the part of the waveform that leaves the display area. When the waveform is returned to the display area, it will remain clipped until new data is acquired.

Acquired XY displays from the Window time base are horizontally sized by controlling the vertical trace separation. They can be positioned off-screen in either direction and returned to graticule center without clipping.

When Horizontally sizing and positioning a complex waveform, the **Chan Sel** function will be available in the menu/status area. The **Chan Sel** function allows each waveform component of a complex trace description to be individually adjusted. Each touch of the **Chan Sel** label selects the next waveform component of the trace description. Size limitations of the individual components are as previously described.

Stored XY Waveforms

XY displays using stored waveform components are mainframe dependent and can be be horizontally sized only by controlling the vertical magnification of the X axis waveform. Stored waveforms can be vertically magnified over a large range.

Horizontal Position

Touching the Horizontal Size and Position icon (see Fig. 2-9) assigns the Top and Bottom Controls to control horizontal size and position of the selected (highlighted) waveform. When so assigned, the Bottom Control will change the horizontal position for acquired waveforms or horizontal graphic position for stored waveforms.

Horizontal Position is continuously variable with either coarse or fine resolution. Horizontal Position adjustment is normally in the coarse mode. Fine resolution can be selected by touching **Fine** in the Numeric Keypad pop-up menu. To return to coarse resolution, select **Coarse**. See "Control Knobs and Numeric Keypad Operation," earlier in this section.

Different types of waveforms are horizontally positioned in different ways. Waveforms acquired with the Main time base are horizontally positioned by changing the ratio of pre-trigger to post-trigger record duration that is acquired and displayed. Similarly, Window waveforms are positioned relative to the Window time base trigger, although with different limitations. (See Figs. 2-24, 2-25, and 2-26 under Window Holdoff in "Triggering" later in this section for examples of Main and Window waveform positioning.)

Stored waveforms are graphically positioned by changing which segment of record points is displayed from a previously expanded (horizontally sized) waveform. This is possible only for stored waveforms with record lengths greater than 512 points.

XY waveforms are horizontally positioned by vertically offsetting the X-axis source signal. For X-axis signals acquired with the Main time base, the plug-in amplifier dc offset is controlled. Signals acquired with the Window time base and stored waveforms are vertically offset by changing their vertical position with the display processor. Waveforms may be positioned independently in both graticule areas of a split screen display.

Acquired YT Waveforms

The waveform record is positioned with respect to the trigger point of its acquiring time base. This means that the record can be set to precede, succeed, or surround the trigger point.

When controlling Window record position with the time base, the Window records may be positioned over the full range of the Main record or past either end so long as they coincide with the Main record at one point. When a Window record uses the window trigger, the record may be many screens past the end of the main record.

Pan/Zoom allows you to temporarily expand and search the entire acquired record without affecting any acquisition parameters (e.g., time base settings size and position). Maximum **Pan/Zoom** expansion is restricted to the record length/512 (e.g., a 1K waveform can only be expanded two times, or a 10 K waveform 20 times). **Pan/Zoom** is selected from the menu/status area. **Zoom** is dedicated to the Top Control, labeled **Horz Mag**, which controls waveform expansion. **Pan** is dedicated to the Bottom Control, labeled **Horz Pos Gr**, which graphically controls the segment of the record to be expanded.

Stored YT Waveforms

The displayed segment of the stored waveform trace can be positioned throughout the waveform record. When you use the **Horz Mag** function to expand part of the record, the **Horz Pos Gr** knob lets you graphically select the part of the record which will be displayed. The position shown below the knob label is the left-most point displayed from the waveform record.

Acquired XY Waveforms

Acquired XY waveforms are acquired with either the Main time base or the Window time base.

The horizontal position limits of a waveform acquired with the Main time base are determined by the offset range of the plug-in amplifier. Moving a waveform out of the display area will clip the part of the waveform that leaves the display area. When the waveform is returned to the display area, it will remain clipped until new data is acquired.

Waveforms acquired with the Window time base and stored waveform components are mainframe dependent and can be positioned off-screen in either direction. Their positioning does not affect acquisition.

Stored XY Waveforms

Stored waveform components are mainframe dependent and can be vertically positioned off-screen in either direction.

Waveform Segment Expansion

Touching a **Window 1 or 2** label (refer to Fig. 2-18) allows the user to view an expanded section of a waveform being acquired with the Main time base. This is achieved by using the Window time base set to a shorter time/div than that of the Main time base to acquire a window waveform that is an expanded section of the main waveform record. Windowing is similar to delayed sweep in other dual time base oscilloscopes.

The Window labels operate on the selected waveform, which is shown at medium intensity. Window 1 must be invoked first. Window 2 will be selectable after the Window 1 waveform is displayed. Touch the Main waveform, then select **Window 2**.

Windows may be used from any menu while the labels are selectable (medium intensity). Windows are selectable only for waveforms composed entirely of continuously acquired sources acquired with the Main time base. Windows cannot be invoked for displayed stored waveforms or other window waveforms.

Window Triggering

The Window time base is triggered from the Main trigger point by default. Window triggering options can be changed with the **Window Holdoff Mode** function in the Trigger major menu. Window trigger options include holdoff by time or number of events (Window trigger occurrences). For a detailed discussion refer to "Triggering" later in this section.

Window 1

Touching the **Window 1** label (see Fig. 2-18) allows the user to view an expanded portion of a waveform being acquired with the Main time base. To acquire a Window waveform that is an expanded section of the main waveform, set the Window time base to a faster time/div than that of the Main time base.

The following changes occur on the display when the Window 1 label is touched.

1. A second (lower) graticule is created if not already defined.
2. Window acquisition is started and the expanded segment of the selected waveform is displayed on the lower graticule with the scale factor (time/div) of the Window time base.
3. A highlighted (high intensity) zone representing the horizontal size and position of the windowed segment is displayed on the selected waveform.
4. The Top Control knob is assigned to control the size of the expanded window segment and the Bottom Control knob is assigned to position the segment on the selected waveform.

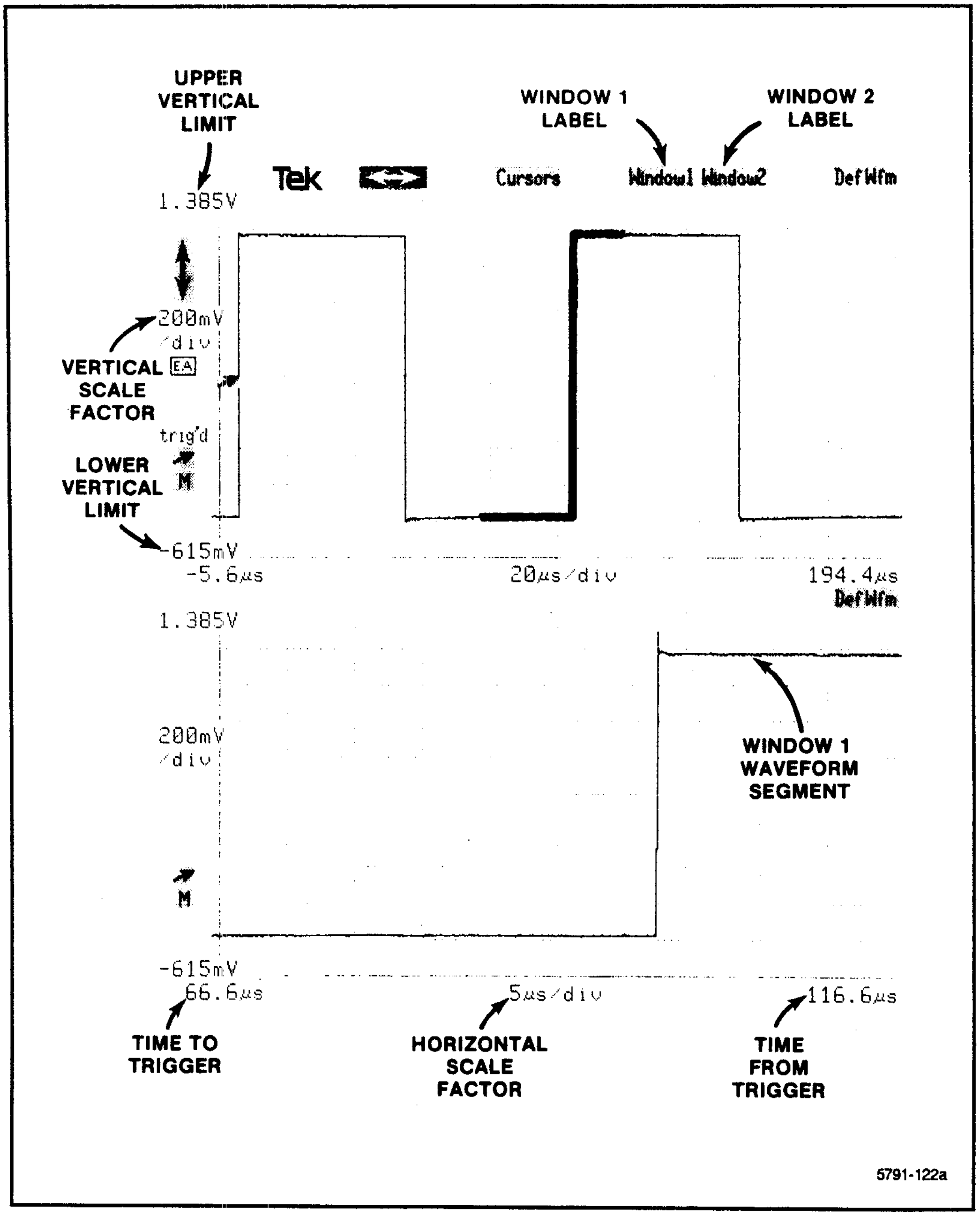


Figure 2-18. Location of screen-displayed nomenclature and scale factors.

Windows are allowed on any YT waveforms, so long as they include components that are continuously acquired with the main time base. These waveforms can each have Window 1 and Window 2 expanded segments for up to eight total waveforms displayed at a time. Window waveforms can also be sources for XY waveforms when combined with stored or other Window waveforms.

Some additional factors that affect windowing are:

- The size and record lengths of Window 1 and Window 2 are kept equal. Changing the size of one changes the other. Their positions on the Main waveform are independently controlled.
- The type of window waveform is the same as its corresponding main waveform (e.g., an averaged YT Main waveform produces an averaged YT Window waveform).
- Changing the horizontal position or size of any of the defined Window 1 displays will change all the defined Window 1 positions or sizes.
- The Window waveform may be moved to the upper graticule, or the two graticules may be combined via the Graticules function label in the Waveform major menu.
- When another waveform is selected, the Main record waveform with the intensified zone is displayed at dim intensity with a normal intensity zone (window area). The intensity drops one level for the main record and the window zone.
- A Window 1 waveform can be combined with another waveform by editing the window waveform's description in the **Vertical Description** pop-up menu.

Window 2

Touching the **Window 2** label (see Fig. 2-18) allows the user to view a second expanded portion of a waveform being acquired with the Main time base. This is achieved by using the Window time base to acquire an expanded window waveform record that corresponds to the intensified section of the main waveform record. The original waveform and the two expanded views of the original waveform comprise a Main record, Window 1 record, and Window 2 record, respectively. Window 2 may not be invoked without a prior definition of a Window 1 record. Touch the Main waveform, then select **Window 2**.

The following changes occur on the display when the **Window 2** label is touched.

1. A second lower graticule is created if not already defined. When a second graticule is created, all existing waveforms are displayed on the upper graticule.
2. Acquisition is started and the expanded segment of the last selected waveform is displayed on the lower graticule with the scale factor (time/div) of the Window time base.

3. A highlighted (high intensity) zone representing the horizontal magnitude and position of the windowed segment is displayed on the selected waveform.

4. The Top Control knob is assigned to control the size of the expanded Window segment and the Bottom Control knob is assigned to position the segment on the selected waveform.

Windows are allowed on any YT waveforms so long as they include components that are continuously acquired with the main time base. These waveforms can each have Window 1 and Window 2 expanded segments for up to eight total waveforms displayed at a time. Window waveforms can also be sources for XY waveforms when combined with stored or other Window waveforms.

Some additional factors that affect windowing are:

- The size and record lengths of Window 1 and Window 2 are kept equal. Changing the size of one changes the other. Their positions on the main waveform are independently controlled.
- The type of window waveform is the same as its corresponding main waveform (e.g., an averaged YT Main waveform produces an averaged YT Window waveform).
- Changing the horizontal position or size of any of the defined Window 2 displays will change all the defined Window 2 display positions or sizes.
- When another waveform is selected, the main record waveform is displayed at a low intensity with a medium intensity zone (window segment).
- A Window 2 waveform can be combined with another waveform by editing the window waveform's description in the **Vertical Description** pop-up menu.

Activating the Screen Touch Panel

When the TOUCH PANEL ON/OFF button is set to ON the crt screen will respond to touches. When set to OFF, the screen will not respond to touches, but the display will remain the same. All front-panel buttons remain functional regardless of the TOUCH PANEL ON/OFF selection.

An external interface command can disable all input from the Touch Panel and the other front panel controls.

Digitizer Run/Stop

When waveform acquisition is in process and DIGITIZER RUN/STOP is set to STOP, acquisition stops and stored data is retained. When set to RUN, newly acquired data is again sent to the waveform memory. The status also indicates when acquisition is started or stopped by other means.

The acquisition process is performed only on waveforms originating from plug-in channels. Waveforms received from the GPIB or retrieved from memory and displayed (stored waveforms), have already been digitized and need not be acquired.

If none of the plug-in channels is selected, the DIGITIZER RUN/STOP button is inactive.

The acquisition process can be stopped when specified criteria are met by the **Stop Acquisition On** function. Even though the DIGITIZER RUN/STOP button is set to RUN, acquisition can be stopped when the criteria for the Stop Acquisition function is met. Pressing the DIGITIZER RUN/STOP button when it is at STOP will remove any Stop Acquisition criteria that was set and begin continuous acquisition. For further information, refer to "Acquire Description" earlier in this section.

Starting Acquisition

DIGITIZER RUN/STOP is set to RUN when you perform any of these actions which start the acquisition process:

1. Creating a waveform by pressing a plug-in channel button or selecting the **DefWfm** label and choosing a plug-in channel source;

2. Exit the **Acquire Description** pop-up menu with one of the Stop Acquisition functions selected;

3. Define a new Window waveform;

4. Adjust any acquisition parameter such as horizontal or vertical size of an acquired trace; or

5. Remove a waveform leaving an acquired waveform still displayed.

Stopping Acquisition

Three ways of stopping the acquisition process are:

1. Set DIGITIZER RUN/STOP to STOP;

2. Remove all the plug-in channel components from the trace descriptions; or

3. When the criteria for the **Stop Acquisition On** function is satisfied, the acquisition process will stop. Refer to "Acquire Description" earlier in this section.

How to Obtain a Hardcopy of the Screen Display

Pressing the HARDCOPY front-panel button sends data to the hardcopy unit connected to the rear-panel PRINTER port. All the data necessary to reproduce the entire crt screen display are sent to the hardcopy unit. When the HARDCOPY button is pressed, the display will freeze and change appearance for about 15 seconds. It will then revert to normal operation while the copy is printed. A hardcopy request can be aborted while the screen is still "frozen" by pressing the HARDCOPY button again or by selecting **Hardcopy Abort** in the **Instr Options** pop-up menu found in the UTILITY major menu. If the button is pressed while a copy is printing the display will remain frozen until the first copy is complete. Acquisition continues while the display is frozen.

To preview the hardcopy from an active display, press the DIGITIZER RUN/STOP button to stop acquisition. This has the effect of freezing the display. Run and stop the digitizer until the display contains the desired image, then press the HARDCOPY button.

Refer to "Printer Connection" in Section 1, "Installation" for information on connecting a printer to the PRINTER port.

Refer to the "Hardcopy Mode" of "Utilities" for more information on hardcopies.

Pressing the TRIGGER MENUS button causes the Trigger major menu to be displayed in the menu/status area of the screen (see Fig. 2-19).

The Trigger major menu allows users to set the Main and Window trigger parameters, listed in Table 2-3.

Control of the Window trigger parameters provides versatile operation of the Window time base. Initially, the Window time base shares a trigger source with the Main time base and is triggered at the same time. In this default condition, any segment of the main waveform record can be expanded and displayed. The horizontal controls allow the Window time base to run before, after or straddling the Main trigger point with controllable time per division.

The Window Holdoff Mode pop-up menu allows the Window time base to be held off (delayed from running) by a user specified time or number of Window trigger events. In these holdoff modes, a separate source and level can be selected for the Window trigger to provide more versatile triggering.

Each Main record can have two independently positioned Window time base records (Window 1 and Window 2) but only one trigger setup. The same source, trigger mode, holdoff setting, holdoff mode, slope and size (time/div) is used for both runs of the Window time base.

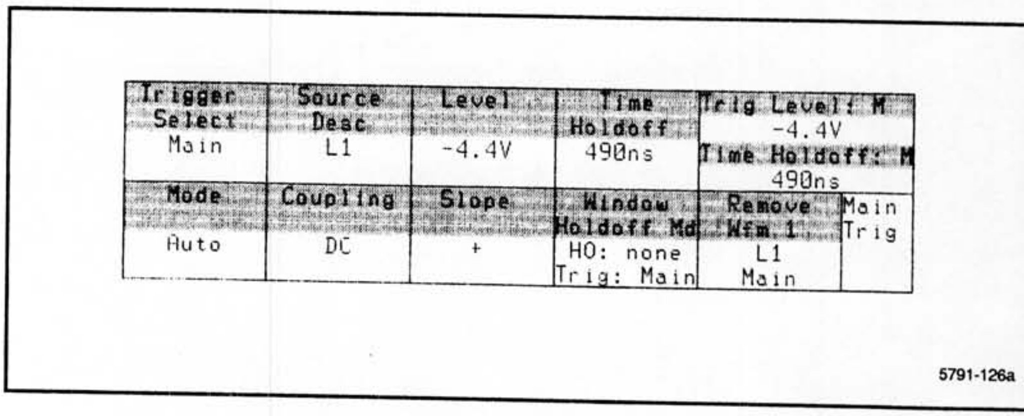


Figure 2-19. Trigger Major Menu.

Trigger Menu Function Selections

Functions that can be performed through the Trigger major menu are listed in Table 2-3. A detailed description of each function listed in the table is given in the text following the table.

TABLE 2-3
Trigger Major Menu Functions

Function	Operation Performed
Trigger Select	Selects the Main or Window time base for trigger parameter control using the menu items.
Source Desc	Selects the Left, Center, or Right plug-in channel signal or a combination of these channels or the ac line, as the trigger source.
Level and **Time** or **Event Holdoff**	Assigns the triggering level function to the Top Control Knob and the holdoff time/event function to the Bottom Control knob.
Mode	Sets the Main or Window triggering mode to Auto Level, Auto, or Normal.
Coupling	Assigns trigger coupling to: • AC • AC Low-Frequency Reject • AC High-Frequency Reject • AC Noise Reject • DC • DC High-Frequency Reject • DC Noise Reject
Slope	Sets the triggering slope to plus or minus.
Window Holdoff Md	Selects Window triggering holdoff: no holdoff, holdoff by time, or holdoff by events.
Remove Wfm	Displays the **Verify Wfm Removal** function.
Verify Wfm Removal	Allows removal of the waveform described below the label.

Selecting a Time Base Trigger

The two time base trigger selections are:

- Main Timebase Trigger
- Window Timebase Trigger

The user can assign different trigger sources, mode, coupling, etc. to each of the two time bases.

The Trigger Select label toggles between the Main and Window time bases. The selected time base trigger parameters are then controlled by the various trigger functions.

Trigger Source

The trigger source description is displayed below the Source Desc label in the menu/ status area (e.g., L1). The **Main** or **Window Trigger Source Description** pop-up menu is selectable only from the Trigger major menu.

The Trigger Select label toggles between the Main and Window time bases. The selected time base trigger parameters are then controlled by the various trigger functions.

The trigger source description allows the user to specify the input signal used to trigger the selected time base.

The trigger source description may be one of the following:

- Any single plug-in channel.
- A combination (addition or subtraction only) of channels in the Left and Center plug-ins.
- The ac line.
- A combinatin (addition or subtraction only) of channels in the Right plug-in .

Trigger Source Description Pop-up Menus

When Source Desc is selected, its label is highlighted in the menu/status area, and either the **Main Trigger Source Description** or the **Window Trigger Source Description** pop-up menu is displayed in the waveform display area. Figure 2-20 shows the **Main Trigger Source Description** pop-up menu.

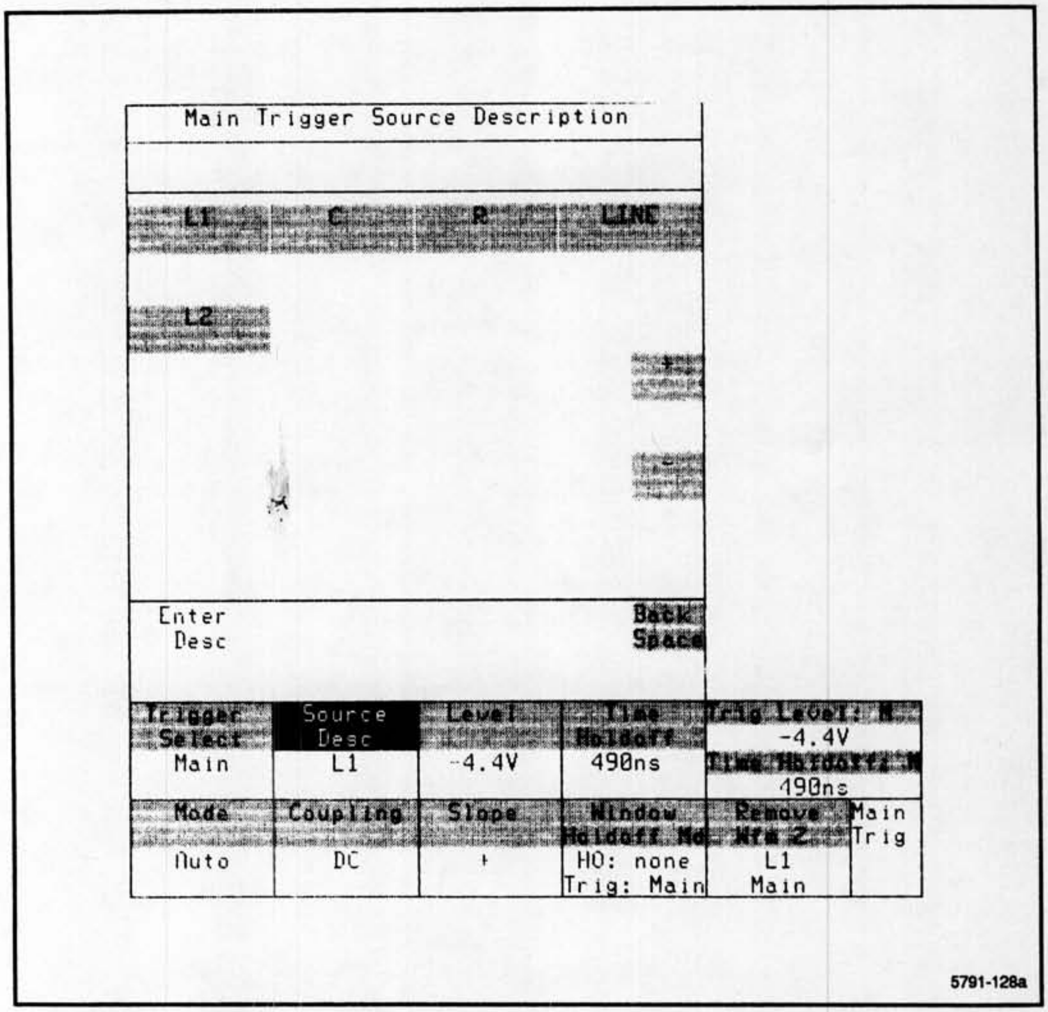


Figure 2-20. Main Trigger Source Description pop-up menu (similar to Window Trigger Source Description pop-up menu).

The following items are entries in the Trigger Source Description pop-up menus:

- Plug-In Channels—there is an entry for each plug-in channel available as a trigger source (e.g., L1 and L2).
- **Line**—Allows the user to select the AC line frequency as trigger source.
- Operators—The operators are + (add) and – (subtract or invert).
- **Enter Desc**—Exits the pop-up menu, executes the selections and displays the trigger source description below the **Source Desc** label in the menu/status area.
- **Back Space**—Provides a deleting backspace for changing (error corrections) the trigger source descriptions.

Trigger Level and Holdoff

Touching the Trigger icon (refer to Fig. 2-3 for its location) allows you to adjust the triggering level and holdoff of an acquired, selected waveform. In this mode, the Top Control is assigned to vary triggering level, and the Bottom Control is assigned to adjust holdoff. Trigger level and holdoff can also be selected by touching either the **Level** or **Holdoff** labels in the Trigger major menu.

Touching either the Top Control or Bottom Control function labels will access you to that function's Numeric Entry Keypad and Knob Res pop-up menu. Triggering can be adjusted using the soft keypad displayed.

The displayed Trigger icon itself indicates the following conditions:

1. The time base currently triggered, indicated by an M (Main time base) or W (Window time base).

2. The word "**trig'd**" appears above the Trigger icon to indicate that the time base is currently triggered. When not triggered the words "**!not! trig'd**" will appear.

Trigger Level

The triggering level can be set using the Top Control knob, or by touching a knob label and using the **Numeric Entry** keypad.

The Trigger Level function determines the voltage level, on the trigger signal, at which triggering will occur. When the trigger Level is increased, the trigger circuit responds at a more positive point on the trigger signal, and vice versa. The level value is displayed below the **Level** label in the menu/status area. The level value is displayed in divisions when **AC** coupled or with a complex source (e.g., L1+C1), and in volts with a single DC coupled source. The position of the trigger point arrow (see location in Figure 2-3 under "Display Information") on the waveform represents the trigger level setting. When the trigger signal is ac coupled or when complex waveforms are dc coupled, the trigger point arrow is not displayed.

Trigger Holdoff

The Trigger Holdoff function improves trigger stability on complex waveforms by adjusting the time period after one trigger during which triggers are ignored. The holdoff setting is displayed below the **Holdoff** label in the menu/status area.

The range of the Main holdoff function is <500 nanoseconds to 10 seconds. The Window time holdoff range is 20 ns to the end of the Main record duration.

Window trigger holdoff may be controlled either as a user-set time or as a user-set number of events (window triggers). The Window Event holdoff range is 1 to 1 billion events. Only time Holdoff is available for Main triggers.

Set the trigger holdoff for the trigger listed under **Trigger Select** by touching the **Holdoff** label or the Trigger icon.

Trigger Mode

The triggering **Mode** determines if the time base manually or automatically.

Trigger Mode Pop-up Menu

When the **Mode** label is selected from the Trigger major menu its label is highlighted in the menu/status area, and its pop-up menu is displayed in the waveform display area (see Fig. 2-21).

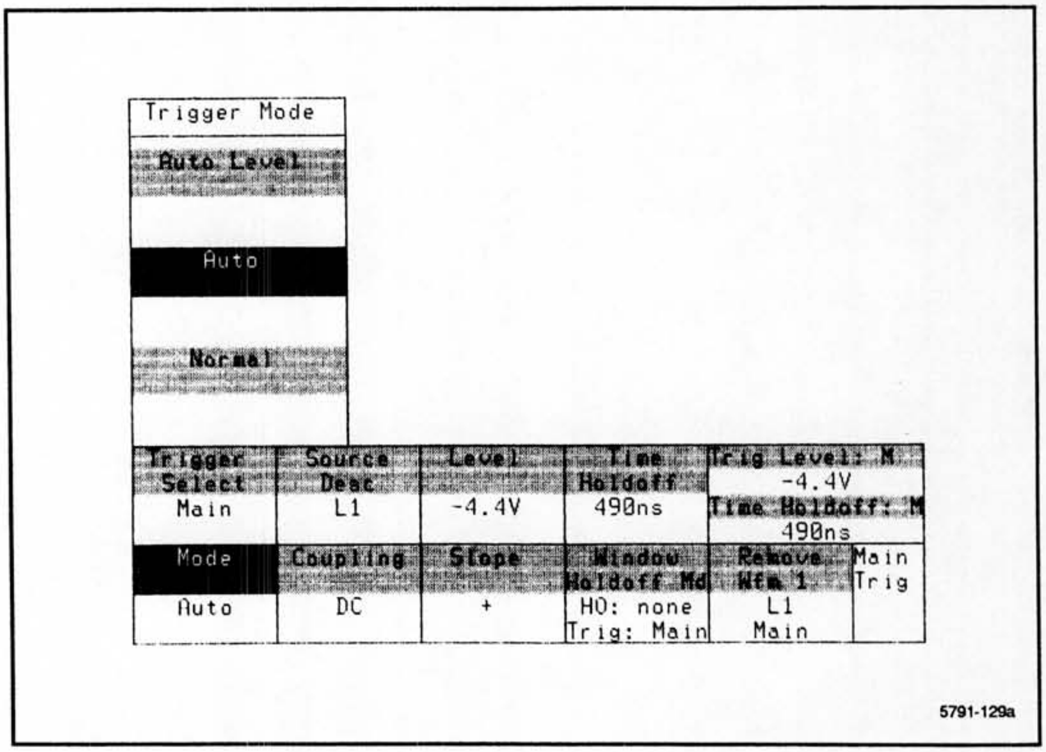


Figure 2-21. Trigger Mode pop-up menu.

Menu Items

The following items are entries in the **Trigger Mode** pop-up menu:

- **Auto Level**—Automatically establishes the trigger level on a trigger signal, and free runs the time base in the absence of a triggering signal. The trigger level can be changed with the Top Control knob between 20% and 80% of the peak-to-peak signal range. This mode should not be used when the trigger repetition rate is below 30 Hz.

  The peak-to-peak signal range is redefined and the trigger Level is reset whenever triggering ceases due to signal variations.

- **Auto**—Provides triggered signal acquisition when the Level control (Top knob) is correctly set and when an adequate trigger signal is present. **Auto** mode is similar to **Normal** mode, except that an inadequate trigger signal or an incorrect Level setting will cause the time base counter to free-run. An adequate trigger signal ends the free running condition. Not selectable for Window triggering.

- **Normal**—Provides triggered signal acquisition whenever an adequate trigger signal is applied, and the Level control (Top knob) is correctly set. When the trigger signal is not adequate, or when the Level control is not properly set, acquisition stops. Even though acquisition stops, contents of the waveform memory continue to be displayed. This triggering mode must be used to acquire signals with repetition rates below 30 Hz.

Trigger Coupling

The trigger **Coupling** function allows selection of various filters to permit the rejection or selection of some frequency components of the trigger signal.

Trigger Coupling Pop-up Menu

When the **Coupling** label is selected from the Trigger major menu, its label is highlighted in the menu/status area, and the Main or Window pop-up menu is displayed in the waveform display area. Figure 2-22 shows the Main Trigger Coupling pop-up menu.

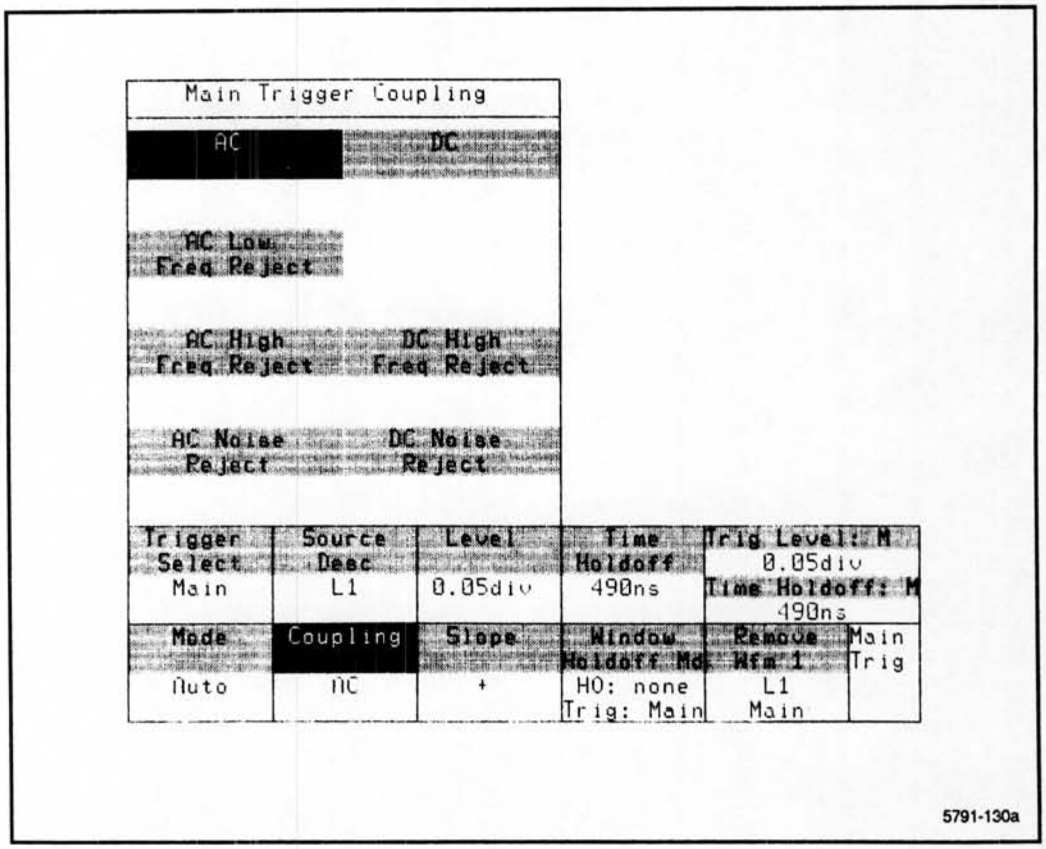


Figure 2-22. Main Trigger Coupling pop-up menu.

Menu Items

The following items are entries in the **Trigger Coupling** pop-up menus:

- **AC**—Blocks the dc component of the trigger signal.
- **AC Low Freq Reject**—Rejects dc, and attenuates low-frequency trigger signals below about 40 kHz.
- **AC High Freq Reject**—Rejects dc, and attenuates high-frequency signals above 40 kHz.
- **AC Noise Reject**—All frequency components of the trigger source signal, except dc, are coupled to the trigger circuit, but the peak-to-peak signal amplitude required to produce a trigger event is increased. Signals below about 40 Hz are attenuated.
- **DC**—Triggers acquisition when the trigger signal reaches a dc level set by the **Level** function.
- **DC High Freq Reject**—Rejects signals above 40 kHz, while retaining the dc component of the trigger signal.
- **DC Noise Reject**—All frequency components of the trigger source signal are coupled to the trigger circuit, but a greater peak-to-peak signal amplitude is needed to produce a trigger.

Trigger Slope

The trigger **Slope** determines whether the trigger circuit responds on the positive or negative transition of the trigger signal. To select the trigger **Slope** function, touch the **Slope** label in the menu/status area.

The **Slope** function toggles between positive and negative. The status of the Trigger Slope for the selected time base is shown below the **Slope** label in the menu/status area.

Window Holdoff Mode

The **Window Holdoff Mode** is used in conjunction with the Window 1 and 2 labels. The **Window Holdoff Mode** determines how the windows will be triggered. The default mode is Triggered from Main which means the window time base is triggered by the Main trigger. Choosing Window holdoff by time or events sets the Window trigger to start the Window time base. Figures 2-24, 2-25, and 2-26 show the three holdoff trigger modes in relationship to Main and Window records positioning. For more information on horizontal positioning see "Horizontal Size and Position" earlier in this section of the manual.

The status of the **Window Holdoff Mode** is shown beneath its label in the menu/status area.

Window Holdoff Mode Pop-up Menu

When **Window Holdoff Mode** is selected, its label is highlighted in the menu/status area, and its pop-up menu is displayed in the waveform display area (see Fig. 2-23).

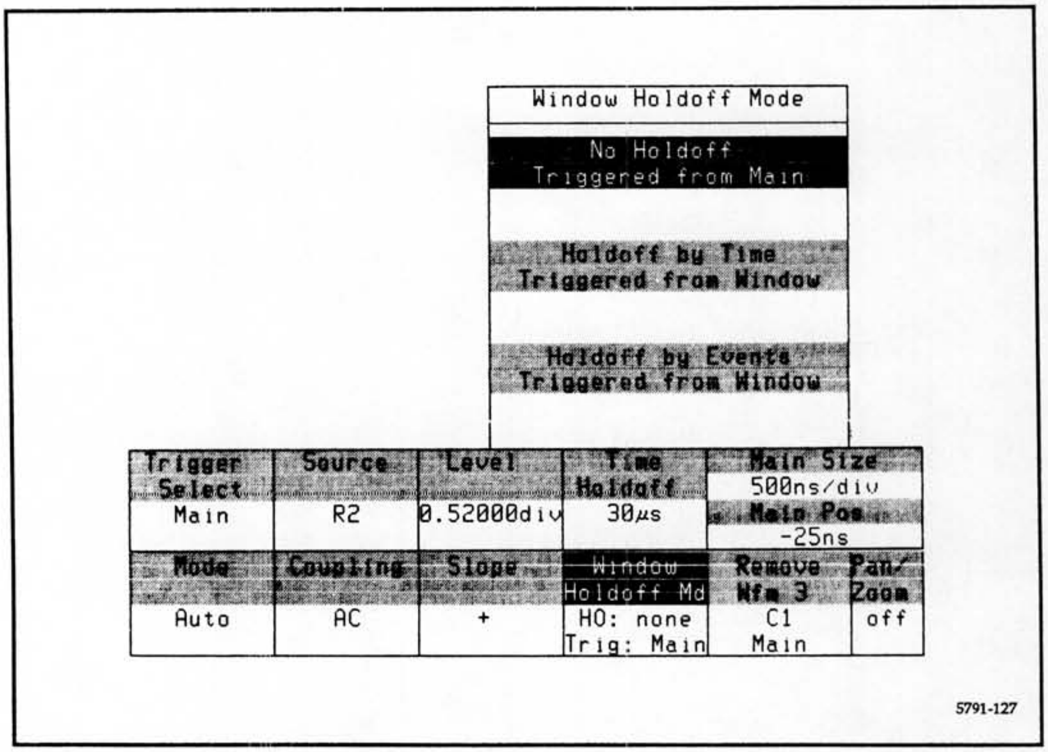


Figure 2-23. Window Holdoff Mode pop-up menu.

Menu Items

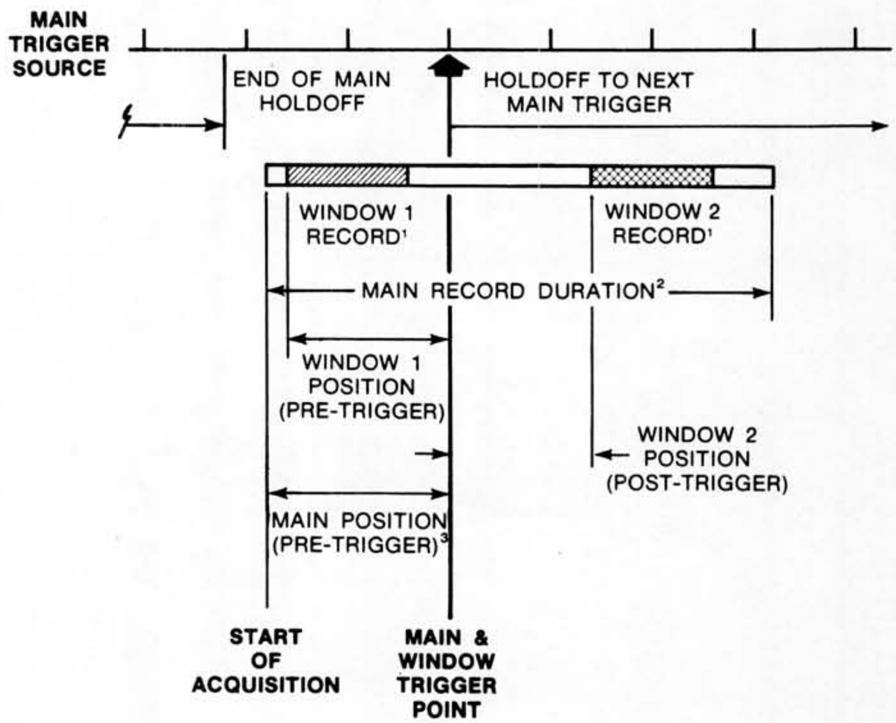
The following items are entries in the **Window Holdoff Mode** pop-up menu:

- **No Holdoff Triggered from Main**—Window trigger time base is not held off. The Window time base uses the Main trigger signal. Window records are positioned with respect to the main trigger point. Window trigger parameters (i.e., source, level, etc.) have no effect in this mode. Figure 2-24 presents an example of this trigger holdoff mode in graphic form.

Window Trigger with:

- **Holdoff by Time Triggered from Window**—The Window time base trigger is held off (not allowed) for a user-set time period after the Main trigger. The Control knobs are assigned to vary the time holdoff when the **Holdoff** label or Trigger icon is selected. Window records are positioned with respect to the Window trigger point. Touch the Horizontal Size and Position icon to position the Windows. Figure 2-25 presents an example of this trigger holdoff mode in graphic form.

- **Holdoff by Events Triggered from Window**—The Window time base trigger is held off (not allowed) for a user-set number (n) of events (window triggers) after the Main trigger. The Control knobs are assigned to vary the events holdoff when the **Holdoff** label or Trigger icon is selected. The Window time base triggers when the the nth event occurs. Window records are positioned with respect to the window trigger point. Touch the Horizontal Size and Position icon to position the Windows. Figure 2-26 presents an example of this trigger holdoff mode in graphic form.



[1]THE WINDOW 1 AND WINDOW 2 RECORDS CAN BE INDIVIDUALLY POSITIONED FROM PRE TO POST MAIN RECORD DURATION SO LONG AS THEY COINCIDE WITH THE MAIN RECORD AT ONE POINT.

[2]THE MAIN RECORD DURATION CAN BE POSITIONED 0 TO 100% PRE-TRIGGER OR 0 TO 100% POST-TRIGGER WITH REFERENCE TO THE MAIN TRIGGER POINT.

[3]THE MAIN TIME BASE WILL REJECT TRIGGERS UNTIL ENOUGH MAIN AND WINDOW PRE-TRIGGER POINTS ARE ACQUIRED TO FULFILL THE POSITION (PRE-TRIGGER DURATION) SETTINGS.

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Figure 2-24. Main and Window time bases both triggered from the Main Trigger Point.

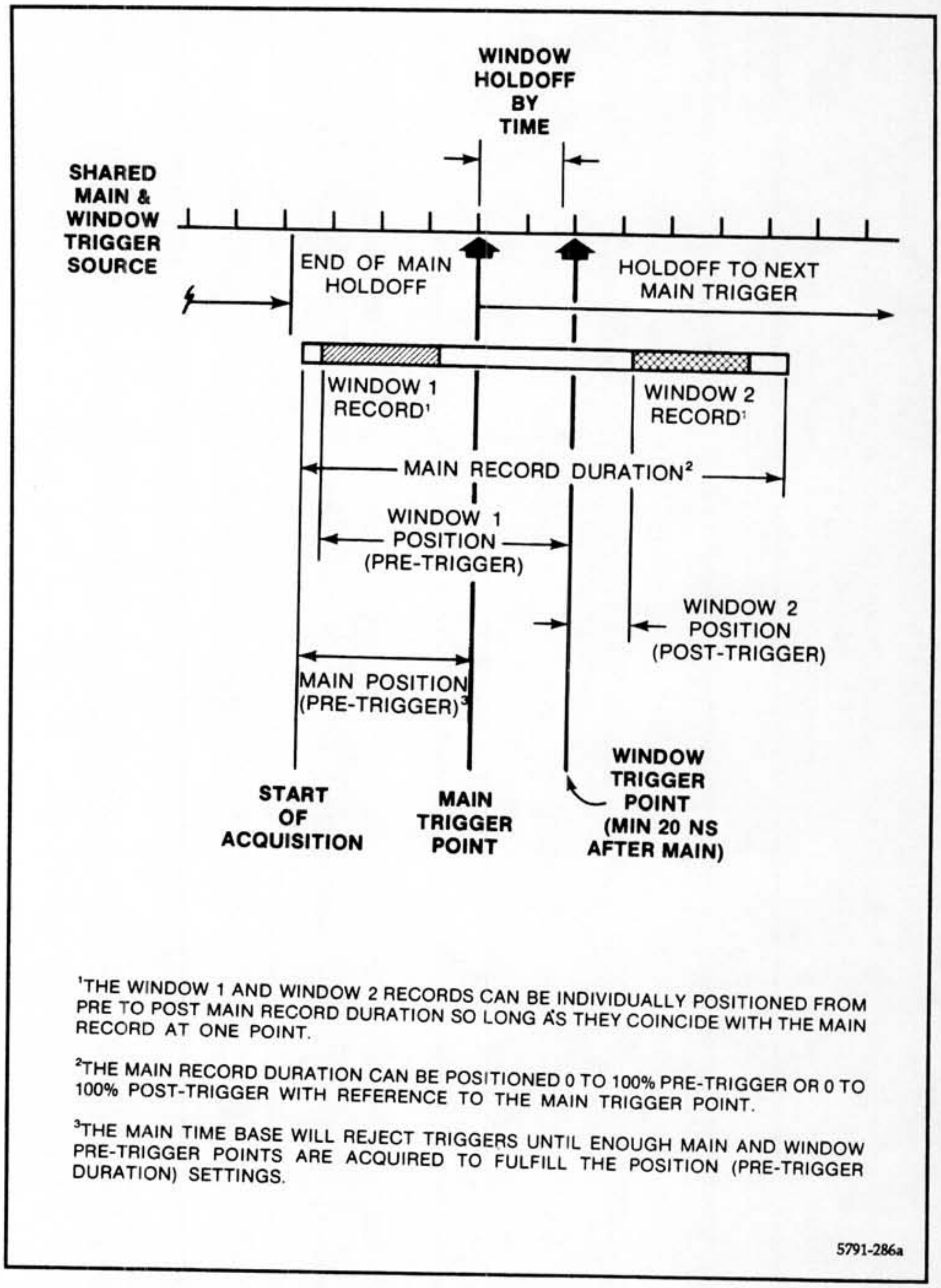

Figure 2-25. Window Trigger point holdoff by time from the Main Trigger Point.

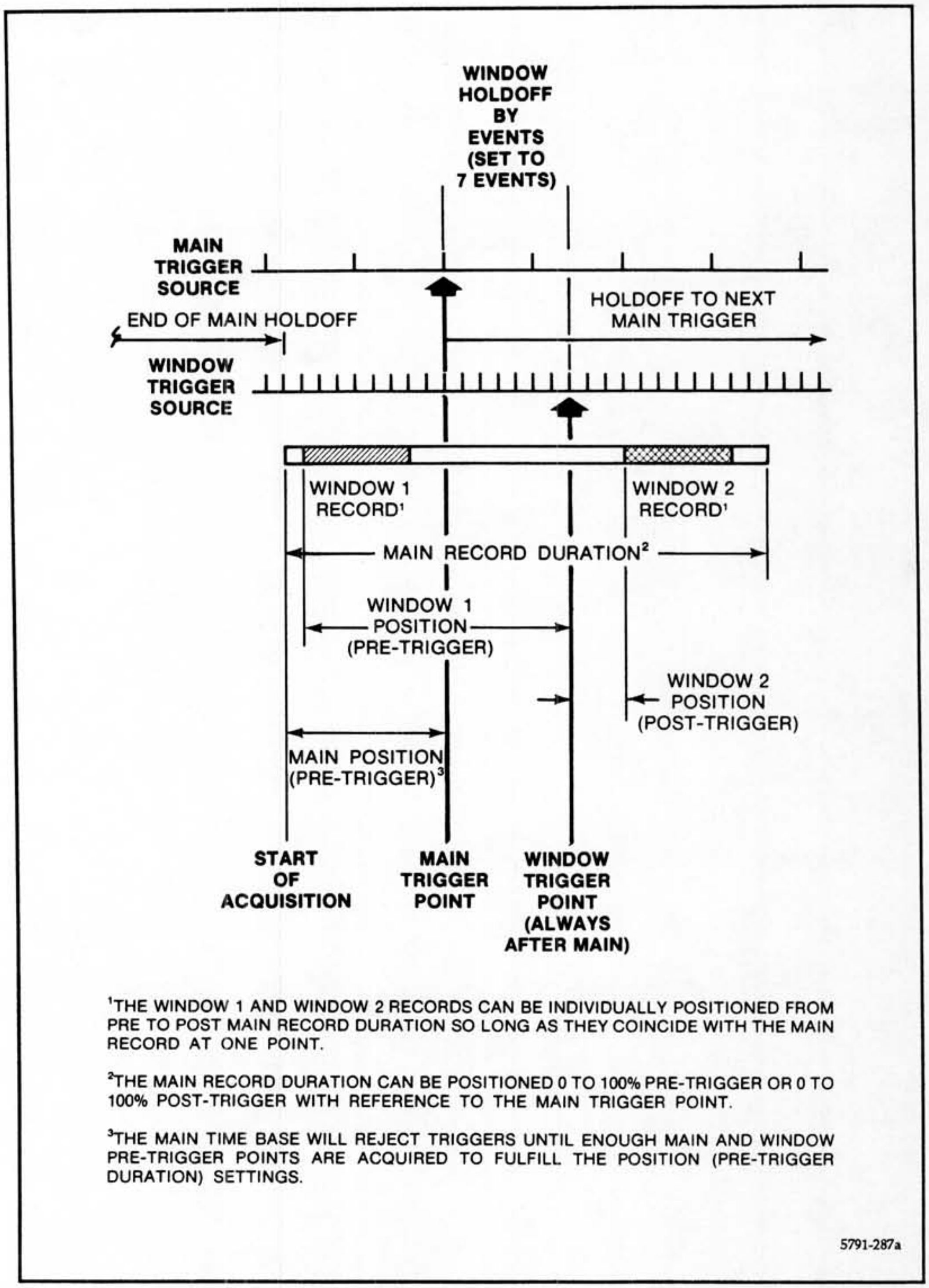

Figure 2-26. Window Trigger point holdoff by events from the Main Trigger Point.

Measuring Waveforms

Pressing the MEASURE button causes the Measure major menu to be displayed in the menu/status area of the screen (see Fig. 2-27). The Measure major menu allows users to set the various measurement parameters.

The 11401/11402 can make two types of measurements; standard and custom. Standard measurements are discussed under "Standard Measurement Functions" later in this section. Custom measurements, which are made using cursors, are described under "Custom Measurement Functions" later in this section.

Measure Menu Function Selections

Functions that can be performed through the Measure major menu are listed in Table 2-4. A detailed description of each function listed in the table is discussed in the text following the table.

TABLE 2-4
Measure Major Menu Functions

Function	Operation Performed
Measurements	Selects the amplitude, timing and area/energy functions to perform standard measurements.
Compare & References	Compares stored reference values with the values of the selected waveform and displays the result.
Remove Wfm	Allows removal of the selected waveform display (described below the label).
Active measurements	Displays up to six measurement function labels. Refer to Figure 2-27.

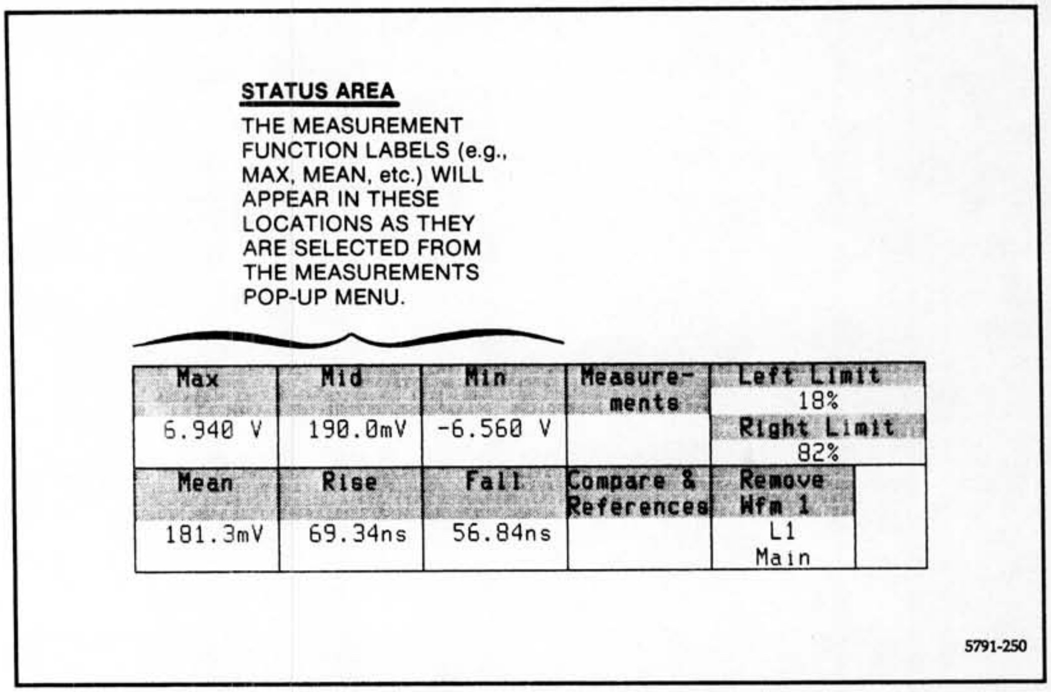

Figure 2-27. Measure Major Menu.

Selecting and Ending Measurements

The **Measurement Functions** category of the **Measurements** pop-up menu allows selection of such measurement functions as **Max, Min, Rise, Fall,** etc. These functions can be added to, or removed from, the list of measurements displayed in the menu/status area. Touching a function label that was previously selected (highlighted) from the **Measurements** pop-up menu will remove it from the status area.

Measurements Pop-up Menu

When **Measurements** is selected, its label is highlighted in the menu/status area, and the **Measurements** pop-up menu is displayed in the waveform display area. Figure 2-28 shows the **Measurements** pop-up menu.

Two menu categories can be selected within the **Measurements** pop-up menu: one category displays **Measurement Functions** menu items (see Fig. 2-28); the other displays the **Default Parameters** menu items (see Fig. 2-29).

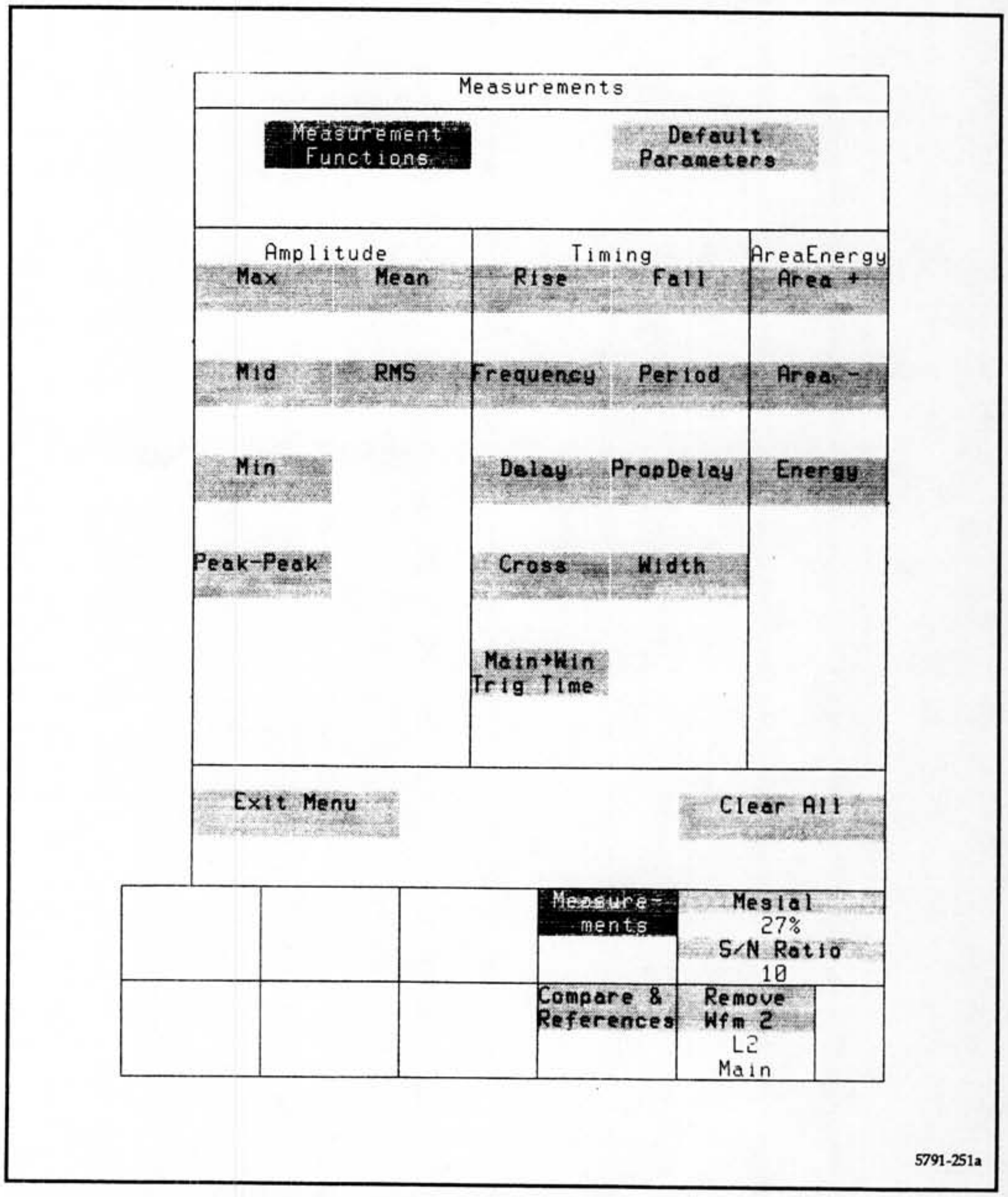

Figure 2-28. Measurements pop-up menu with **Measurement Functions** selected.

Measurement Functions Menu Category

The **Measurement Functions** category is divided into three classifications; **Amplitude, Timing,** and **Area/Energy.** Each individual measurement function (e.g., **Max, Min,** etc.) is discussed in detail under "Standard Measurement Functions" later in this section.

- **Amplitude**—Provides selections for measuring various waveform parameters dealing with amplitude.

  Max—Provides readout of the maximum waveform value within the Measurement Zone.

  Min—Provides readout of the minimum waveform value within the Measurement Zone.

  Mid—Provides readout of the maximum waveform value plus the minimum waveform value divided by two within the Measurement Zone.

  Peak-to-Peak—Provides readout of the maximum waveform value minus the minimum waveform value.

  Mean—Provides readout of the mean waveform value over one cycle or the entire Measurement Zone.

  RMS—Provides readout of the root mean square waveform value over one cycle or the entire Measurement Zone.

- **Timing**—Provides selections for measuring various waveform parameters dealing with the timing of a selected signal or signals.

  Rise—Provides readout of the time duration between the Proximal and Distal points on the first rising edge of a waveform within the measurement zone.

  Fall—Provides readout of the time duration between the Distal and Proximal points on the first falling edge of a waveform within the measurement zone.

  Width—Provides readout of the time duration between the first two Mesial level crossings on successive edges of a waveform within the measurement zone.

  Period—Provides readout of the time duration between the Mesial level on the first edge to the Mesial level on the next edge of the same slope within the measurement zone.

  Frequency—Provides readout of the inverse of the Period measurement.

  Delay—Provides readout of the time duration between the first Mesial crossing and the last Mesial crossing on the selected waveform within the measurement zone.

  Main→Win Trig Time—Provides readout of the time duration between the Main trigger event and the Window trigger event.

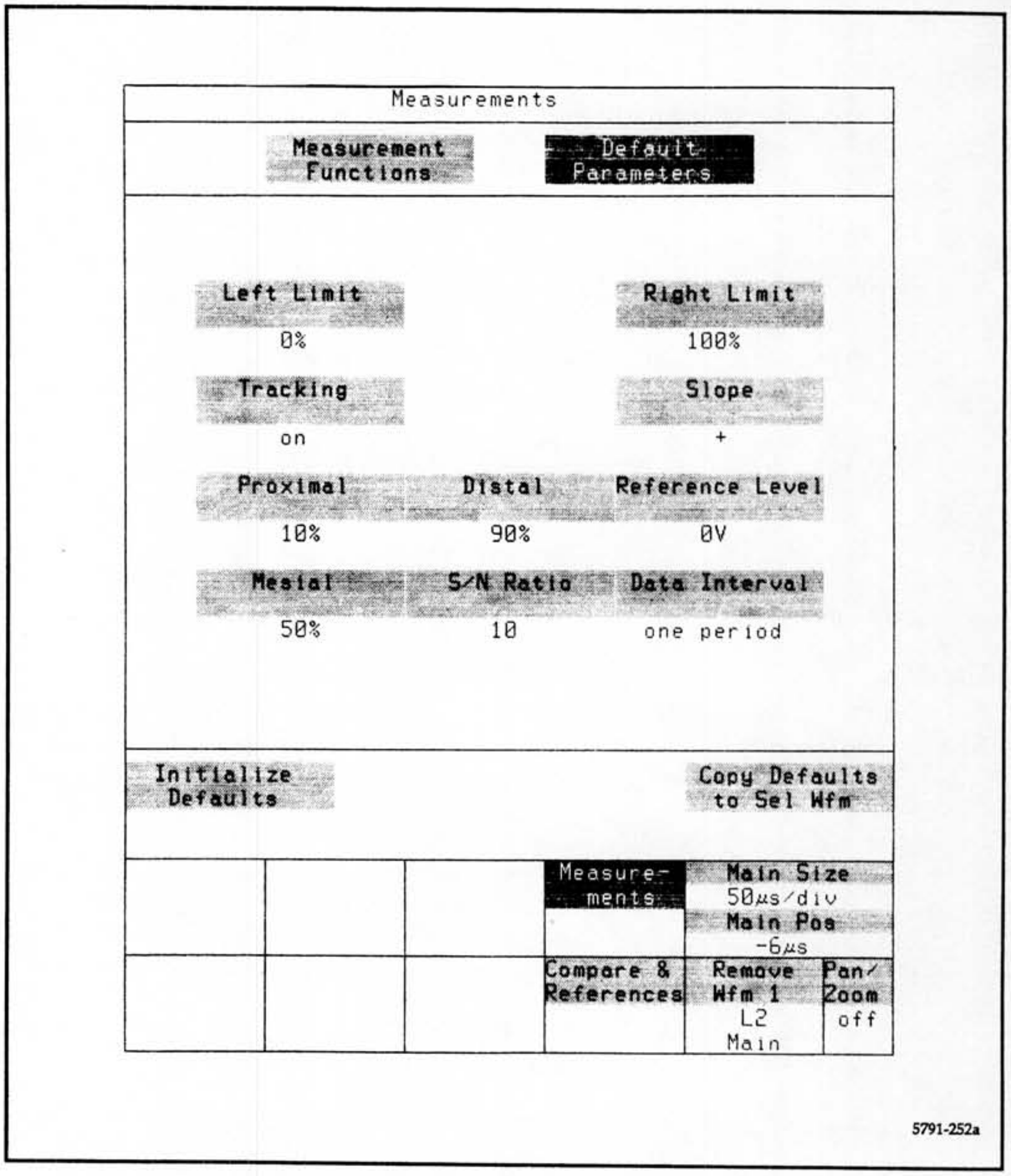

Figure 2-29. Default Parameters category of the Measurements pop-up menu.

Cross—Provides readout of the time duration between the Trigger Point and the crossing of the reference level on the first edge of the specifiedslope within the measurement zone.

Prop Delay—Provides readout of the time duration difference between the first mesial crossing on the selected waveform to the first mesial crossing on another delayed waveform.

- **Area/Energy**—Provides selections for measuring the energy content of a selected waveform or waveforms.

  Area +—Provides readout of the total absolute value of all areas between a YT waveform and a user-specified Reference Level for one cycle or the entire Measurement Zone.

  Area –—Provides a readout of the area bound by a YT waveform above a user specified Reference Level minus the area bound below the Reference Level for one cycle or the entire Measurement Zone.

  Energy—Provides readout of the energy under a YT curve, relative to ground for one cycle or the entire Measurement Zone.

- **Exit Menu**—Executes the selections and exits the menu.
- **Clear All**—Removes all selected measurements from the menu/status area.

Default Parameters Menu Category

Touching the **Default Parameters** label replaces the initial **Measurement Functions** menu category with the **Default Parameters** menu category items. (see Fig. 2-29). Parameter settings displayed in the **Default Parameters** category are the criteria for making measurements. Figure 2-30 illustrates where measure parameter annotations are located on the screen.

For detailed parameter definitions, refer to "Common Measurement Parameters" defined under "Standard Measurement Functions" later in this section.

The following items are entries in the **Default Parameters** category:

- **Left Limit** and **Right Limit**—Defines the Measurement Zone limits. Waveform measurements are performed only within these limits.
- **Proximal**—Defines the lower measurement point for **Rise** time and **Fall** time measurements.
- **Mesial**—Defines the middle measurement point for Width, Period, Frequency, Prop Delay and Delay, and indirectly affects Mean, RMS, Area +, Area –, and Energy when Data Interval is set to Single.
- **Distal**—Defines the upper measurement point for **Rise** time and **Fall** time measurements.
- **S/N Ratio**—Defines the signal-to-noise ratio (hysteresis) of the displayed signal to qualify Mesial crossings.
- **Reference Level**—Defines the dc reference level for **Cross**, **Area+**, and **Area–** measurements.

- **Tracking**—Controls whether the Topline and Baseline values track the changing waveform levels, or remain fixed.
- **Data Interval**—Sets the measured portion of a waveform to one period or the **whole** Measurement Zone.
- **Slope**—Sets the slope polarity for the **Cross** Measurement.
- **Initialize Defaults**—Sets the variable parameters in the **Default Parameter** category to the settings shown in Table 2-5.
- **Copy Defaults to Sel Wfm**—Sets measurement parameters from the Default Parameters to the selected waveform settings.

Most displayed parameters can be changed by touching the parameter label and rotating the appropriate Control knob. The three exceptions are **Data Interval, Tracking,** and **Slope** which toggle between their two states.

TABLE 2-5
Initialized Default Parameters Settings

Parameter	Default at Initialize
Left Limit	First point on waveform display (0%).
Right Limit	Last point on waveform display (100%).
Topline	100% level automatically calculated from waveform data.
Distal	90% of the difference between Topline and Baseline.
Mesial	50% of the difference between Topline and Baseline.
Proximal	10% of the difference between Topline and Baseline.
Baseline	0% level automatically calculated from waveform data.
S/N Ratio	10.
Data Interval	One period.
Reference Voltage	0 volts.
Tracking	On.
Slope	+.

Tracking Measurement Mode

Amplitude, Timing, Area, and Energy measurements may operate in one of the two following modes:

1. Tracking—The waveform parameters (Topline and Baseline) and all active measurements track the changing waveform data.

2. Nontracking—The waveform parameters (Topline and Baseline) are user set and will not follow waveform data changes. This mode is useful when the user does not want these parameters automatically set. The parameters Proximal, Mesial, and Distal, which are based on Topline and Baseline, will not follow waveform variations.

Waveform Annotation

Waveform annotation for the waveform parameters is displayed in the graticule area on the selected waveform. Waveform annotation for measurement functions consists of a combination of:

1. Measurement zone indicators—The Left Limit and Right Limit bracket the portion of the selected waveform to be used for measurements. Once set, these limits are used for all measurements of that waveform.

2. Information-only measurement annotations—Waveform parameters that have significant meaning to a measurement's algorithm, but which cannot be changed by the user (e.g., the intensified portion of a waveform measuring rise time).

3. Adjustable measurement annotations—Waveform parameters that have significant meaning to the algorithm, and are set by the Control knobs (e.g., Mesial or Reference voltage).

These waveform annotations are displayed on the screen relative to the waveform point or area. They appear in the form of intensified regions on the waveform, or as vertical or horizontal dashed lines. (See Fig. 2-30 for a typical waveform annotation.)

Only one measurement's waveform annotation and parameter pop-up menu may be displayed at a time. Any measurement function (e.g., **Rise**, **Mean**, etc.) may be selected to show its particular waveform annotation. To observe a measurement's annotation or to change its parameters, select that measurement (touch the label) in the menu/status area.

Waveform annotation is displayed only when the Measure major menu is selected. The annotation is removed when any menu key is pressed.

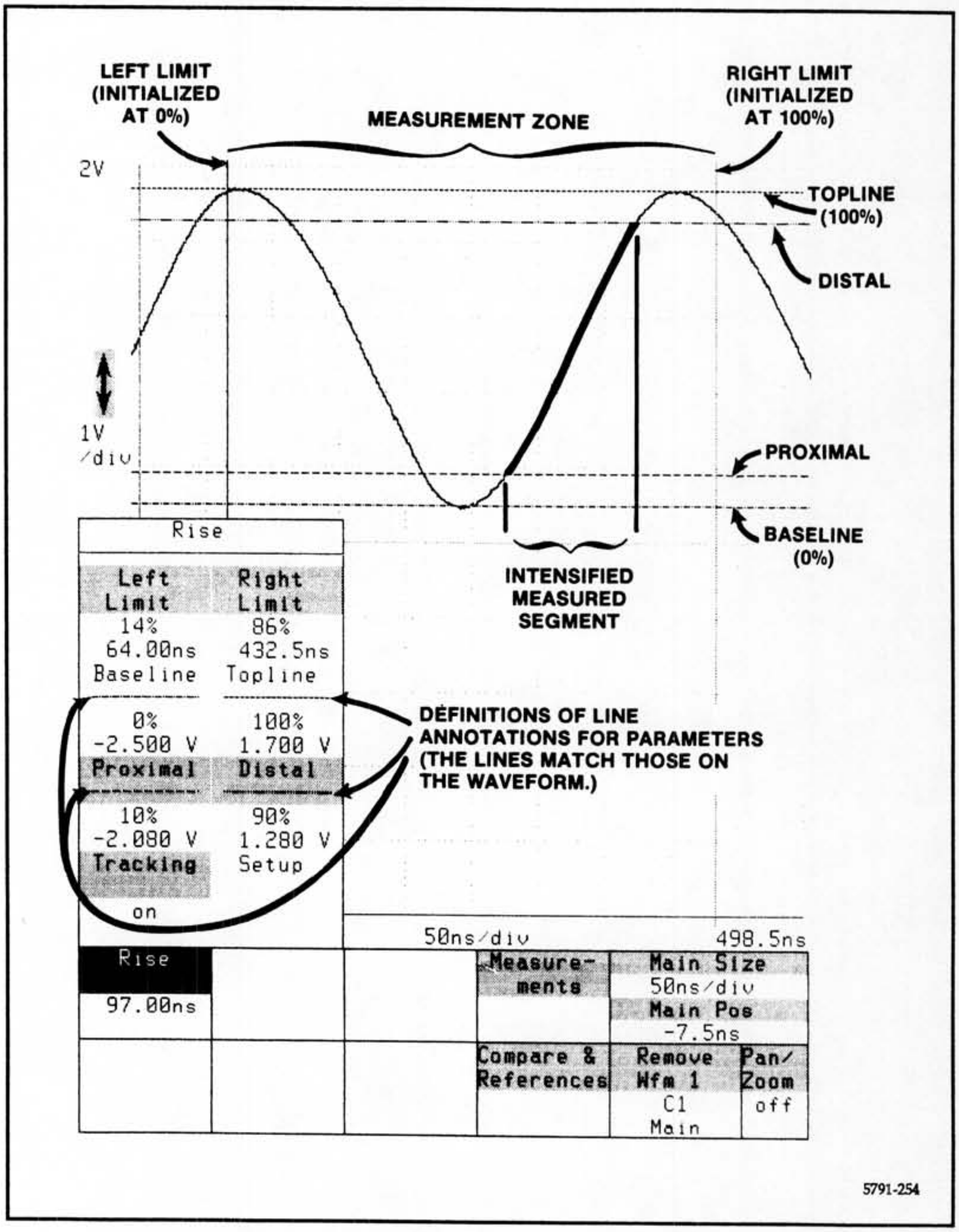

Figure 2-30. Waveform measurement parameters annotation.

Unacquired and Out-of-Range Waveform Data Points Reduce Accuracy

Acquired data points that are out of the range of the digitizer are stored as "out-of-range points." Such points affect the measurement function's accuracy and result. Out of range data points within the measurement zone produce an approximate result with a qualification symbol such as ≥ or ≤ or ?.

Unacquired (null) waveform data points also affect the measurement function's accuracy. The results may be the same as for out-of-range points, or the measurement function may be unable to resolve an answer. When no result is obtainable, an error or undefined status is shown below the function label.

A number of conditions can cause the waveform record to contain some null or unacquired points. An example is the use of the "% Record Fill" option on the Acquire Description menu in order to reduce acquistion. In some cases, Single Trigger acquisitions will also produce incomplete records. If only a few such points exist, they may not be visible in the trace, but will nontheless affect measurement results.

A simple procedure that uses interpolation to fill in the missing points in records that contain a small percentage of null points:

Store the incomplete waveform.

Define a new waveform as (Intp(STO1)).

The new waveform has the missing points filled in by linear interpolation.

Compare and Reference

This function allows the user to store desirable waveform measurement values as a reference for comparison against other waveform values.

The **Compare and Reference Values** pop-up menu provides the means to save current measurement results as the new reference values, or to manually adjust the measurement reference values. Once a set of measurement references are saved, the same set of measurements can be performed on other waveforms and compared to the reference values.

Compare and Reference Values Pop-up Menu

Touching the **Compare and References** label in the menu/status area causes its pop-up menu to be displayed in the waveform display area (see Fig. 2-31).

The **Compare and Reference Values** pop-up menu displays the current set of stored reference values.

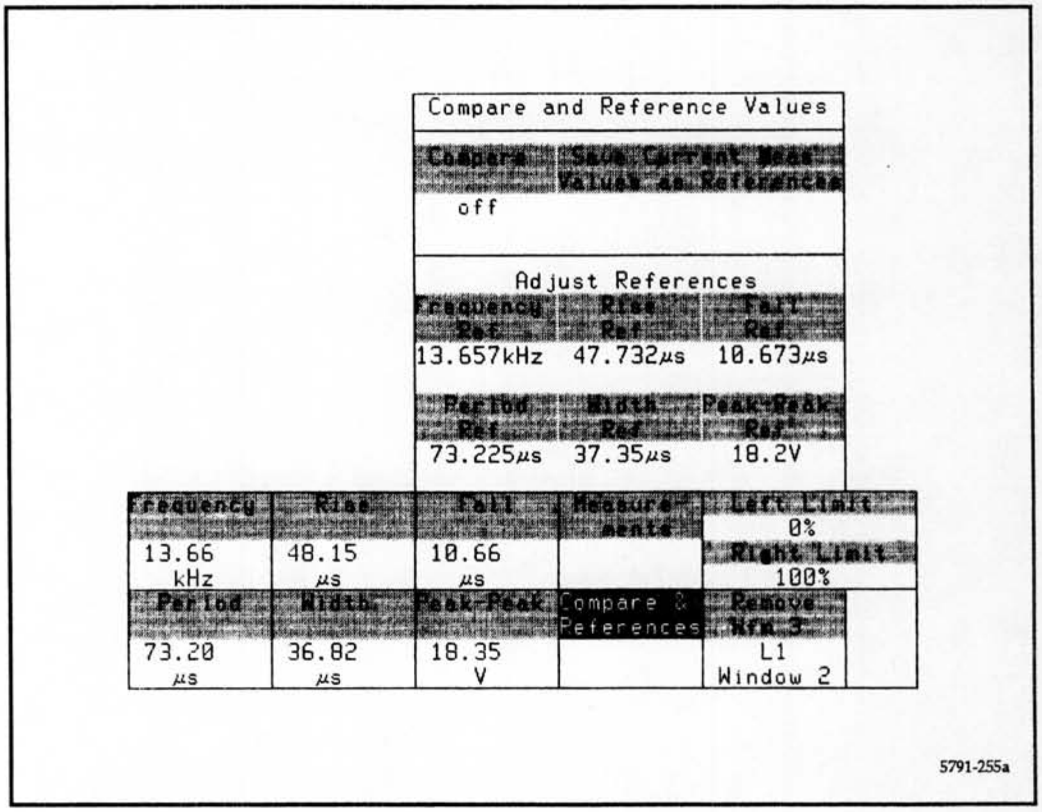

Figure 2-31. Compare and Reference Values pop-up menu.

Menu Items

The following categories and items are entries in the **Compare and Reference Values** pop-up menu:

- **Compare**—Currently selected measurements are compared to a stored set of reference values (one for each selected measurement function) by toggling the **Compare** label **On**.

    1. The measurement functions' results change to delta measurement results. This is calculated as the measurement function result minus the stored reference value for that function. For example: ΔFrequency=Frequency-Frequency Ref.

    2. Measurement function labels change from a simple function to a delta function (e.g., **Max** changes to Δ**Max**).

    Measurement comparison is toggled "**On**" or "**Off**" by selecting the **Compare** label.

    The status of the Compare function is displayed in the menu/status area below the **Compare and References** label.

- **Save Current Meas Values as References**—Current measurement function results are stored as references.

- **Adjust References**—Selecting any measurement from the **Adjust References** category assigns control of that measurement's reference value to one of the Control knobs. Changes in the Control knob settings will be indicated under the selected reference label.

Standard Measurement Functions

All standard measurement functions can be selected from the **Measurements** pop-up menu by touching the **Measurements** label in the Measure major menu. Chosen measurements and their results appear in the menu/status area. Measurements are performed continuously on plug-in channel waveforms and only once on stored waveforms.

Most measurements produce four digits for Fast Waveforms and six digits for HiPrec Waveforms. All timing measurements yield four-digit results. **Cross** and **Main to Window Trigger Time** measurements are exceptions; they return eight-digit results. Area and Energy measurements return four digits. Mean and RMS measurements return six-digit reults.

For a discussion of data quality and waveform Averaging refer to "Data Used for Measurements" at the end of "Oscilloscope System Architecture" which immediately follows this manual's introductory statement.

The following text discusses the common measurement parameters used by the various measurement functions. Each measurement function in the **Measurements** pop-up menu is then described.

Common Measurement Parameters Defined

The Standard Measurement parameters used in this instrument are described in detail here, and illustrated in Figure 2-30. Table 2-5 gives initialized **default** settings for the measurement parameters listed alphabetically below.

Baseline—The Baseline vertical value is the zero percent level to which Proximal, Mesial, and Distal are referenced. (Topline is the 100 percent level.) The Baseline vertical value is used to determine:

- Proximal and Distal values for measuring **Rise** and **Fall.**
- Mesial value used for measuring **Period, Frequency, Width, Mean, RMS, Delay, Area+, Area–,** and **Energy, Prop Delay.**

By default, Baseline is automatically determined by an algorithm. The algorithm finds the average vertical value then looks for a lower than average vertical value that occurs very frequently in a waveform record. If a low recurrent value is not found, then the minimum vertical value is used for the Baseline level. For example, the vertical value of the flat bottom of a square wave would meet the low recurrent value condition and become the Baseline level. A sawtooth waveform would default to the second condition and its minimum vertical value would become the Baseline level.

Normally, the **Tracking** function is on so Baseline is automatically set. When Tracking is set to off, Baseline can be selected from the measurement's pop-up menu and set with a Control knob to any value less than or equal to the Topline value. The Setup function will determine a Baseline value on a single scan when used with Tracking off.

Baseline is not selectable when **Tracking** is on. Further, Baseline is not selectable when the **Data Interval** is set to the entire zone in the Mean, RMS, AREA+, and Energy pop-up menus. Period, Freq, Delay, and Width still allow selection. When Baseline is selected, Topline and Baseline are assigned to the Control knobs. A unique dashed line displays the baseline level.

Data Interval—Data Interval determines which Measurement Zone data will be measured. It can be toggled between a single period of the selected waveform and the entire Measurement Zone (see Fig. 2-32). The period is from one Mesial crossing on the selected waveform to next Mesial crossing with the same slope. S/N Ratio levels must be crossed within the Measurement Zone. Data Interval is available on the **Mean, RMS, Area+, Area–**, and **Energy** measurements from their pop-up menus.

When Data Interval is set to the entire zone, parameters Topline, Mesial, Baseline, Signal/Noise Ratio, Tracking, and Setup are not selectable.

Distal—The Distal (most-distant from the baseline) vertical value determines one end of the timing region for **Rise** and **Fall** measurements (see Proximal). Distal is set to some percentage of the vertical range between Baseline (0%) and Topline (100%) vertical values. The initialized default level of Distal is 90%.

When selected from a measurement's pop-up menu, Distal assigns Proximal % and Distal % to the Control knobs. Distal can be up to 100% of the Topline value and will always be greater than or equal to Mesial and Proximal. Distal will be pushed up by Mesial and Proximal if they are increased above its level. A unique dashed line is displayed for a visual reference (see Fig. 2-30), along with the Distal % and corresponding vertical value.

The current status of Distal is shown below the **Distal** label in the measurement's pop-up menu.

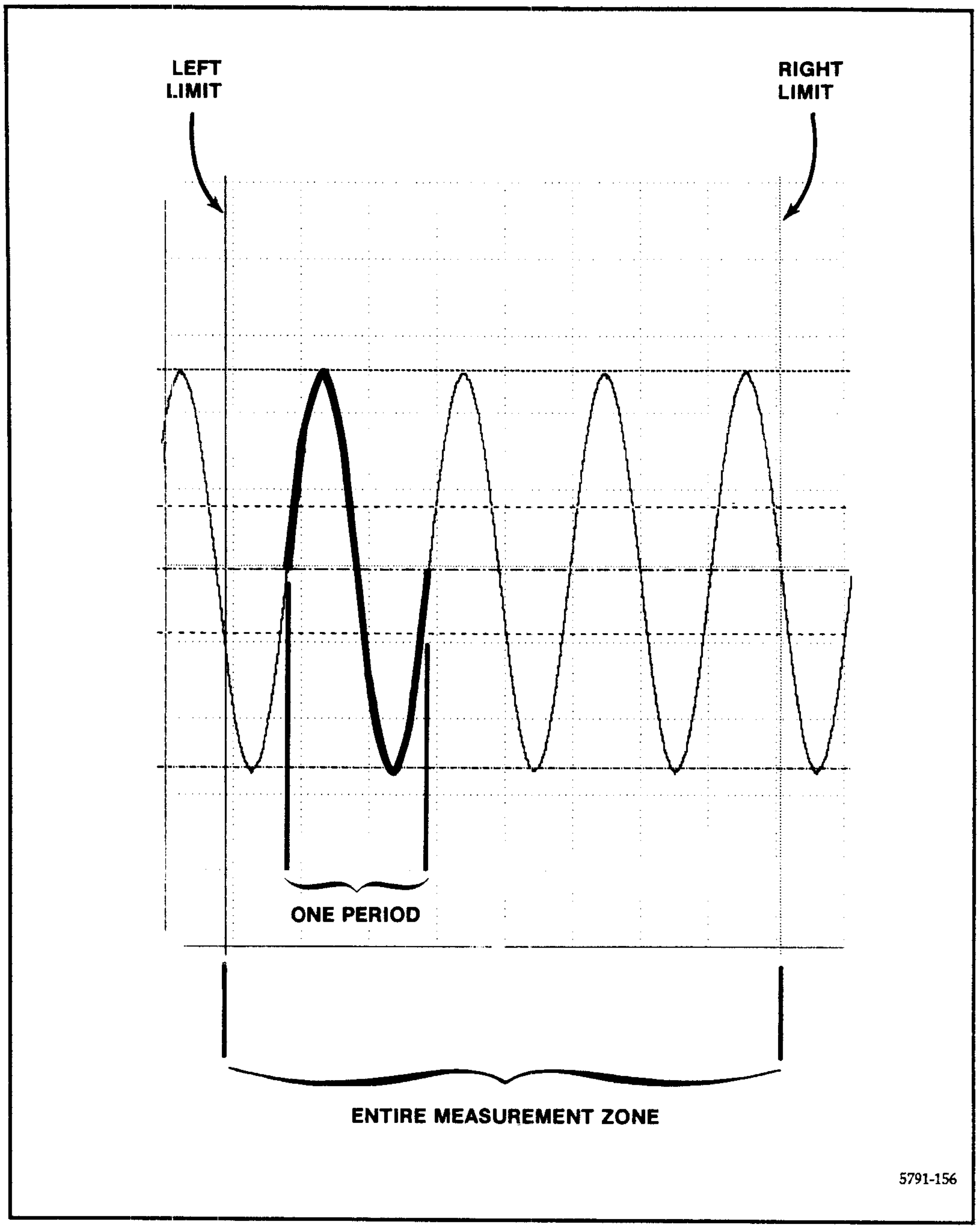

Figure 2-32. Data Interval Parameter.

Measurement Zone—The Measurement Zone is the segment of the waveform (bracketed by the **Left** and **Right Limits**) where measurements are performed. All active measurements are taken within the selected waveform's Measurement Zone. Each displayed waveform has its own set of Measurement Zone limits which are displayed and used for measurements whenever the waveform is selected. The **Left** and **Right Limits** can be positioned to bracket a particular portion of a waveform for measurement. The limits are tied to the waveform record points, not the display points, for better resolution. In horizontal Pan/Zoom, the limits may be off screen, so measurements may not correspond to the displayed portion of the waveform. (See Fi. 2-32).

Selecting the **Left** or **Right Limit** label from a measurement's pop-up menu assigns the Control knobs to the **Left Limit** and the **Right Limit.**

The **Left** and **Right Limits** are displayed as vertical bars the full height of the graticule for YT waveforms. Initially, the Left Limit is at the extreme left (0%) and the **Right Limit** is at the extreme right (100%). (See Fig. 2-30). As the Measurement limits are moved, their position readout (Control knob labels) will show the percentage of travel from left to right. The position statuses of the **Left** and **Right Limits** are also shown below their labels in the **Measurement's** pop-up menu.

Measurements performed on a full period require the full period to be contained in the Measurement Zone. This implies that the Mesial and Signal/Noise Level crossings must occur within the Measurement Zone.

Mesial—The Mesial (middle) vertical value determines the end points of the waveform period used for **Mean, RMS, Period, Frequency, Width, Delay, Prop Delay, Area+, Area-,** and **Energy** measurements. Mesial is set to some percentage of the vertical range between Baseline (0%) and Topline (100%) values. The initialized default level of Mesial is 50%.

When selected from a measurement's pop-up menu, Mesial % and Signal/Noise Ratio are assigned to the Control knobs. Mesial must be less than or equal to Distal and greater than or equal to Proximal. If Mesial is increased to 100% it will push Distal to 100%. Likewise, Mesial may be decreased to 0% pushing Proximal to 0%. A unique dashed line is displayed (see Figure 2-30) with the Mesial % and corresponding vertical value. The current Mesial status is shown below the **Mesial** label in the measurement's pop-up menu.

Proximal—The Proximal (closest to the baseline) vertical value determines one end of the timing region for **Rise** and **Fall** (see Distal). Proximal is set to some percentage of the Vertical range between Baseline (0%) and Topline (100%) values. The initialized default value of Proximal is 10%.

When selected from a measurement's pop-up menu, Proximal % and Distal % are assigned to the Control knobs. Proximal can be set to any percentage down to the Baseline which is 0%. The percentage of Proximal must always be less than or equal to Mesial. As Proximal is increased it may encounter Mesial at which time they will both increase to stay equal. A unique dashed line is displayed (see Fig. 2-30), with the Proximal % and corresponding vertical value. The current Proximal status is shown below the **Proximal** label in the measurement's pop-up menu.

Compare & References— The other vertical boundary is the selected waveform. The initialized default value of Reference Voltage is zero volts. A unique dashed line displays the Reference Voltage.

When selected from a measurement's pop-up menu, Reference Voltage is assigned to the Control knobs. Reference Voltage is normally adjusted with a resolution of one division per click of the knob. Fine resolution is available by touching the Control knob label, then selecting Fine from the Numeric Entry and Knob Res pop-up menu. The vertical value is displayed below the **Compare & References** label in the measurement's pop-up menu.

Setup—The Setup function does a single Tracking scan of the waveform to determine a Topline value and a Baseline value (refer to Tracking on the following page). Setup is selectable only from a measurement's pop-up menu when Tracking is available and turned off. Once Setup has determined the Topline and Baseline values, they may be manually adjusted with the Control knobs.

S/N Ratio (Signal/Noise)—The Signal-Noise Ratio is a user set value that helps define the Mesial crossings used for the end points of measurements (e.g., **Period** and **Width**). The ratio value is converted to a voltage region whose size is based on the peak-to-peak value of the waveform segment being measured (within the Measurement Zone). The S/N Ratio region is split evenly above and below the Mesial level. The upper and lower limits of the S/N Ratio region are marked with unique dotted lines. (See Fig. 2-33.) For a 10 volt peak-to-peak signal with a S/N Ratio of 20 the S/N Ratio region will be 1/2 volt. This region value is split so that S/N Ratio lines are displayed 1/4 volt above and 1/4 volt below the Mesial line.

S/N Ratio can be set to any positive value from 1 to 99. Lower values produce larger S/N Ratio regions and better immunity to noise. The initialized default value of S/N Ratio is 10. Selecting the **S/N Ratio** label from a measurement's pop-up menu assigns S/N Ratio and Mesial % to the Control knobs. The current setting of S/N Ratio is shown under its pop-up menu label and under its Control knob label. Fine control of S/N Ratio is available by touching its Control knob label and selecting Fine. The Numeric Keypad may also be used to enter a value.

S/N Ratio and Mesial can be used together to define the period or pulse to be measured within the Measurement Zone. Noisy signals can be reliably measured by setting the S/N Ratio so the peak noise level will not qualify Mesial crossings. (See Fig. 2-33 for an example of using the S/N Ratio to define the Period on a noisy waveform.) For oddly shaped, repetitive waveforms Mesial can be positioned and S/N Ratio adjusted so that only the desired period or pulse is measured.

Topline—The Topline vertical value is the 100% level to which Proximal, Mesial and Distal are referenced. (Baseline is the Zero percent level.) The Topline vertical value is used to determine:

- Proximal and Distal values for measuring **Rise** and **Fall** times.
- Mesial value used in measuring **Width, Frequency, Mean, RMS, Delay, Area+, Area–**, and **Energy, Prop Delay**.

By default, Topline is automatically determined by an algorithm. The algorithm finds the average vertical value, then looks for an above average vertical value that occurs very frequently in the waveform record. If a high recurrent value is not found, then the maximum vertical value is used for the Topline level. For example, the vertical value of the flat top of a square wave would meet the high recurrent value condition and become the Topline level. A sawtooth waveform would default to the second condition and its maximum vertical value would become the Topline level.

Normally, the Tracking function is on so Topline is automatically set. When Tracking is set to off, Topline can be selected from the measurement's pop-up menu and set with a Control knob to any value greater than or equal to the Baseline value. The Setup function will determine a Topline value on a single scan when used with Tracking off. Topline can then be adjusted manually.

Topline is not selectable when Tracking is on or when Data Interval is set to the entire zone. When selected, the Topline and Baseline adjustments are assigned to the Control knobs. A unique dashed line displays the Topline level. (See Fig. 2-30.)

Tracking—Tracking toggles **on** and **off**. When on, Tracking automatically extracts the Topline and Baseline values from the Measurement Zone data. Topline and Baseline are not selectable when Tracking is on. When turned off, the values for Topline and Baseline do not follow waveform changes but may be set by the user. If no user-defined values for Topline and Baseline are entered, the present values are used. The measurement parameters Proximal, Mesial, and Distal are referenced to Topline and Baseline values. With Tracking off, these measurement parameters will be referenced to user-set values for Topline and Baseline.

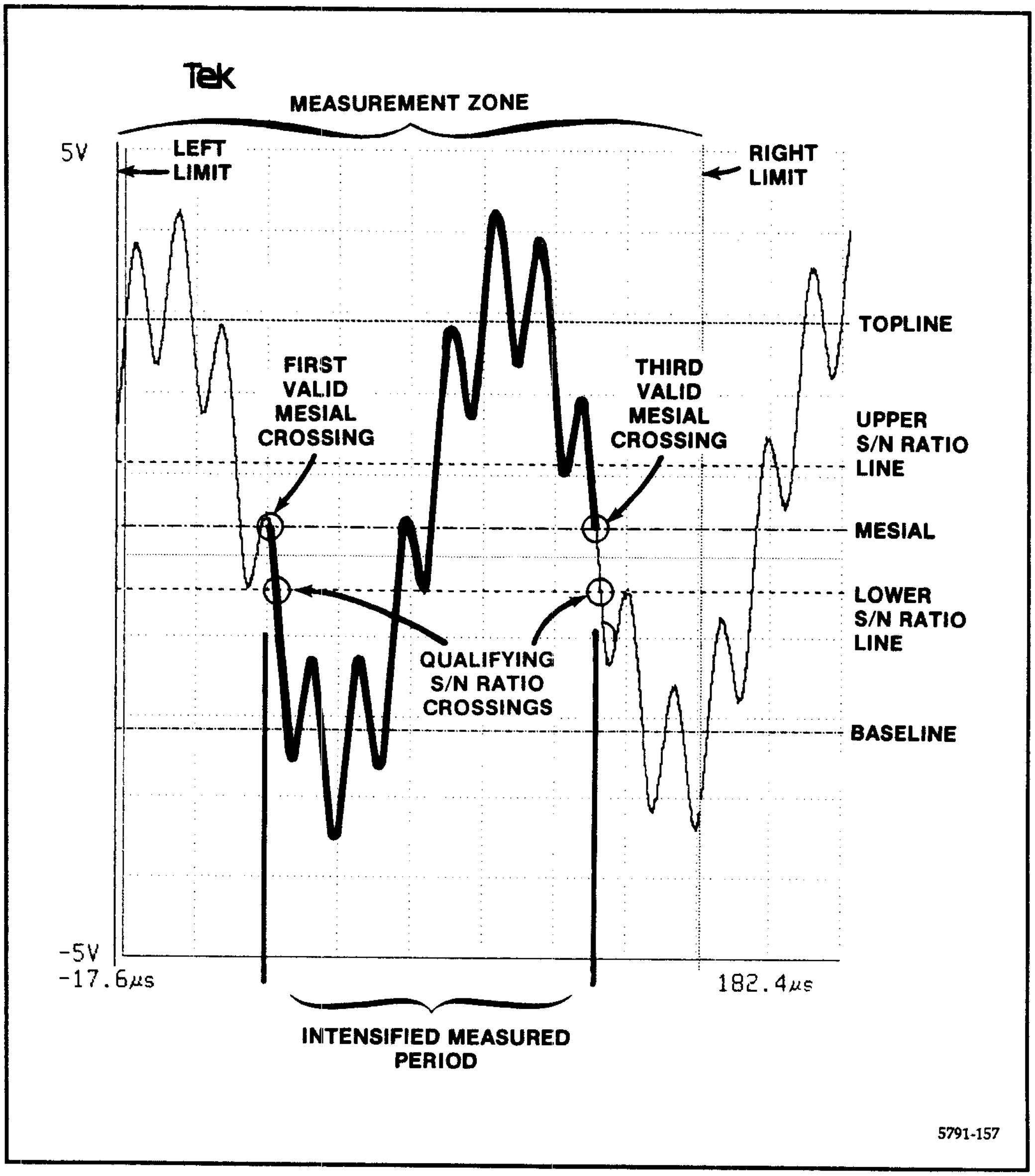

Figure 2-33. Using the Signal/Noise Ratio to define the Period of a noisy waveform.

Max Vertical Value

Press the MEASURE MENUS button to display the Measure major menu at the bottom of the screen. Then touch the **Measurements** *label to display the* **Measurements** *pop-up menu. Select the* **Max** *label from the pop-up menu to invoke the measurement. The* **Max** *label with its measurement result will be displayed at the bottom of the screen. Refer to "Selecting and Ending Measurements" earlier in this section for further information.*

Max measures the most positive peak voltage with respect to the zero volt reference level. The waveform segment being measured must be displayed within the Measurement Zone. Figure 2-34 shows a typical Max measurement example. The measurement is reported to four-digits.

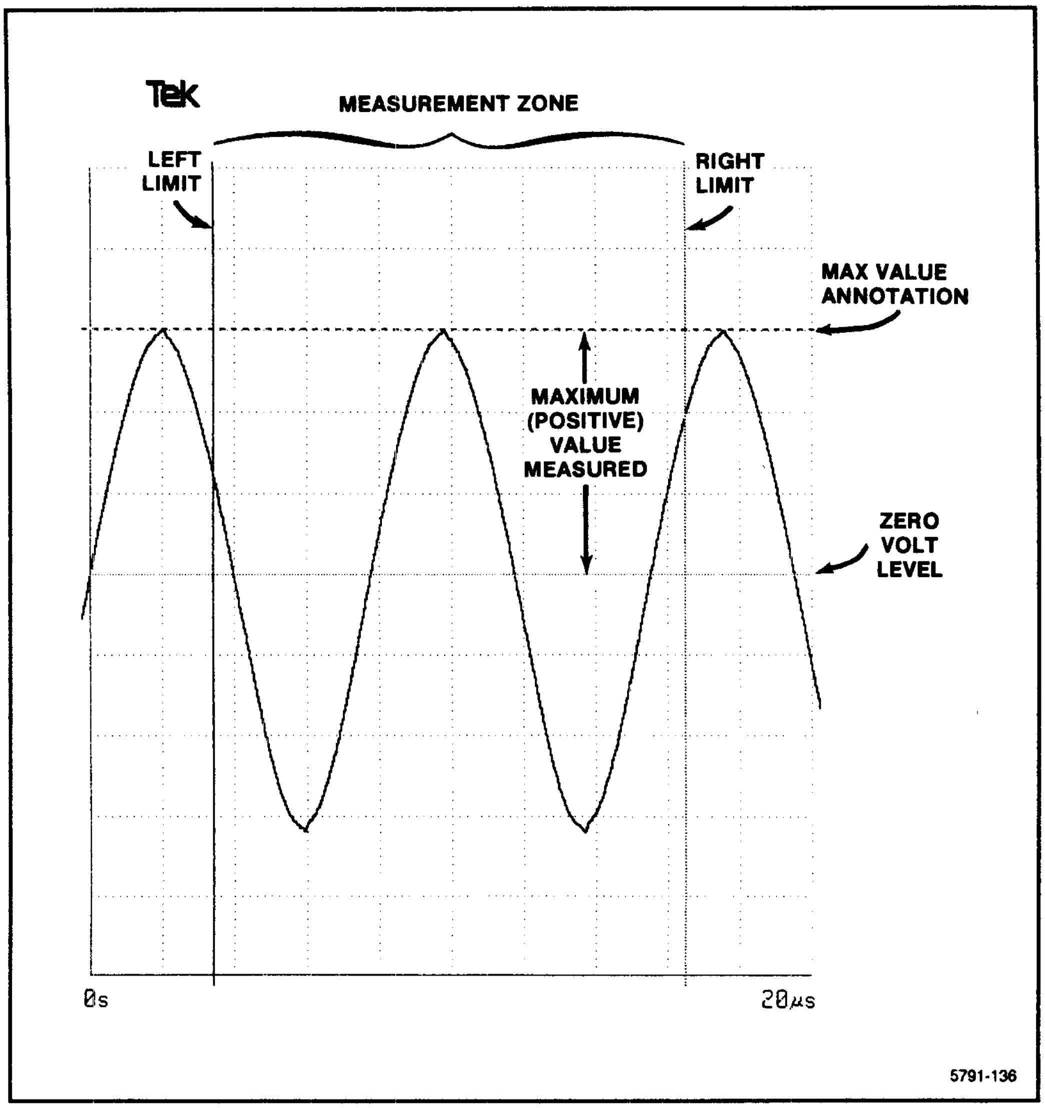

Figure 2-34. Max measurement example.

The Max measurement is normally performed using the Default Parameter settings for the parameters shown in Figure 2-34. These measurement parameters are used by other active measurements and can be changed with:

- The **Max** pop-up menu,
- the pop-up menu of another active measurement that uses the same parameters, and
- the Default Parameters category of the **Measurements** pop-up menu. Refer to "Default Parameters Menu Category" under "Measurements Pop-up Menu" earlier in this section for detailed information.

The maximum positive voltage value is displayed below the **Max** label in the menu/status area.

This measurement can be performed only on YT waveforms. The status is displayed as undefined for XY waveforms.

The **Compare & Reference** function (in the menu/status area) alters the status of the **Max** function, and adds a delta symbol to the name of the function (i.e., Δ**Max**).

Algorithms for all standard measurement functions are defined in Appendix B.

Max Pop-up Menu

Selecting **Max** causes the **Max** pop-up menu to appear in the waveform display area, and highlights its label in the menu/status area (see Fig. 2-35).

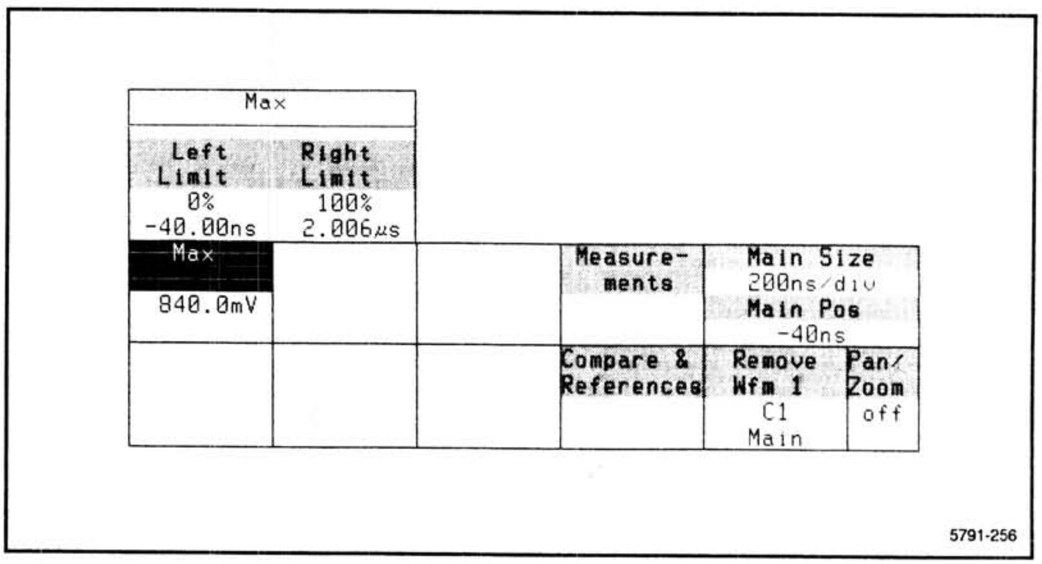

Figure 2-35. **Max** pop-up menu.

Menu Items

The **Max** pop-up menu has a **Left** and **Right Limit** menu item.

For a detailed discussion of the Measurement Zone refer to "Common Measurement Parameters" defined under "Standard Measurement Functions" earlier in this section.

Waveform Annotation

Selecting the **Max** label (in the menu/status area) causes the following annotation on the waveform:

1. Two vertical bars define the Measurement Zone. **Left** and **Right Limit** bars can be moved with the Control knobs when selected from the pop-up menu.

2. A dotted line displayed across the screen defines the positive-peak voltage (Max value), within the Measurement Zone.

Min Vertical Value

Press the MEASURE MENUS button to display the Measure major menu at the bottom of the screen. Then touch the **Measurements** *label to display the* **Measurements** *pop-up menu. Select the* **Min** *label from the pop-up menu to invoke the measurement. The* **Min** *label with its value will be displayed at the bottom of the screen. Refer to "Selecting and Ending Measurements" earlier in this section for further information.*

Min measures the most negative peak voltage with respect to the zero volt reference level. The waveform segment being measured must be displayed within the Measurement Zone. Figure 2-36 shows a typical Min measurement example. The measurement is reported to the four-digits.

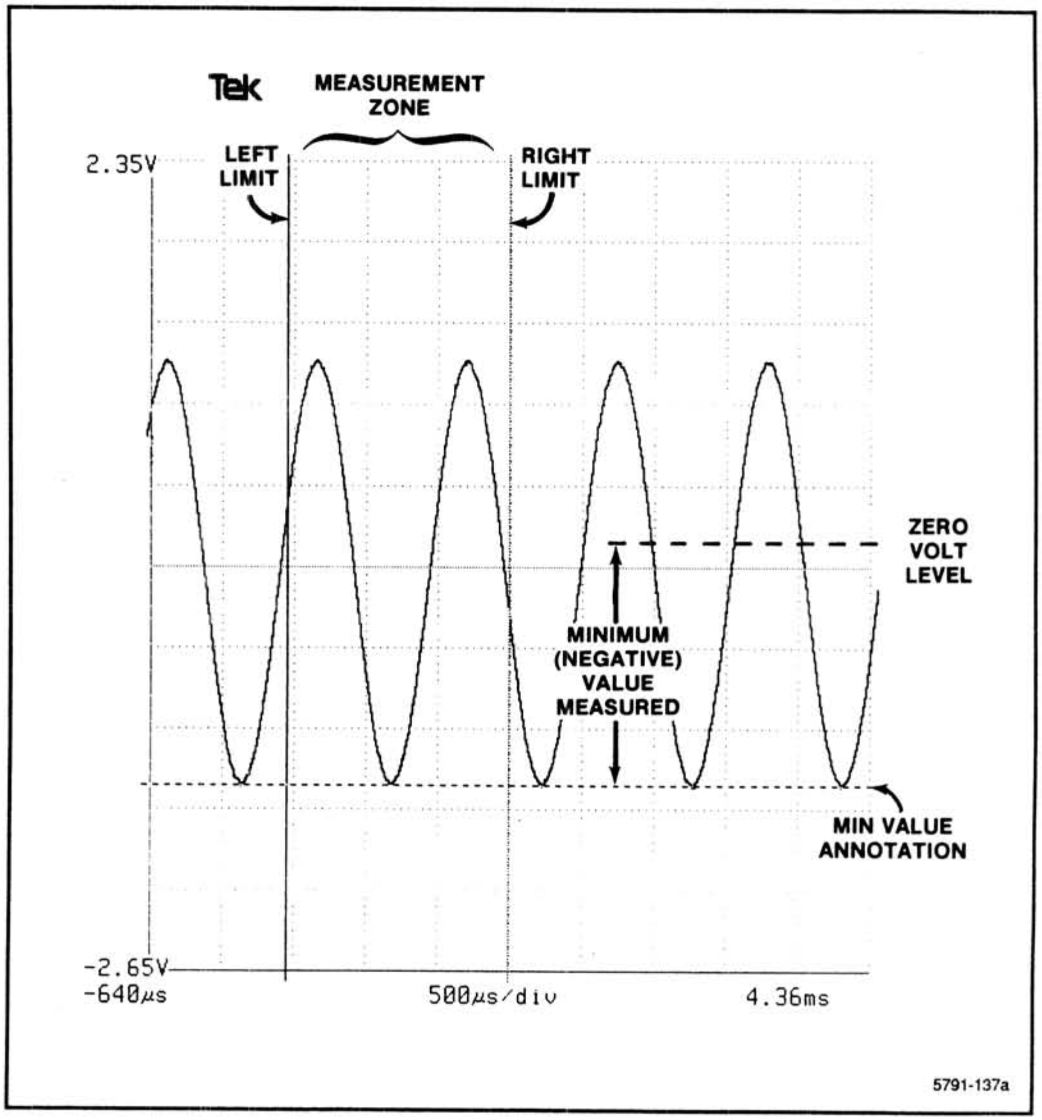

Figure 2-36. Min measurement example.

The Min measurement is normally performed using the Default Parameter settings for the parameters shown in Figure 2-36. These measurement parameters are used by other active measurements and can be changed with:

- The **Min** pop-up menu,
- the pop-up menu of another active measurement that uses the same parameters, and
- the Default Parameters category of the **Measurements** pop-up menu. Refer to "Default Parameters Menu Category" under "Measurements Pop-up Menu" for detailed information.

The minimum negative voltage value is displayed below the **Min** label in the menu/status area.

This measurement can be performed only on YT waveforms. The status is displayed as undefined for XY waveforms.

The **Compare & References** function (in the menu/ status area) alters the status of the **Min** function, and adds a delta symbol to the name of the function (i.e., Δ**Min**).

Algorithms for all standard measurement functions are defined in Appendix B.

Min Pop-up Menu

Selecting **Min** causes the **Min** pop-up menu to appear in the waveform display area and highlights its label in the menu/status area (see Fig. 2-37).

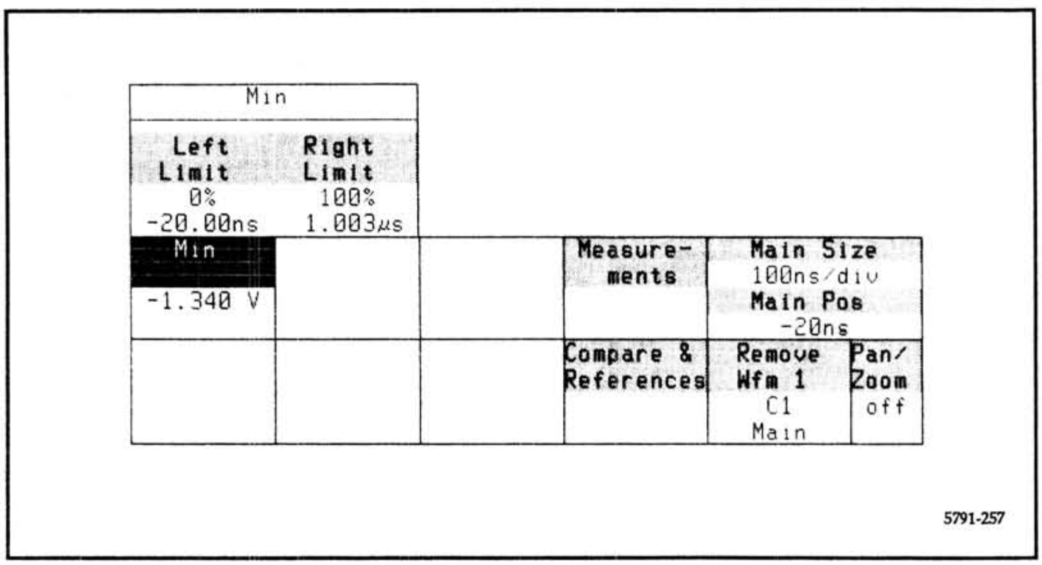

Figure 2-37. **Min** pop-up menu.

The items in the pop-up menu allow control of the measurement's parameters, when selected. Current settings are displayed below the item labels. Unless previously modified for this or another active measurement, the current settings of the measurement parameters will be equal to the Default Parameter values.

Menu Items

The **Min** pop-up menu has a **Left** and **Right Limit** menu item.

For a detailed discussion of the Measurement Zone refer to "Common Measurement Parameters" defined under "Standard Measurement Functions" earlier in this section.

Waveform Annotation

Selecting the **Min** label (in the menu/status area) causes the following annotation to be shown on the waveform:

1. Two vertical bars define the Measurement Zone. The **Left** and **Right Limit** bars can be moved with the Control knobs when selected from the pop-up menu.

2. A dotted line displayed across the screen defines the negative-peak voltage (Min value), within the Measurement Zone.

Mid Vertical Value

Press the MEASURE MENUS button to display the Measure major menu at the bottom of the screen. Then touch the **Measurements** *label to display the* **Measurements** *pop-up menu. Select the* **Mid** *label from the pop-up menu to invoke the measurement. The* **Mid** *label with its value will be displayed at the bottom of the screen. Refer to "Selecting and Ending Measurements" earlier in this section for further information.*

Mid measures the voltage difference (plus or minus) between the waveform midpoint and the zero volt reference level. The waveform segment being measured must be within the Measurement Zone. Figure 2-38 shows a typical Mid measurement example. The measurement is reported to four-digits.

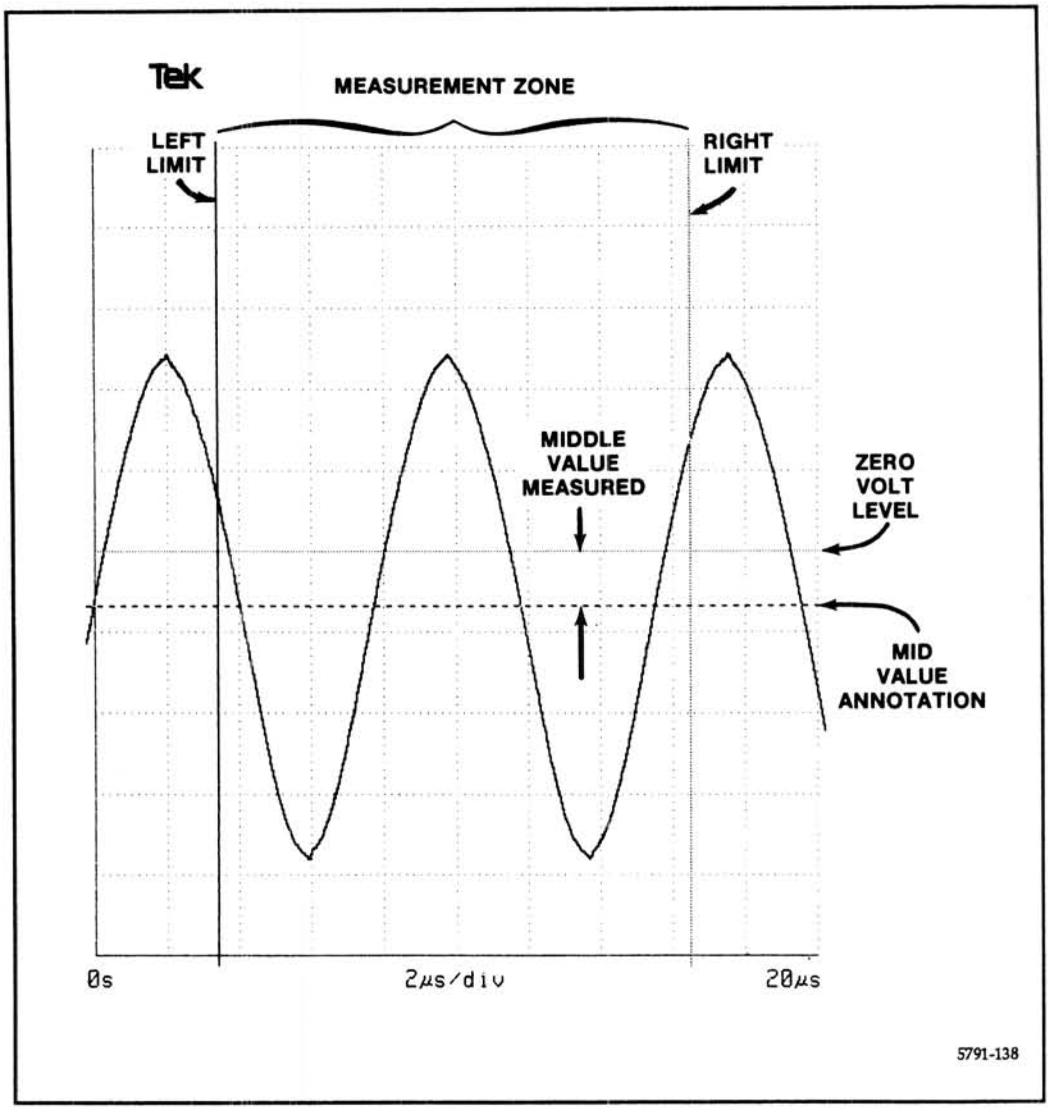

Figure 2-38. Mid measurement example.

The Mid measurement is normally performed using the Default Parameter settings for the parameters shown in Figure 2-38. These measurement parameters are used by other active measurements and can be changed with:

- The **Mid** pop-up menu,
- the pop-up menu of another active measurement that uses the same parameters, and
- the Default Parameters category of the **Measurements** pop-up menu. Refer to "Default Parameters Menu Category" under "Measurements Pop-up Menu"earlier in this section for detailed information.

The middle vertical value of the selected waveform is displayed below the **Mid** label in the menu/status area.

This measurement can be performed only on YT waveforms. The status is displayed as undefined for XY waveforms.

The **Compare & References** function (in the menu/ status area) alters the status of the **Mid** function, and adds a delta symbol to the name of the function (i.e., Δ**Mid**).

Algorithms for all standard measurement functions are defined in Appendix B.

Mid Pop-up Menu

Selecting **Mid** causes the **Mid** pop-up menu to appear in the waveform display area and highlights its label in the menu/status area (see Fig. 2-39).

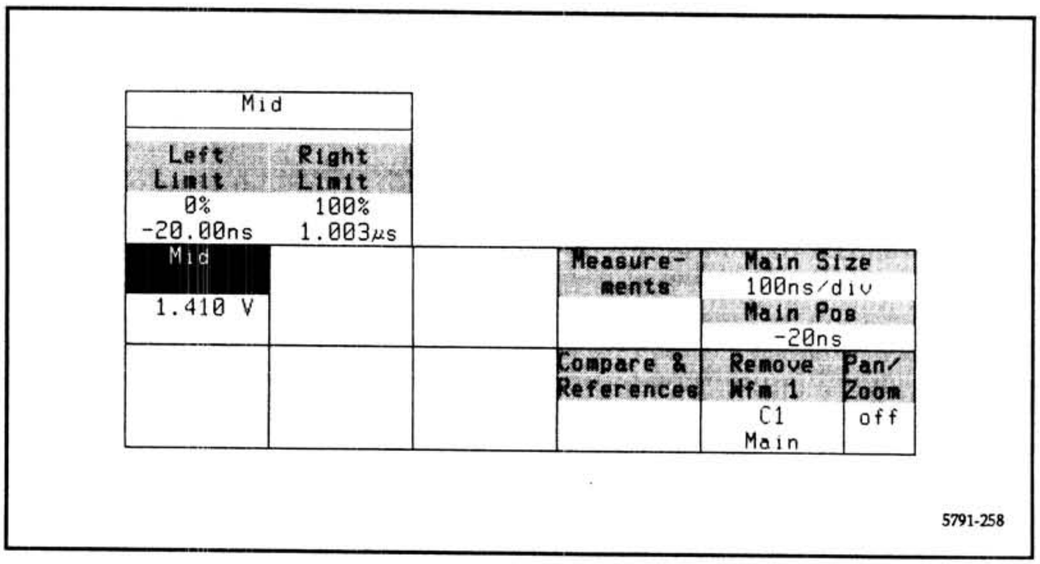

Figure 2-39. Mid pop-up menu.

The items in the pop-up menu allow control of the measurement's parameters, when selected. Current settings are displayed below the item labels. Unless previously modified for this or another active measurement, the current settings of the measurement parameters will be equal to the Default Parameter values.

Menu Items

The **Mid** pop-up menu has **Left** and **Right Limit** menu items.

For a detailed discussion of the Measurement Zone refer to"Common Measurement Parameters" defined under "Standard Measurement Functions"earlier in this section.

Waveform Annotation

Selecting the **Mid** label (in the menu/status area) causes the following annotation on the waveform:

1. Two vertical bars define the Measurement Zone. The **Left** and **Right Limit** bars can be moved with the Control knobs when selected from the pop-up menu.

2. A dotted line displayed across the screen defines the waveform midpoint (Mid value) within the Measurement Zone.

Peak-Peak Vertical Value

Press the MEASURE MENUS button to display the Measure major menu at the bottom of the screen. Then touch the ***Measurements*** *label to display the* ***Measurements*** *pop-up menu. Select the* ***Peak-Peak*** *label from the pop-up menu to invoke the measurement. The* ***Peak-Peak*** *label with its value will be displayed at the bottom of the screen. Refer to "Selecting and Ending Measurements" earlier in this section for further information.*

Peak-Peak measures the difference between the Max and the Min vertical values. The waveform segment being measured must be displayed within the Measurement Zone. Figure 2-40 shows a typical Peak-Peak measurement example. The measurement is reported to four-digits.

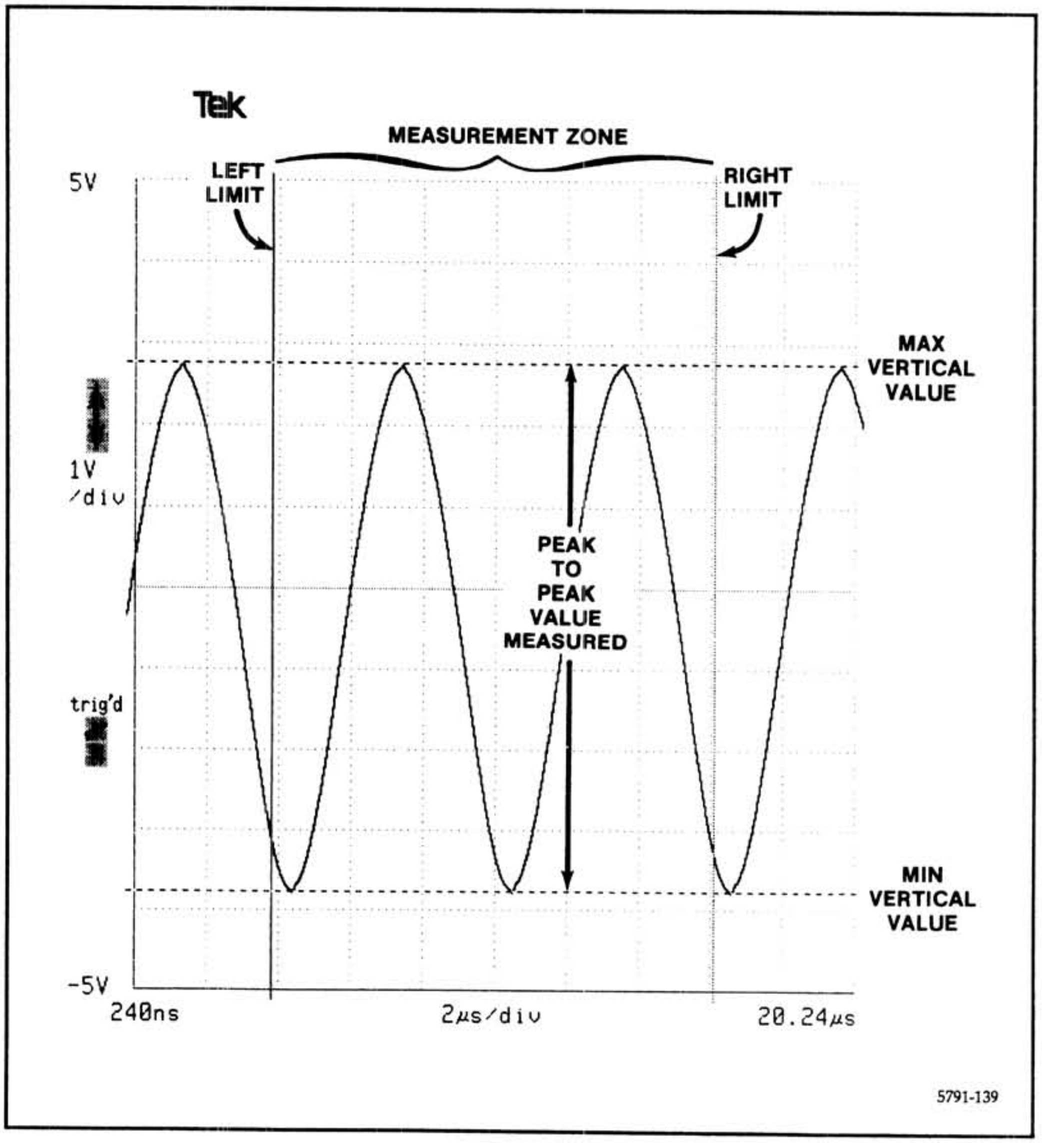

Figure 2-40. Peak-Peak measurement example.

The Peak-to-Peak measurement is normally performed using the Default Parameter settings for the parameters shown in Figure 2-40. These measurement parameters are used by other active measurements and can be changed with:

- The **Peak-Peak** pop-up menu,
- the pop-up menu of another active measurement that uses the same parameters, and
- the Default Parameters category of the **Measurements** pop-up menu. Refer to "Default Parameters Menu Category" under "Measurements Pop-up Menu" earlier in this section for detailed information.

The peak-to-peak vertical value of the selected waveform is displayed below the **Peak-Peak** label in the menu/status area.

This measurement can be performed only on YT waveforms. The status is displayed as undefined for XY waveforms.

The **Compare & References** function (in the menu/status area) alters the status of the **Peak-Peak** functions and adds a delta symbol to the name of the function (i.e., Δ**Peak-Peak**).

Algorithms for all standard measurement functions are defined in Appendix B.

Peak-Peak Pop-up Menu

Selecting **Peak-Peak** causes the **Peak-Peak** pop-up menu to appear in the waveform display area, and highlights its label in the menu/status area (see Fig. 2-41).

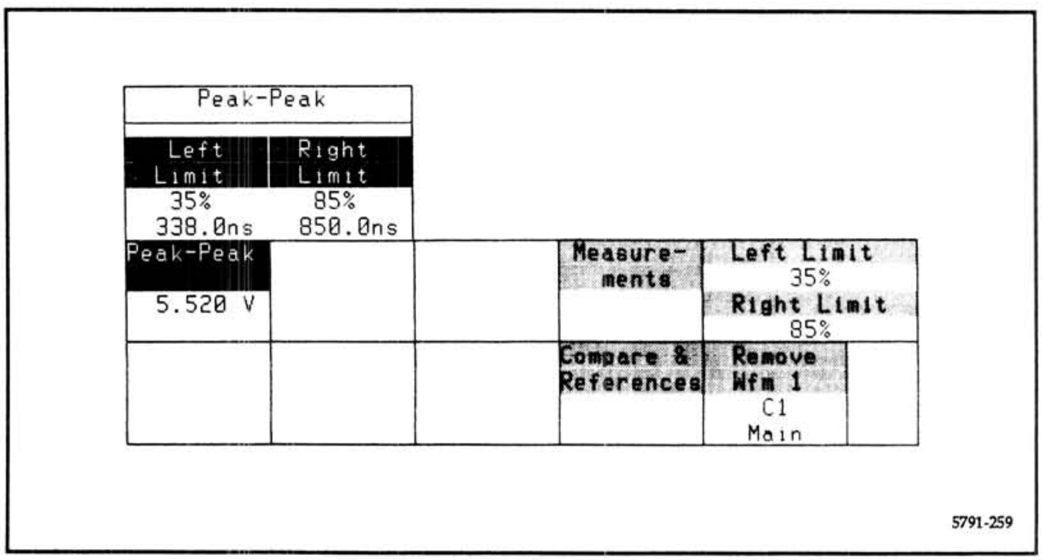

Figure 2-41. **Peak-Peak** pop-up menu.

The items in the pop-up menu allow control of the measurement's parameters, when selected. Current settings are displayed below the item labels. Unless previously modified for this or another active measurement, the current settings of the measurement parameters will be equal to the Default Parameter values.

Menu Items

The **Peak-Peak** pop-up menu has a **Left** and **Right Limit** menu item.

For a detailed discussion of the Measurement Zone refer to "Common Measurement Parameters" defined under "Standard Measurement Functions" earlier in this section.

Waveform Annotation

Selecting the **Peak-Peak** label (in the menu/status area) causes the following annotation on the waveform:

1. Two vertical bars define the Measurement Zone. The **Left** and **Right Limit** bars can be moved with the Control knobs when selected from the pop-up menu.

2. Two dotted lines displayed across the screen that intersect the positive and negative peak-voltage points, within the Measurement Zone.

Mean Vertical Value

Press the MEASURE MENUS button to display the Measure major menu at the bottom of the screen. Then touch the **Measurements** *label to display the* **Measurements** *pop-up menu. Select the* **Mean** *label from the pop-up menu to invoke the measurement. The* **Mean** *label with its value will be displayed at the bottom of the screen. Refer to "Selecting and Ending Measurements" earlier in this section for further information.*

Mean computes the average of the vertical values (from the zero volt level) of all waveform points within the waveform segment being measured. The vertical values are totaled and divided by the number of points to provide a readout. The waveform segment being measured must be within the Measurement Zone. Figure 2-42 shows a typical Mean measurement example with the Data Interval set for a single period. The mesurement is reported to six-digits.

The Mean measurement is normally performed using the Default Parameter settings for the parameters shown in Figure 2-42. These measurement parameters are used by other active measurements and can be changed with:

- The **Mean** pop-up menu,
- the pop-up menu of another active measurement that uses the same parameters, and
- the Default Parameters category of the **Measurements** pop-up menu. Refer to "Default Parameters Menu Category" under "Measurements Pop-up Menu" earlier in this section for detailed information.

When **Data Interval** is set to **one period, Mean** finds the first interval equal to one period by invoking the Period function. This interval, as determined by Period, corresponds to the portion of waveform data to be used in the **Mean** measurement. The waveform parameters **Topline, Mesial, Baseline, Signal/Noise Ratio, Tracking,** and **Setup** are all pertinent to finding the first period within the Measurement Zone.

When **Data Interval** is set for the entire Measurement Zone, **Mean** measures the mean value of the entire zone, whether or not it contains a full period of data.

The mean vertical value of the selected waveform is displayed below the **Mean** label in the menu/status area.

This measurement can be performed only on YT waveforms. The status is displayed as undefined for XY waveforms.

The **Compare & References** function (in the menu/status area) alters the status of the **Mean** function, and adds a delta symbol to the name of the function (i.e., Δ**Mean**).

Algorithms for all standard measurement functions are defined in Appendix B.

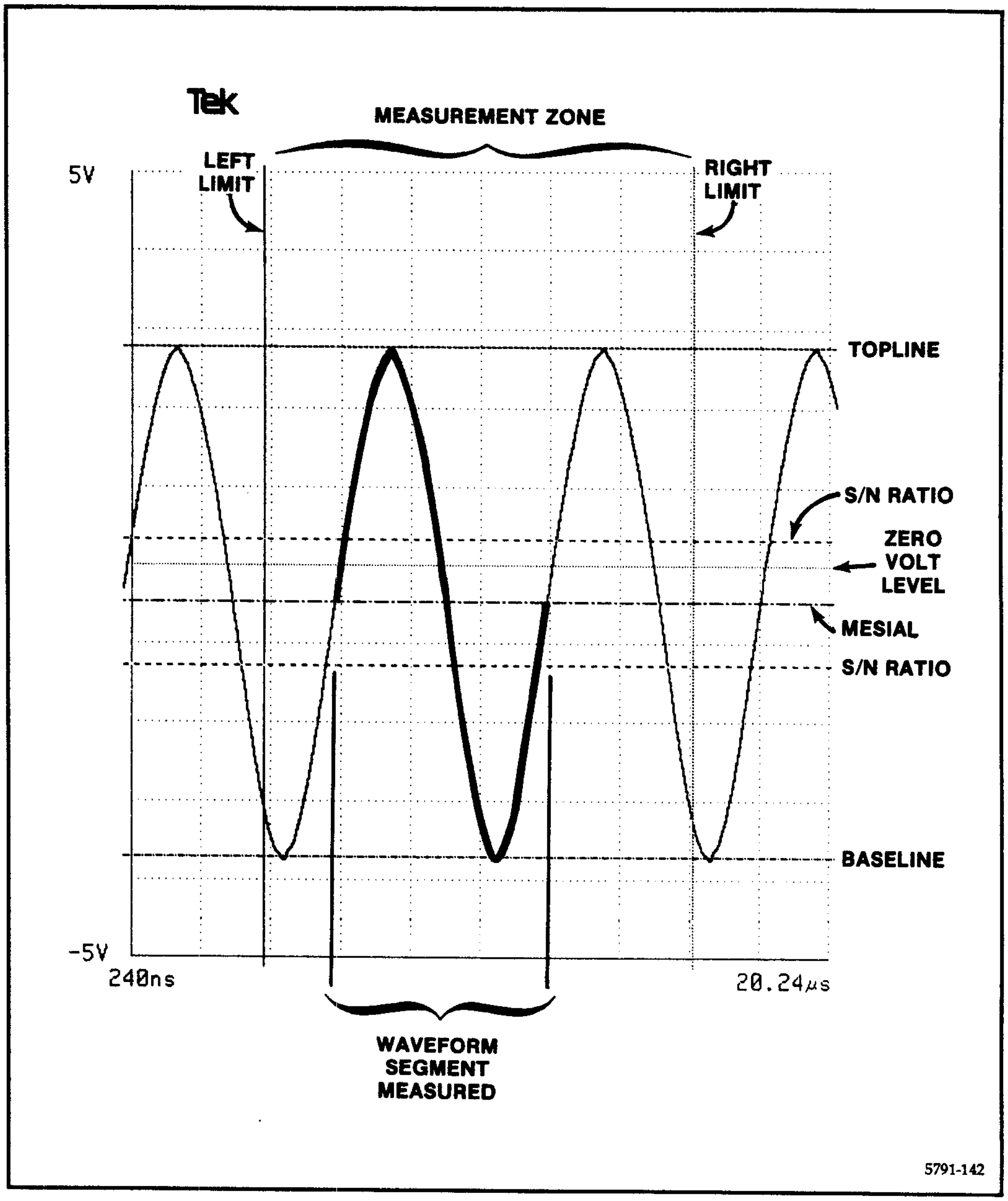

Figure 2-42. Mean measurement example for a single period.

Mean Pop-up Menu

Selecting **Mean** causes the **Mean** pop-up menu to appear in the waveform display area and highlights its label in the menu/status area (see Fig. 2-43).

The items in the pop-up menu allow control of the measurement's parameters, when selected. Current settings are displayed below the item labels. Unless previously modified for this or another active measurement, the current settings of the measurement parameters will be equal to the Default Parameter values.

Menu Items

The following measurement parameters are entries in the **Mean** pop-up menu:

1. **Left** and **Right Limit**
2. **Data Interval**
3. **Topline**
4. **Mesial**
5. **Baseline**
6. **S/N Ratio (Signal/Noise)**
7. **Tracking**
8. **Setup**

For a detailed discussion of these measurement parameters refer to "Common Measurement Parameters" defined under "Standard Measurement Functions" earlier in this section.

Waveform Annotation

Selecting the **Mean** label (in the menu/status area) causes the following annotation on the waveform:

1. Two vertical bars define the Measurement Zone. The **Left** and **Right Limit** bars can be moved with the Control knobs when selected from the pop-up menu.

2. The Topline level of the Measurement Zone is displayed as a unique dashed line across the top of the waveform. Normally, Tracking is on so Topline is set automatically. Topline can be set with a Control knob by setting Tracking off in the pop-up menu and selecting Topline. Data Interval must be in the Single Period mode.

3. The Mesial percentage of the Measurement Zone is displayed as a unique dashed line across the middle of the waveform. It is variable with the Control knobs when selected from the pop-up menu. Data Interval must be in the single period mode.

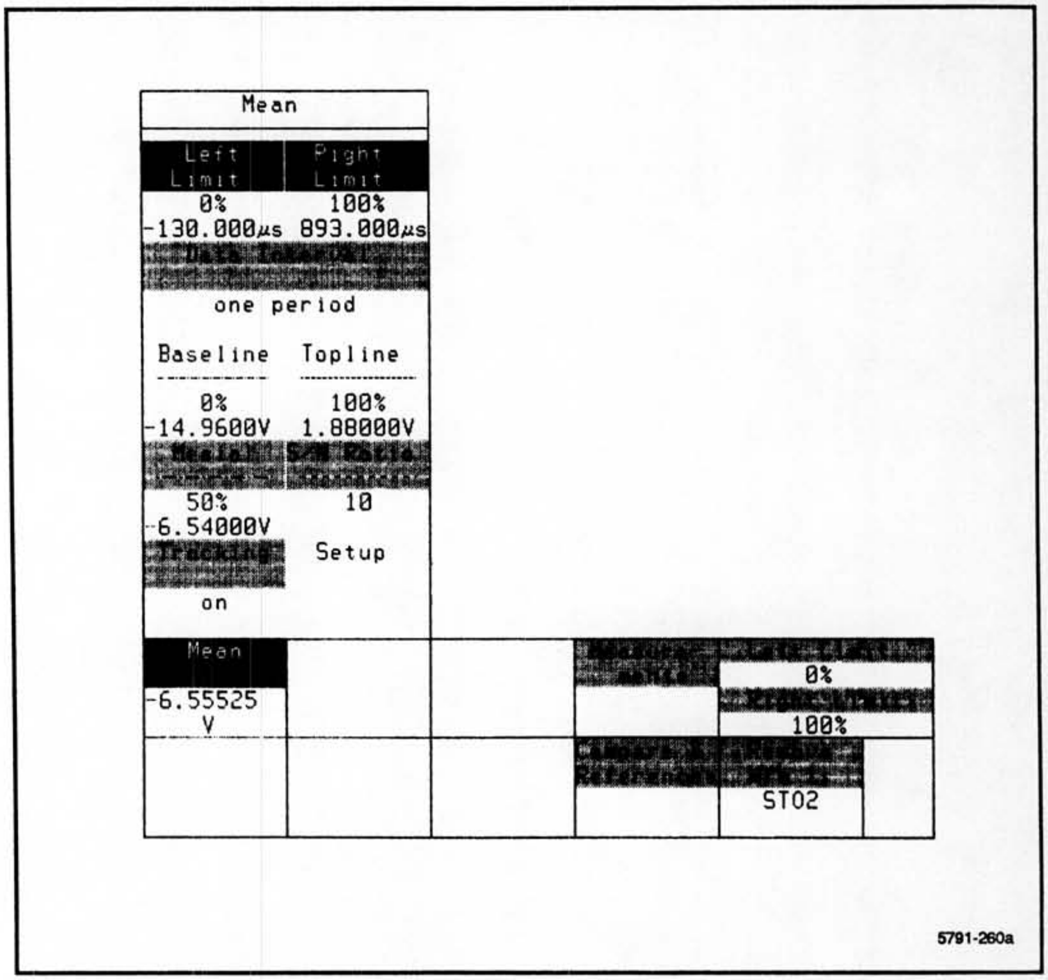

Figure 2-43 Mean pop-up menu.

4. The Baseline level of the Measurement Zone is displayed as a unique dashed line across the bottom of the waveform. Normally, Tracking is on so Baseline is automatically set. Baseline can be set with a Control knob by setting Tracking off in the pop-up menu and selecting Baseline. Data Interval must be in the single period mode.

5. The Signal-to-Noise Ratio value is displayed as a pair of unique dashed lines that are positioned equidistant from the Mesial line. S/N Ratio can be set with a Control knob by selecting it from the pop-up menu. Data Interval must be in the single period mode.

6. The segment of the waveform used (one period or entire Measurement Zone) to determine the Mean result is displayed at high intensity. When the period is intensified, no windows for the selected waveform are displayed.

RMS Vertical Value

Press the MEASURE MENUS button to display the Measure major menu at the bottom of the screen. Then touch the **Measurements** *label to display the* **Measurements** *pop-up menu. Select the* **RMS** *label from the pop-up menu to invoke the measurement. The* **RMS** *label with its value will be displayed at the bottom of the screen. Refer to "Selecting and Ending Measurements" earlier in this section for further information.*

RMS computes the root mean square of the vertical values (from zero volt level) for all points in the measured waveform segment. The total of these squared vertical values is then divided by the number of points measured. The square root of the result is displayed as the RMS readout voltage. The waveform segment being measured must be within the Measurement Zone. Figure 2-44 shows a typical RMS measurement example with the Data Interval set for a single period. The measurement is reported to six-digits.

The RMS measurement is normally performed using the Default Parameter settings for the parameters shown in Figure 2-44. These measurement parameters are used by other active measurements and can be changed with:

- The **RMS** pop-up menu,
- the pop-up menu of another active measurement that uses the same parameters, and
- the Default Parameters category of the **Measurements** pop-up menu. Refer to "Default Parameters Menu Category" under "Measurements Pop-up Menu" earlier in this section for detailed information.

When **Data Interval** is set to **one period, RMS** finds the first interval equal to one period by invoking the Period function. This interval, as determined by Period, is used in the **RMS** measurement. The waveform parameters of **Topline, Mesial, Baseline, Signal/Noise Ratio,** and **Tracking** are all pertinent to finding the first period within the Measurement Zone.

When the **Data Interval** is the whole Measurement Zone, **RMS** measures the rms value of the entire zone, whether or not it contains a full period of data.

The rms vertical value of the selected waveform is displayed below the **RMS** label in the menu/status area.

This measurement can be performed only on YT waveforms. The status is displayed as undefined for XY waveforms.

The **Compare & References** function (in the menu/status area) alters the status of the **RMS** function, and adds a delta symbol to the name of the function (i.e., Δ**RMS**).

Algorithms for all standard measurement functions are defined in Appendix B.

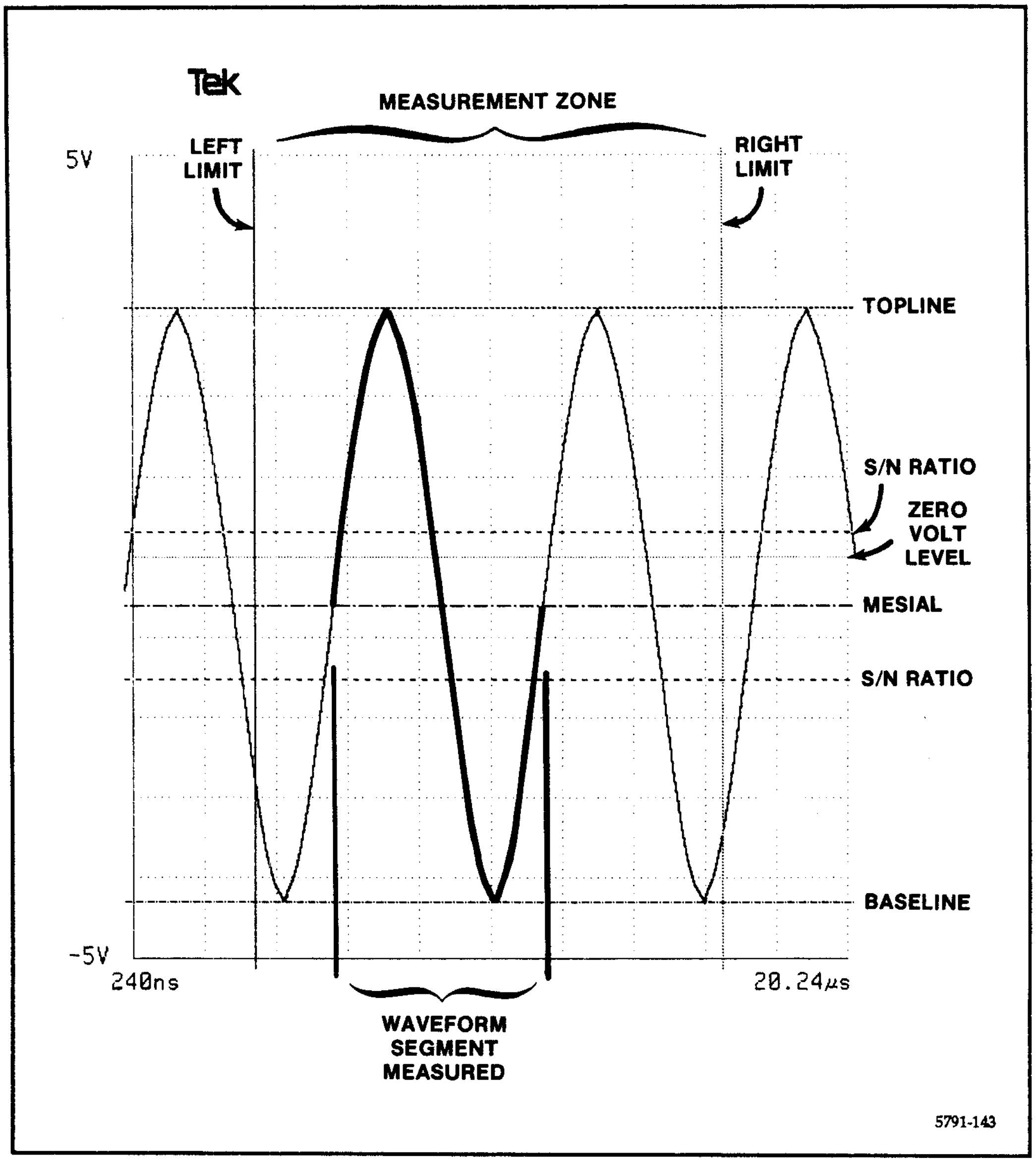

Figure 2-44. RMS measurement example.

RMS Pop-up Menu

Selecting **RMS** causes the **RMS** pop-up menu to appear in the waveform display area and highlights its label in the menu/status area (see Fig. 2-45).

The items in the pop-up menu allow control of the measurement's parameters, when selected. Current settings are displayed below the item labels. Unless previously modified for this or another active measurement, the current settings of the measurement parameters will be equal to the Default Parameter values.

Menu Items

The following measurement parameters are entries in the **RMS** pop-up menu:

1. **Left** and **Right Limit**
2. **Data Interval**
3. **Topline**
4. **Mesial**
5. **Baseline**
6. **S/N Ratio (Signal/Noise)**
7. **Tracking**
8. **Setup**

For a detailed discussion of these measurement parameters refer to "Common Measurement Parameters" defined under "Standard Measurement Functions".earlier in this section.

Waveform Annotation

Selecting the **RMS** label (in the menu/status area) causes the following annotation on the waveform:

1. Two vertical bars define the Measurement Zone. The **Left** and **Right Limit** bars can be moved with the Control knobs when selected from the pop-up menu.

2. The Topline level of the Measurement Zone is displayed as a unique dashed line across the top of the waveform. Normally, Tracking is on so Topline is set automatically. Topline can be set with the Control knob by setting Tracking off in the pop-up menu and selecting Topline. Data Interval must be in the single period mode.

3. The Mesial percentage of the Measurement Zone is a displayed as a unique dashed line across the middle of the waveform. It is variable with the Control knobs when selected from the pop-up menu. Data Interval must be in the single period mode.

4. The Baseline level of the Measurement Zone is displayed as a unique dashed line across the bottom of the waveform. Normally, Tracking is on so Baseline is automatically set. Baseline can be set with a Control knob by setting Tracking off in the pop-up menu and selecting Baseline. Data Interval must be in the single period mode.

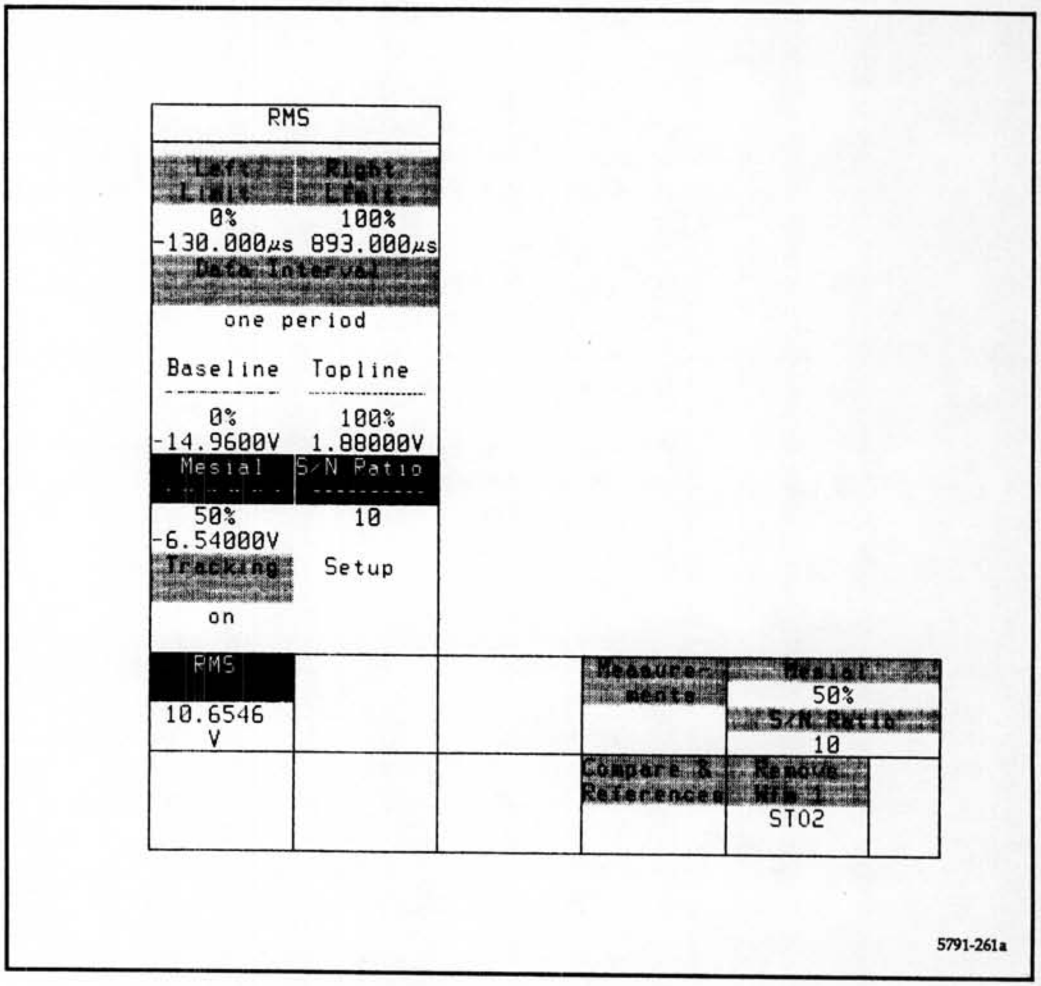

Figure 2-45. RMS pop-up menu.

5. The Signal-to-Noise Ratio value is displayed as a pair of unique dashed lines that are positioned equidistant from the Mesial line. S/N Ratio can be set with a Control knob by selecting it from the pop-up menu. Data Interval must be in the single period mode.

6. The segment of the waveform used (one period or entire Measurement Zone) to determine the RMS result is displayed at high intensity. Window indicators on the selected waveform are not displayed when the period is intensified.

Rise Time

Press the MEASURE MENUS button to display the Measure major menu at the bottom of the screen. Then touch the **Measurements** *label to display the* **Measurements** *pop-up menu. Select the* **Rise** *label from the pop-up menu to invoke the Rise time measurement. The* **Rise** *label with its value will be displayed at the bottom of the screen. Refer to "Selecting and Ending Measurements" earlier in this section for further information.*

Rise calculates the time duration from the Proximal waveform crossing to the Distal waveform crossing and displays the result below the **Rise** label. The waveform segment being measured must be within the Measurement Zone. Figure 2-46 shows a typical rise time measurement example. The measurement is reported to four-digits.

The Rise measurement is normally performed using the Default Parameter settings for the parameters shown in Figure 2-46. These measurement parameters are used by other active measurements and can be changed with:

- The **Rise** pop-up menu,
- the pop-up menu of another active measurement that uses the same parameters, and
- the Default Parameters category of the **Measurements** pop-up menu. Refer to "Default Parameters Menu Category" under "Measurements Pop-up Menu" for detailed information.

This measurement can be performed only on YT waveforms. The status is displayed as undefined for XY waveforms.

The **Compare & References** function (in the menu/status area) alters the status of the **Rise** label in the menu/status area and adds a delta symbol to the name of the function (i.e., Δ**Rise**).

Algorithms for all standard measurement functions are defined in Appendix B.

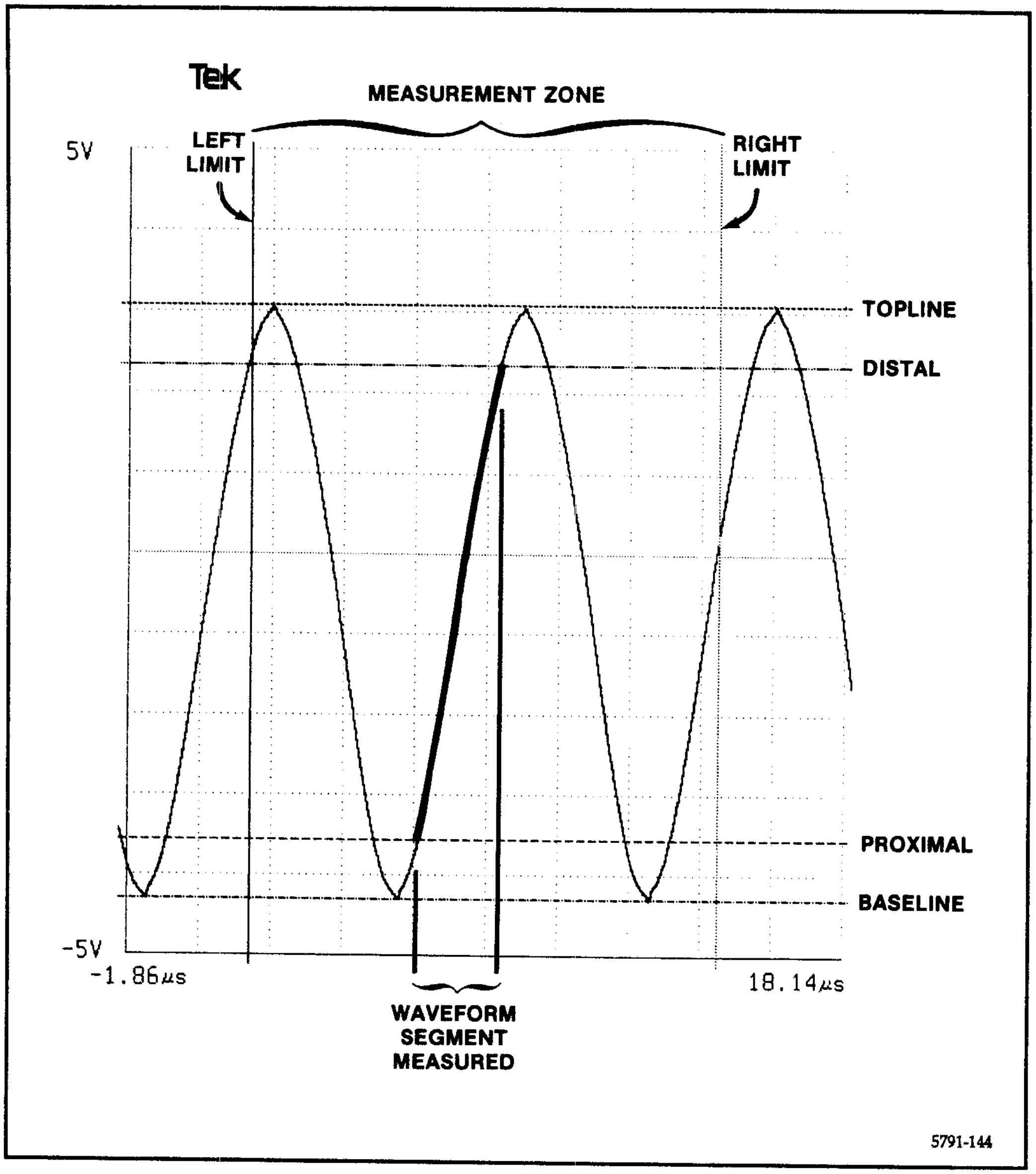

Figure 2-46. Rise measurement example.

Rise Pop-up Menu

Selecting **Rise** causes the **Rise** pop-up menu to appear in the waveform display area and highlights its label in the menu/status area (see Fig. 2-47).

The items in the pop-up menu allow control of the measurement's parameters, when selected. Current settings are displayed below the item labels. Unless previously modified for this or another active measurement, the current settings of the measurement parameters will be equal to the Default Parameter values.

Menu Items

The following measurement parameters are entries in the **Rise** pop-up menu:

1. **Left** and **Right Limit**
2. **Topline**
3. **Distal**
4. **Proximal**
5. **Baseline**
6. **Tracking**
7. **Setup**

For a detailed discussion of these measurement parameters refer to "Common Measurement Parameters" defined under "Standard Measurement Functions" earlier in this section.

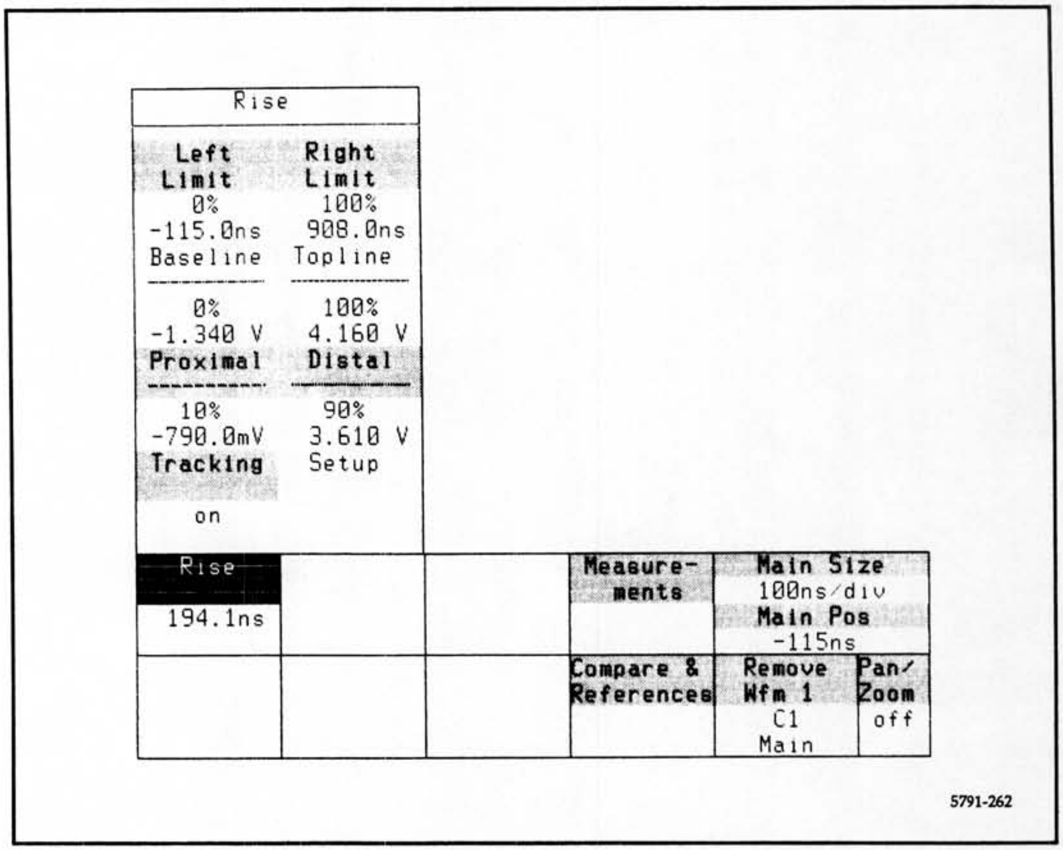

Figure 2-47. Rise pop-up menu.

Waveform Annotation

Selecting the **Rise** label (in the menu/status area) causes the following annotation on the waveform.

1. Two vertical bars define the Measurement Zone. The **Left** and **Right Limit** bars can be moved with the Control knobs when selected from the pop-up menu.

2. The Topline level of the Measurement Zone is displayed as a unique dashed line across the top of the waveform. Normally, Tracking is on so Topline is set automatically. Topline can be set with a Control knob by setting Tracking off in the pop-up menu and Selecting Topline.

3. The Distal percentage of the Measurement Zone is displayed as a unique dashed line across the waveform. It is variable with the Control knobs when selected from the pop-up menu.

4. The Proximal percentage of the Measurement Zone is displayed as a unique dashed line across the waveform. It is variable with the Control knobs when selected from the pop-up menu.

5. The Baseline level of the Measurement Zone is displayed as a unique dashed line across the bottom of the waveform. Normally, Tracking is on so Baseline is automatically set. Baseline can be set with a Control knob by setting Tracking off in the pop-up menu and selecting Baseline.

6. The region of the waveform corresponding to the rise time is displayed at high intensity. Window indicators on the selected waveform are not displayed when the region is intensified.

Fall Time

Press the MEASURE MENUS button to display the Measure major menu at the bottom of the screen. Then touch the ***Measurements*** *label to display the* ***Measurements*** *pop-up menu. Select the* ***Fall*** *label from the pop-up menu to invoke the measurement. The* ***Fall*** *label with its value will be displayed at the bottom of the screen. Refer to "Selecting and Ending Measurements" earlier in this section for further information.*

Fall calculates the time duration from the Distal waveform crossing to the Proximal waveform crossing and displays the result below the **Fall** label. The waveform segment being measured must be within the Measurement Zone. Figure 2-48 shows a typical Fall Time measurement example. The measurement is reported to four-digits.

The Fall measurement is normally performed using the Default Parameter settings for the parameters shown in Figure 2-48. These measurement parameters are used by other active measurements and can be changed with:

- The **Fall** pop-up menu,
- the pop-up menu of another active measurement that uses the same parameters, and
- the Default Parameters category of the **Measurements** pop-up menu. Refer to "Default Parameters Menu Category" under "Measurements Pop-up Menu" earlier in this section for detailed information.

This measurement can be performed only on YT waveforms. The status is displayed as undefined for XY waveforms.

The **Compare & References** function (in the menu/status area) alters the status of the **Fall** function, and adds a delta symbol to the name of the function (i.e., Δ**Fall**).

Algorithms for all standard measurement functions are defined in Appendix B.

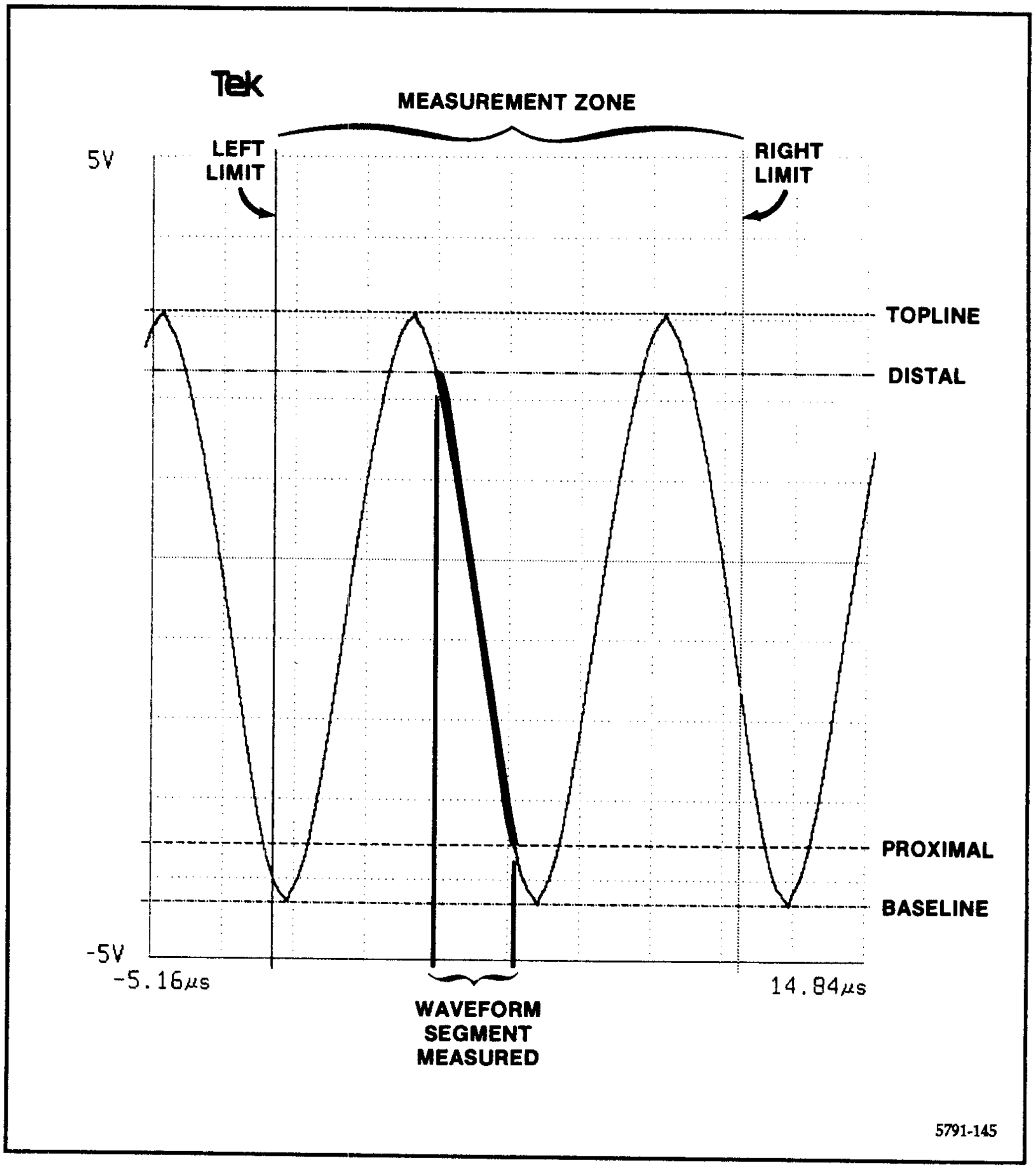

Figure 2-48. Fall measurement example.

Fall Pop-up Menu

Selecting **Fall** causes the **Fall** pop-up menu to appear in the waveform display area and highlights its label in the menu/status area (see Fig. 2-49).

The items in the pop-up menu allow control of the measurement's parameters, when selected. Current settings are displayed below the item labels. Unless previously modified for this or another active measurement, the current settings of the measurement parameters will be equal to the Default Parameter values.

Menu Items

The following measurement parameters are entries in the **Fall** pop-up menu:

1. **Left** and **Right Limit**
2. **Topline**
3. **Distal**
4. **Proximal**
5. **Baseline**
6. **Tracking**
7. **Setup**

For a detailed discussion of these measurement parameters refer to "Common Measurement Parameters" defined under "Standard Measurement Functions" earlier in this section.

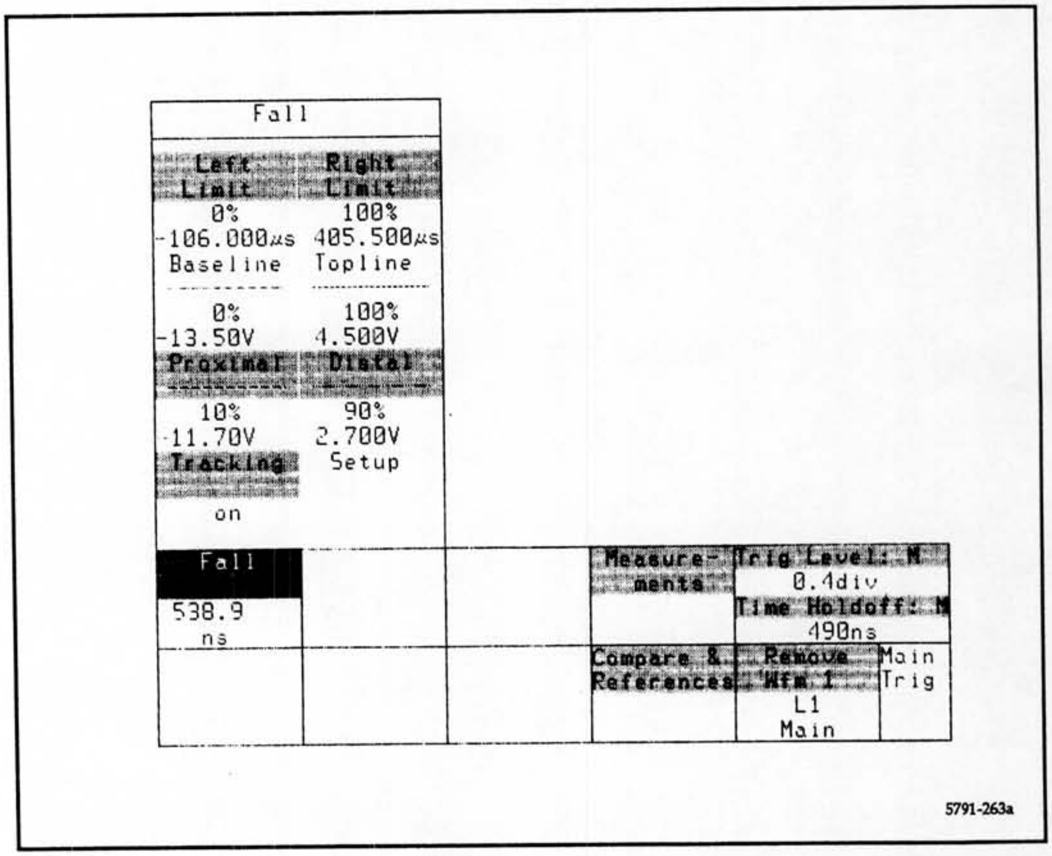

Figure 2-49. **Fall** pop-up menu.

Waveform Annotation

Selecting the **Fall** label (in the menu/status area) causes the following waveform annotation:

1. Two vertical bars define the Measurement Zone. The **Left** and **Right Limit** bars can be moved with the Control knobs when selected from the pop-up menu.

2. The Topline level of the Measurement Zone is displayed as a unique dashed line across the top of the waveform. Normally, Tracking is on so Topline is set automatically. Topline can be set with a Control knob by setting tracking off in the pop-up menu and selecting Topline.

3. The Distal percentage of the Measurement Zone is displayed as a unique dashed line across the waveform. It is variable with the Control knobs when selected from the pop-up menu.

4. The Proximal percentage of the Measurement Zone is displayed as a unique dashed line across the waveform. It is variable with the Control knobs when selected from the pop-up menu.

5. The Baseline level of the Measurement Zone is displayed as a unique dashed line across the bottom of the waveform. Normally, Tracking is on so Baseline is automatically set. Baseline can be set with a Control knob by setting Tracking off in the pop-up menu and selecting Baseline.

6. The region of the waveform corresponding to the fall time is displayed at high intensity. Window indicators on the selected waveform are not displayed when the region is intensified.

Period

Press the MEASURE MENUS button to display the Measure major menu at the bottom of the screen. Then touch the **Measurements** *label to display the* **Measurements** *pop-up menu. Select the* **Period** *label from the pop-up menu to invoke the measurement. The* **Period** *label with its value will be displayed at the bottom of the screen. Refer to "Selecting and Ending Measurements" earlier in this section for further information.*

Period calculates the time duration between the first mesial waveform crossing and the third mesial waveform crossing. The first and third crossings are validated when the waveform crosses a S/N Ratio level after crossing the mesial. The waveform segment being measured including the S/N Ratio crossings must be within the Measurement Zone. Figure 2-50 shows a typical Period measurement example. The measurement is reported to four-digits.

The Period measurement is normally performed using the Default Parameter settings for the parameters shown in Figure 2-50. These measurement parameters are used by other active measurements and can be changed with:

- The **Period** pop-up menu,
- the pop-up menu of another active measurement that uses the same parameters, and
- the Default Parameters category of the **Measurements** pop-up menu. Refer to "Default Parameters Menu Category" under "Measurements Pop-up Menu" earlier in this section for detailed information.

The period time value of the selected waveform is displayed below the **Period** label in the menu/status area.

This measurement can be performed only on YT waveforms. The status is displayed as undefined for XY waveforms.

The **Compare & References** function (in the menu/status area) alters the status of the **Period** function, and adds a delta symbol to the name of the function (i.e., Δ**Period**).

Algorithms for all standard measurement functions are defined in Appendix B.

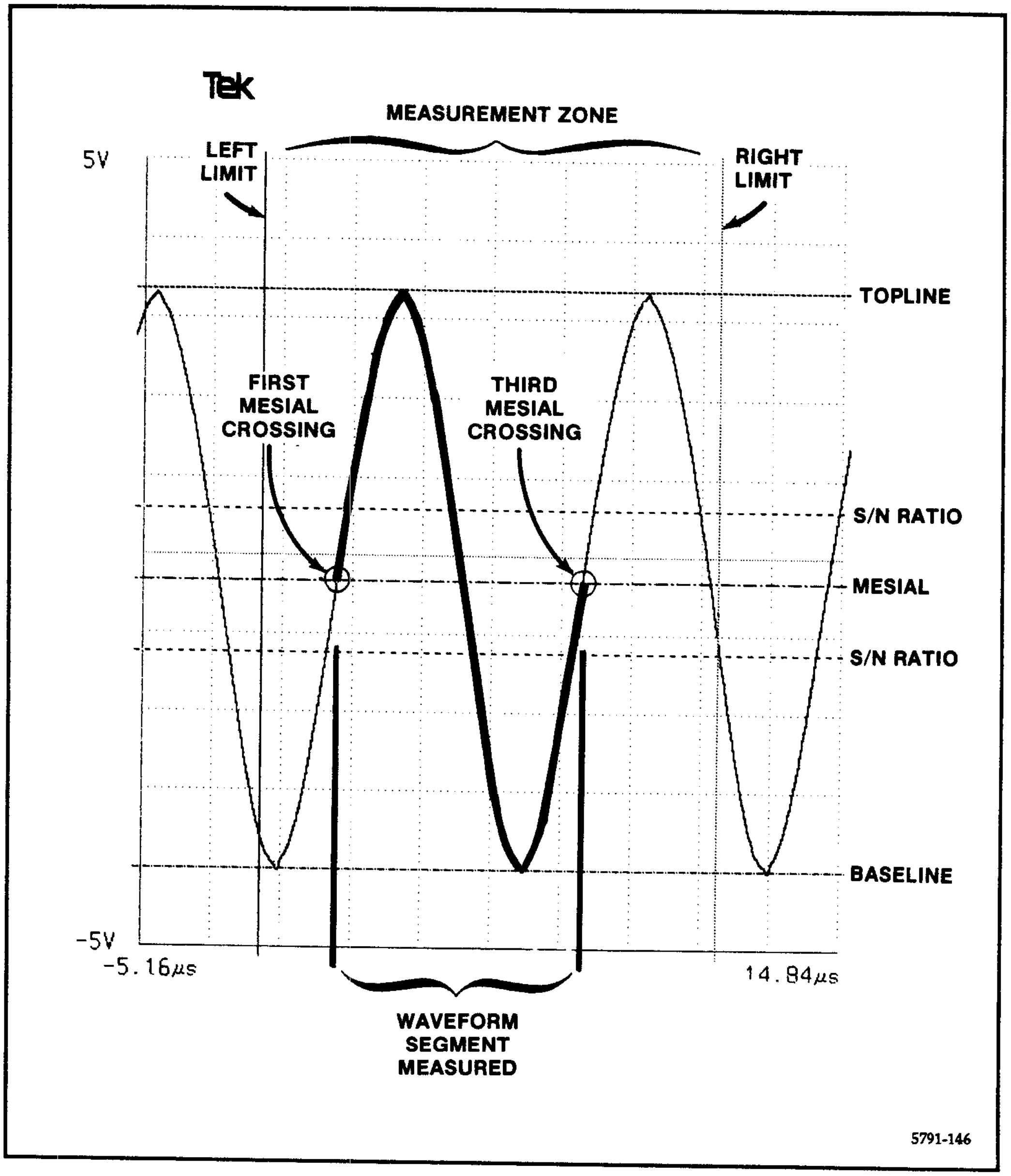

Figure 2-50. Period measurement example.

Period Pop-up Menu

Selecting **Period** causes the **Period** pop-up menu to appear in the waveform display area and highlights its label in the menu/status area (see Fig. 2-51).

The items in the pop-up menu allow control of the measurement's parameters, when selected. Current settings are displayed below the item labels. Unless previously modified for this or another active measurement, the current settings of the measurement parameters will be equal to the Default Parameter values.

Menu Items

The following measurement parameters are entries in the **Period** pop-up menu:

1. **Left** and **Right Limit**
2. **Topline**
3. **Mesial**
4. **Baseline**
5. **S/N Ratio (Signal/Noise)**
6. **Tracking**
7. **Setup**

For a detailed discussion of these measurement parameters refer to "Common Measurement Parameters" defined under "Standard Measurement Functions" earlier in this section.

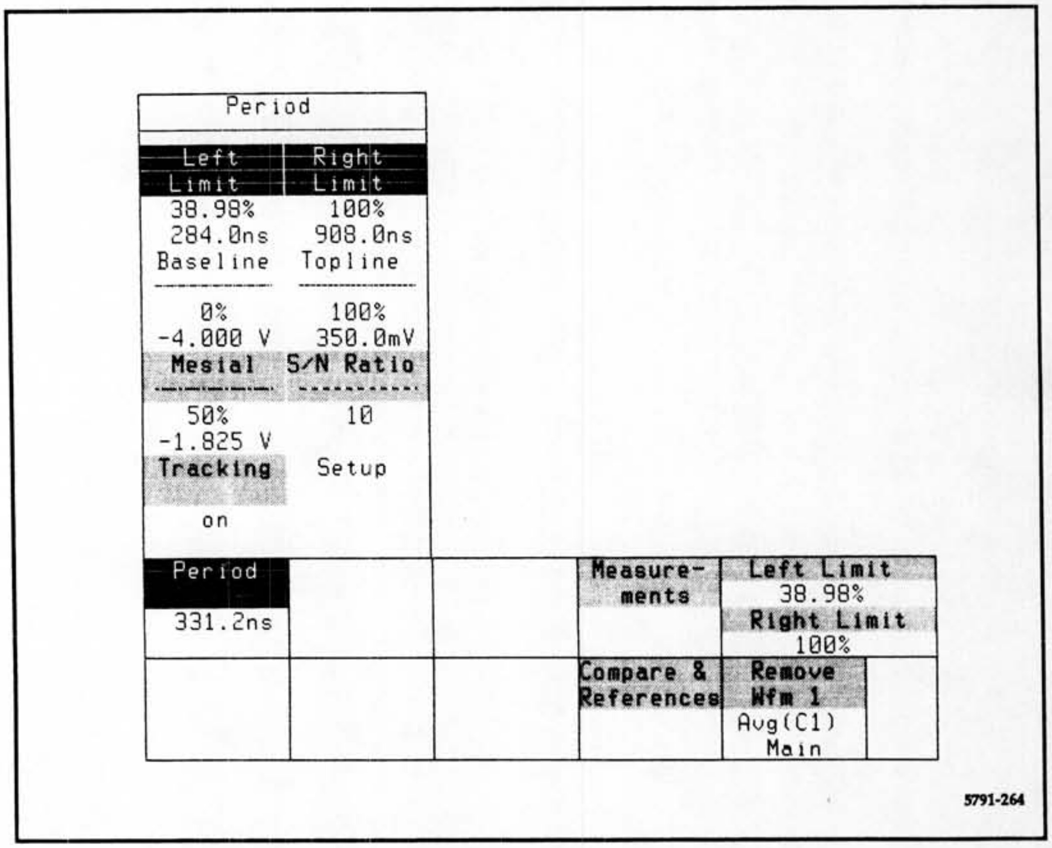

Figure 2-51. **Period** pop-up menu.

Waveform Annotation

Selecting the **Period** label (in the menu/status area) causes the following annotation on the waveform:

1. Two vertical bars define the Measurement Zone. The **Left and Right Limit** bars can be moved with the Control knobs when selected from the pop-up menu.

2. The Topline level of the Measurement Zone is displayed as a unique dashed line across the top of the waveform. Normally, Tracking is on so Topline is set automatically. Topline can be set with a Control knob by setting Tracking off in the pop-up menu and selecting Topline.

3. The Mesial percentage of the Measurement Zone is displayed as a unique dashed line across the middle of the waveform. It is variable with the Control knobs when selected from the pop-up menu.

4. The Baseline level of the Measurement Zone is displayed as a unique dashed line across the bottom of the waveform. Normally, Tracking is on so Baseline is automatically set. Baseline can be set with a Control knob by setting Tracking off in the pop-up menu and selecting Baseline.

5. The Signal-to-Noise Ratio value is displayed as a pair of unique dashed lines that are positioned equidistant from the Mesial line. S/N Ratio can be set with a Control knob by selecting it from the pop-up menu.

6. The region of the waveform corresponding to the period is displayed at high intensity. Window indicators on the selected waveform are not displayed when the region is intensified.

Frequency

Press the MEASURE MENUS button to display the Measure major menu at the bottom of the screen. Then touch the **Measurements** *label to display the* **Measurements** *pop-up menu. Select the* **Frequency** *label from the pop-up menu to invoke the measurement. The* **Frequency** *label with its value will be displayed at the bottom of the screen. Refer to "Selecting and Ending Measurements" earlier in this section for further information.*

Frequency calculates the reciprocal of the period. The frequency of the selected waveform is displayed below the **Frequency** label in the menu/status area. The waveform segment being measured including the S/N Ratio crossings must be within the Measurement Zone. Figure 2-52 shows a typical frequency measurement example. The measurement is reported to four-digits.

The Frequency measurement is normally performed using the Default Parameter settings for the parameters shown in Figure 2-52. These measurement parameters are used by other active measurements and can be changed with:

- The **Frequency** pop-up menu,
- the pop-up menu of another active measurement that uses the same parameters, and
- the Default Parameters category of the **Measurements** pop-up menu. Refer to "Default Parameters Menu Category" under "Measurements Pop-up Menu" earlier in this section for detailed information.

This measurement can be performed only on YT waveforms. The status is displayed as undefined for XY waveforms.

The **Compare & References** function (in the menu/status area) alters the status of the **Frequency** function, and adds a delta symbol to the name of the function (i.e., Δ**Frequency**).

Algorithms for all standard measurement functions are defined in Appendix B.

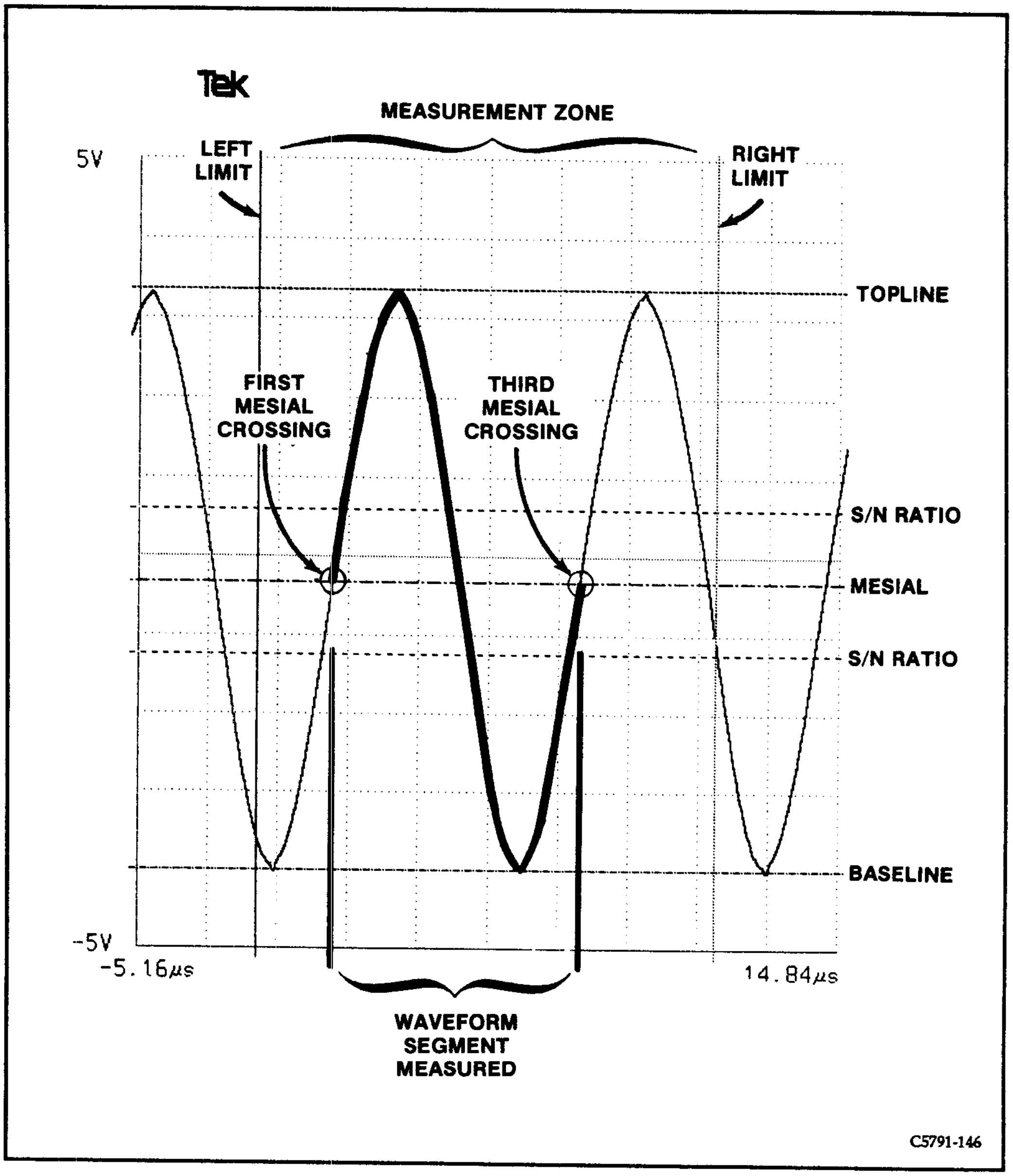

Figure 2-52. Frequency measurement example.

Frequency Pop-up Menu

Selecting **Frequency** causes the **Frequency** pop-up menu to appear in the waveform display area and highlights its label in the menu/status area (see Fig. 2-53).

The items in the pop-up menu allow control of the measurement's parameters, when selected. Current settings are displayed below the item labels. Unless previously modified for this or another active measurement, the current settings of the measurement parameters will be equal to the Default Parameter values.

Menu Items

The following measurement parameters are entries in the **Frequency** pop-up menu:

1. **Left** and **Right Limit**
2. **Topline**
3. **Mesial**
4. **Baseline**
5. **S/N Ratio (Signal/Noise)**
6. **Tracking**
7. **Setup**

For a detailed discussion of these measurement parameters refer to "Common Measurement Parameters" defined under "Standard Measurement Functions" earlier in this section.

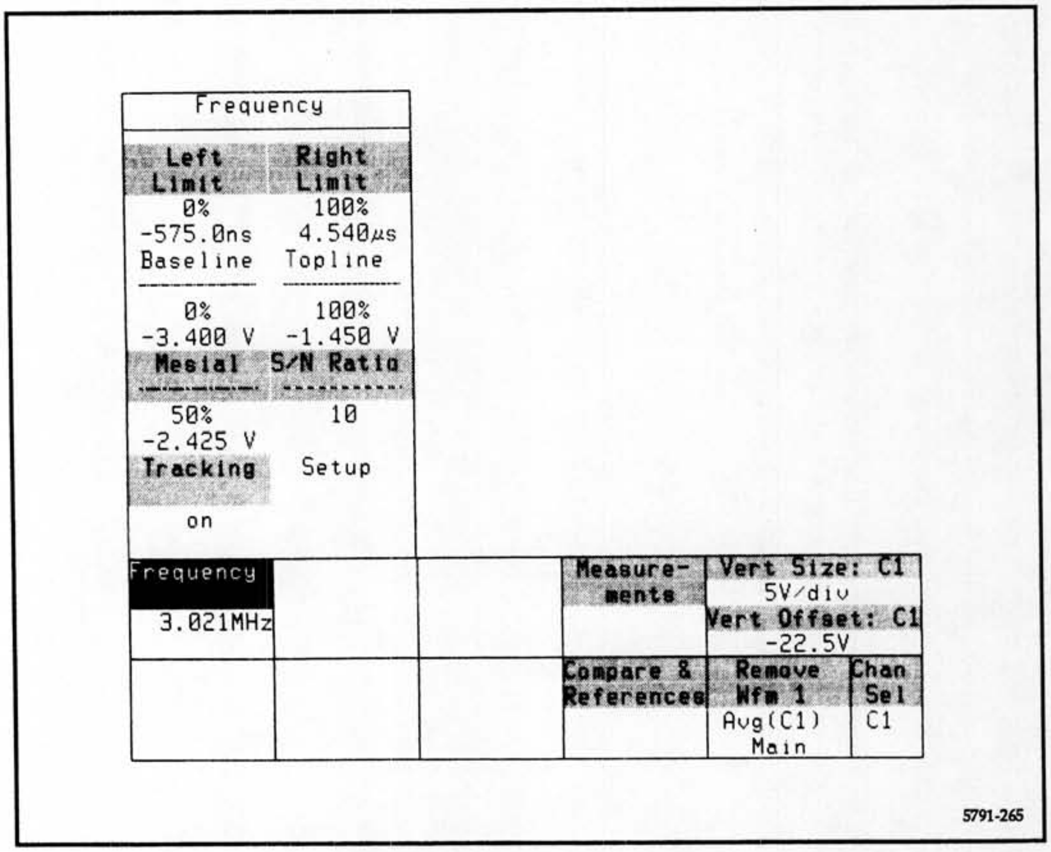

Figure 2-53. Frequency pop-up menu.

Waveform Annotation

Selecting the **Frequency** label (in the menu/status area) causes the following annotation on the waveform:

1. Two vertical bars define the Measurement Zone. The **Left** and **Right Limit** bars can be moved with the Control knobs when selected from the pop-up menu.

2. The Topline level of the Measurement Zone is displayed as a unique dashed line across the top of the waveform. Normally, Tracking is on so Topline is set automatically. Topline can be set with a Control knob by setting Tracking off in the pop-up menu and selecting Topline.

3. The Mesial percentage of the Measurement Zone is displayed as a unique dashed line across the middle of the waveform. It is variable with the Control knobs when selected from the pop-up menu.

4. The Baseline level of the Measurement Zone is displayed as a unique dashed line across the bottom of the waveform. Normally, Tracking is on so Baseline is automatically set. Baseline can be set with a Control knob by setting Tracking off in the pop-up menu and selecting Baseline.

5. The Signal-to-Noise Ratio value is displayed as a pair of unique dashed lines that are positioned equidistant from the Mesial line. S/N Ratio can be set with a Control knob by selecting it from the pop-up menu.

6. The region of the waveform corresponding to the frequency is displayed at high intensity. Window indicators on the selected waveform are not displayed when the region is intensified.

Width (Pulse Duration)

*Press the MEASURE MENUS button to display the Measure major menu at the bottom of the screen. Then touch the **Measurements** label to display the **Measurements** pop-up menu. Select the **Width** label from the pop-up menu to invoke the measurement. The **Width** label with its value will be displayed at the bottom of the screen. Refer to "Selecting and Ending Measurements" earlier in this section for further information.*

Width measures the time on the selected waveform from the first Mesial crossing after the Left Limit to the second Mesial crossing. The second Mesial crossing must occur before the Right Limit. Both crossings must be qualified within the Measurement Zone by the **S/N Ratio**. (See Fig. 2-54 for a typical measurement example.) The measurement is reported to four-digits.

The Width measurement is normally performed using the Default Parameter settings for the parameters shown in Figure 2-54. These measurement parameters are used by other active measurements and can be changed with:

- The **Width** pop-up menu,
- the pop-up menu of another active measurement that uses the same parameters, and
- the Default Parameters category of the **Measurements** pop-up menu. Refer to "Default Parameters Menu Category" under "Measurements Pop-up Menu" earlier in this section for detailed information.

The pulse width time value for the selected waveform is displayed below the **Width** label in the menu/status area.

This measurement can be performed only on YT waveforms. The status is displayed as undefined for XY waveforms.

The **Compare & References** function (in the menu/status area) alters the status of the **Width** function, and adds a delta symbol to the name of the function (i.e., Δ**Width**).

Algorithms for all standard measurement functions are defined in Appendix B.

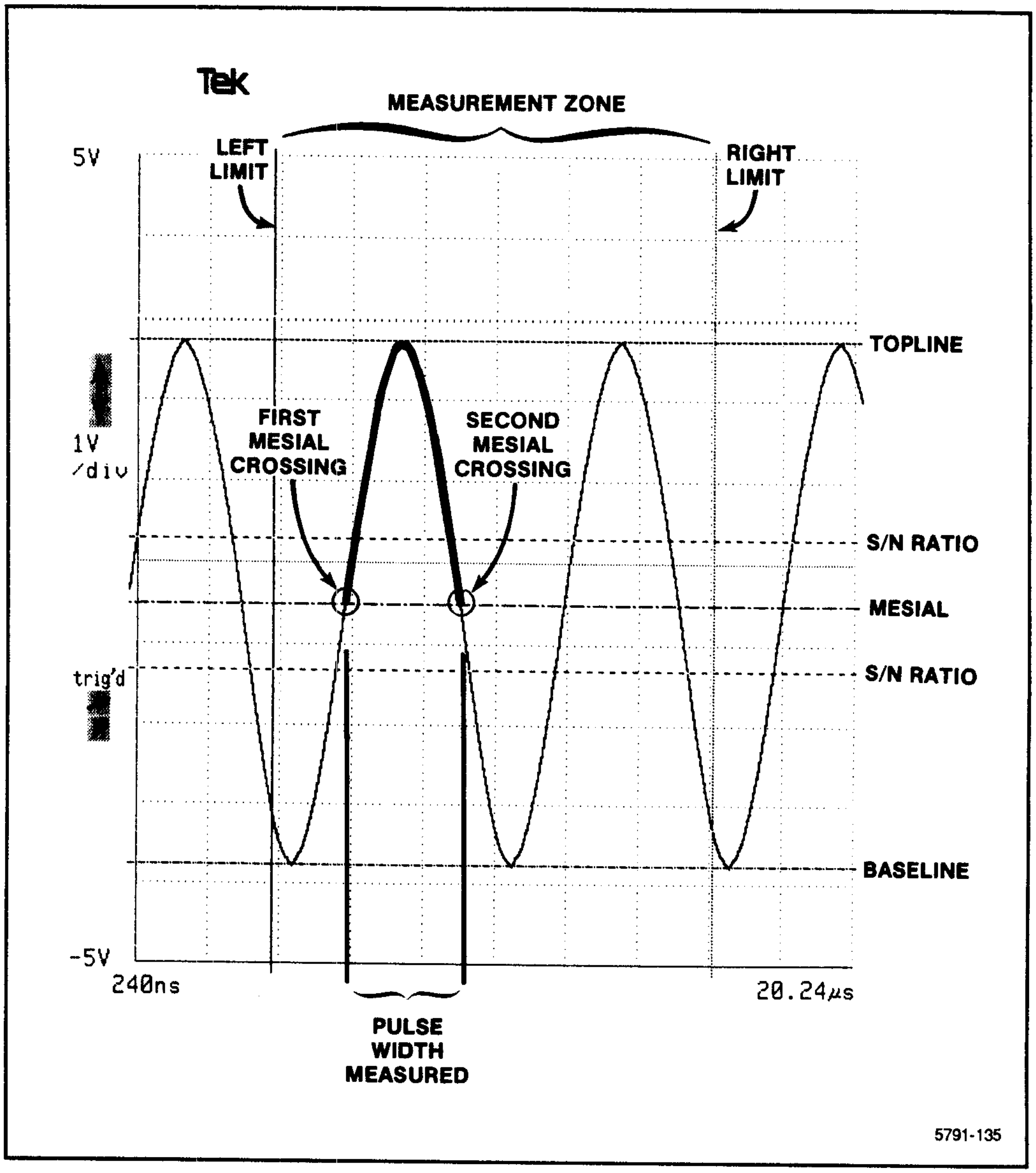

Figure 2-54. Width measurement example.

Width Pop-up Menu

Selecting **Width** causes the **Width** pop-up menu to appear in the waveform display area and highlights its label in the menu/status area (see Fig. 2-55).

The items in the pop-up menu allow control of the measurement's parameters, when selected. Current settings are displayed below the item labels. Unless previously modified for this or another active measurement, the current settings of the measurement parameters will be equal to the Default Parameter values.

Menu Items

The following measurement parameters are entries in the **Width** pop-up menu:

1. **Left** and **Right Limit**
2. **Topline**
3. **Mesial**
4. **Baseline**
5. **S/N Ratio (Signal/Noise)**
6. **Tracking**
7. **Setup**

For a detailed discussion of these measurement parameters refer to "Common Measurement Parameters" defined under "Standard Measurement Functions" earlier in this section.

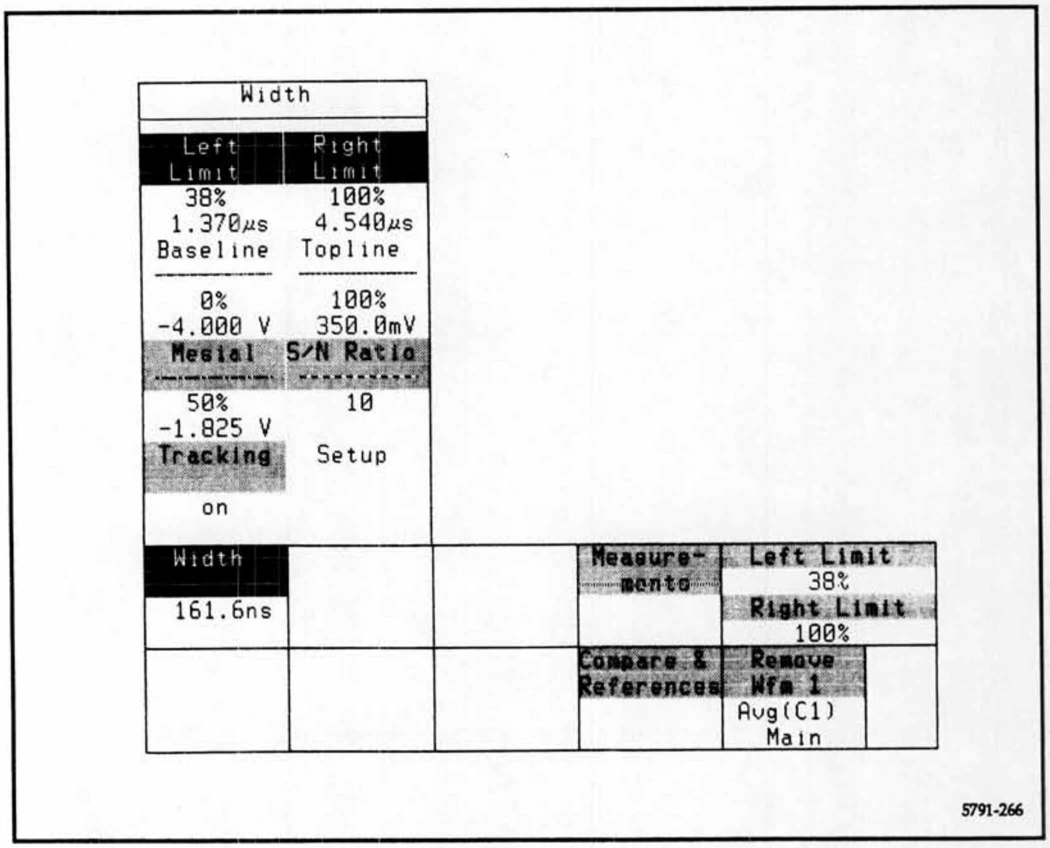

Figure 2-55. Width pop-up menu.

Waveform Annotation

Selecting the **Width** label (in the menu/status area) causes the following annotations on the display:

1. Two vertical bars define the Measurement Zone. The **Left** and **Right Limit** bars can be moved with the Control knobs when selected from the pop-up menu.

2. The Topline level of the Measurement Zone is displayed as a unique dashed line across the top of the waveform. Normally, Tracking is on so Topline is set automatically. Topline can be set with a Control knob by setting Tracking off in the pop-up menu and selecting Topline.

3. The Mesial percentage of the Measurement Zone is displayed as a unique dashed line across the middle of the waveform. It is variable with the Control knobs when selected from the pop-up menu.

4. The Baseline level of the Measurement Zone is displayed as a unique dashed line across the bottom of the waveform. Normally, Tracking is on so Baseline is automatically set. Baseline can be set with a Control knob by setting Tracking off in the pop-up menu and selecting Baseline.

5. The Signal-to-Noise Ratio value is displayed as a pair of unique dashed lines that are positioned equidistant from the Mesial line. S/N Ratio can be set with a Control knob by selecting it from the pop-up menu.

6. The region of the waveform corresponding to the width time is displayed at high intensity. Window indicators on the selected waveform are not displayed when the period is intensified.

Delay Duration

Press the MEASURE MENUS button to display the Measure major menu at the bottom of the screen. Then touch the **Measurements** *label to display the* **Measurements** *pop-up menu. Select the* **Delay** *label from the pop-up menu to invoke the measurement. The* **Delay** *label with its value will be displayed at the bottom of the screen. Refer to "Selecting and Ending Measurements" earlier in this section for further information.*

Delay calculates the time duration between the first mesial waveform crossing to the last mesial waveform crossing within the Measurement Zone. The delay-time value between the first and last mesial crossings is displayed below the **Delay** label in the menu/status area. The S/N Ratio crossings must qualify the mesial crossings within the Measurement Zone. Figure 2-56 shows a typical Delay measurement example. The measurement is reported to four-digits.

The Delay measurement is normally performed using the Default Parameter settings for the parameters shown in Figure 2-56. These measurement parameters are used by other active measurements and can be changed with:

- The **Delay** pop-up menu,
- the pop-up menu of another active measurement that uses the same parameters, and
- the Default Parameters category of the **Measurements** pop-up menu. Refer to "Default Parameters Menu Category" under "Measurements Pop-up Menu" earlier in this section for detailed information.

This measurement can be performed only on YT waveforms. The status is displayed as undefined for XY waveforms.

The **Compare & References** function (in the menu/status area) alters the status of the **Delay** function, and adds a delta symbol to the name of the function (i.e., **ΔDelay**).

Algorithms for all standard measurement functions are defined in Appendix B.

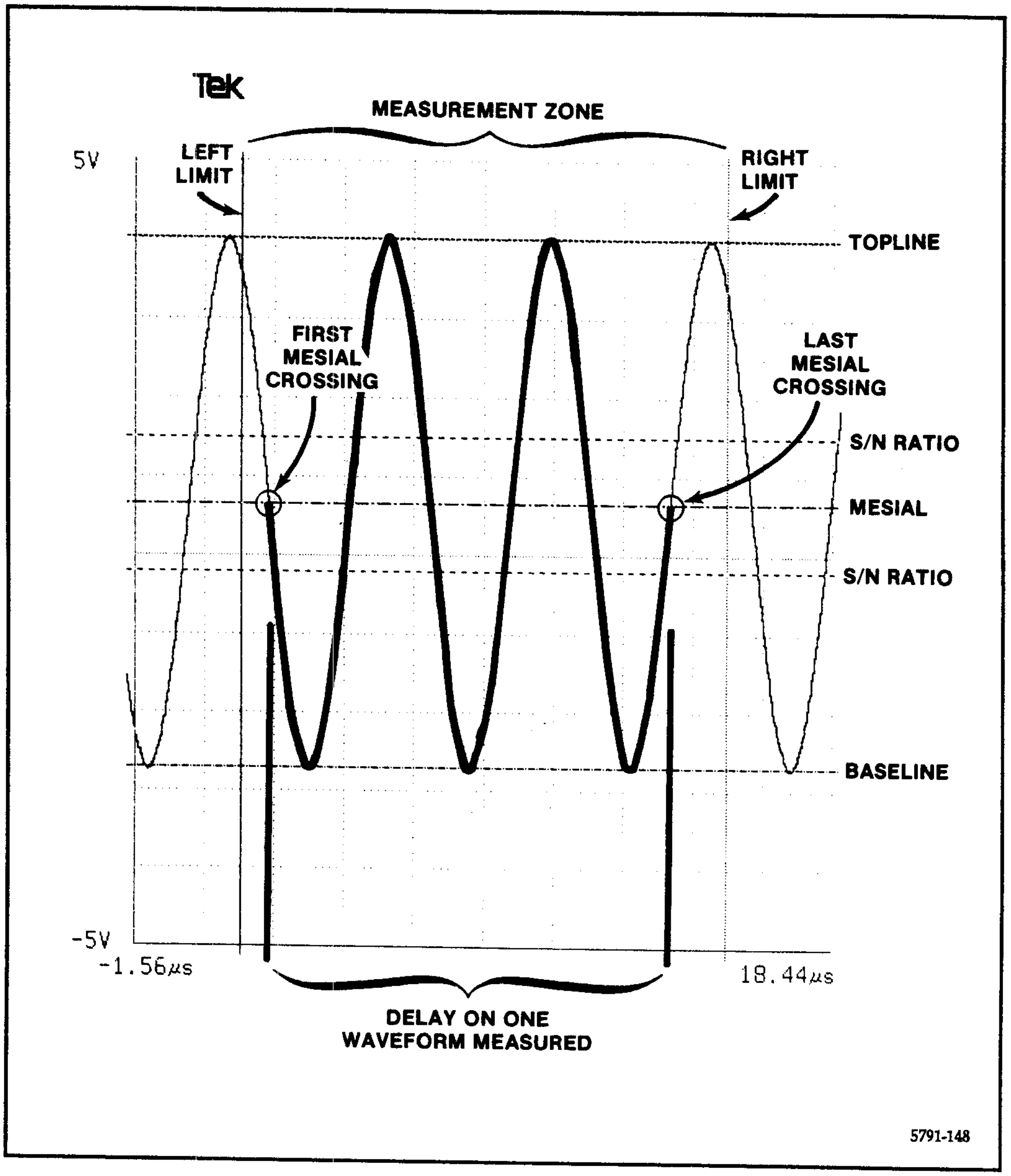

Figure 2-56. Delay measurement example.

Delay Pop-up Menu

Selecting the **Delay** label causes the **Delay** pop-up menu to appear in the waveform display area and highlights its label in the menu/status area. The **Delay** pop-up menu is shown in Figure 2-57.

The items in the pop-up menu allow control of the measurement's parameters, when selected. Current settings are displayed below the item labels. Unless previously modified for this or another active measurement, the current settings of the measurement parameters will be equal to the Default Parameter values.

Menu Items

The following measurement parameters are entries in the **Delay** pop-up menu:

1. **Left** and **Right Limit**
2. **Baseline**
3. **Topline**
4. **Mesial**
5. **S/N Ratio (Signal/Noise)**
6. **Tracking**
7. **Setup**

For a detailed discussion of these measurement parameters, refer to "Common Measurement Parameters" defined under "Standard Measurement Functions" earlier in this section.

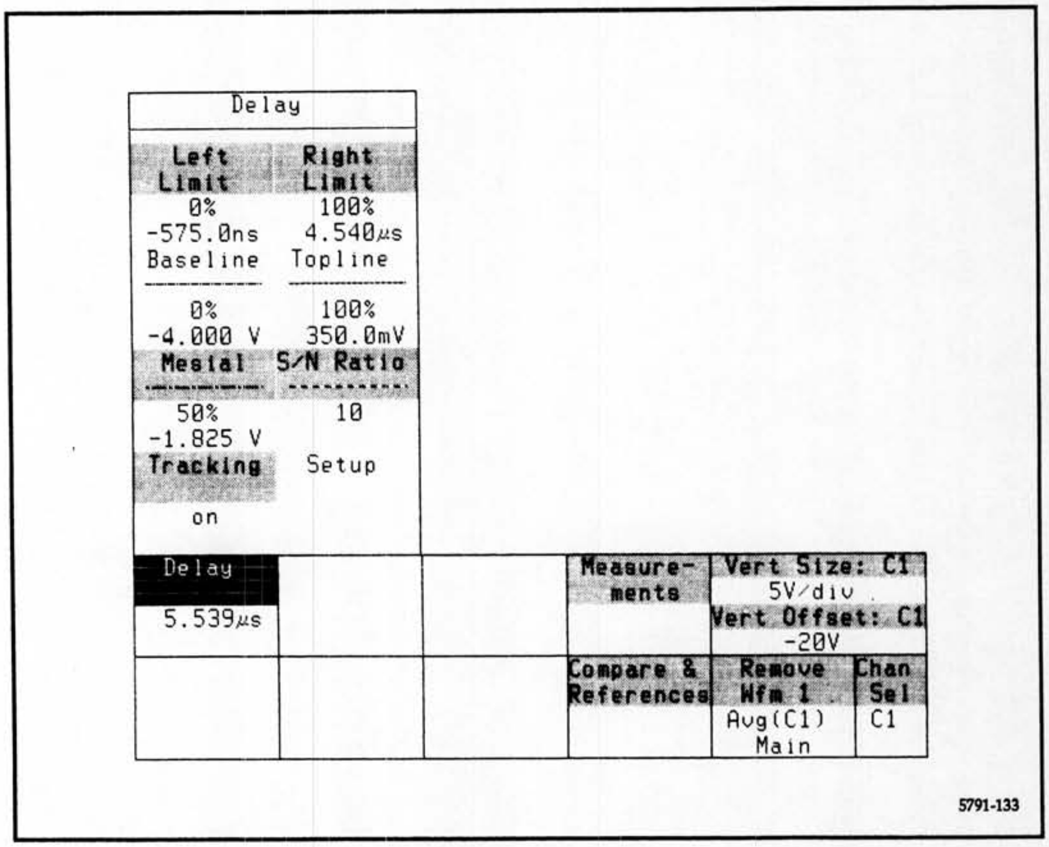

Figure 2-57. **Delay** pop-up menu.

Waveform Annotation

Selecting the **Delay** label in the menu/status area causes the following annotation to appear on the waveform:

1. Two vertical bars define the Measurement Zone. The **Left** and **Right Limit** bars can be moved with the Control knobs when selected from the pop-up menu.

2. The Topline level of the Measurement Zone is displayed as a unique dashed line across the top of the waveform. Normally, Tracking is on so Topline is set automatically. Topline can be set with a Control knob by setting Tracking off in the pop-up menu and selecting Topline.

3. The Mesial percentage of the Measurement Zone is displayed as a unique dashed line across the middle of the waveform. It is variable with the Control knobs when selected from the pop-up menu.

4. The Baseline level of the Measurement Zone is displayed as a unique dashed line across the bottom of the waveform. Normally, Tracking is on so Baseline is automatically set. Baseline can be set with a Control knob by setting Tracking off in the pop-up menu and selecting Baseline.

5. The Signal-to-Noise Ratio value is displayed as a pair of unique dashed lines that are positioned equidistant from the Mesial line. S/N Ratio can be set with a Control knob by selecting it from the pop-up menu.

6. The measured segment on the selected waveform is shown at high intensity. Window indicators on the selected waveform are not displayed when the period is intensified.

Propagation Delay

Press the MEASURE MENUS button to display the Measure major menu at the bottom of the screen. Then touch the **Measurements** *label to display the* **Measurements** *pop-up menu. Select the* **Prop Delay** *label from the pop-up menu to invoke the measurement. The* **Prop Delay** *label with its value will be displayed at the bottom of the screen. Refer to "Selecting and Ending Measurements" earlier in this section for further information.*

Propagation Delay measures the absolute time between a mesial waveform crossing on the currently selected waveform and a mesial waveform crossing on any other specified delayed waveform. The propagation time value between the two mesial crossings is displayed below the Prop Delay label in the menu status area. Figure 2-57a shows a typical Prop Delay measurement example. The measurement reportrd to four-digits.

The Prop Delay measurement is normally performed using the Default Parameter settings for the parameters shown in Figure 2-58. These measurement parameters are used by other active measurements and can be changed with:

- The **Prop Delay** pop-up menu,
- the pop-up menu of another active measurement that uses the same parameters, and
- the Default Parameters category of the **Measurements** pop-up menu. Refer to "Default Parameters Menu Category" under "Measurements Pop-up Menu" earlier in this section for detailed information.

This measurement can be performed only on YT waveforms. The status is displayed as undefined for XY waveforms.

The **Compare & References** function (in the menu/status area) alters the status of the **Prop Delay** function, and adds a delta symbol to the name of the function (i.e., Δ**Prop Delay**).

Algorithms for all standard measurement functions are defined in Appendix B.

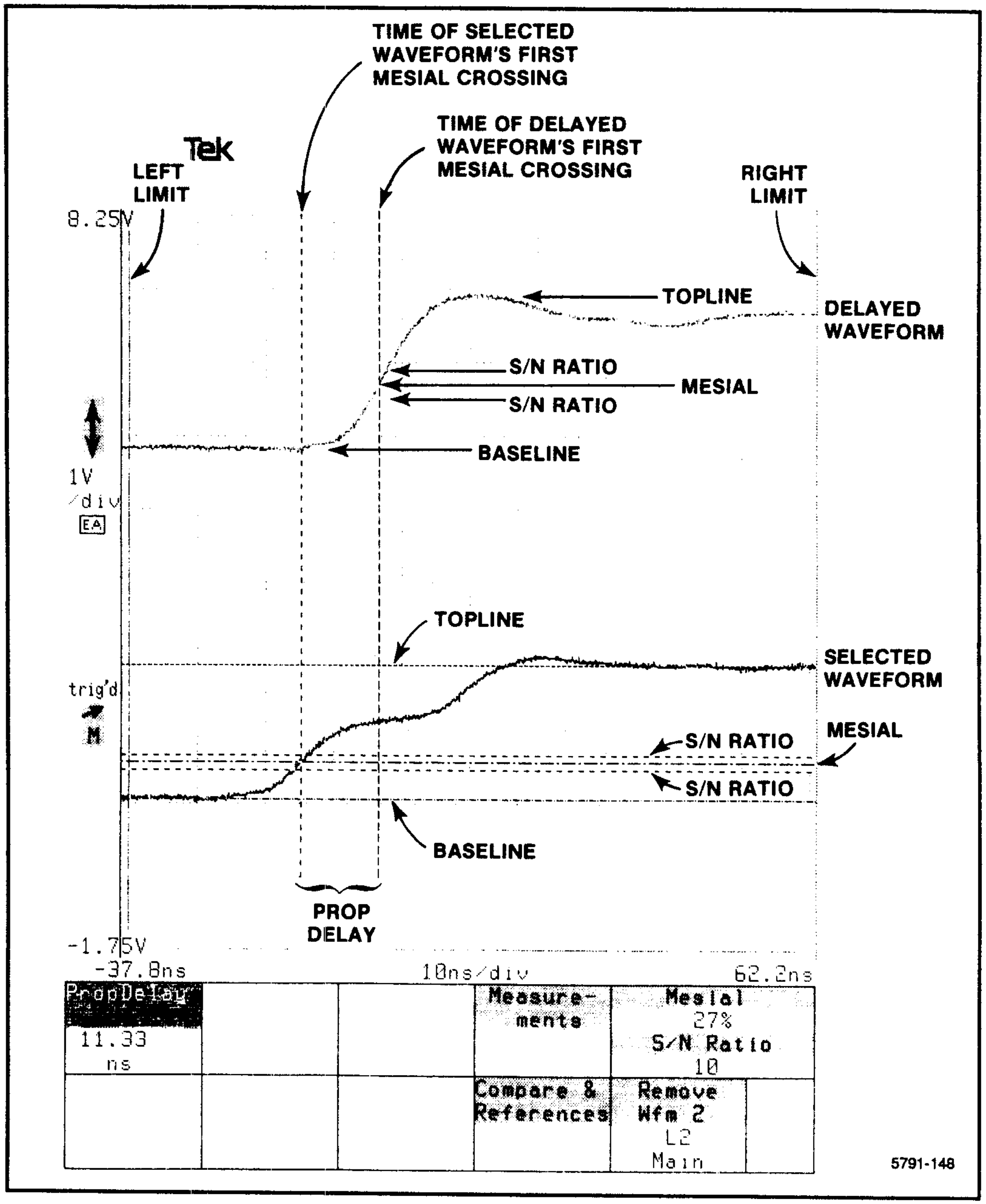

Figure 2-58. Propagation Delay measurement example.

Prop Delay Pop-up Menu

Selecting the **Prop Delay** label causes the **Prop Delay** pop-up menu to appear in the waveform display area and highlights its label in the menu/status area. The **Prop Delay** pop-up menu is shown in Figure 2-59.

The items in the pop-up menu allow control of the measurement's parameters, when selected. Current settings are displayed below the item labels. Unless previously modified for this or another active measurement, the current settings of the measurement parameters will be equal to the Default Parameter values.

Menu Items

The selected waveform and the specified delayed waveform both have the following measurement parameters as entries in the **Prop Delay** pop-up menu:

1. **Left** and **Right Limit**
2. **Baseline**
3. **Topline**
4. **Mesial**
5. **S/N Ratio (Signal/Noise)**
6. **Tracking**
7. **Setup**

For a detailed discussion of these measurement parameters, refer to "Common Measurement Parameters" defined under "Standard Measurement Functions" earlier in this section.

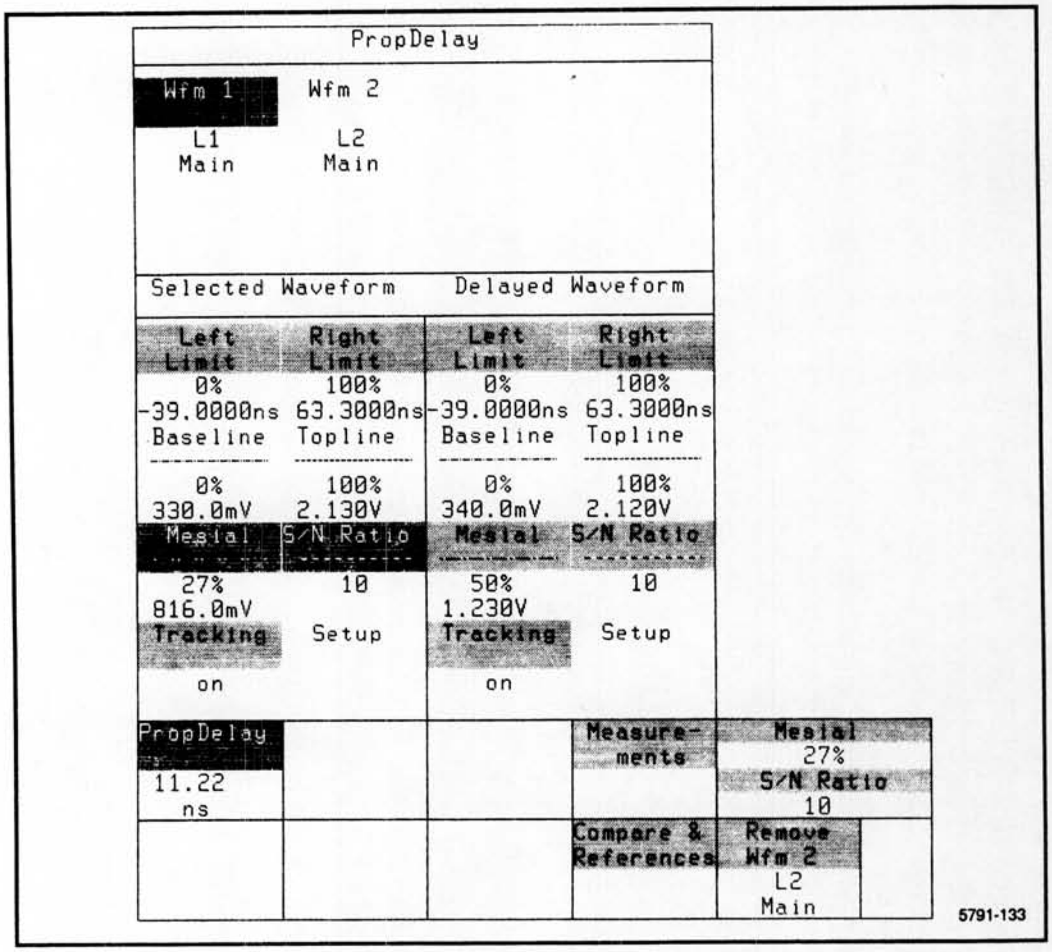

Figure 2-59. Prop Delay pop-up menu.

Waveform Annotation

Selecting the **Prop Delay** label in the menu/status area causes the following annotation to appear on the display screen:

1. Two vertical bars define the Measurement Zone[1]. The **Left** and **Right Limit** bars can be moved with the Control knobs when selected from the pop-up menu.
2. The Topline level of the Measurement Zone is displayed as a unique dashed line across the top of the waveform.[1] Normally, Tracking is on so Topline is set automatically. Topline can be set with a Control knob by setting Tracking off in the pop-up menu and selecting Topline.
3. The Mesial percentage of the Measurement Zone is displayed as a unique dashed line across the middle of the waveform[1]. It is variable with the Control knobs when selected from the pop-up menu.
4. The Baseline level of the Measurement Zone is displayed as a unique dashed line across the bottom of the waveform[1]. Normally, Tracking is on so Baseline is automatically set. Baseline can be set with a Control knob by setting Tracking off in the pop-up menu and selecting Baseline.
5. The Signal-to-Noise Ratio value is displayed as a pair of unique dashed lines that are positioned equidistant from the Mesial line[1]. S/N Ratio can be set with a Control knob by selecting it from the pop-up menu.
6. Two vertical timing bars denote mesial crossings on the selected waveform and on the delayed waveform.

[1] **Used to annotate the selected waveform or the delayed waveform but not both at once.**

Main to Window Trigger Time

Press the MEASURE MENUS button to display the Measure major menu at the bottom of the screen. Then touch the **Measurements** *label to display the* **Measurements** *pop-up menu. Select the* **Main→Win Trig Time** *label from the pop-up menu to invoke the measurement. The* **Main→Win Trig Time** *label with its value will be displayed at the bottom of the screen. Refer to "Selecting and Ending Measurements" earlier in this section for further information.*

Main to Window Trigger Time calculates the time duration between Main trigger point and the Window trigger point. The Main and Window trigger points can be varied with the Level, Holdoff, and Slope trigger parameters in the pop-up menu. Adjusting a trigger parameter to select the trigger points will affect the waveform display, and could affect the trigger stability. The measurement is reported to eight-digits.

The Window time base must be set for triggering by the Window trigger for a valid measurement. Initially, the Window time base is triggered by the Main trigger, which produces an undefined measurement result. Set the Window Holdoff Mode in the Trigger major menu to holdoff by time or events (Window triggers) for correct Window time base triggering. Both a Main Waveform record & Window Waveform record must be displayed if the Window and Main Trigger sources are not the same.

Stable trigger settings are necessary for a valid measurement. A measurement result of "undefined" implies a triggering problem. Improper trigger level is a likely problem if using the Normal trigger mode. The Auto trigger modes can be used down to trigger repetition rates of 60 ms. Below 60 ms, the Auto trigger modes enter a freerun condition that produces a random or undefined result. An undefined result will also occur if the Window holdoff is increased such that the Window time base is set to trigger past the end of the Main time base sweep.

The Main to Window Trigger Time measurement is normally in the unaveraged mode. That is, the function performs another measurement after each trigger. Select the unaveraged mode by touching the **Avg 1** label in the pop-up menu.

Measurement accuracy can be improved using the averaging function in the pop-up menu. Averaging reduces the effects of waveform jitter (noise), and increases the measurement resolution of the trigger points. This measurement is performed in the Digitizer . For accuracy and resolution information, refer to the Precision Time Measurement entry in Table 4-2.

The trigger-to-trigger time value is displayed below the **Main→Win Trig Time** label in the menu/status area. Figure 2-60 shows a typical Main to Window Trigger Time measurement example with dc coupled trigger signals. The measurement annotation appears when both displayed trigger sources are single channel dc coupled signals , but the measurement result is valid when ac or dc coupled.

Main-Window Trigger time is a unique measurement in that it is not derived from a waveform record. Rather, the timebase directly measures the time between the two trigger events. The requirements for a Main-Window trigger measurement are

A waveform must be defined on the Main time base.

Both the Main and the Window trigger systens must be set to detect a trigger.

Window Holdoff Mode must be set to either Holdoff by Time, Trigger from Window, or Holdoff by events, Trigger from Window.

It is not necessary that either the main or the Window records be complete. In fact, single-shot measurements may be done by using these settings:

Trigger Menu:	Trigger Select: Main Trigger Mode: Normal
	Trigger Select: Window Trigger Mode: Normal
Measure Menu: Main-Win Trig Time pop-up:	Avg 1
Waveform Menu: Acquire Desc pop-up:	Single Trigger

The window Time Holdoff or Events Holdoff must be set to a value that will arm the Window trigger at a point that will allow a triggerable edge to be detected prior to the end of the Main time base duration.

When the Window is triggered, Window Position may be adjusted over the full range of the Main time base duration. This means that the Window trigger point may not be represented in the Window record, even though the Window is triggered. Setting Window position to zero will place the Window trigger point at the start of the Window record.

The Main to Window Trigger Time measurement is normally performed using the trigger parameter settings for the parameters shown in Figure 2-60. These measurement parameters can be changed with:

- The **Main→Win Trig Time** pop-up menu,
- the Trigger major menu, or
- the Trigger icon, then adjusting level and holdoff with the Control knobs.

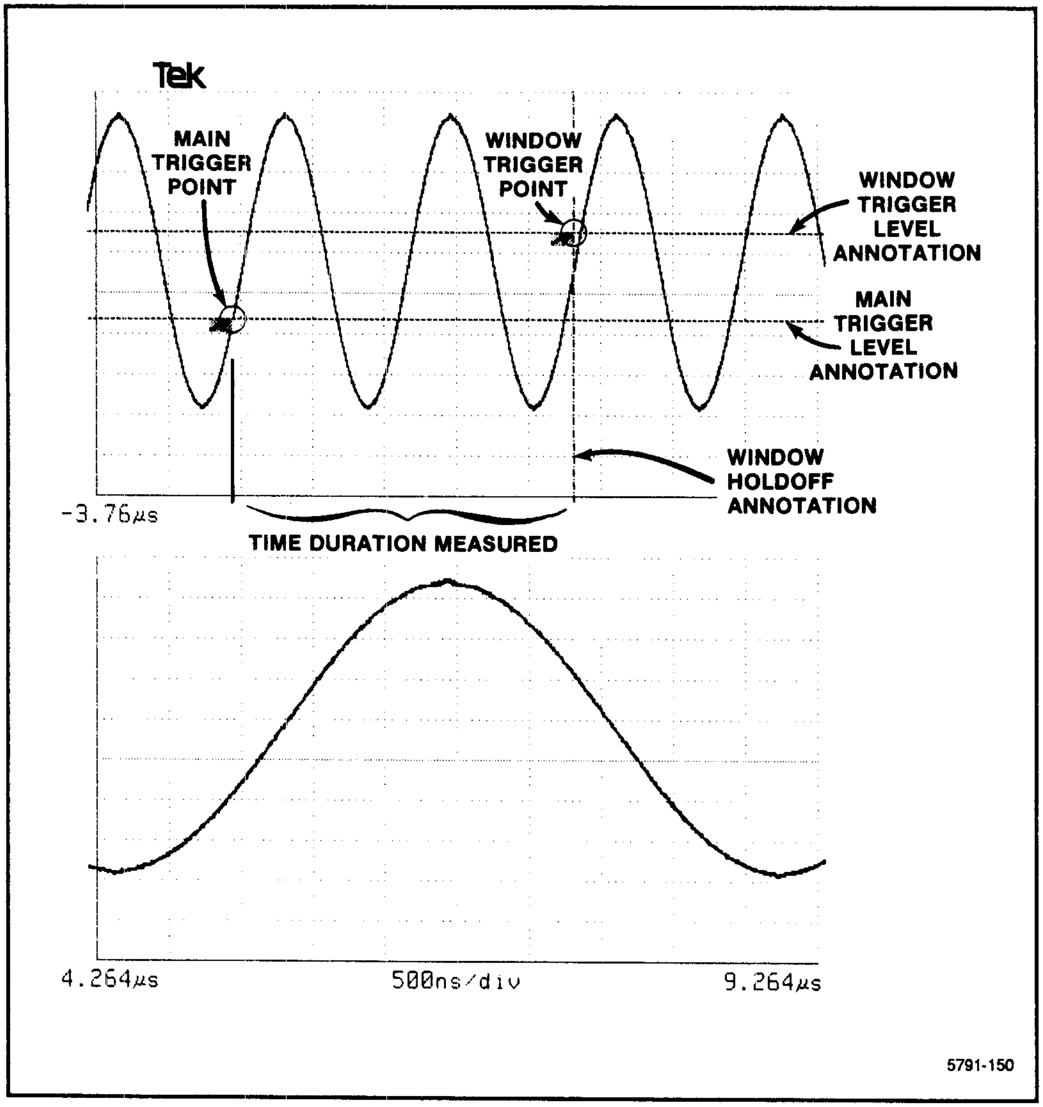

Figure 2-60. Main to Window Trigger Time measurement example.

This measurement can be performed only on YT waveforms. The status is displayed as undefined for XY waveforms.

The **Compare & References** function (in the menu/status area) alters the status of the **Main to Window Trigger Time** function, and adds a delta symbol to the name of the function (i.e., **ΔMain→Win Trig Time**).

Algorithms for all standard measurement functions are defined in Appendix B.

Main→Win Trig Time Pop-up Menu

Selecting the **Main→Win Trig Time** label causes the **Main to Window Trig Time** pop-up menu to appear in the waveform display area and highlights its label in the menu/status area (see Fig. 2-61).

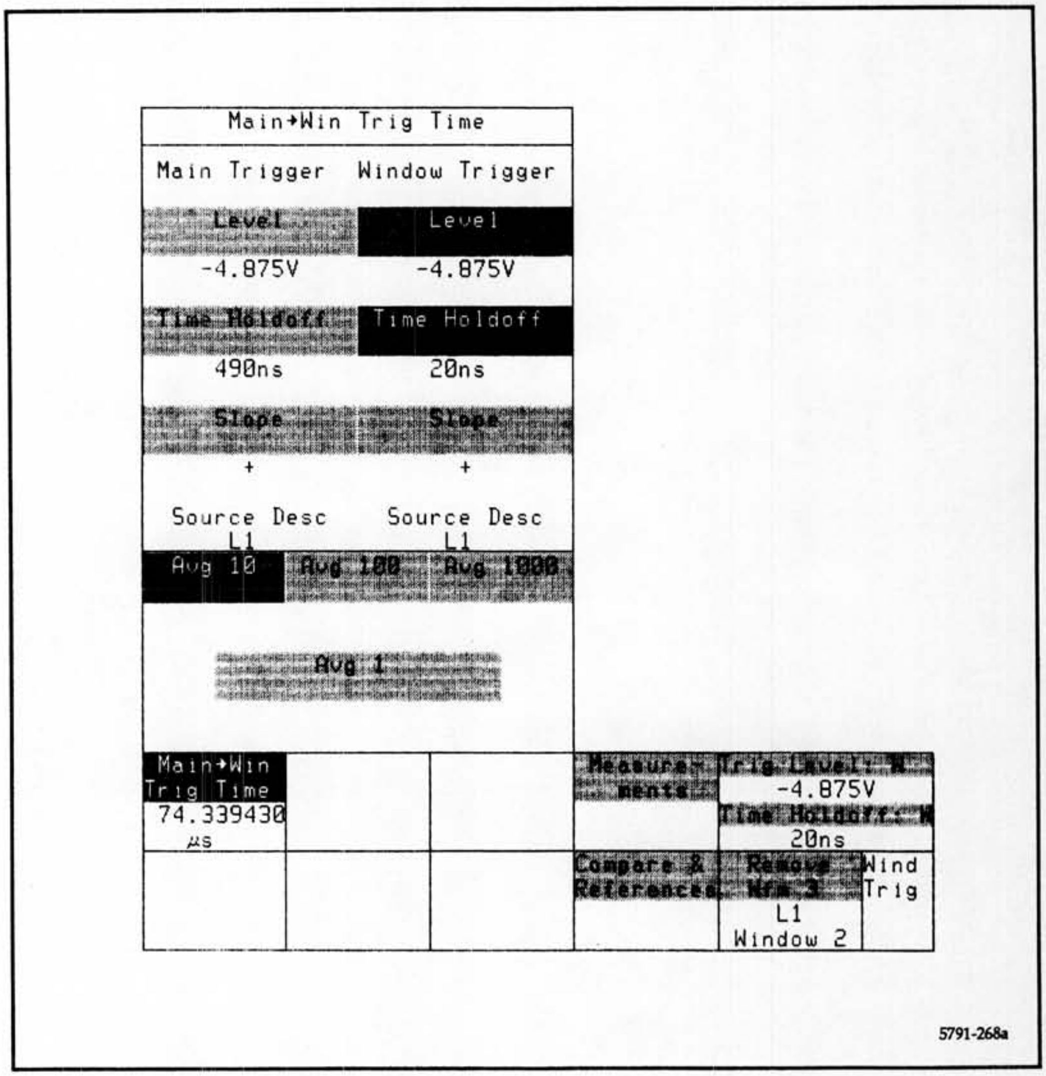

Figure 2-61. Main→Win Trig Time pop-up menu.

The items in the pop-up menu allow control of the measurement's parameters, when selected. Current trigger parameter settings are displayed below the item labels.

Menu Items

The following trigger parameters are entries in the **Main→Win Trig Time** pop-up menu:

- **Main Trigger**

  Level—Assigns Main trigger level and holdoff to the Control knobs.

  Time Holdoff—Assigns Main trigger level and holdoff to the Control knobs.

  Slope—Toggles the Main trigger slope between + and –.

  Source Desc—Status information indicating the Main trigger's source.

- **Window Trigger**

  Level—Assigns Window trigger level and holdoff to the Control knobs.

  Time or **Events Holdoff**—Assigns Window trigger level and holdoff to the Control knobs.

  Slope—Toggles the Window trigger slope between + and –.

  Source Desc—Status information indicating the Window trigger's source.

- **Measurement Mode**

  Avg 1—Continuously displays individual trigger to trigger measurement values.

  Avg 10—Averages 10 occurrences of the trigger-to-trigger measurement before displaying the value.

  Avg 100—Averages 100 occurrences of the trigger-to-trigger measurement before displaying the value.

  Avg 1000—Averages 1000 occurrences of the trigger-to-trigger measurement before displaying the value.

Waveform Annotation

Selecting the **Main→Win Trig Time** function label (in the menu/status area) and having dc coupled trigger signals causes the following waveform annotation on the waveform:

1. Horizontal lines for the Main and Window Trigger Levels.
2. Vertical line for the Window and Main Trigger points.

Cross

*Press the MEASURE MENUS button to display the Measure major menu at the bottom of the screen. Then touch the **Measurements** label to display the **Measurements** pop-up menu. Select the **Cross** label from the pop-up menu to invoke the measurement. The **Cross** label with its value will be displayed at the bottom of the screen. Refer to "Selecting and Ending Measurements" earlier in this section for further information.*

Cross measures the time from the trigger point to the waveform point after the Left Limit where the waveform first crosses the Reference Level with the specified slope polarity. The crossing must occur before the Right Limit. Reference Level can be selected from the Cross pop-up menu and set to the desired positive or negative value. Figure 2-62 shows an example of the Cross measurement performed on a waveform positioned completely post-trigger (i.e., triggered at the first waveform point). Measurements are reported to eight-digits.

The Cross measurement is normally performed using the Default Parameter settings for the parameters shown in Figure 2-62. These measurement parameters are used by other active measurements and can be changed with:

- the **Cross** pop-up menu,
- the pop-up menu of another active measurement that uses the same parameters, and
- the Default Parameters category of the **Measurements** pop-up menu. Refer to "Default Parameters Menu Category" under "Measurements Pop-up Menu" earlier in this section for detailed information.

This measurement can be performed only on YT waveforms. The status is displayed as undefined for XY waveforms.

The **Compare & References** function (in the menu/status area) alters the status of the **Cross** function, and adds a delta symbol to the name of the function (i.e., Δ**Cross**).

Algorithms for all standard measurement functions are defined in Appendix B.

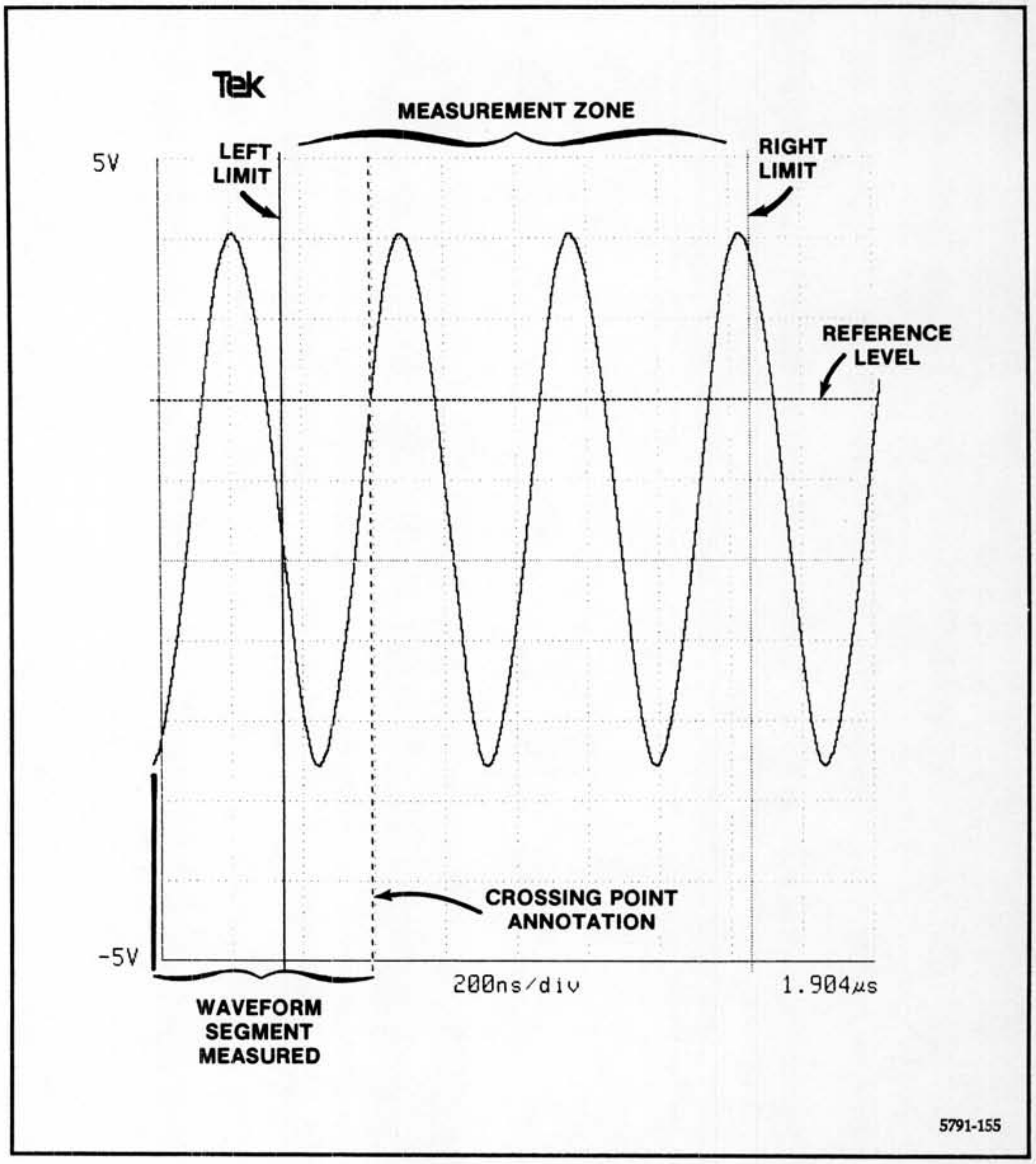

Figure 2-62. Cross measurement example.

Cross Pop-up Menu

Selecting **Cross** causes the **Cross** pop-up menu to appear in the waveform display area and highlights its label in the menu/status area (see Figure 2-63).

The items in the pop-up menu allow control of the measurement's parameters, when selected. Current settings are displayed below the item labels. Unless previously modified for this or another active measurement, the current settings of the measurement parameters will be equal to the Default Parameter values.

Menu Items

The following menu parameters are entries in the **Cross** pop-up menu:

1. **Left** and **Right Limit**
2. **Reference Level**
3. **Slope**

For a detailed discussion of these measurement parameters refer to "Common Measurement Parameters" defined under "Standard Measurement Functions" earlier in this section.

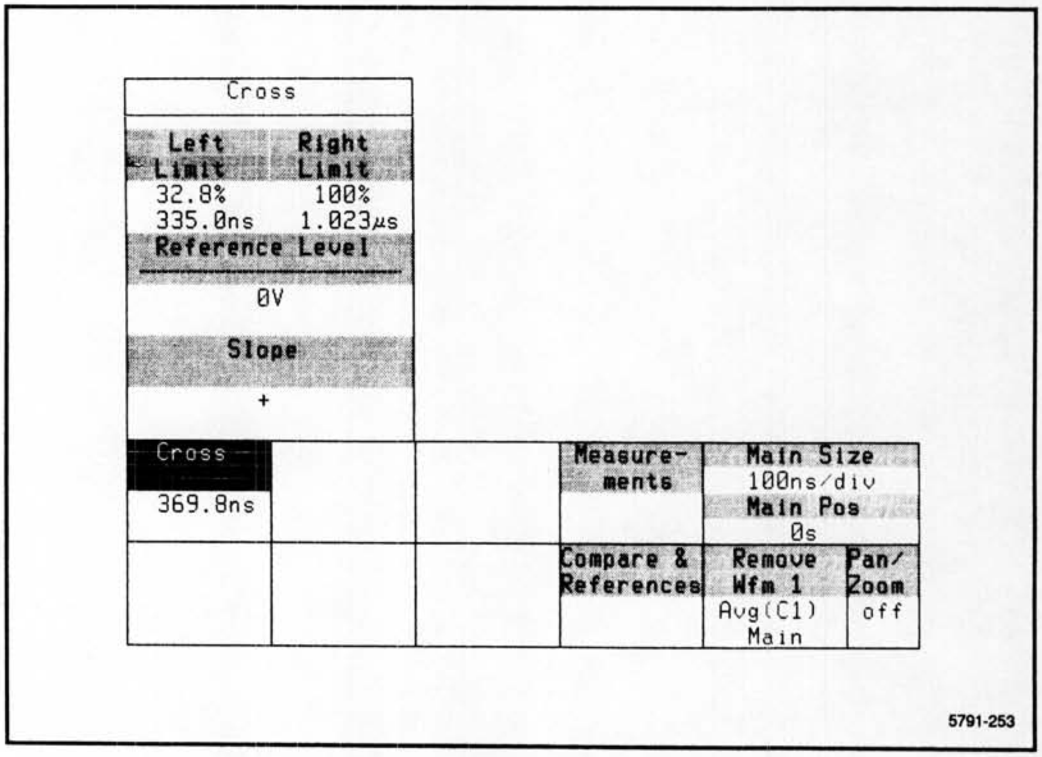

Figure 2-63. Cross pop-up menu.

Waveform Annotation

Selecting the **Cross** label (in the menu/status area) causes the following annotation on the waveform:

1. Two vertical bars define the Measurement Zone. The **Left** and **Right Limit** bars can be moved with the Control knobs when selected from the pop-up menu.

2. The Reference level is displayed as a unique dashed horizontal line across the waveform. It is variable with the Control knobs when selected from the pop-up menu.

3. A vertical dashed line displayed on the screen defines the crossing point on the waveform where the measurement is taken.

Area+ Computation

Press the MEASURE MENUS button to display the Measure major menu at the bottom of the screen. Then touch the **Measurements** *label to display the* **Measurements** *pop-up menu. Select the* **Area+** *label from the pop-up menu to invoke the measurement. The* **Area+** *label with its value will be displayed at the bottom of the screen. Refer to "Selecting and Ending Measurements" earlier in this section for further information.*

Area + computes the sum of the absolute value of the waveform area above the Reference Level and the absolute value of the waveform area below the Reference. When Data Interval is set to one Period, the first full period within the Measurement Zone is found and the areas above and below the Reference Level are totaled. Figure 2-64 shows an example of the Area+ measurement with Data Interval set to one period. Measurements are reported to four-digits.

When Data Interval is set to the entire zone, all areas within the Measurement Zone that are bound by the waveform and the Reference Level are totaled. The Reference Level can be selected from the pop-up menu and positioned from the upper to the lower limit of the screen.

The Area+ value is displayed below the **Area+** label in the menu/status area. This measurement can be performed only on YT waveforms. The status is displayed as undefined for XY waveforms.

The Area+ measurement is normally performed using the Default Parameter settings for the parameters shown in Figure 2-64. These measurement parameters are used by other active measurements and can be changed with:

- The **Area+** pop-up menu,
- the pop-up menu of another active measurement that uses the same parameters, and
- the Default Parameters category of the **Measurements** pop-up menu. Refer to "Default Parameters Menu Category" under "Measurements Pop-up Menu" earlier in this section for detailed information.

The **Compare & References** function (in the menu/status area) alters the status of the **Area+** function, and adds a delta symbol to the name of the function (i.e., Δ**Area+**).

Algorithms for all standard measurement functions are defined in Appendix B.

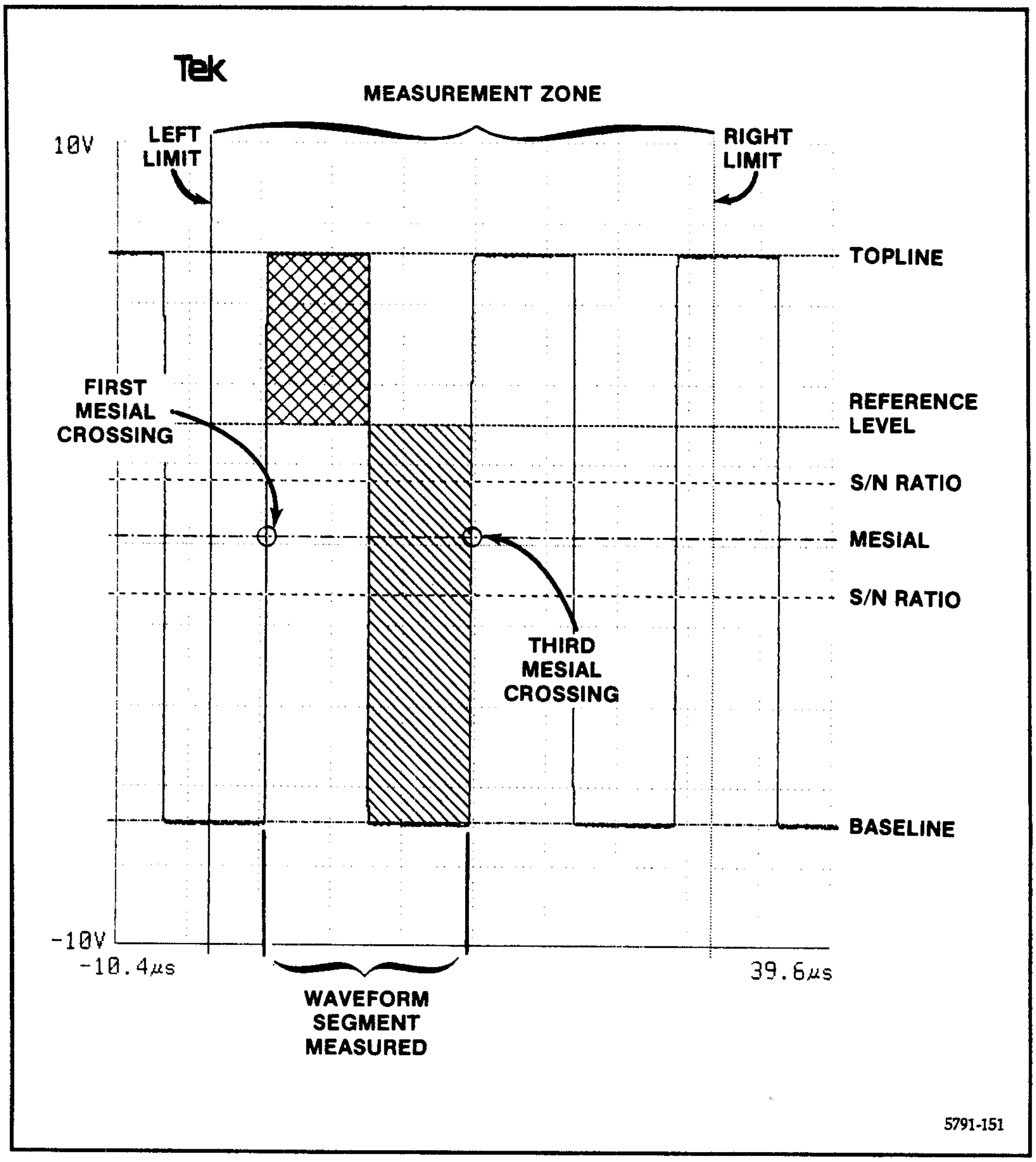

Figure 2-64. Area+ measurement example.

Area+ Pop-up Menu

Selecting **Area+** causes the **Area+** pop-up menu to appear in the waveform display area and highlights its label in the menu/status area (see Fig. 2-65).

The items in the pop-up menu allow control of the measurement's parameters, when selected. Current settings are displayed below the item labels. Unless previously modified for this or another active measurement, the current settings of the measurement parameters will be equal to the Default Parameter values.

Menu Items

The following menu parameters are entries in the **Area+** pop-up menu:

1. **Left** and **Right Limit**
2. **Data Interval**
3. **Topline**
4. **Mesial**
5. **Baseline**
6. **S/N Ratio (Signal/Noise)**
7. **Tracking**
8. **Setup**
9. **Reference Level**

For a detailed discussion of these measurement parameters refer to "Common Measurement Parameters" defined under "Standard Measurement Functions" earlier in this section.

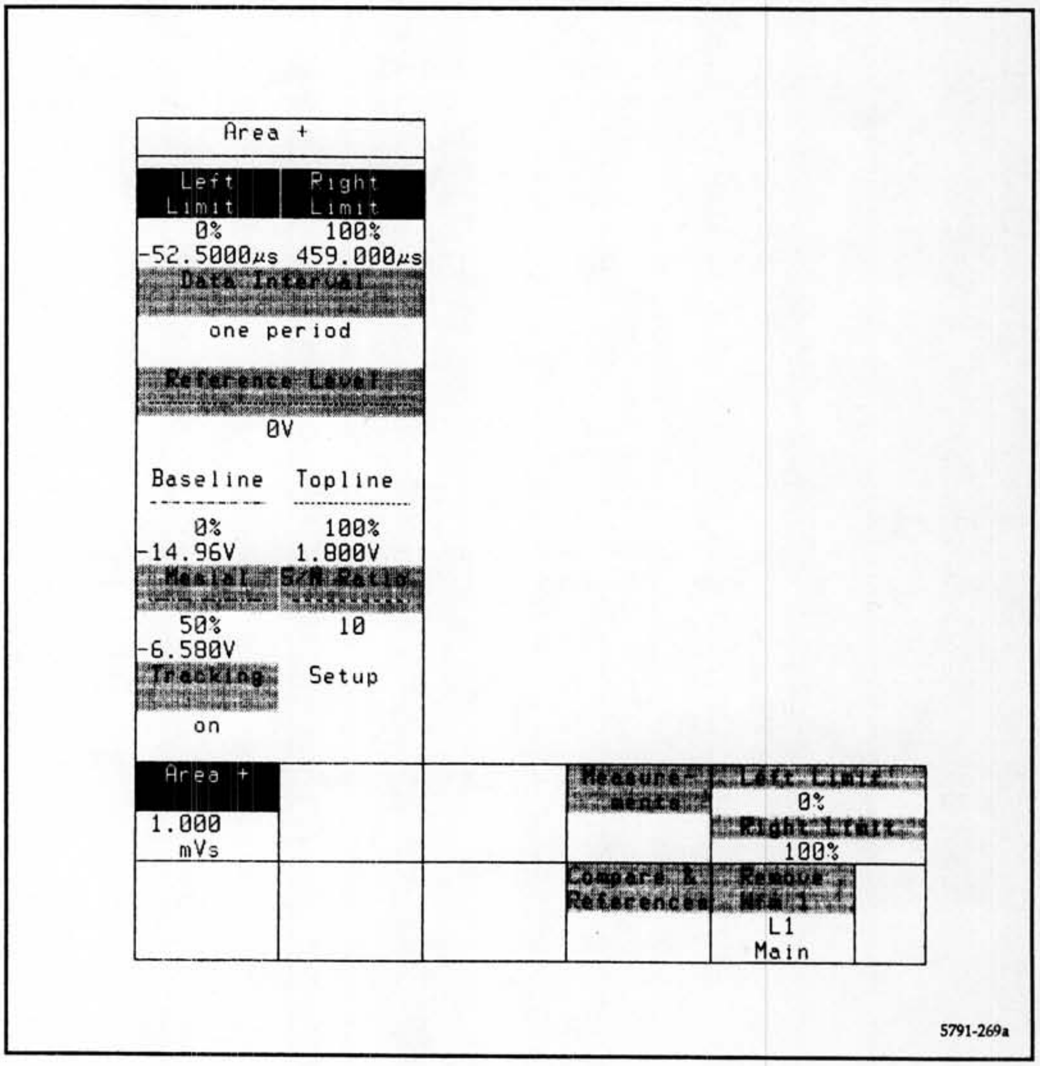

Figure 2-65. **Area+** pop-up menu.

Waveform Annotation

Selecting the **Area+** label (in the menu/status area) causes the following annotation on the waveform:

1. Two vertical bars define the Measurement Zone. The **Left** and **Right Limit** bars can be moved with the Control knobs when selected from the pop-up menu.

2. The Topline level of the Measurement Zone is displayed as a unique dashed line across the top of the waveform. Normally, Tracking is on so Topline is set automatically. Topline can be set with a Control knob by setting Tracking off in the pop-up menu and selecting Topline. Data Interval must be in the single period mode.

3. The Mesial percentage of the Measurement Zone is displayed as a unique dashed line across the middle of the waveform. It is variable with the Control knobs when selected from the pop-up menu. Data Interval must be in the single period mode.

4. The Baseline level of the Measurement Zone is displayed as a unique dashed line across the bottom of the waveform. Normally, Tracking is on so Baseline is automatically set. Baseline can be set with a Control knob by setting Tracking off in the pop-up menu and selecting Baseline. Data Interval must be in the single period mode.

5. The Signal-to-Noise Ratio value is displayed as a pair of unique dashed lines that are positioned equidistant from the Mesial line. S/N Ratio can be set with a Control knob by selecting it from the pop-up menu. Data Interval must be in the single period mode.

6. The segment of the waveform used (one period or entire Measurement Zone) to determine the Area+ result is displayed at high intensity. When the period is intensified, no window indicators on the selected waveform are displayed.

7. The Reference level is displayed as a unique dashed line across the waveform. It is variable with the Control knobs when selected from the pop-up menu.

Area– Computation

Press the MEASURE MENUS button to display the Measure major menu at the bottom of the screen. Then touch the **Measurements** *label to display the* **Measurements** *pop-up menu. Select the* **Area–** *label from the pop-up menu to invoke the measurement. The* **Area–** *label with its value will be displayed at the bottom of the screen. Refer to "Selecting and Ending Measurements" earlier in this section for further information.*

Area– computes the difference between the waveform area above the Reference Level and the waveform area below the Reference level. When Data Interval is set to one period, the measurement is performed on the first full period in the Measurement Zone. Figure 2-66 shows an example of the Area– measurement with Data Interval set to one period. Measurements are reported to four-digits.

When Data Interval is set to the entire zone, all Measurement Zone areas bounded by the waveform below the Reference Level are subtracted from the areas above the Reference Level. The Reference Level can be selected from the pop-up menu and positioned from the upper to the lower limit of the screen. The Area– value is displayed below the **Area–** label in the menu/status area. This measurement can be performed only on YT waveforms. The status is displayed as undefined for XY waveforms.

The Area– measurement is normally performed using the Default Parameter settings for the parameters shown in Figure 2-66. These measurement parameters are used by other active measurements and can be changed with:

- The **Area–** pop-up menu,
- the pop-up menu of another active measurement that uses the same parameters, and
- the Default Parameters category of the **Measurements** pop-up menu. Refer to "Default Parameters Menu Category" under "Measurements Pop-up Menu" earlier in this section for detailed information.

The **Compare & References** function (in the menu/status area) alters the status of the **Area–** function, and adds a delta symbol to the name of the function (i.e., Δ**Area–**).

Algorithms for all standard measurement functions are defined in Appendix B.

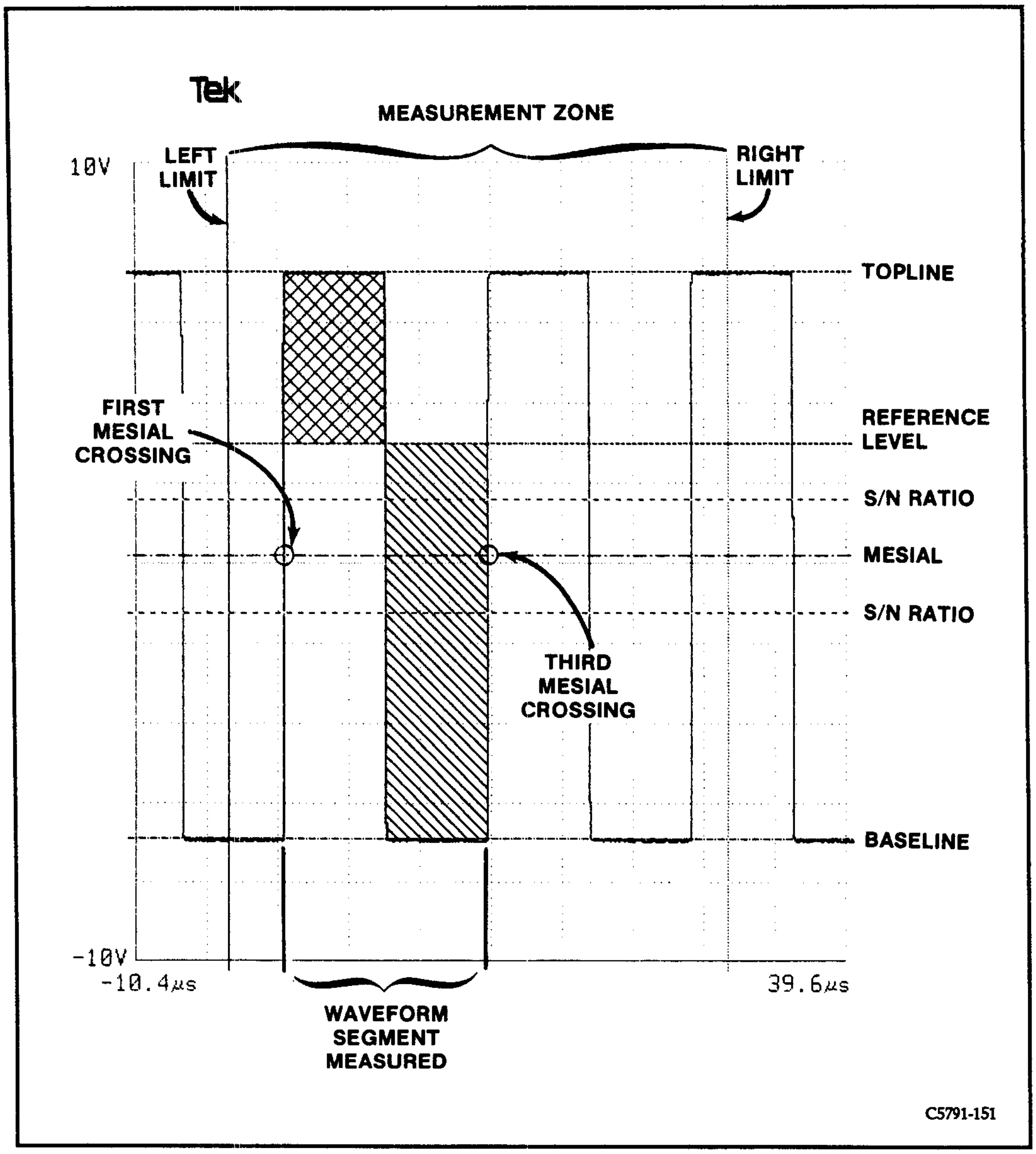

Figure 2-66. Area– measurement example.

Area– Pop-up Menu

Selecting **Area–** causes the **Area–** pop-up menu to appear in the waveform display area and highlights its label in the menu/status area (see Fig. 2-67).

The items in the pop-up menu allow control of the measurement's parameters, when selected. Current settings are displayed below the item labels. Unless previously modified for this or another active measurement, the current settings of the measurement parameters will be equal to the Default Parameter values.

Menu Items

The following menu parameters are entries in the **Area–** pop-up menu:

1. **Left** and **Right Limit**
2. **Data Interval**
3. **Topline**
4. **Mesial**
5. **Baseline**
6. **S/N Ratio (Signal/Noise)**
7. **Tracking**
8. **Setup**
9. **Reference Level**

For a detailed discussion of these measurement parameters refer to "Common Measurement Parameters" defined under "Standard Measurement Functions" earlier in this section.

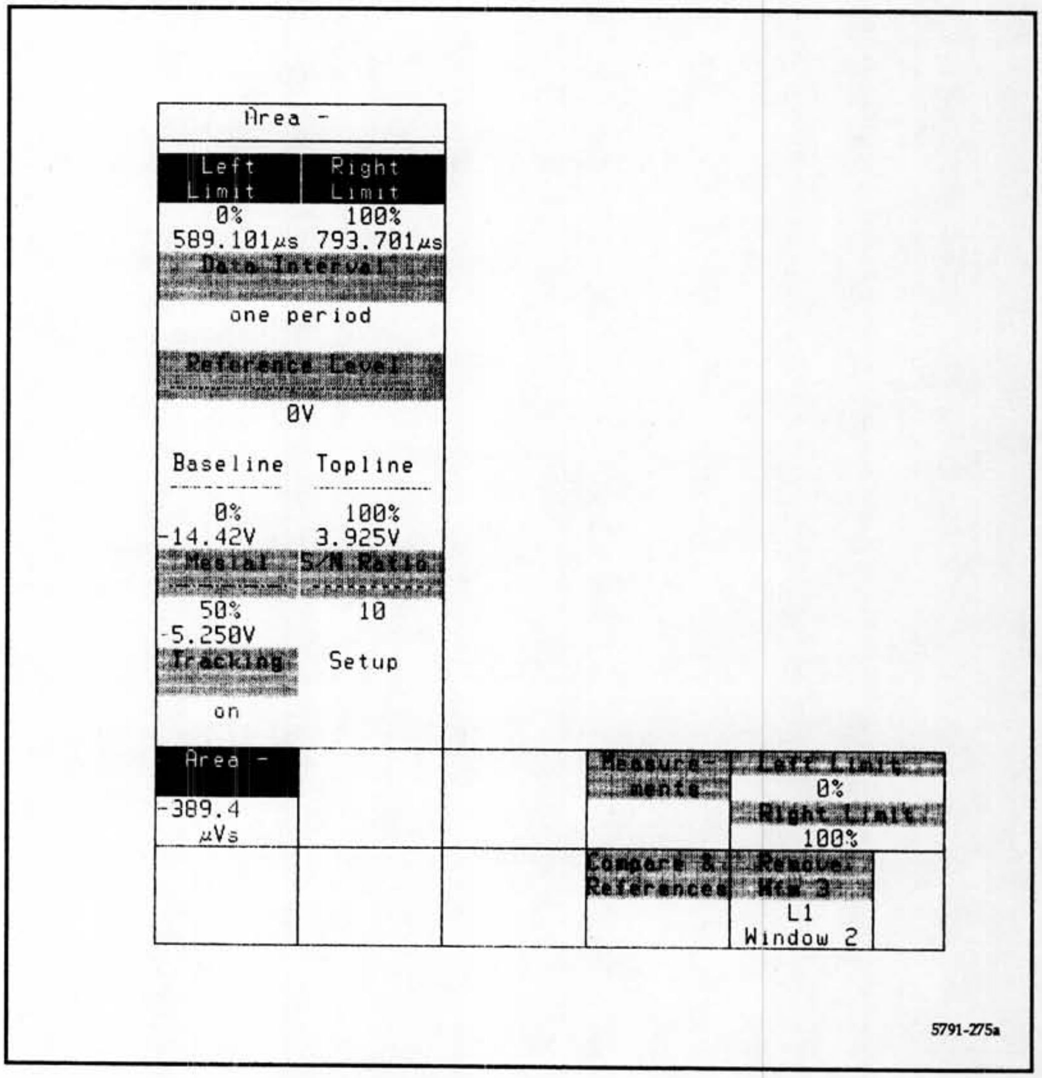

Figure 2-67. Area– pop-up menu.

Waveform Annotation

Selecting the **Area–** label (in the menu/status area) causes the following annotation on the waveform:

1. Two vertical bars define the Measurement Zone. The **Left** and **Right Limit** bars can be moved with the Control knobs when selected from the pop-up menu.
2. The Topline level of the Measurement Zone is displayed as a unique dashed line across the top of the waveform. Normally, Tracking is on so Topline is set automatically. Topline can be set with a Control knob by setting Tracking off in the pop-up menu and selecting Topline. Data Interval must be in the single period mode.
3. The Mesial percentage of the Measurement Zone is displayed as a unique dashed line across the middle of the waveform. It is variable with the Control knobs when selected from the pop-up menu. Data Interval must be in the single period mode.
4. The Baseline level of the Measurement Zone is displayed as a unique dashed line across the bottom of the waveform. Normally, Tracking is on so Baseline is automatically set. Baseline can be set with a Control knob by setting Tracking off in the pop-up menu and selecting Baseline. Data Interval must be in the single period mode.
5. The Signal-to-Noise Ratio value is displayed as a pair of unique dashed lines that are positioned equidistant from the Mesial line. S/N Ratio can be set with a Control knob by selecting it from the pop-up menu. Data Interval must be in the single period mode.
6. The waveform segment used (one period or entire Measurement Zone) in the determination of the **Area–** result is displayed at high intensity. Window indicators on the selected waveform are not displayed when the period is intensified.
7. Reference Level is displayed as a unique dashed line across the waveform. It is variable with the Control knob when selected from the pop-up menu.

Energy Computation

Press the MEASURE MENUS button to display the Measure major menu at the bottom of the screen. Then touch the **Measurements** *label to display the* **Measurements** *pop-up menu. Select the* **Energy** *label from the pop-up menu to invoke the measurement. The* **Energy** *label with its value will be displayed at the bottom of the screen. Refer to "Selecting and Ending Measurements" earlier in this section for further information.*

Selecting the **Energy** label in the menu/status area allows you to specify criteria for measuring the energy under a YT curve, within the Measurement Zone, relative to ground. When Data Interval is set to one period, the measurement is performed on the first full period in the Measurement Zone. With Data Interval set to the whole zone, the area bound by Left and Right Limits and the waveform and ground is used for the measurement. Measurements are reported to four-digits.

Voltage (V) dropped across the measured circuit or system is required for the vertical source. The energy is calculated by taking the integral of the electrical equation for power $P=V^2/R$. The measured circuit's resistance value (R) is a constant value and assumed to be one ohm. Dividing the **Energy** result by the real circuit resistance will give the actual circuit energy.

The **Energy** function is performed continuously on active waveforms, and once on stored waveforms. The energy value is displayed below the **Energy** label in the menu/status area. This measurement can be performed only on YT waveforms. The status is displayed as undefined for XY waveforms.

The Energy measurement is normally performed using the Default Parameter settings for the parameters shown in Figure 2-68. These measurement parameters are used by other active measurements and can be changed with:

- The **Energy** pop-up menu,
- the pop-up menu of another active measurement that uses the same parameters, and
- the Default Parameters category of the **Measurements** pop-up menu. Refer to "Default Parameters Menu Category" under "Measurements Pop-up Menu" earlier in this section for detailed information.

Invoking the **Compare & References** function (in the menu/status area) alters the status of the **Energy** function, and adds a delta symbol to the name of the function (i.e., Δ**Energy**).

Algorithms for all standard measurement functions are defined in Appendix B.

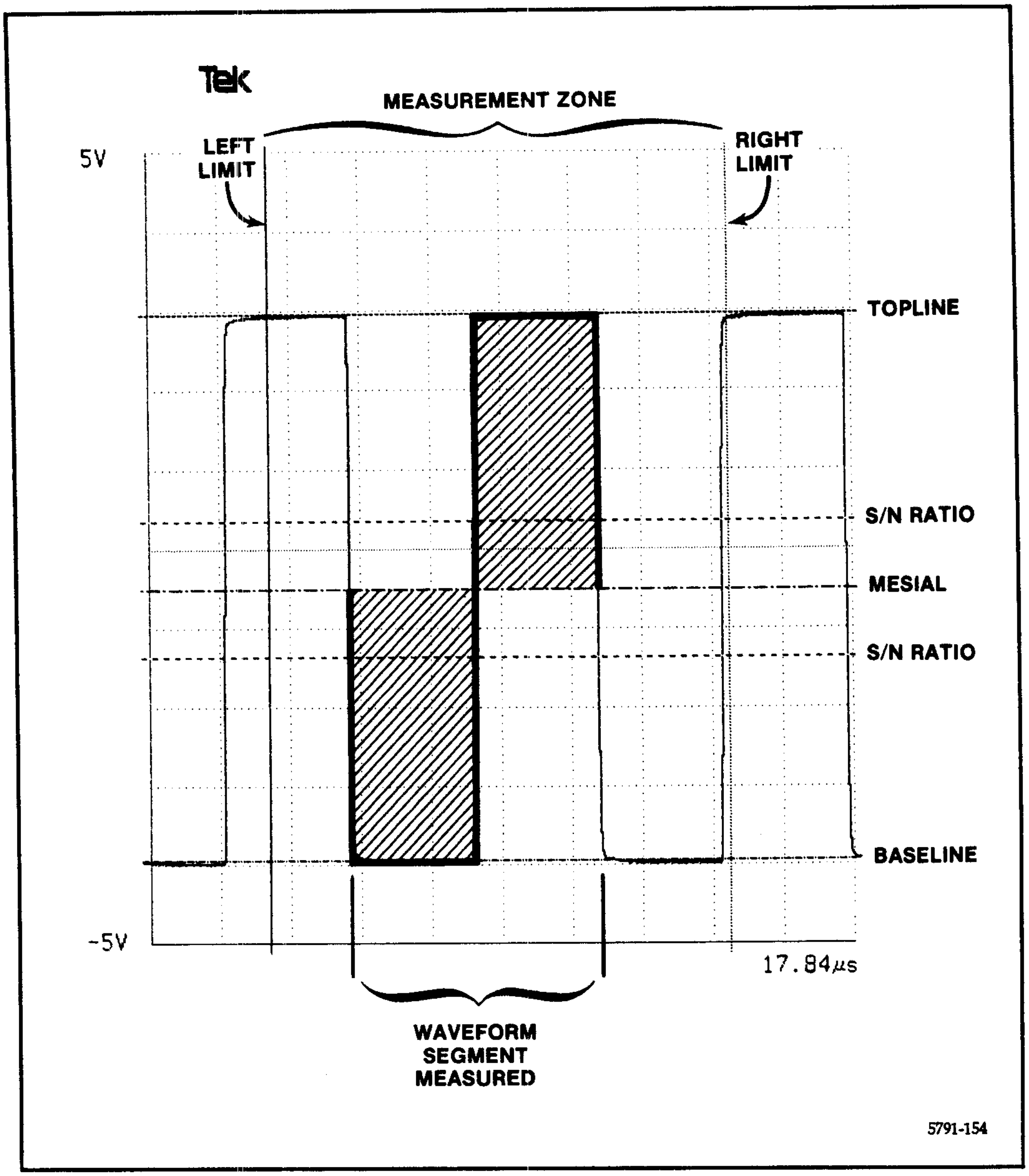

Figure 2-68. Energy measurement example.

Energy Pop-up Menu

Selecting **Energy** causes the **Energy** pop-up menu to appear in the waveform display area and highlights its label in the menu/status area (see Fig. 2-69).

The items in the pop-up menu allow control of the measurement's parameters, when selected. Current settings are displayed below the item labels. Unless previously modified for this or another active measurement, the current settings of the measurement parameters will be equal to the Default Parameter values.

Menu Items

The following menu parameters are entries in the **Energy** pop-up menu:

1. **Left** and **Right Limit**
2. **Data Interval**
3. **Topline**
4. **Mesial**
5. **Baseline**
6. **S/N Ratio (Signal/Noise)**
7. **Tracking**
8. **Setup**

For a detailed discussion of the Measurement Zone refer to "Common Measurement Parameters" defined under Standard "Measurement Functions" earlier in this section.

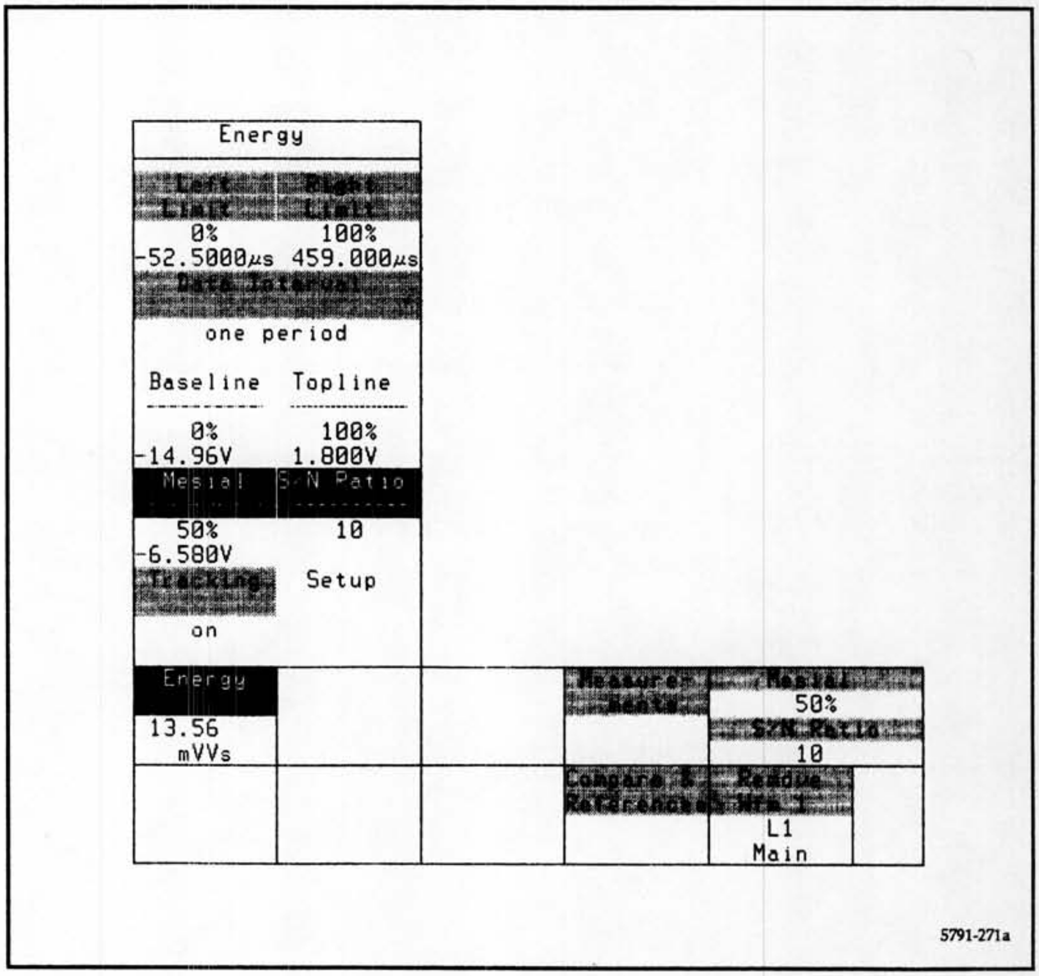

Figure 2-69. **Energy** pop-up menu.

Waveform Annotation

Selecting the **Energy** label (in the menu/status area) causes the following annotation on the waveform:

1. Two vertical bars define the Measurement Zone. The **Left** and **Right Limit** bars can be moved with the Control knobs when selected from the pop-up menu.

2. The Topline level of the Measurement Zone is displayed as a unique dashed line across the top of the waveform. Normally, Tracking is on so Topline is set automatically. Topline can be set with a Control knob by setting Tracking off in the pop-up menu and selecting Topline. Data Interval must be in the single period mode.

3. The Mesial percentage of the Measurement Zone is displayed as a unique dashed line across the middle of the waveform. It is variable with the Control knobs when selected from the pop-up menu. Data Interval must be in the single period mode.

4. The Baseline level of the Measurement Zone is displayed as a unique dashed line across the bottom of the waveform. Normally, Tracking is on so Baseline is automatically set. Baseline can be set with a Control knob by setting Tracking off in the pop-up menu and selecting Baseline. Data Interval must be in the single period mode.

5. The Signal-to-Noise Ratio value is displayed as a pair of unique dashed lines that are positioned equidistant from the Mesial line. S/N Ratio can be set with a Control knob by selecting it from the pop-up menu. Data Interval must be in the single period mode.

6. The segment of the waveform used (one period or entire Measurement Zone) to determine the Energy result is displayed at high intensity. When the period is intensified, no Window indicators on the selected waveform are displayed.

Custom Measurement Functions

Selecting the **Cursors** label at the top of a graticule displays a set of cursors (see Fig. 2-70). These cursors can be used to measure the vertical or horizontal difference between two points on the selected waveform. If a different icon or label is selected, the cursors readout will remain active on the display, however you must select the **Cursors** icon to resume control of the cursors.

The Control knobs are assigned to position the cursors. Resolution can be set to coarse, medium, or fine by touching a knob label and selecting the desired resolution.

The following items are displayed in the Cursors major menu:

- **Cursor Type** label—Displays the **Cursor Type** pop-up menu (see Fig. 2-71) which allows selection of several types of cursors:

  Paired Dots—Two intensified dots (the default) residing on the selected waveform.

  Split Dots—Two intensified dots, one on the selected waveform, and the other on a second waveform.

  Vertical Bars—Two vertical bar cursors the full height of the graticule with the selected waveform.

  Horizontal Bars—Two horizontal bar cursors the full width of the graticule with the selected waveform.

  Cursors' status—The absolute position of each cursor with respect to the trigger point and/or the zero-volt level. Also shown are the difference between the cursor position (delta) and 1/delta (frequency) for cursor time measurements. When the dot cursor resides on an out-of-range data point, the status readout will display ≥ or ≤.

- **Remove Wfm**—Produces the **Remove Wfm** pop-up.

A single cursor can be used to perform absolute vertical and horizontal coordinate data measurements for any point on a waveform. Two cursors allow difference vertical and horizontal measurements between two points on one waveform or different waveforms.

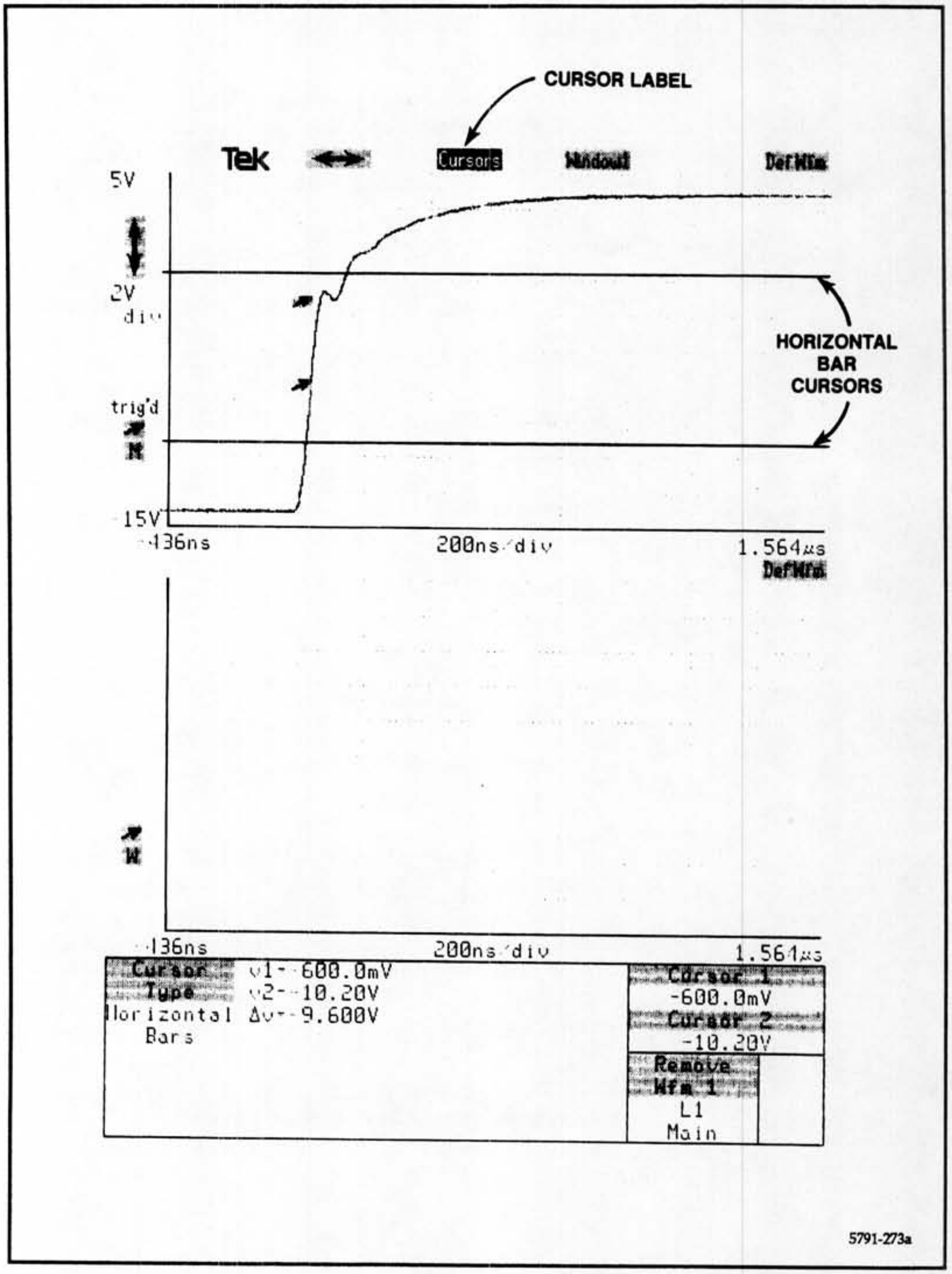

Figure 2-70. Two-graticule display with **Cursors** label and Horizontal Bar Cursors.

Cursor Type Pop-up Menu

Touching the **Cursor Type** label in the menu/status area will display the **Cursor Type** pop-up menu in the waveform display area.

The **Cursor Type** pop-up menu allows the user to select the type of cursors associated with the selected waveform, and assign control of those cursors to the Control knobs.

The positions of each type of cursor are remembered, so that when changing cursor types, the previous locations are restored.

When only one waveform is displayed, cursors cannot be split. Therefore, when the **Cursor Type** label is selected, the pop-up menu will list no waveforms under the **Split** label.

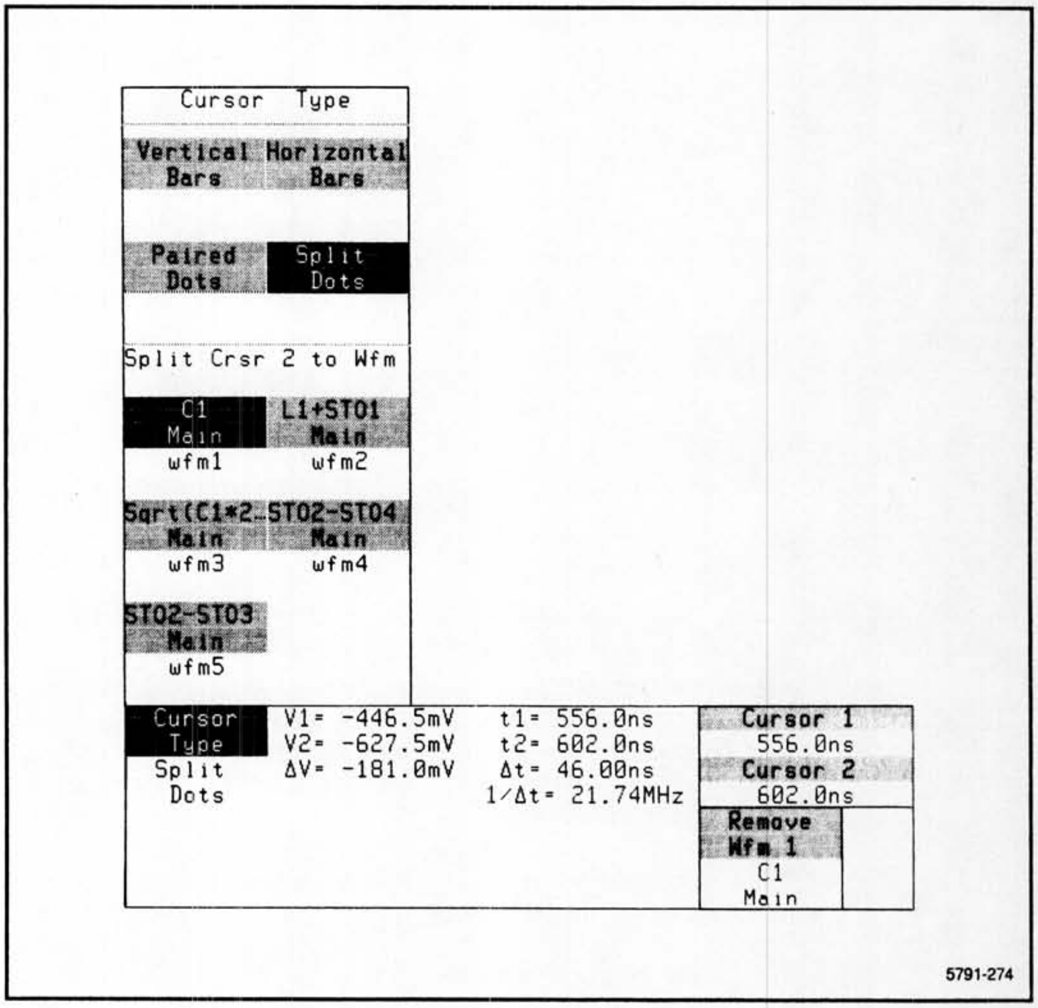

Figure 2-71. **Cursor Type** pop-up menu.

Cursor Type Menu Items

The **Cursor Type** pop-up menu makes various types of cursors available, as follows:

- **Vertical Bars**—Two Vertical Bar Cursors are placed on the screen. Other than their screen placement, readout relationship to time t=0, and the size of the horizontal scale, these bars are not related to waveform data. The bars extend the full height of the graticule containing the selected waveform, and are displayed at the high-intensity level. Generally, vertical bars 1 and 2 are initially placed at horizontal divisions 1 and 9, respectively.
- **Horizontal Bars**—Two Horizontal Bar Cursors are placed on the screen. Other than their screen placement, readout relationship to ground, v=0, and the size of the vertical scale, these bars are not related to waveform data. The bars extend the full width of the graticule containing the selected waveform and are displayed at the high-intensity level. Generally, horizontal bars 1 and 2 are initially placed at vertical divisions 1 and 9, respectively.
- **Paired Dots**—Two bright dot cursors are placed on the selected waveform. Generally, cursors 1 and 2 are initially placed at the beginning and end, respectively, of the waveform record.
- **Split Dots**—Two bright dot cursors are placed on waveform data points. Cursor 2 is placed on the waveform selected in the pop-up menu at the last point of the record. Cursor 1 is placed on the selected waveform.
- **Split Crsr 2 to Wfm**—List of displayed waveforms for selection as second waveform when using Split Dot cursors.

Selecting any function from the **Cursor Type** pop-up menu causes an exit from the pop-up menu, and assigns cursor-movement functions to the Top and Bottom Control knobs.

Positioning the Dot Cursor

Cursor 1 can be located before or after Cursor 2. Because paired and split cursors are positioned with respect to the waveform data record, their resolution is determined by the data record resolution, not by the horizontal display resolution.

Cursors associated with one waveform are independent of cursors on other waveforms. Moving one waveform's cursors does not affect the position of the other waveform's cursors.

Whenever a dot-cursor-bearing display is moved offscreen, an arrow at the edge of the graticule indicates the location of the offscreen dot cursor.

The Control knobs can be set for coarse, medium, or fine adjustments. Refer to "Control Knobs and Numeric Keypad Operation" under "Touch Panel Operation" earlier in this section for information on Control knob operation.

Paired or Split Dot Cursors

Dot cursors can be used on one waveform, or the two dots can be separated and placed on two waveforms. Putting the dot cursors on separate waveforms produces a split-dot cursor display.

Vertical Bars

The time relationship between the vertical bar cursors and T=0 (trigger point) is displayed below the Control knob labels and in the menu/status area. (Refer to Fig. 2-70). That is, the time difference between vertical bar 1 and T=0 is displayed below the Top Control knob label (**Cursor1**), and the time difference between vertical bar 2 and T=0 is displayed below the Bottom Control knob label (**Cursor2**). The time difference between bar 1 and bar 2 (Δt) is displayed in the menu/status area. The $1/\Delta t$ (frequency) is also calculated and displayed in the menu/status area. Each cursor is based upon the current scale factor (time/div for YT and voltage for XY) of the selected waveform.

Horizontal Bars

The voltage difference between each Horizontal Bar Cursor and V=0 (ground reference) is displayed below its Control knob label, and, with the voltage difference between the two Horizontal Bar Cursors, displayed in the menu/status area. (See Fig. 2-70.)

Storing and Recalling Waveforms

The Store/Recall major menu provides access to functions that permit storing, clearing, deleting, and recalling waveforms and front-panel settings.

Pressing the STORE/RECALL button causes the Store/Recall major menu to be displayed in the menu/status area of the screen (see Fig. 2-72).

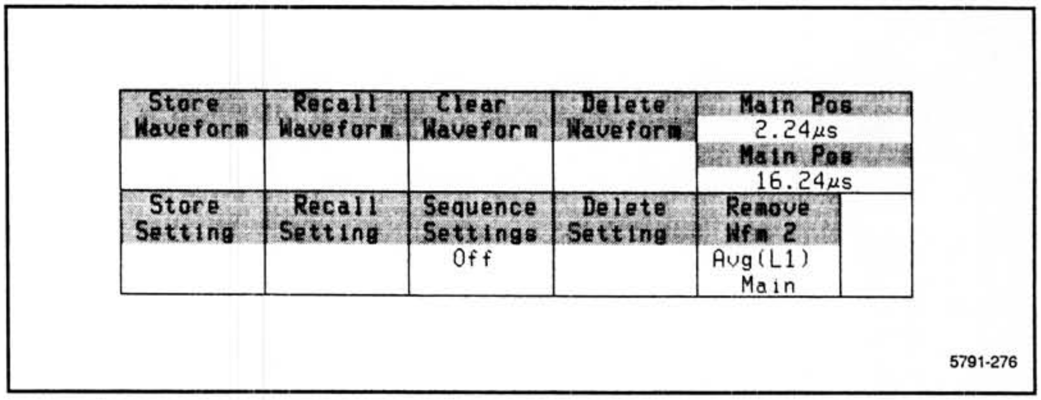

Figure 2-72. Store/Recall Major Menu.

Store/Recall Menu Function Selections

Functions selectable in the Store/Recall major menu are listed in Table 2-6. A detailed description of each function listed in the table is given in the text following the table.

TABLE 2-6
Store/Recall Major Menu Functions

Function	Operation
Store Waveform	Stores one or all displayed waveforms in internal memory.
Recall Waveform	Recalls a stored waveform from memory and displays it.
Clear Waveform	Stops acquisition, erases displayed waveform, and restarts acquisition.
Delete Waveform	Deletes any or all continuously acquired and stored waveforms.
Store Setting	Stores up to ten sets of front-panel settings in NV ram for available Recall Setting info.

TABLE 2-6 (cont)
Store/Recall Major Menu Functions

Function	Operation
Recall Setting	Recalls a set of front-panel settings previously stored in nonvolatile memory.
Sequence Settings	Sequentially steps through all sets of front-panel settings previously stored in nonvolatile memory.
Delete Setting	Deletes previously stored sets of front-panel settings.

Storing a Waveform

The **Store Waveform** function provides the means to store a duplicate of any or all continuously acquired waveforms, or displayed, stored waveforms.

XY waveforms may be stored only by storing the two individual components as YT waveforms. Point Accumulate waveforms cannot be stored.

If a waveform is displayed, the **Store Waveform** label is highlighted in the menu/status area, and any valid selection from the pop-up menu is highlighted. If no waveforms are displayed, the **Store Waveform** function is not selectable from the menu/status area and its label is low intensity.

Store Waveform Pop-up Menu

Selecting the **Store Waveform** label will display the **Store Waveform** pop-up menu in the waveform display area and highlight its label in the menu/status area. The **Store Waveform** pop-up menu is shown in Figure 2-73.

Selecting any item in the **Store Waveform** pop-up menu will store the subject waveform or waveforms, and exit the pop-up menu. The instrument assigns a name to the stored waveform. **Stored xxx**, where xxx is the **Next Storage:** number in the automatic numbering scheme.

Menu Items

The following items are entries in the **Store Waveform** pop-up menu:

- **Next Storage:** #—Gives the number that will be assigned to the next waveform stored. If the **Store All** function is invoked for multiple waveforms, numbering proceeds through the listed waveforms top to bottom and left to right. After the first waveform in the list, numbers are assigned to waveforms to fill vacancies in the numerical sequence displayed in the **Recall Waveform** pop-up menu.

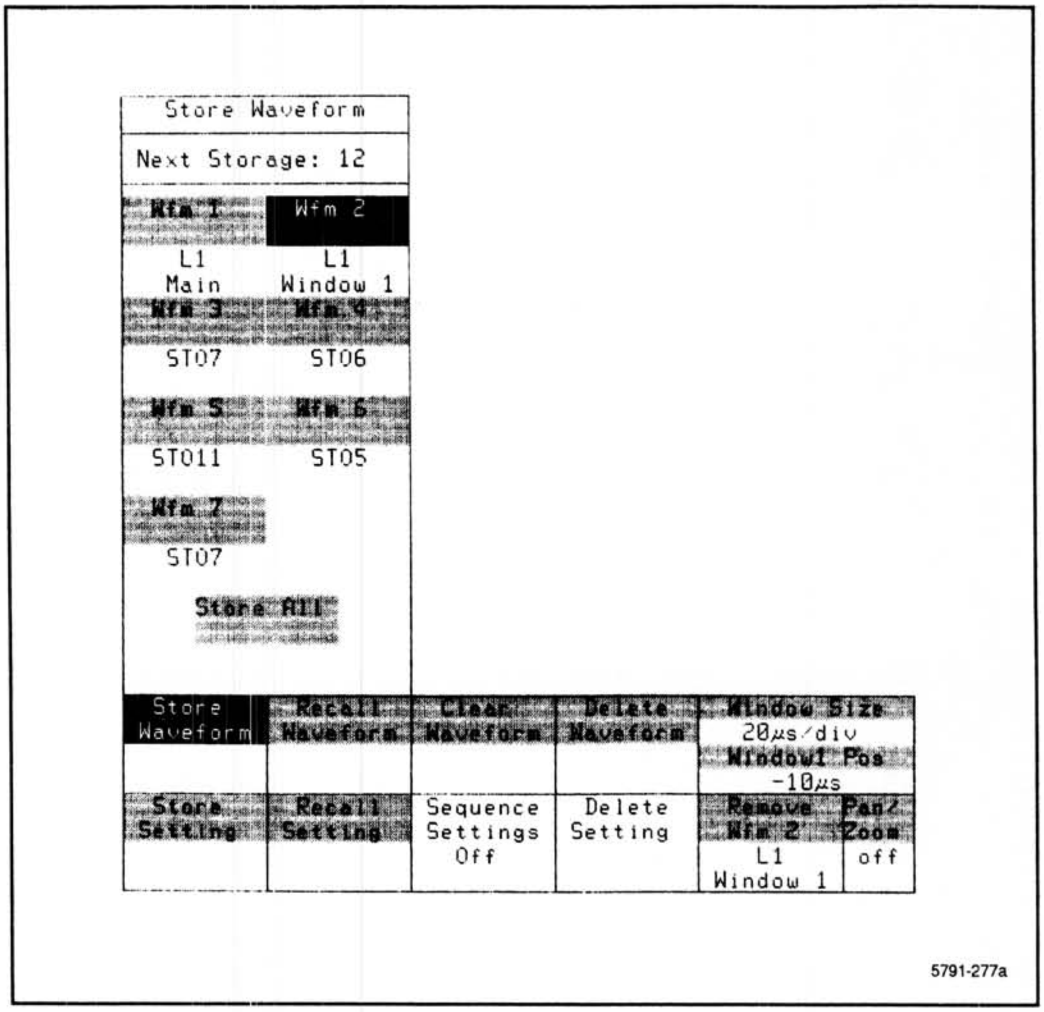

Figure 2-73. Store Waveform pop-up menu.

- Waveform labels—Up to eight YT waveform labels are listed in the pop-up menu, which is the maximum number of waveforms the instrument can display. The label for each displayed waveform identifies its source. Touching any waveform label will store that waveform and exit the pop-up menu.

  When the **Store Waveform** pop-up menu is called, the label for the selected waveform will be highlighted.

- **Store All**—Stores all displayed waveforms simultaneously and exits the pop-up menu.

Recalling a Waveform

The **Recall Waveform** function allows up to eight previously stored waveforms to be recalled and displayed. Only eight waveforms can be displayed on the screen at one time.

Recall Stored Waveform Pop-up Menu

Selecting the **Recall Waveform** label in the menu/status area will highlight its label and cause the **Recall Stored Waveform** pop-up menu to appear in the waveform display area. The **Recall Waveform** pop-up menu is shown in Figure 2-74.

Menu Items

The following items are entries in the **Recall Stored Waveform** pop-up menu.

- **Stored x**—The waveform stored at each menu selection is identified with the number assigned by the instrument when the waveform was stored. Up to eight waveforms can be recalled from memory and displayed.
- **Page ↑ and Page ↓**—These functions allow paging through the stored waveform list one page at a time (ten waveforms) when more than 12 waveforms are stored. The page labels will be highlighted when the waveform list extends beyond the current page.

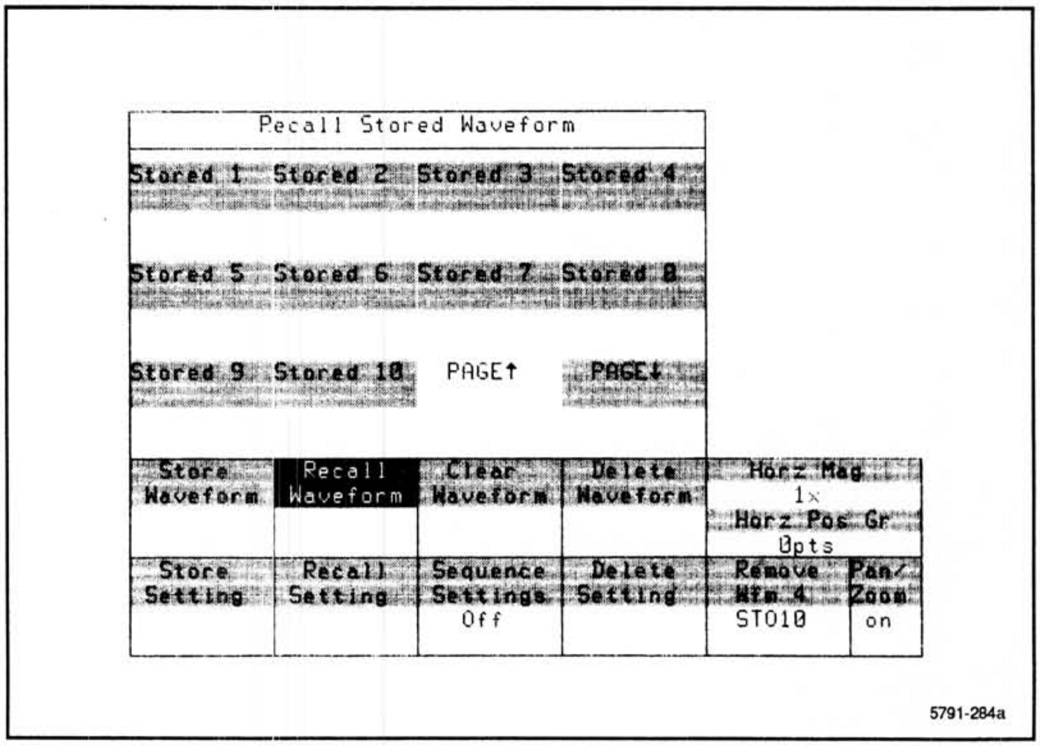

Figure 2-74. Recall Stored Waveform pop-up menu.

Clearing a Waveform

The **Clear Waveform** function clears one or all of the continuously acquired waveform records. Clearing a waveform results in stopping the acquisition and nullifying the waveform. Acquisition will resume if the digitizer was running when the **Clear Waveform** function was activated.

Clear Waveform Pop-up Menu

Touching the **Clear Waveform** label in the menu/status area will highlight its label and display the **Clear Waveform** pop-up menu in the waveform display area. The **Clear Waveform** pop-up menu is shown in Figure 2-75.

Selecting any item in the **Clear Waveform** pop-up menu results in that waveform being nullified and the menu exited.

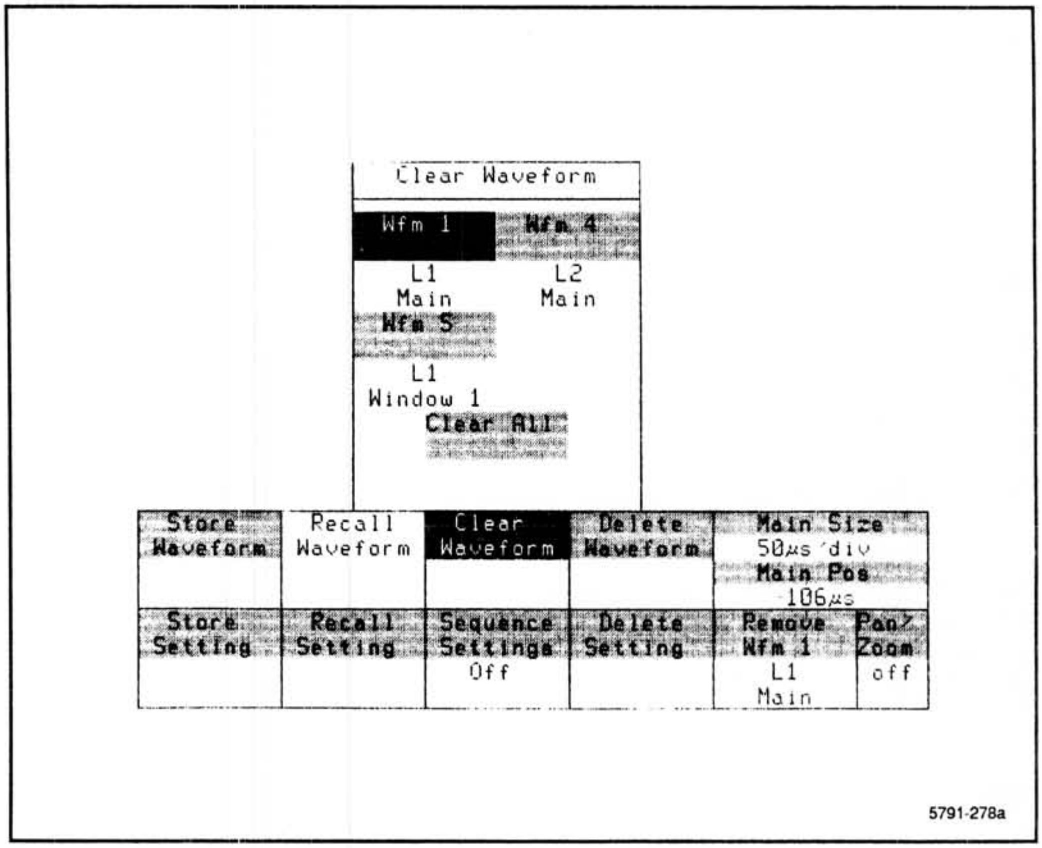

Figure 2-75. Clear Waveform pop-up menu.

Menu Items

The following items are entries in the **Clear Waveform** pop-up menu:

- **Wfm** (Waveform labels)—Up to eight XY (combined vertical and horizontal source descriptions) or YT waveform descriptions are shown in the pop-up menu; that is, one for each displayed waveform. The instrument assigns names to waveforms based on their origin (e.g., L1 for channel 1 in the left vertical compartment and Main for main horizontal). The label for the selected waveform will be highlighted.

- **Clear All**—This item clears all continuously acquired waveforms.

Deleting Waveforms

The **Delete Waveform** function allows deletion of any or all waveforms. Previously stored waveforms are deleted from memory, and acquisition of continuously acquired waveforms is stopped. Displayed stored waveforms can be selected from the Displayed category, then selected from the Stored category. This deletes them from the display and memory. All deleted waveforms are removed from the display.

Delete Waveform Pop-up Menu

Selecting **Delete Waveform** in the menu/status area will highlight its label and cause the **Delete Waveform** pop-up menu to appear in the waveform display area. The pop-up menu has two categories, **Displayed Waveforms** and **Stored Waveforms.** The **Delete Waveform** pop-up menu is shown in Figure 2-76.

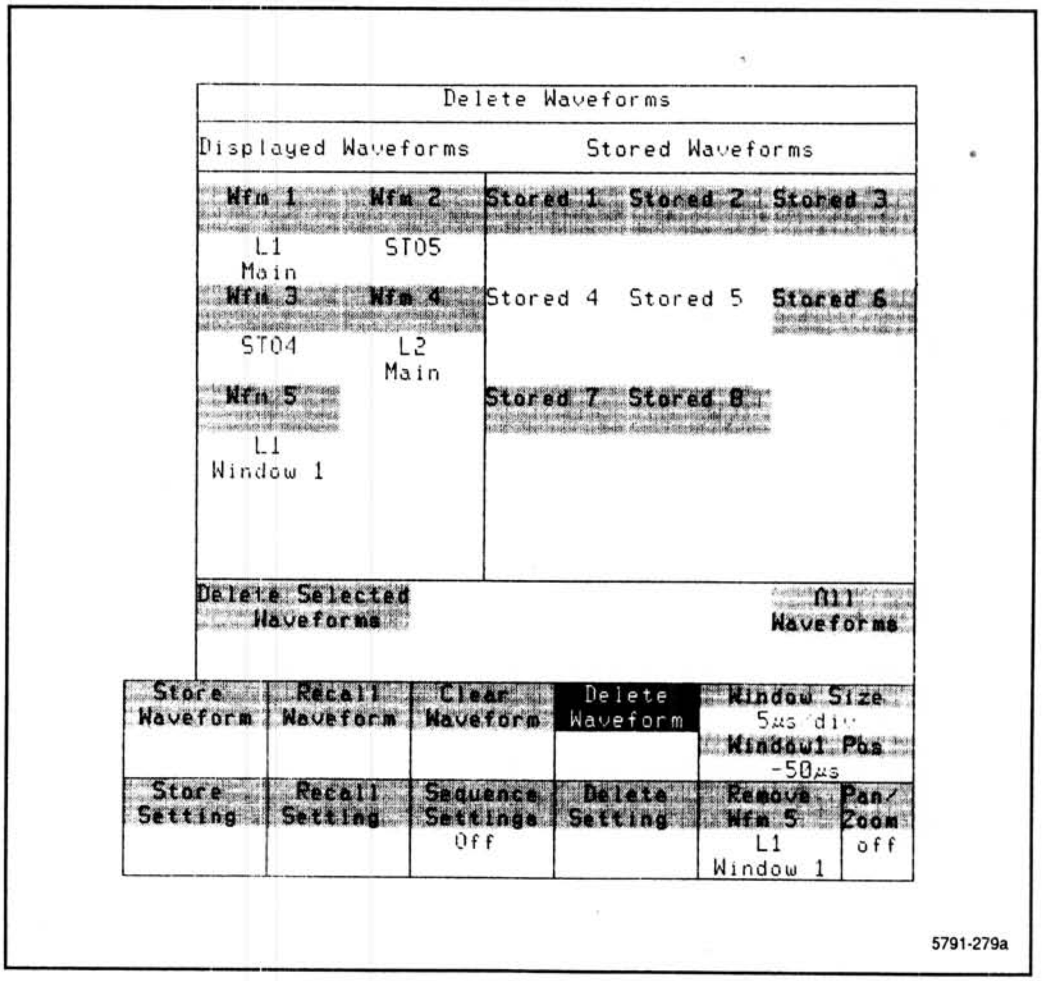

Figure 2-76. Delete Waveform pop-up menu.

Menu Items

The following items are entries in the **Delete Waveform** pop-up menu.

- **Displayed Waveforms**—This portion of the pop-up menu contains labels for up to eight displayed waveforms. Each label corresponding to a waveform contains the vertical and horizontal source information for that waveform. To select a waveform for deletion, touch its label in the pop-up menu. The label will be highlighted and the waveform will be deleted when all selections have been made and the **Delete Selected Waveforms** label is touched. Stored waveforms are deleted from the display, but not from memory.

- **Stored Waveforms**—This portion of the pop-up menu contains labels for all previously stored waveforms. The label for each stored waveform contains the waveform name assigned by the instrument when it was stored. The label will be highlighted when selected, and the corresponding waveform will be deleted when all selections have been made and the **Delete Selected Waveforms** label is touched. Stored waveforms that are displayed are not selectable unless they have been first selected from **Displayed Waveforms**.

- **Page ↑ and Page ↓**—These functions allow paging through the stored waveform list one page at a time (ten waveforms) when more than 12 waveforms are stored. The page labels will be highlighted when the waveform list extends beyond the current page.

- **Delete Selected Waveforms**—Touching this label removes the **Delete Waveform** pop-up menu from the display and removes all waveforms whose labels have been selected (medium-intensity background).

- **All Waveforms**—Touching this label selects all waveform entries for deletion.

Storing Front-Panel Settings

This function provides the ability to store a copy of the present front-panel settings in nonvolatile memory. The settings of the 11401/11402 and its plug-ins are stored, however, trace description and scaling information for stored waveform displays are saved only while the power remains on. Settings that do not include stored components are saved when instrument power is turned off. Table 2-7 lists the parameters stored for the current setting.

Store Present Front Panel Setting Pop-up Menu

Touching **Store Setting** in the menu/status area will highlight its label and cause the **Store Present Front Panel Setting** pop-up menu to appear in the waveform display area. The **Store Present Front Panel Setting** pop-up menu is shown in Figure 2-77.

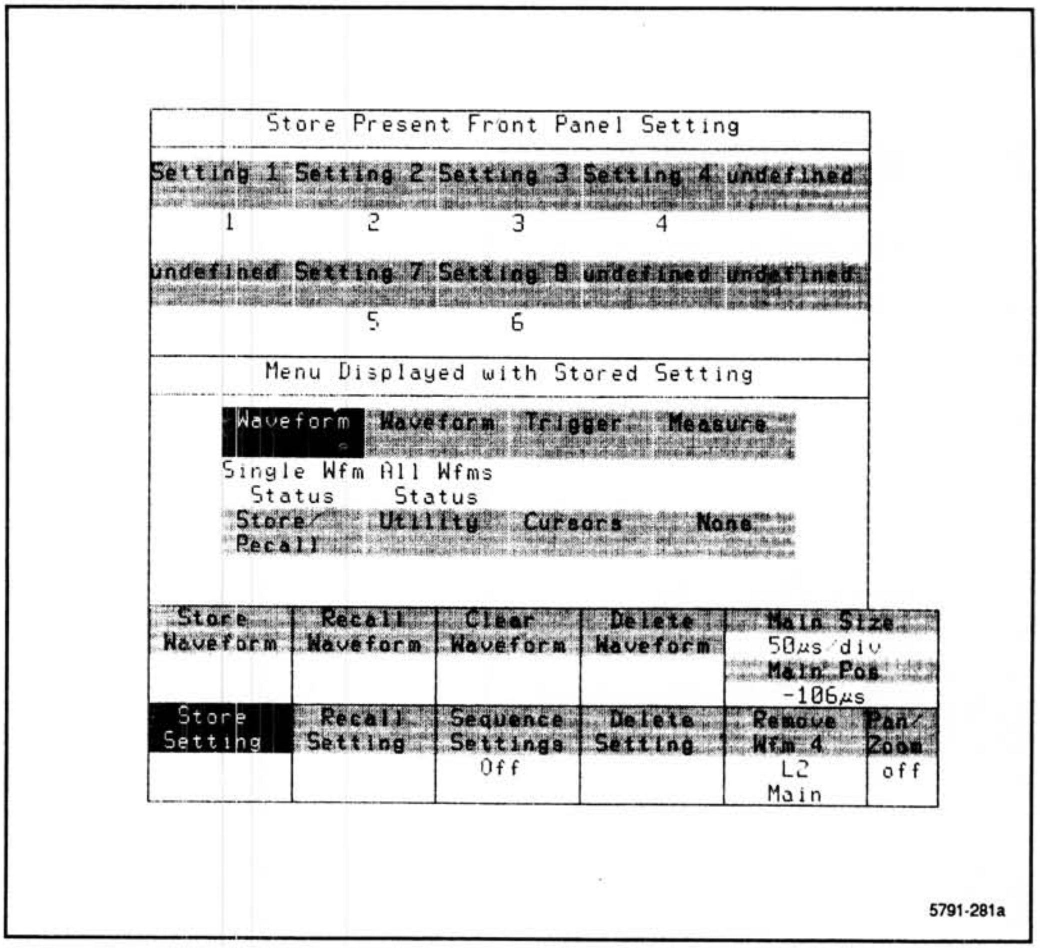

Figure 2-77. Store Present Front Panel Setting pop-up menu.

TABLE 2-7
Parameters Stored for Current Settings

Hardware Configuration Plug-in Units Installed	**Trigger (Main, Window)**
Type Serial number Number of channels Probes Offset value	Source Coupling Mode Slope Level Holdoff Time Events (Windows only)
Active Plug-in Channels	**Acquisition Options**
Sensitivity Offset Coupling (+,–) Impedance Bandwidth Limit (upper,lower) Differential Amp offsets	% Fill Number of Averages Number of Envelopes Stop Conditions Single Shot mode
Displayed Traces*	**Measurements**
Type (YT,XY) Vertical description Graticule location (single,upper,lower) Vertical Size Vertical Position YT Display Mode (Normal/Point Accumulate) Horizontal Size Horizontal Position Cursor type and positions Pan/Zoom Measurement parameters	Selected active Default Parameters settings Compare (on/off) Reference measurement values
	Options Selected
	Autoset Waveform Scaling (forced/optional) Vectored Display (on/off) Display Intensity Audio Feedback (on/off)
Time Base (Main and Window)	**Major Menus**
Record length Duration of sweep Sample interval Horizontal scale factor Window Holdoff Mode Position from trigger Main Window 1 Window 2	Control Knob assignments Save Setting selection

*Setting parameters for displayed, stored waveforms are saved so long as the instrument remains on.

Menu Items

The following items are entries in the **Store Present Front Panel Setting** pop-up menu:

- Setting locations—Touch locations for each of the 10 front-panel settings are shown in the pop-up menu, in numerical order.

  The entries have two types of labels: **undefined**, where no front-panel settings have been assigned to that location, and **Setting xx**, where xx is a number from one to ten corresponding to its location in the pop-up menu.

  Selecting any entry in the pop-up menu results in storing the front-panel setting in that location. If the location was undefined, the name is changed to the default numbering described above, and the pop-up menu is exited.

  The status below each setting label indicates the front-panel sequencing order (see the explanation of **Sequence Setting** later in this section). If a front-panel setting is stored or deleted, the sequence will automatically be renumbered.

- **Menu Displayed with Stored Setting**—allows selection of the major menu that will appear in the menu/status area when a stored setting is recalled. The **None** selection produces a blank major menu area (i.e., no major menu selected) when the setting is recalled.

Recalling Front-Panel Settings

The **Recall Setting** function provides the ability to recall a previously stored front-panel setting from nonvolatile memory.

When recalling a setting, the major menu stored with the setting appears in the menu/status area, and the front-panel settings are replaced by the recalled settings. This will cause an exit from the Store/Recall major menu, unless the Store/Recall major menu was saved with the setting.

Recall Front Panel Settings Pop-up Menu

Touching the **Recall Setting** label in the menu/status area will highlight its label and cause the **Recall Front Panel Setting** pop-up menu to appear in the waveform display area. The **Recall Front Panel Setting** pop-up menu is shown in Figure 2-78.

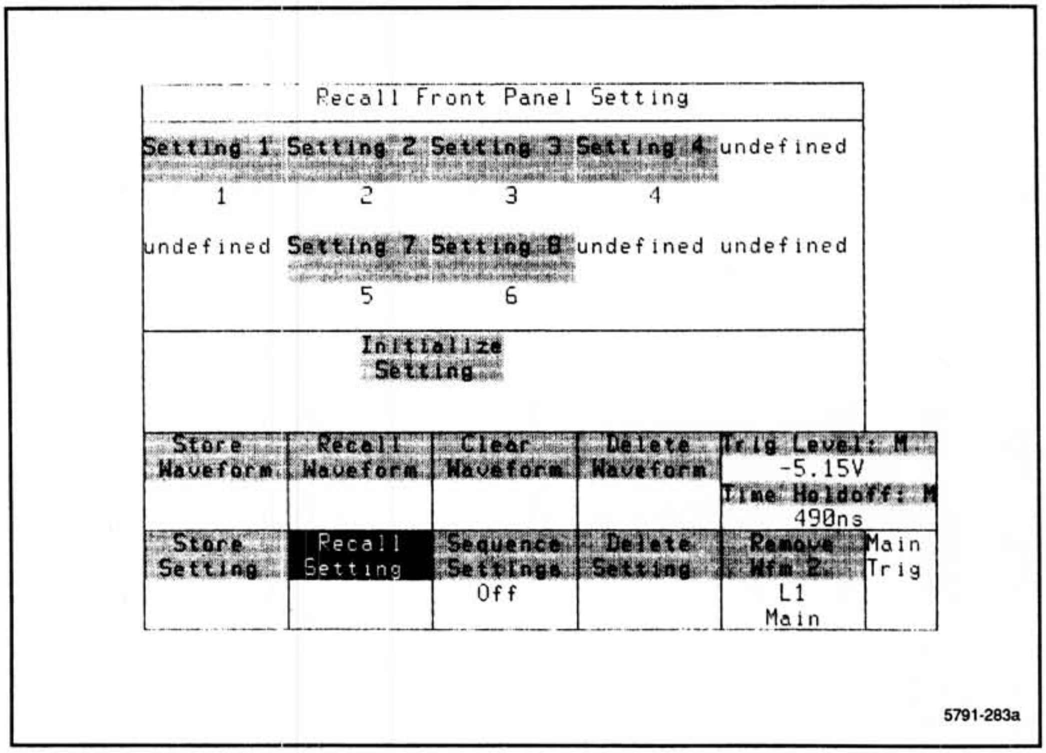

Figure 2-78. Recall Front Panel Setting pop-up menu.

Menu Items

The following are entries in the **Recall Front Panel Setting** pop-up menu:

- Setting locations—Touch locations for each of the ten possible front-panel settings are shown in the pop-up menu, in numerical order.

  The entries have two types of labels: **undefined**, where no front-panel setting has been assigned to that location, and **Setting xx**, where xx is a number from one to ten corresponding to its location in the pop-up menu.

- **Initialize Setting**—This eleventh location is available to recall the instrument default settings. These settings are those assigned when the instrument is initialized through the **Utility** major menu and are listed in Table 2-9.

  If **Sequence Setting** is turned on (its label highlighted), the status below each label touch area indicates the front-panel sequencing order (see the explanation of **Sequencing Setting** later in this section). Storing or deleting a front-panel setting will cause renumbering of the sequence when the **Recall Front Panel Setting** pop-up menu is called again.

Sequencing Front-Panel Settings

The **Sequence Setting** function provides the ability to sequence through front-panel stored settings.

After **Sequence Settings** has been selected in the Store/Recall major menu and the **Sequencing** label is selected, touching the **Next Setting** label in the pop-up menu will recall the next front-panel setting in sequence. To assign the probe ID buttons to sequence through the stored settings, use the **Probes** function in the Utility major menu.

Front-panel settings are recalled in order as they appear in the **Recall Front Panel Setting** pop-up menu. Sequencing is from one to ten, skipping any undefined location(s). Automatic looping occurs at the last setting in the sequence and returns to the first front-panel setting. This function enables a user to recall a front-panel setting used for a particular test routine, then sequence to the next stored setting for another test routine.

The **Sequencing** function toggles on and off, and allows selection of the **Next Setting** label. If turned on, the sequence will begin at the first front-panel setting when the **Next Setting** label is touched.

If no front-panel settings are stored, the sequence function is invalid, and its label is dim in the menu/status area.

Sequence Front Panel Settings Pop-up Menu

Touching the **Sequence Setting** label in the menu/status area will highlight its label and cause the **Sequence Front Panel Settings** pop-up menu to appear in the waveform display area. The **Sequence Front Panel Settings** pop-up is shown in Figure 2-79.

Menu Items

The following items are entries in the **Sequence Front Panel Settings** pop-up menu:

- **Sequencing**—Touching this label causes the status to toggle **on**, which assigns the **Next Sequence** pop-up menu label to sequence front-panel settings. **Off** assigns the probe ID buttons for waveform and input channel selection if they were previously assigned to sequencing with the **Probes** pop-up menu.

  When the **Sequence Setting** function is selected, one of two status messages will appear beneath its label in the menu/status area:

  1. **Off**—Indicates that sequence function is not operating and that all probe ID buttons are assigned to waveform and input channel selection.

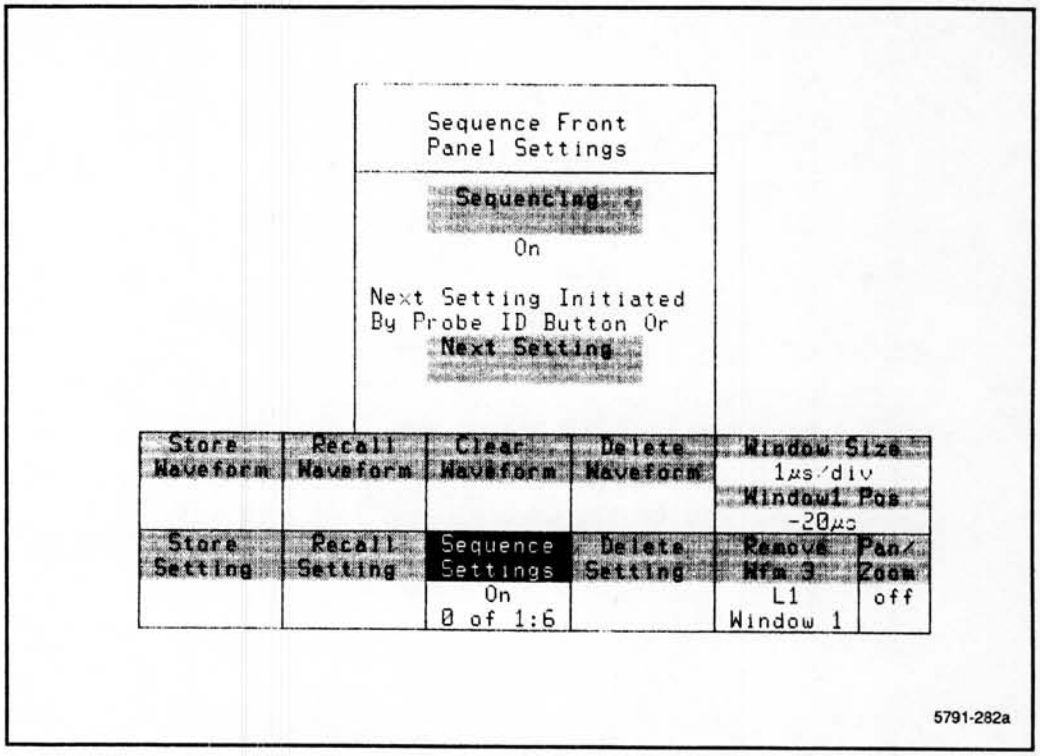

Figure 2-79. Sequence Front Panel Settings pop-up menu.

2. **On n of 1:m**—Indicates that sequence function is on and that the present sequence location is n of the sequence range 1 to m. Maximum value for m is 10 (the number of setting locations). N=0 when the sequence function is initially turned on and will increment to 1 when the probe ID button is pressed or the **Next Sequence** label is touched.

- **Next Setting**—When **Sequencing** is on, sequences to the next front-panel setting when touched.

Deleting Settings

The **Delete Setting** function allows deletion of front-panel settings previously stored with the **Store Setting** function in the Store/Recall major menu.

Delete Setting Pop-up Menu

Touching the **Delete Setting** in the menu/status area will highlight its label and cause the **Delete Setting** pop-up menu to appear in the waveform display area. The **Delete Setting** pop-up menu is shown in Figure 2-80.

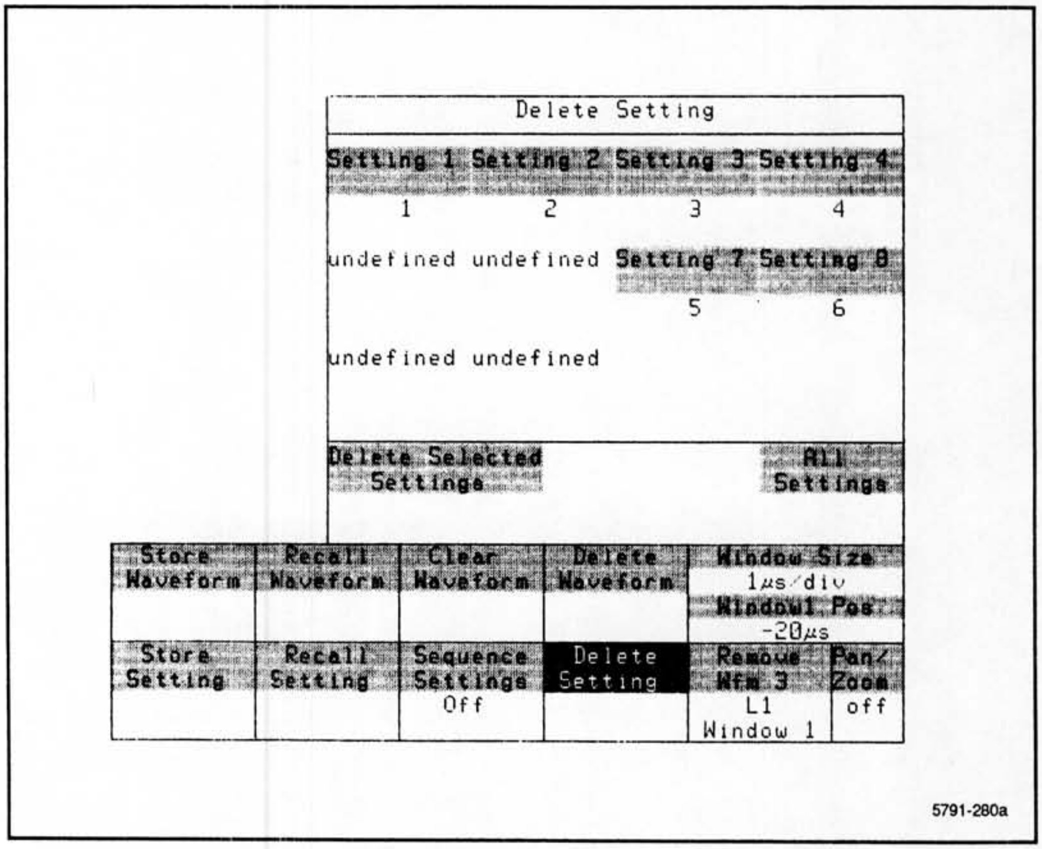

Figure 2-80. Delete Setting pop-up menu.

Menu Items

The following are entries in the **Delete Setting** pop-up menu:

- Setting locations—Only the labels for locations containing stored front-panel settings are selectable in the pop-up menu. Any or all settings' labels may be selected for deletion, which is executed when the **Delete Selected Settings** label is touched.
- **Delete Selected Settings**—Deletes selected settings and exits the pop-up menu.
- **All Settings**—All stored settings are selected for deletion.

Utilities

Pressing the UTILITY button displays the Utility major menu in the menu/status area of the screen (see Fig. 2-81).

The Utility major menu provides access to functions that are infrequently used in the normal operations of waveform acquisition and measurements.

The currently selected waveform (medium intensity) is used for all waveform related operations while in the Utility major menu. "Currently selected" means the last waveform selected or displayed.

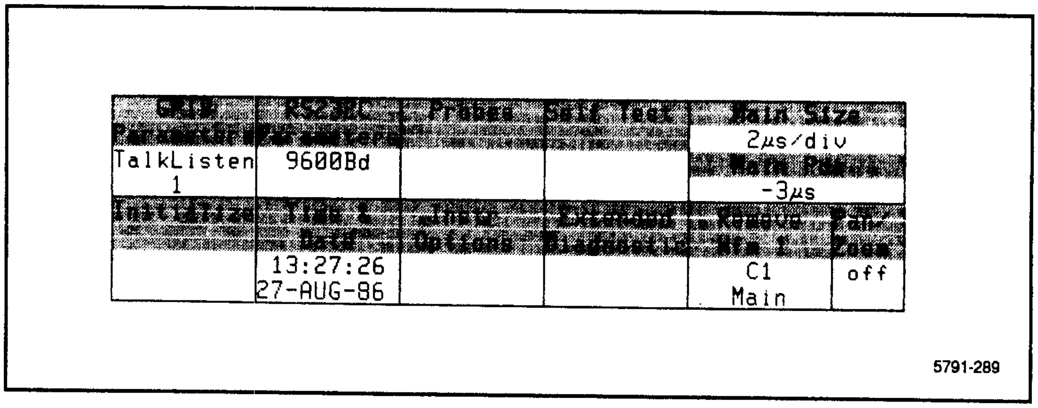

Figure 2-81. Utility Major Menu.

Utility Menu Function Selection

Functions that can be performed through the Utility major menu are listed in Table 2-8. A detailed description of each function listed in the table is discussed in the text following the table.

TABLE 2-8
Utility Major Menu Functions

Function	Operation Performed
GPIB Parameters	Sets the parameters related to GPIB communication.
RS232C Parameters	Sets the parameters related to RS-232-C communication.
Probes	Sets the parameters to compensate, calibrate, and deskew the probes, and the action associated with probe ID's.
Self-Test	Executes an immediate Self-Test performance check of the instrument.

TABLE 2-8 (cont)
Utility Major Menu Functions

Function	Operation Performed
Initialize	Sets all functions and controls to the state shown in Table 2-9, Initialized Settings.
Time & Date	Sets the time of day and date.
Instr Options	Sets the Operating Configuration, AutoSet options, Enhanced Accuracy mode, touch sense audio feedback, display intensity, display mode, Hardcopy mode, and Hardcopy abort. Configuration data is displayed including the instrument codes, the firmware version, the amount of memory installed, and the ID numbers of all system modules.
Extended Diagnostic	Enters the extended diagnostic mode and allows you to check the integrity of individual test modules.

GPIB Communication Parameters

Selecting the **GPIB Parameters** label in the Utilities major menu allows the user to set the characteristics of the GPIB parallel interface, in order to send and receive messages or data. The selected settings are stored in nonvolatile memory for use at the next power up, or in case of power loss.

For a detailed description of the GPIB interface, refer to section 3, "GPIB and RS-232-C Interfaces."

GPIB Parameters Pop-up Menu

Touching the **GPIB Parameters** label will display the **GPIB Parameters** pop-up menu in the waveform display area (see Fig. 2-82).

Menu Items

The following items are entries in the **GPIB Parameters** pop-up menu:

- **Mode**—The GPIB mode may be toggled between **Talk/Listen** and **Off Bus** by successively touching the **Mode** label.
- **Address**—The GPIB address may be changed with a Control knob when the **Address** label is touched. The acceptable address range is from 0 to 30.
- **Terminator**—The GPIB message terminator is toggled between EOI,(End of Input) and EOI/LF(End of Input/Line Feed) with successive touches of this

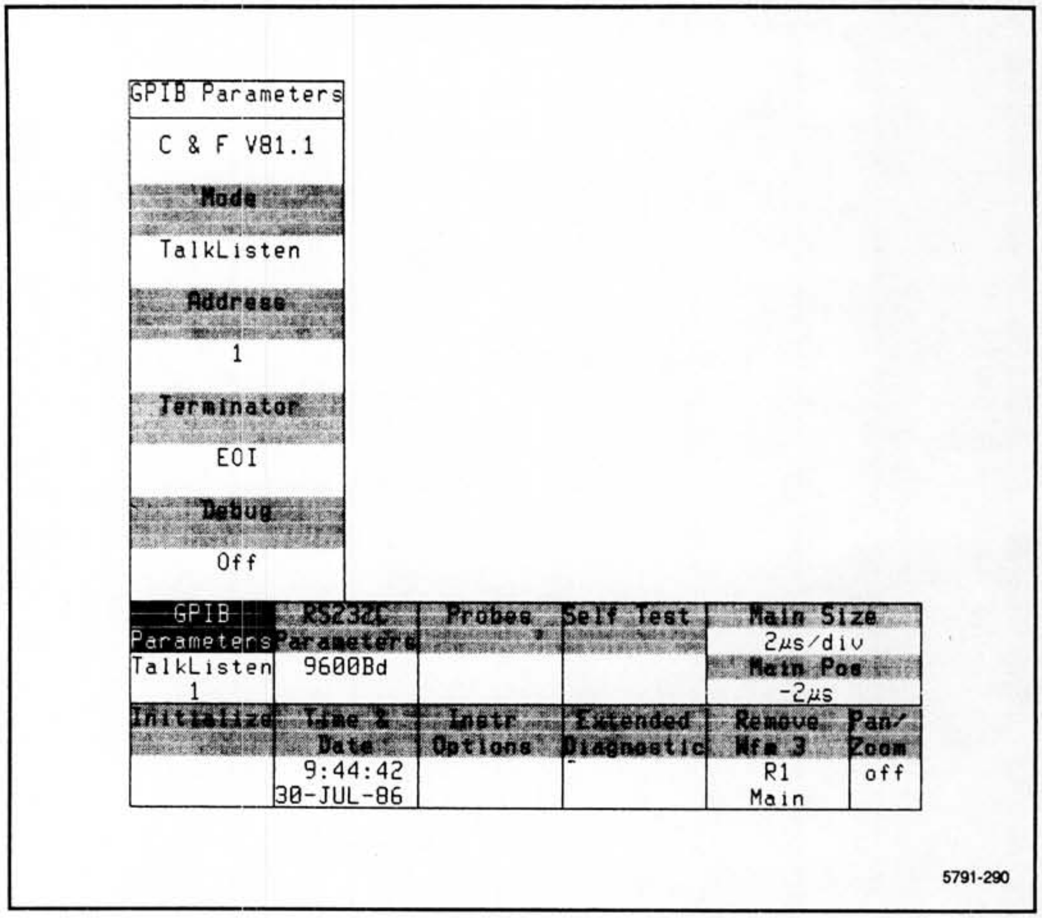

Figure 2-82. GPIB Parameters pop-up menu.

- **Debug**—The debug mode may be toggled **On** or **Off** by touching the Debug label. **Debug On** displays commands in the order of occurrence in the message area of the screen. This significantly reduces the transmission rate. A command or query that follows an EOI will clear the message area before it is displayed. If an error occurs, an event code message is displayed which describes the error. The event codes and messages are listed and discussed under "Event Code Reporting" in Section 3 "GPIB and RS-232-c Interfaces" of this manual. ASCII waveform transmissions are displayed; binary waveform transmissions and binary settings are not.

RS-232-C Communications Parameters

Selecting the **RS232C Parameters** label in the Utilities major menu allows the user to set the various physical characteristics of the RS-232-C serial communication interface.

The selected settings are stored in nonvolatile memory for use at the next power up, or in case of power loss. For a detailed description of the RS-232-C interface, refer to Section 3, "GPIB and RS-232-C Interfaces".

RS232C Parameters Pop-up Menu

Touching the **RS232C Parameters** label will display the **RS232C Parameters** pop-up menu in the waveform display area (see Fig. 2-83).

Menu Items

The following items are entries in the **RS232C Parameters** pop-up menu:

- **Baud Rate**—The baud rate of the RS-232-C interface may be changed by a Control knob when the **Baud Rate** label is selected. The accepted settings are 110, 150, 300, 600, 1200, 2400, 4800, 9600, and 19,200.
- **Echo**—The echo of the RS-232-C interface may be toggled between **On** and **Off**.
- **Stop Bits**—The stop bits for RS-232-C interface may be toggled to toggled among **Soft** (DC1/DC3), **Hard** (CTS/DTR), or **None**.
- **Flagging**—The control of transmission for RS-232-C data may be to select 1, 1.5, or 2 bits.
- **Parity**—The parity of the RS-232-C interface may be toggled among **Even**, **Odd**, or **None**.
- **Delay**—The minimum delay (in seconds) from receipt of an RS-232-C query or output command to the time the response can be sent. When selected, this label assigns a Control knob to adjust the delay time parameter.
- **EOL String**—The end-of-line query terminator is toggled between **CR/LF**, **LF/CR**, **CR**, and **LF** with successive touches of this label.
- **Verbose**—When the **Verbose** mode is toggled **On**, a prompt informs the Controller of the outcome of each command and indicates success or failure. When **Off**, the Controller must query the instrument to check for events.

- **Debug**—The debug mode may be toggled **On** or **Off** by touching the appropriate label. **Debug On** displays commands by order of occurrence in the message area of the screen. This significantly reduces the transmission rate. A command or query that follows an EOI will clear the message area before it is displayed. If an error occurs, an event code message is displayed to describe the error. The event codes and messages are listed and discussed under "Event Code Reporting" in Section 3 "GPIB and RS-232-C Interfaces" of this manual. ASCII waveform transmissions are displayed; binary waveform transmissions and binary settings are not.

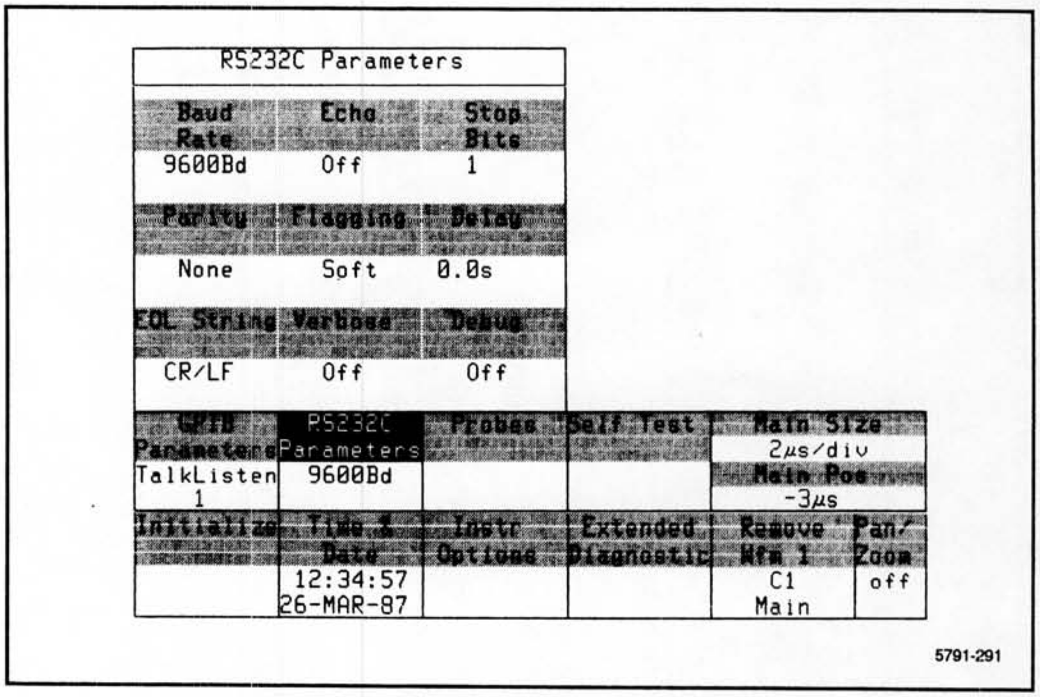

Figure 2-83. RS232C Parameters pop-up menu.

Probe Calibration and ID Function

Selecting the **Probes** label in the Utility major menu provides the ability to compensate, calibrate, and deskew (restore delayed signals to proper phase) connected probes and to assign the action of the probes' ID buttons. Compensation, calibration, and deskewing are possible whether or not the channel is presently in use. Once calibration is complete for one channel, other channels can be calibrated by attaching a channel probe to the CALIBRATOR output and returning to the **Probes** pop-up menu.

The Probe ID function selected applies to all probes connected to generic two or four channel plug-in units.

Probes Pop-up Menu

Touching the **Probes** label will display the **Probes** pop-up menu in the waveform display area (see Fig. 2-84(A)).

Menu Items

The following categories and items are entries in the **Probes** pop-up menu:

- **Probe ID Function**—the action associated with the probe ID buttons may be one of the following:

  1. **Waveform Select/New Wfm:**

     Displays a waveform from the associated plug-in unit channel if the channel was not previously being acquired. If the channel was being acquired, then an existing display composed solely of that channel will be selected (brightened to medium intensity). Otherwise, displayed waveforms with the channel as a component can be sequentially selected by repeatedly pushing the probe ID button. In addition, an appropriate event will be reported to the RS-232-C and GPIB ports, if the IDProbe SRQMASK is enabled.

  2. **Wfm Select/New Wfm & AutoSet:**

     Displays a waveform following the same rules defined for **Waveform Select/New Wfm** plus newly acquired waveforms are automatically sized and positioned on the screen.

  3. **Sequence Settings:**

     Sets the instrument to perform according to the next front panel setting stored in nonvolatile memory. See the discussions of front panel settings under "Storing and Recalling Waveforms" earlier in this section. In addition, an appropriate event will be reported to the RS-232-C and GPIB ports, if active.

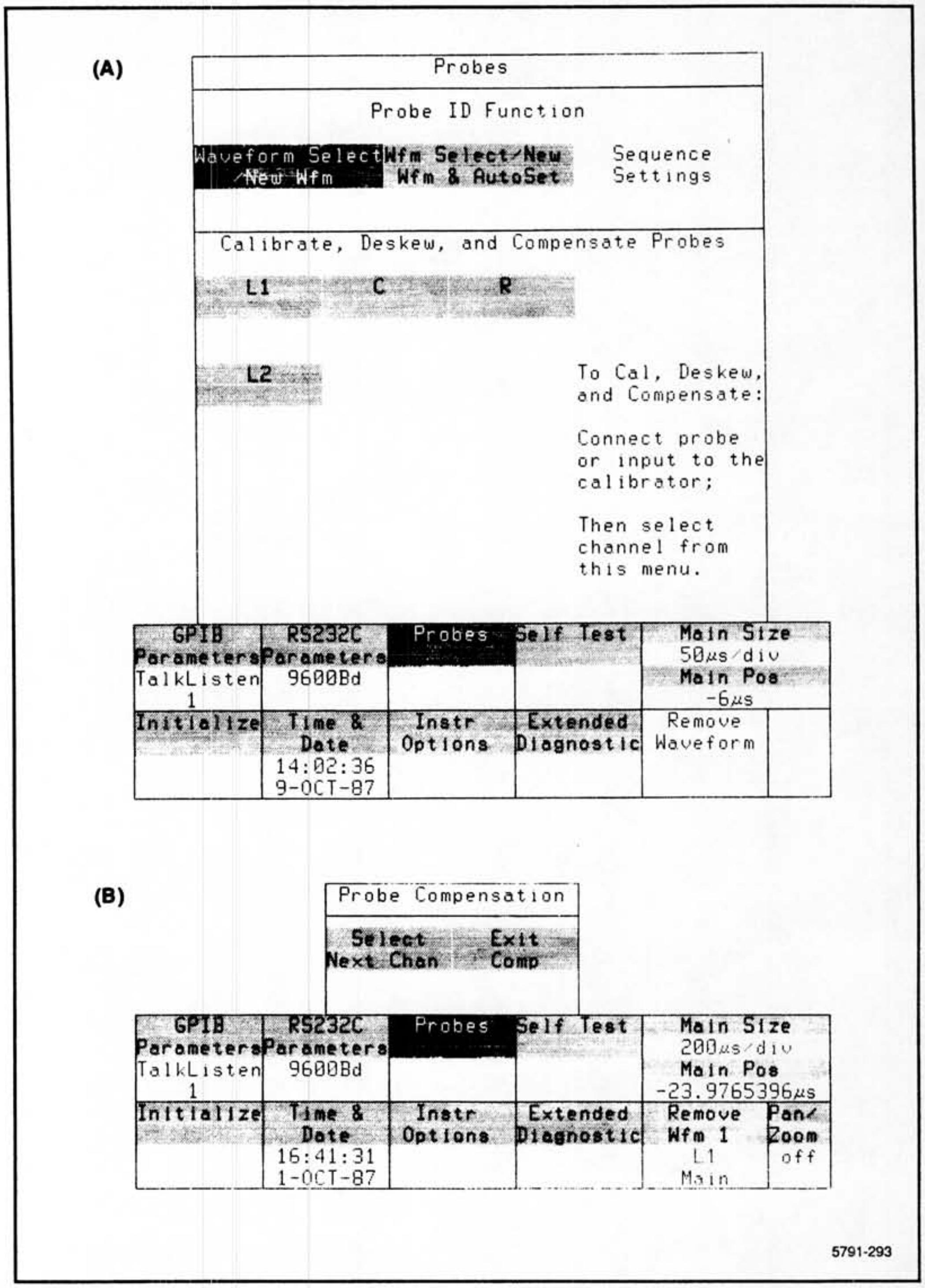

Figure 2-84. Probes and Probe Compensation menus.

- **Calibrate, Deskew, and Compensate Probes**

All presently installed plug-in channels are listed so that each may be deskewed, calibrated, and compensated. A simplified procedure, to calibrate, deskew, and compensate probes is displayed on the screen. A more detailed procedure is given here:

NOTE

The following procedure 1. is valid only for standard amplifier plug-ins. Refer to the procedure 2. for calibrating differential amplifier plug-ins.

1. Standard Amplifier Plug-ins.

   a. Connect the probe or other input lead to the front-panel CALIBRATOR's signal and ground connections.

   b. Touch the **Probes** pop-up menu label that describes the channel (e.g., R1 for Right, channel 1). The channel will be vertically calibrated, then deskewed (balances the propagation delay) against an internal reference signal. The deskew operation aligns waveform records to negate differences in the propagation delays through different channels. Inductance and resistance of the probes and channels as seen by the incoming signal are not changed. Calibration and deskewing are complete when a message appears at the top of the screen that prompts you to compensate the probe.

   c. When the **Probe Compensation** pop-up menu is displayed (refer to Fig. 2-84(B)), compensate the probe by adjusting the compensation control on the probe. Adjust the control so the displayed square wave has a flat top.

   d. If another channel is to be calibrated, touch the **Select Next Chan** label to return to the **Probes** pop-up menu. Otherwise touch the **Exit Comp** label to finish compensation.

2. Differential Amplifier Plug-ins.

   This calibration procedure will improve common mode rejection when using probes recommended for a differential amplifier or differential comparator plug-in (e.g., P6135, P6134).

   The two probes used must be of the same type.

   a. Install one probe on the –input of the differential amplifier plug-in. (There must be no probe installed on the + input.)

   b. Perform step a, b, anc c in the procedure described above. On a P6135 probe, both LF COARSE and LF Fine may be used.

c. Install the other probe on the + input of the differential amplifier plug-in. Connect this probe to the front-panel CALIBRATOR's signal and ground connections. Do not remove the other probe from the CALIBRATOR.

d. Observe that the waveform displayed on screen has become nearly a straight line. There may be a small spike where the step was displayed, and the trace segments before and after this horizontal point may be displaced vertically from one another.

e. Compensate the probe connected to the +input. On a P6135 probe, adjust the DC ATTEN and the LF FINE (and the LF COARSE if necessary) to reduce the display to a straight line, eliminating the spike and the vertical displacement. On a P6134 probe, adjust only the compensation adjustment to eliminate the spike. The vertical displacement (dc attenuation mismatch) cannot be removed.

f. To end the procedure, touch the Exit Comp label in the Probe Compensation menu, and disconnect the probes from the CALIBRATOR.

Instrument Configuration and Display Options

Selecting the **Instr Options** label in the Utility major menu allows selection of a variety of operating modes and provides a complete listing of the current system configuration. The display intensity and display mode can also be changed in the **Instrument Options** pop-up menu. Initializing the instrument will set the instrument options to their default settings. Refer to "Initialize Function" later in this section for a listing of Initializing defaults.

The instrument configuration information listed at the bottom of the **Instrument Options** pop-up menu is useful when ordering accessories and plug-is, and for instrument service personnel.

Instrument Options Pop-up Menu

Touching the **Instr Options** label in the Utility major menu causes its pop-up menu to be displayed in the waveform display area (see Fig. 2-85). Current status information is displayed below the pop-up menu labels.

Menu Items

The following categories and items are entries in the **Instrument Options** pop-up menu:

- Configuration information—A listing of mainframe and plug-in identity information.

  Instr—The names of the mainframe and installed plug-in units.

  Section—The major section of the named instruments in column one.

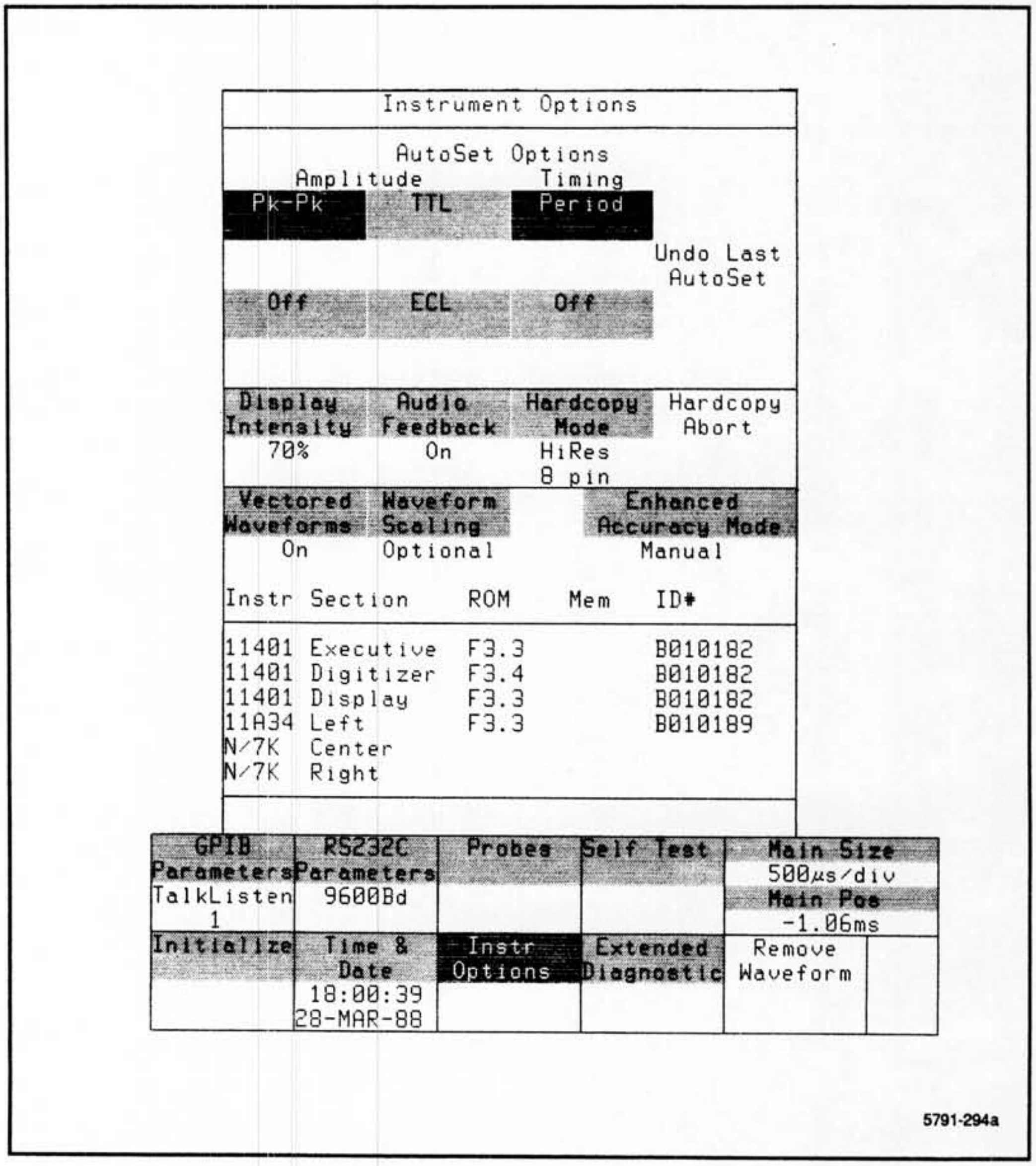

Figure 2-85. Instr Options pop-up menu.

ROM—The version of firmware in each section of the named instruments.

ID#—The identification number for each section of the named instruments.

MEM—The amount of memory in each section of the named instruments if the memory options exist.

- **AutoSet Options**—For more information refer to "Displaying a Waveform Using AUTOSET" in this section.

Timing—The automatic **Timing** (time base control) feature may be turned **Off** or left in the **Period** mode.

Amplitude—The automatic **Amplitude** (vertical sensitivity) feature may be turned Off or put in one of three modes: **Pk-Pk, TTL** or **ECL**. The **TTL** and **ECL** choices set the vertical scale for the logic levels of their respective IC families. The default **Pk-Pk** selection seeks a vertical scale based on an automatic peak-to-peak measurement of the acquired signal.

Undo Last AutoSet—Returns all settings to the state that existed prior to pushing the front-panel AUTOSET button.

- **Display Intensity**—Assigns a Control knob to adjust the intensity of the display screen.

- **Audio Feedback**—Toggles the audible feedback associated with the instrument controls and error messages **On** or **Off**.

- **Enhanced Accuracy Mode**—Toggles the Enhanced Accuracy system between **Manual** and **Automatic** execution. In the automatic mode, the instrument automatically recalibrates itself to the Enhanced Accuracy state when the internal temperature changes ±5°C.

- **Vectored Waveforms**—Toggles the vectoring of waveform displays **On** or **Off**. When **Off**, adjacent waveform data points are not connected by vectors on the display.

- **Waveform Scaling**—Toggles between Forced and Optional. When set to Forced, all subsequently defined Waveform functions are computed using floating point, high precision arithmetic. Resolution is increased to six digits for all Waveform functions, but Average and Envelope, which give adequate results using four-digit integer arithmetic, will take longer to compute.

  When toggled to Optional, subsequently defined Waveform Functions that only need integer arithmetic and four digit resolution will be computed more quickly using integer arithmetic. Functions that require floating point arithmetic (e.g., Log, Diff, etc.) will still be computed using floating point arithmetic.

  Waveforms defined before the status of Waveform Scaling was changed are not affected by the change. They continue to be computed with the mode that was in effect when they were created.

- Hardcopy Mode—Toggles one of these six hardcopy print modes: HiRes/8 pin, Draft/8 pin, Reduced/8 pin, HiRes/24 pin, Draft/24 pin, and Reduced/24 pin.

  Each mode selects a pair of printing attributes. The first attribute is the hardcopy format, which can be either **HiRes, Draft,** or **Reduced.** HiRes hardcopies are approximately 8.5 inches by 11 inches and, as the name suggests, yield the greatest front-panel detail of the three possible formats.

Draft hardcopies are similar to HiRes hardcopies except that no overstriking is used to depict front-panel intensified regions. Reduced hardcopies are much smaller than Draft or HiRes and show absolutely no front-panel intensified regions.

The second attribute selects one of two types of Centronics printers: **8 pin** or **24 pin.** An 8 pin printer supports the standard Epson command set. Examples of such printers include the Tektronix 4644 and Epson EX-800. A 24 pin printer supports the extended Epson command set (often referred to as a "letter quality" dot matrix printer). The Epson LQ-1500 is an example of such a printer.

- **Hardcopy Abort**—dequeues (i.e., deletes) all previously queued hardcopy requests and aborts any hardcopy currently in progress.

Self-Test

Selecting the **Self-Test** label in the Utility major menu initiates a set of internal diagnostic tests that do not require user intervention. The instrument stores settings as in a power-down sequence and proceeds with the tests. After an error-free run of the tests, the previous settings are restored and the instrument resumes normal operations. If an error is discovered, the instrument runs the remaining Self-Tests, then automatically enters the **Extended Diagnostics** mode and displays the detected error(s). To set the display for normal operation, select the **(E)Exit** label at the bottom of the screen. If a fatal error is detected in the Digitizer or Display subsystems, exiting will not be possible.

The set of Self-Tests can also be run when **Extended Diagnostics** are invoked. Some of the **Extended Diagnostics** tests require action by the service person, whereas no Self-Tests require or allow user interaction. Touching the Touch Screen or any front panel buttons during the Self-Test may result in a test error condition. If repair of this instrument is required contact a qualified Service personnel.

Extended Diagnostics

Touching the **Extended Diagnostic** label in the Utility major menu causes the instrument to enter the Extended Diagnostics test mode. This mode provides qualified service personnel with diagnostic tools to help troubleshoot the instrument. If Extended Diagnostics is inadvertently selected, the **Extended Diagnostics** menu will appear in the menu/status area. Normal operation mode can be resumed by touching the **(E)Exit** label in the lower right corner of the screen.

The Extended Diagnostics mode is automatically entered if the instrument Self-Tests fail. If a failure occurs, contact a qualified service person.

Time and Date Control

Selecting the **Time and Date** label in the Utility major menu allows the user to set the time and date and to view their current status. In addition, the number of hours of instrument on-time and the number of power-up operations are displayed.

The time and date function is provided by the hardware. (Battery backup provides nonvolatility.) Once the time and date has been set, the correct time/date will be kept to within seven minutes per year.

Time and Date Pop-up Menu

Selecting the **Time and Date** label from the menu/status area of the Utility menu causes its pop-up menu to be displayed in the waveform display area (see Fig. 2-86).

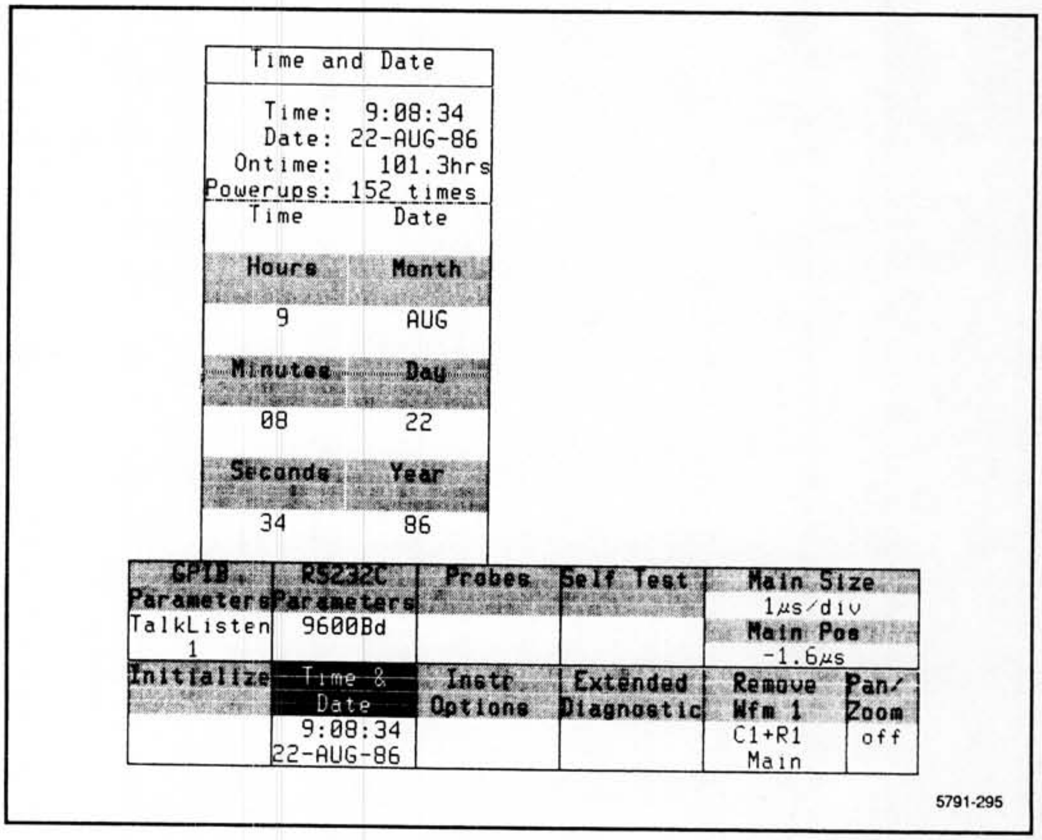

Figure 2-86. Time & Date pop-up menu.

Menu Items

The following category and items are entries in the **Time and Date** pop-up menu:

- **Time and Date**—the current time and date, ontime and number of powerups are shown in the pop-up menu. Time is shown in a 24-hour format (hh:mm.ss). The date is shown in a day, month, year format (dd/mm/yy). **Ontime** is shown as the number of hours during which the instrument has been powered-up (STANDBY switch ON).

  Powerups is shown as the number of times the STANDBY switch has been set to ON from the STANDBY position. The backup power source, which maintains the integrity of this information, will last about five years. If the backup power source (battery) is disconnected for any reason, these parameters are reset to zero.

  The time and date parameters are set by either the Control knobs or the **Numeric Entry and Knob Res** pop-up menu. Touch a Control knob label to use the **Numeric Entry and Knob Res** pop-up menu.

- **Time**—the displayed time can be changed by touching one of the **Hours, Minutes,** or **Seconds** labels. A Control knob is assigned to the selected parameter.

- **Date**—The displayed date can be changed by touching one of the **Month, Day,** or **Year** labels. A Control knob is assigned to the selected parameter.

  If you use the **Numeric Entry and Knob Res** pop-up menu to enter a number that is outside the range of the Time/Date parameter, an error message will be displayed.

Initialize Function

Selecting the **Initialize** label in the Utility major menu sets all functions and controls to known states. To initialize the 11401/11402 to a preset state, press the UTILITY button on the front panel. The screen will then display the Utility major menu in the menu/status area. Select the **Initialize** label to initialize the control settings. Table 2-9 lists the initialized settings.

TABLE 2-9
Initialized Settings

Setting	Initialized Value
Waveform Menu	
Vertical	
Sensitivity (Volts/div)	Depends on plug-in
Offset	Depends on plug-in
Coupling	Depends on plug-in
Input Impedance	Depends on plug-in
Bandwidth Limit	Depends on plug-in
Horizontal	
Description	Main time base
Main Record Length	1024 points
Window Record Length	1024 points
Main Size	500 µsec (50 µs/div)
Window Size	50µsec(5µsec/div)
Window 1 Position	10% of main record
Window 2 Position	80% of main record
Graticule	
Type	Linear
Number	One
Cursors	
Type	Paired
Position	First and last points of record.
Acquire Desc	Stopped
Average N	Off
Envelope N	Off
Avg N	32
Env N	32
% Fill	99
All Waveforms' Status	Single waveform status
Stored Waveforms in Memory	Data and associated parameters will not be affected
Trigger for Main, Window 1, and Window 2	
Source	Left Channel 1
Level	O V
Holdoff	Minimum
Slope	+
Mode	Auto for Main Trigger Normal for Window Trigger
Coupling	DC
Window Holdoff Mode	No Holdoff Triggered from main

TABLE 2-9 (cont)
Initialized Settings

Setting	Initialized Value
Measurement	
Compare Mode Status	Off
Main->Win Trig Time Avg	10
Waveform Parameters Defaults	
Left Measurement Zone	First point in record
Right Measurement Zone	Last point in record
Top Line	100% level automatically calculated from waveform data
Distal (farthest from origin)	90%
Mesial (closest to middle)	50%
Proximal (closest to origin)	10%
Base Line	0% level automatically calculated from waveform data
S/N Ratio (hysteresis)	10
Data Interval	One period
Reference Level	O V
Slope	+
Tracking	On
Store/Recall	
Sequence	Off
Utility	
GPIB Parameters	
RQS Icon	Off
Debug	Off
Pending Events	Cleared
RS-232-C Parameters	
Pending Events	Cleared
Debug	Off
RQS Icon	Off
Probes	
ID Assignment	Waveform selection and new wfm
Waveform Scaling	Optional
Autoset Options	
Timing	Period
Amplitude	Pk-Pk
Knobs and Keypad	
Knob assignment	Top: Main Size Bottom: Main Position

GPIB and RS-232-C Interfaces

Selecting an Interface

This material describes the basic characteristics of these interfaces.

Getting Started

This material describes how to set up the 11401/11402 and start some basic operations via the interfaces.

Command Set

This material describes usage, syntax, and processing conventions, along with the complete command set description.

Status and Event Reporting

This material describes the concepts and operation of the status and event reporting system.

Programming Applications

This material gives the user some useful utility programs.

System Performance Considerations

This material describes ways for the user to estimate and optimize the 11401/11402 GPIB/RS-232-C system performance factors.

Contents

GPIB and RS-232-C Interfaces

The 11401 and 11402 have two external interfaces for convenient data transfer and instrument control (see Fig. 3-1). These interfaces provide external users with functions similar to those found in the front panel menus.

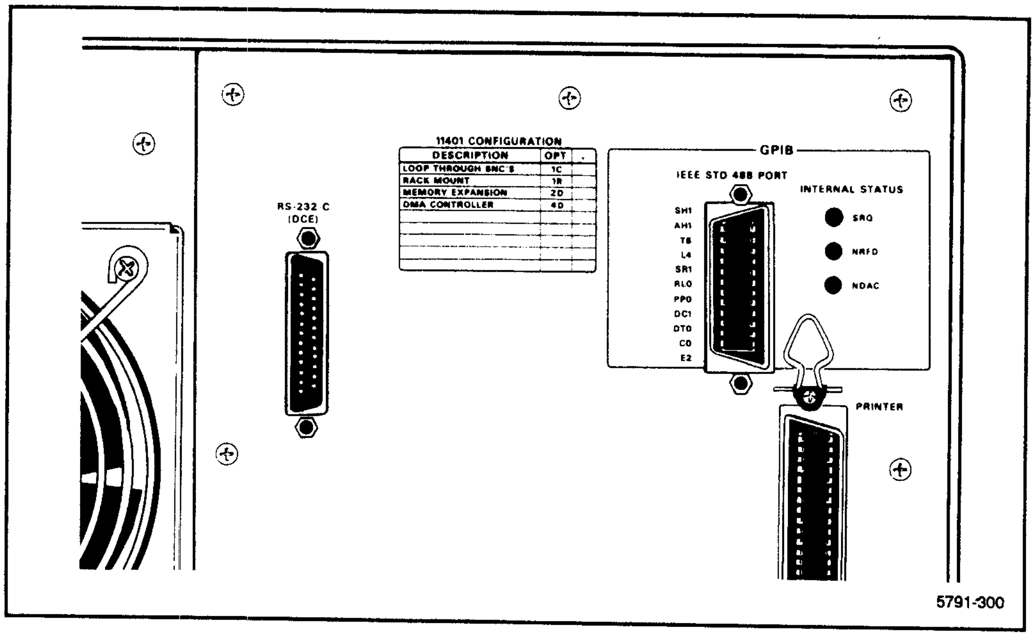

Figure 3-1. Rear-panel view of the GPIB and RS-232-C interface ports.

This section begins with a brief overview of each interface. The level of information is directed toward users with a basic familiarity of programming, GPIB, and RS-232-C concepts. Readers with little or no knowledge of these concepts might find that introductory texts on these subjects will aid them in learning to use the 11401/11402 in computer controlled systems. However, some beginners may find that with careful reading of this entire section, they can use the features the external interfaces provide.

The overview material is followed by "Getting Started" information that should enable intermediate and advanced users to quickly gain enough knowledge to operate the 11401/11402 with either external interface.

The remaining information provides users who are experienced in programmable instrumentation with all the 11401/11402 reference information necessary for developing their own application programs.

Selecting An Interface

Your specific measurement requirements dictate which communication interface best suits your application needs.

Considerations include:

- whether you require a single device or multiple device system environment
- what kind of data transfer speeds are needed
- what your available instrument controller and software require
- what your programming experience is
- what your interrupt handling (operator or process generated) considerations are

The following descriptions of each interface should help you determine the parameters of your application, and which interface best fulfills those requirements.

GPIB & RS-232-C Features

The IEEE-488 General Purpose Interface Bus (GPIB) provides the 11401/11402 with an easy-to-use external communication path.

Its key features include:

- Remote Instrument Control
- Reliable Bi-directional Asynchronous Parallel Data Transfer
- IEEE-488 System Compatibility
- Device Status and Event Reporting
- Multiple devices sharing a single bus

The RS-232-C is the other easy-to-use external communication path.

Its key features include:

- Common Full-Duplex Communication Interface
- Convenient Asynchronous Serial Data Transfer
- Compatibility with Many Personal Computers
- Provision for Device Clear and Service Requests
- Dedicated connection to one device

In addition, a Tektronix device-dependent English-like communication language is specified to make the 11401/11402 commands easy to use and understand (see "Command Set" later in this section).

The programmer uses the same message syntax or format with both interfaces. Data transmissions are made in either ASCII or binary formats. However, the compact binary block transmission format provides maximum throughput.

Contrast: GPIB vs RS-232-C

The GPIB is based on the IEEE Standard 488-1978 Digital Interface for Programmable Instrumentation, which defines mechanical, electrical, and functional interface elements that enable data to be transferred between similarly defined devices.

The RS-232-C is based on the EIA Standard RS-232-C for interfacing between data terminal equipment and data communication equipment employing serial binary data interchange, which defines basic hardware related elements, but with no real data handshake or bus protocol specifications.

Different specifications cause each interface to have certain advantages and disadvantages, depending on the application and system components. The following descriptions contrast the 11401/11402 control interfaces' operating parameter differences:

The GPIB interface uses a bit-parallel, byte-serial binary data format with a maximum transmission rate of 200 kilobytes per second.

NOTE

This rate can be achieved when transferring 10,240 point binary waveforms from the 11401/11402, with the DMA option installed, and the byte order set to LSB. Data transmission rates for other functions may be considerably slower (see System Performance Considerations at the end of this section).

On the other hand, the RS-232-C interface uses a bit-serial, byte-serial binary data format with a maximum transmission rate of 19200 bits per second (approximately 1920 bytes per second).

The GPIB allows for interconnection of up to 15 devices on one contiguous bus in a linear or star configuration, while the RS-232-C provides point-to-point connection of just two devices.

The total GPIB transmission path length (cabling) must not exceed 20 meters (cumulative), while the total RS-232-C transmission path length (without data communication facilities, i.e., modem and telephone lines) may not exceed 15 meters (50 feet).

The GPIB has low-level interface control messages for bus function/signal manipulation by the operator. The RS-232-C does not provide operator low-level interface control.

GPIB and RS-232-C Functional Overview

The following information will briefly review some basic elements of GPIB and RS-232-C operations.

GPIB Interface Functions

Each interface function is a system element that provides the basic operational facility through which the 11401/11402 can receive, process, or send messages over the GPIB.

The 11401/11402 implements the following IEEE Standard 488-1978 interface function subsets:

Source Handshake (SH1)	Device Clear (DC1)
Acceptor Handshake (AH1)	Parallel Poll (PP0)
Talker (T6)	Device Trigger (DT0)
Listener (L4)	Remote/Local (RL0)*
Service Request (SR1)	Controller (C0)

*** The FPANEL OFF command emulates the Local Lockout state.**

For a description of these functions and their subsets, see IEEE Standard 488-1978, Section 2.1 through 2.12.5.

GPIB Protocol

The 11401/11402 GPIB interface enables the instrument to accurately communicate digital measurement data to various peripheral devices. Devices connected to the bus perform these roles:

Talkers— instruments that can send messages and data over the bus. Only one device can be addressed to talk at a time.

Listeners—instruments that can accept messages and data over the bus. Only devices addressed to listen can do so.

Controllers—determine, through software routines, which instrument will talk and which will listen during any time interval. The controller may also assign itself as a talker or listener whenever the application program requires it. The controller uses special codes and commands (called interface messages) to configure some or all devices on the bus for these, or other interface functions. The controller's application program also contains the unique device coding (device dependent messages) which directs the system instruments to perform their tasks (e.g., taking measurements, storing the results, and sending them to a plotter).

The 11401/11402 can be a talker or a listener, but not a controller.

GPIB Messages

Basically, there are three types of system or remote messages: interface, device dependent, and status. Interface messages control the interface functions, and device dependent messages control the instrument functions themselves. The status message is a special class of message (partly defined by the IEEE-488 standard and partly by the device designer) which reports the device's operating condition. This class of message is described in a separate part of this section.

Interface Messages

These cause state transitions within the interface functions of the instruments to which they are addressed. These kinds of messages occur, most often, at a level which is transparent to the user. That is, a GPIB driver program takes care of all the necessary housekeeping interface functions, whatever the controller's operating system and application program might be. However, the low-level interface (control) messages may be of use when, for example, you wish to write an application program to bypass the system controller in order to send messages from the 11401 directly to another device. This would be an advanced user application.

Interface messages may only be sent by the controller in charge. Interface messages are divided into four categories (for 11401/11402 purposes).

Addressed Commands—Only instruments on the bus that are addressed to listen will receive these commands.

Universal Commands—All instruments on the bus will receive these commands, whether or not they are addressed.

Listen Addresses—These are indirectly user set in hardware or software. When sent, they determine which device(s) will listen for messages.

Talk Addresses —These are similarly set in hardware or software. When sent, they determine which device can talk.

These categories of messages occur without operator intervention, except for the initial setting of an 11401/11402 primary address value which determines the resultant values of its talk and listen addresses.

This primary address is used by the controller to uniquely identify the 11401/11402 for sending and receiving messages. The programmable range of 11401/11402 primary addresses is 0 to 30.

Programming with interface addresses and commands (low-level interface messages) is not discussed in this manual. However, some low-level settings (e.g., primary address) are required to set up the bus for use (see "Getting Started" later in this section).

Device Dependent Messages

The interface's message coding and device functions are not specified in the IEEE Standard 488-1978. However, device dependent messages are passed between the device (dependent) functions and the message coding logic via the IEEE-488 specified interface functions (see Fig. 3-2).

Because the IEEE Standard 448-1978 does not specify device dependent message parameters, Tektronix has created the "Tektronix Codes, Formats, Conventions, and Features Standard" or Tek Codes and Formats Standard for short. It is intended to:

- define device dependent message formats and codings to enhance compatibility among instruments that comply with the IEEE 488 Standard, and
- reduce cost and time required to develop system and application software by making it easier to generate understandable code.

The Tek Codes and Formats Standard provides a command language syntax that standardizes the types of communication elements from which messages may be constructed and the rules by which these elements may be combined to transmit meaningful messages. The message character coding for the 11401/11402 is based on the American Standard Code for Information Interchange (i.e., ASCII character set).

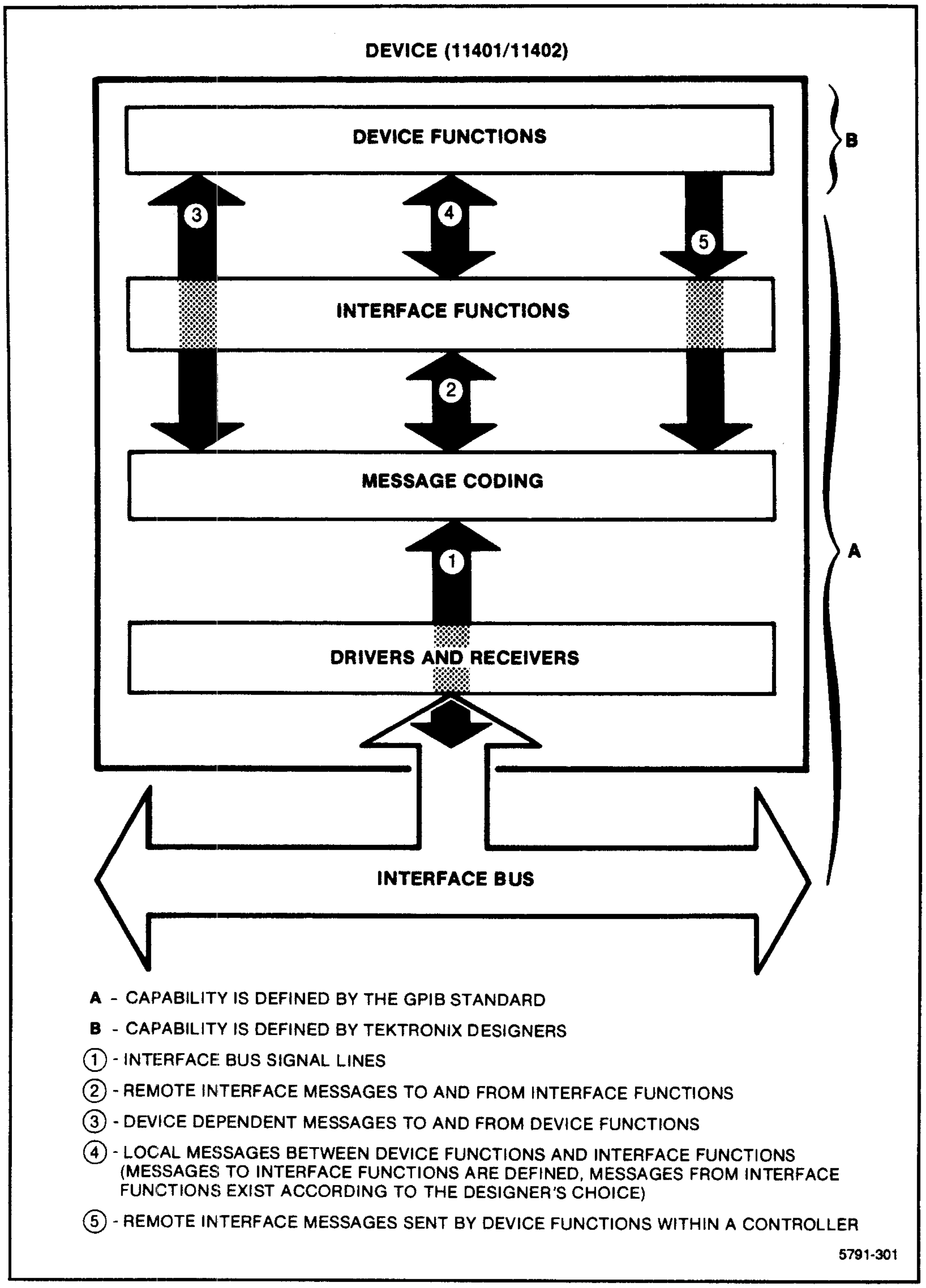

Figure 3-2. Functional partitioning within the 11401/11402.

See "Command Set" and "Getting Started" later in this section, for detailed information on sending and receiving instrument commands/data over the GPIB.

RS-232-C Functional Characteristics

The 11401/11402 RS-232-C interface is a serial, full-duplex (simultaneous two-way), asynchronous communication port.

The first-level protocol (set of rules) that interconnected computers and devices follow to ensure orderly transfer of information for serial, asynchronous operation deals with alerting the receiver that a character is coming; thus, a start bit is sent. Then, the character data bits are sent, followed optionally by a parity bit for error detection. And finally, 1, 1.5, or 2 stop bits are sent to allow the receiver settling time before the next character is sent (see Fig. 3-3).

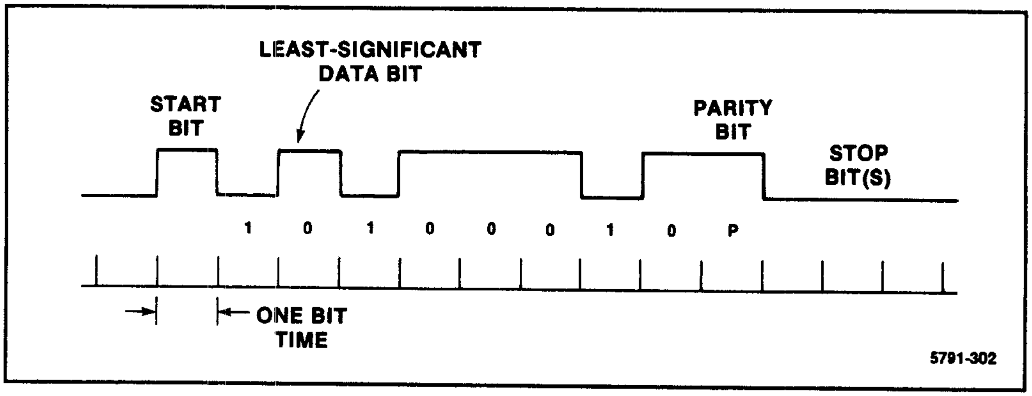

Figure 3-3. Asynchronous serial transmission.

This process is transparent to the user, although the transmission parameters of baud rate, parity, and stop bits must be initially selected.

Besides these basic transmission functions, the 11401/11402 allows the user to select transmission delay time, controller display echoing, flagging for transmission start and stop (handshaking), and manual or automatic reporting of error and warning messages.

For detailed descriptions of these functions, see "Command Set" later in this section.

RS-232-C Messages

As mentioned above, serial asynchronous transmission begins with a start bit, followed by data bits that form a character. The specific encoding used determines the binary data bit patterns that ultimately form the intended message.

Like the GPIB standard, the RS-232-C standard does not define device dependent messages. Tektronix has specified the 11401/11402's RS-232-C port character message coding to also be the ASCII character set. In addition, the RS-232-C command language and syntax is the same as that of the GPIB port.

A complete description of the 11401/11402 Command Set is given later in this section.

For detailed information on sending and receiving data/messages over the RS-232-C interface, see "Getting Started" later in this section.

Conclusion

Since each interface has different attributes, only careful consideration of all the aforementioned elements, in conjunction with the five previously listed system considerations, will indicate the likely interface selection to meet your needs.

If you want more information about GPIB and RS-232 specifications and operations, see the IEEE Standard 488-1978, and the EIA Standard RS-232-C. The GPIB standard is published by the

Institute of Electrical and
Electronics Engineers,Inc.,
345 East 47th Street,
New York, New York 10017,

and the RS-232-C standard is published by the

Electronics Industries Association,
Engineering Dept.,
2001 Eye Street, N.W.,
Washington, D.C. 20006.

Getting Started

Connecting the 11401/11402 Digitizing Oscilloscope to an instrument controller, terminal, etc, which has either a GPIB or RS-232-C interface is easy. The following description assumes that you know how to configure the interface of the instrument that your are connecting to the 11401/11402.

Configuring Your System

GPIB

The GPIB system can be cabled in two configurations; star or linear (see Fig. 3-4). The two configurations can be mixed if the total cable length does not exceed 20 meters, and the instruments are distributed on the bus according to a few rules:

1. No more than 15 total devices (including the controller) can be included on a single bus.

2. In order to maintain bus electrical characteristics, one device load must be connected for every two meters of cable (generally each instrument represents one device load to the bus).

3. At least one-half of the device loads must be powered on.

An IEEE Std 488-1978 GPIB cable is required to interconnect devices. Contact your local Tektronix Field Representative for the Tektronix part number.

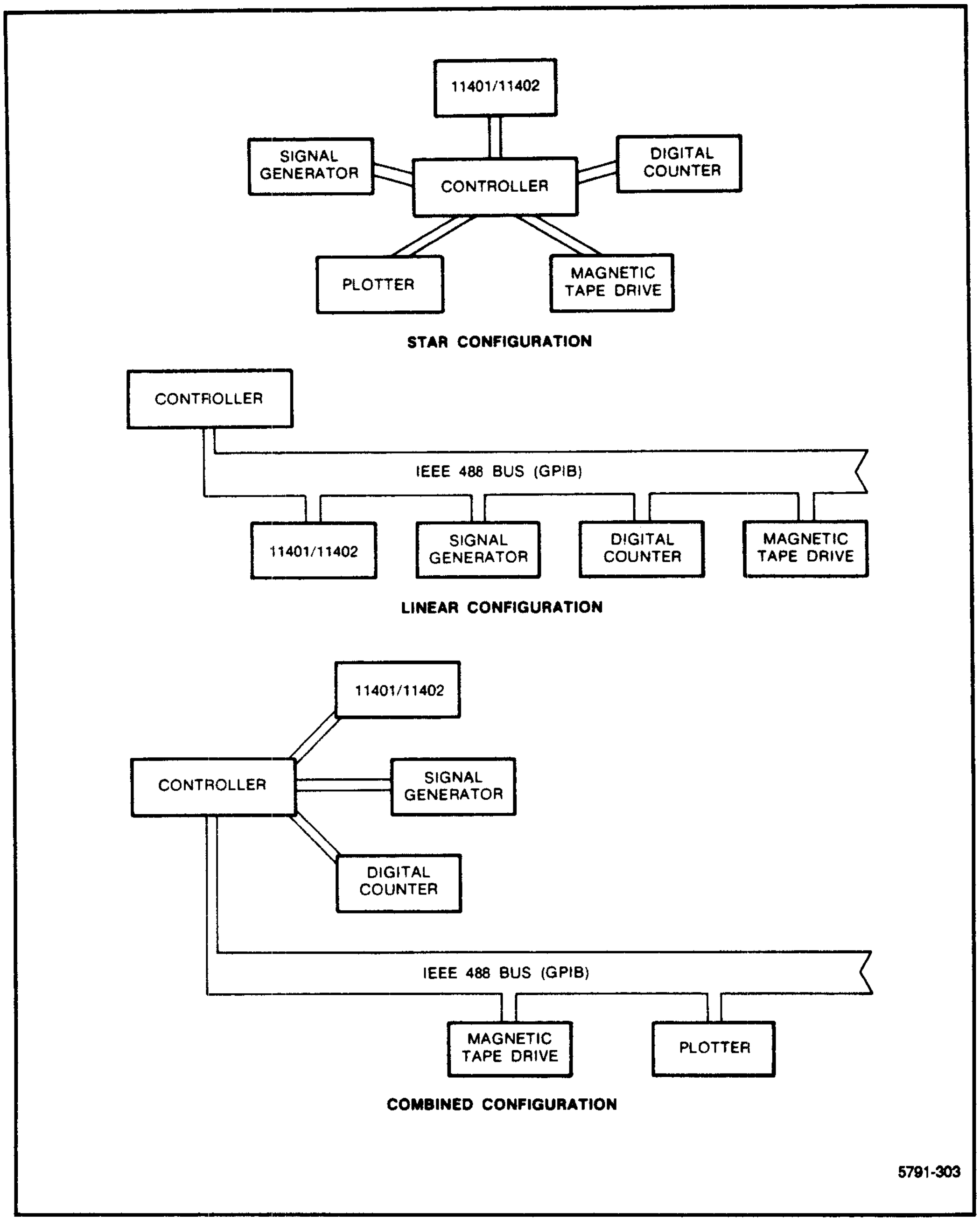

Figure 3-4. GPIB system configurations.

RS-232-C

The RS-232-C interface provides a point-to-point connection between the data terminal equipment (DTE) and the data communication equipment (DCE) (see Fig. 3–5).

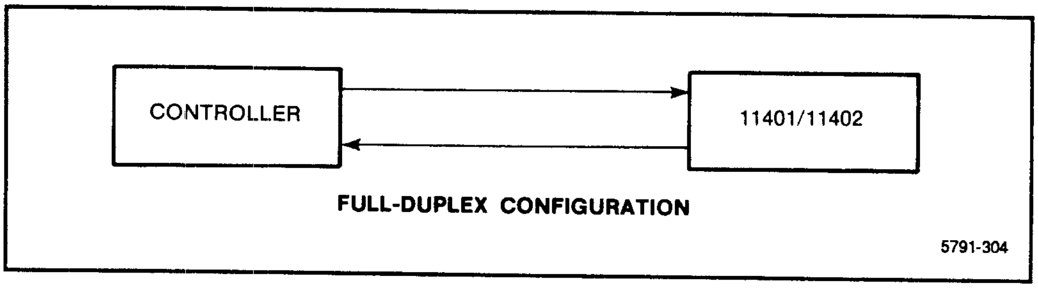

Figure 3-5. RS-232-C point-to-point connection.

While the signal lines and the electrical aspects of the interface are specified, the actual mechanical details of the connector are not. Industry (defacto) standard connectors use a 25-pin male D-connector on data terminal equipment (e.g., a "dumb" terminal) and a 25-pin female D-connector on data communication equipment (e.g., 11401/11402, or modem).

A straight-through male-to-female cable of less than 50 feet is used for local DTE-to-DCE configurations.

However, since any two pieces of electronic equipment with RS-232-C interfaces may both be configured as DCE's, a special male-to-male adapter (null-modem) cable is required for local (under 50 feet) DCE-to-DCE communications. This allows the proper connection for each device to emulate the DTE signals necessary for handshaking data transfers. The 11401/11402 is configured as a DCE device (see Fig. 3-6). Refer to "Special RS-232-C I/O Considerations" later in this section for more details.

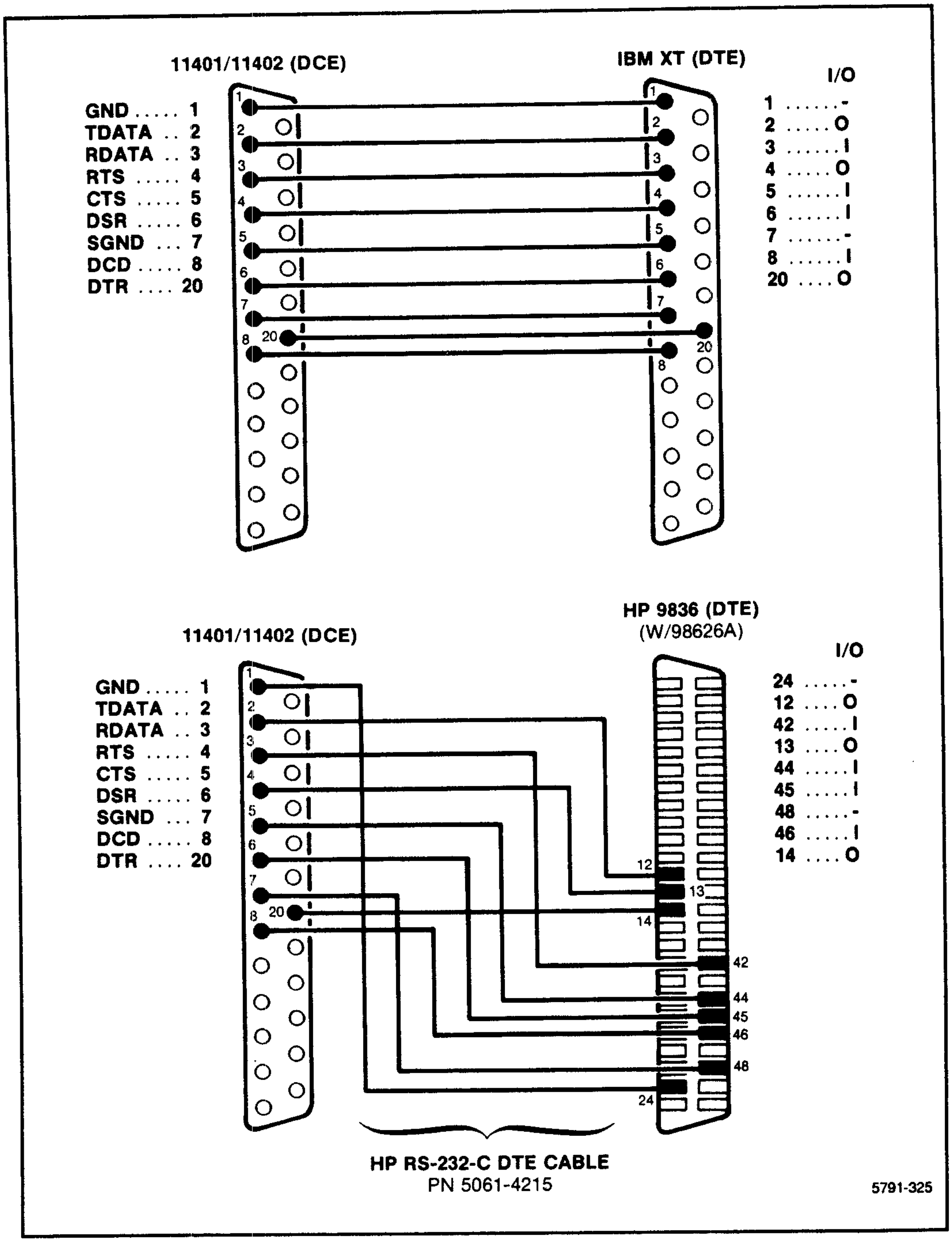

Figure 3-6. Typical RS-232-C port connections.

Setting Up The Interfaces

GPIB

This interface is set up via the **GPIB Parameters** pop-up menu.

1. Touch the UTILITY MENU key to the right of the crt/display area. The Utility menu will appear in the menu/status area, toward the bottom of the display.
2. Touch the **GPIB Parameters** label in the menu/status area. The **GPIB Parameters** pop-up menu will appear in the display area.
3. The GPIB communication interface must have the parameter labels **Mode, Address,** and **Terminator** selected. Their specific settings are determined by hardware and/or software constraints (see Fig. 3-7).

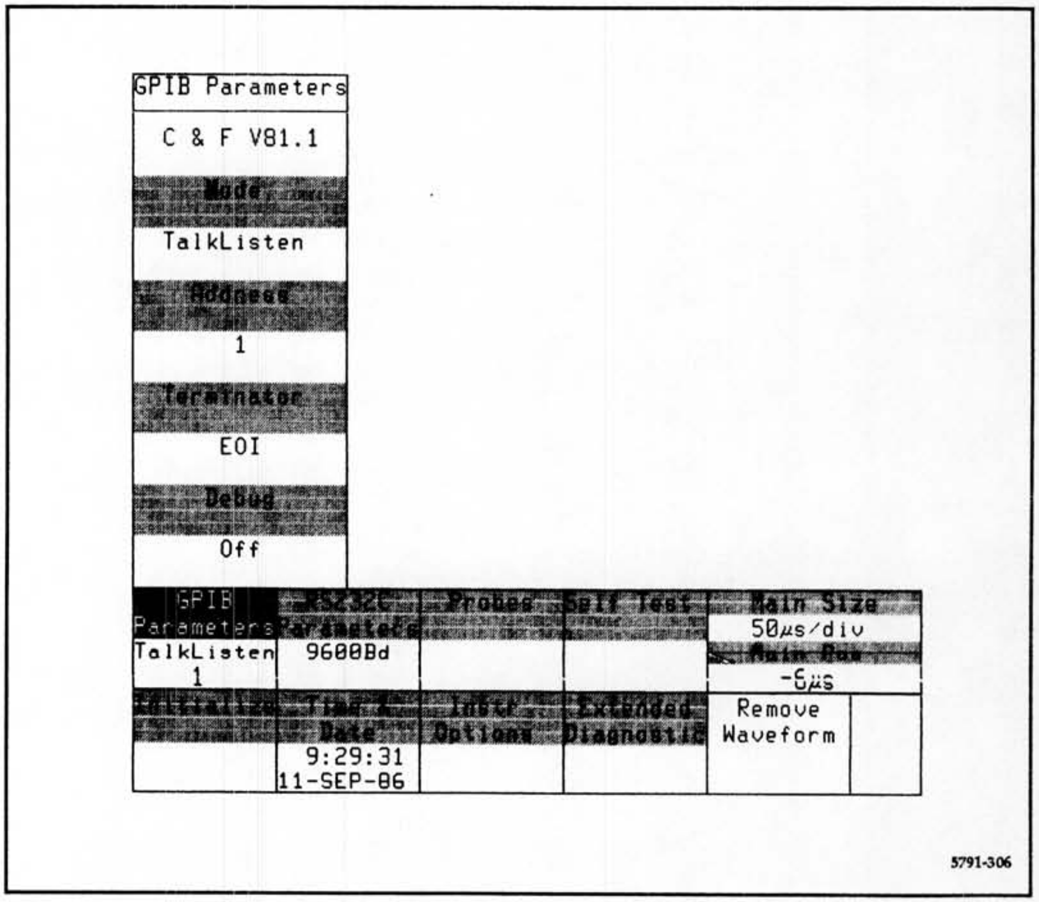

Figure 3-7. Typical GPIB settings.

Mode—the communication role is set to Talk/Listen.

Address—the primary address is set to 1.

Terminator—the message terminator is set to EOI.

After setting the appropriate items in step three above, the interface is ready for operation.

While the **Debug** setting is "**Off**" in Figure 3-7, you may choose to set **Debug** "**On.**" This allows front panel viewing of the GPIB interface input operations via the 11401/11402 screen for program development troubleshooting.

Refer to the earlier explanation of the **GPIB Parameters** pop-up menu given under "Utilities" in Section 2 "Operating Information" for parameter details.

RS-232-C

This interface is set up via the RS-232-C pop-up menu.

1. Touch the UTILITY MENUS key to the right of the crt/display area. The Utility menu will appear in the menu/status area toward the bottom of the display.
2. Touch the RS-232-C label in the menu/status area. The **RS-232-C Parameters** pop-up menu will appear in the display area.
3. The RS-232-C communication interface needs to have three primary parameter labels selected: **Baud Rate, Stop Bits,** and **Parity**. Their specific settings are determined by hardware and/or software constraints (see Fig. 3-8). The remaining parameters are selectable as per the user's personal choice.

Baud Rate—the data transmission rate set to is 9600 bits-per-second.

Stop Bits—the message stop bits set to is 1.

Parity—the message bits error check is set to None.

Echo—the character echo is set to Off.

Flagging—the data flow control is set to Soft (DC1/DC3).

Delay—the minimum delay for an RS-232-C query response is 0.0 seconds.

Verbose—the automatic error and warning response is set to Off.

EOL String—the end-of-line query response terminator is set to CR/LF.

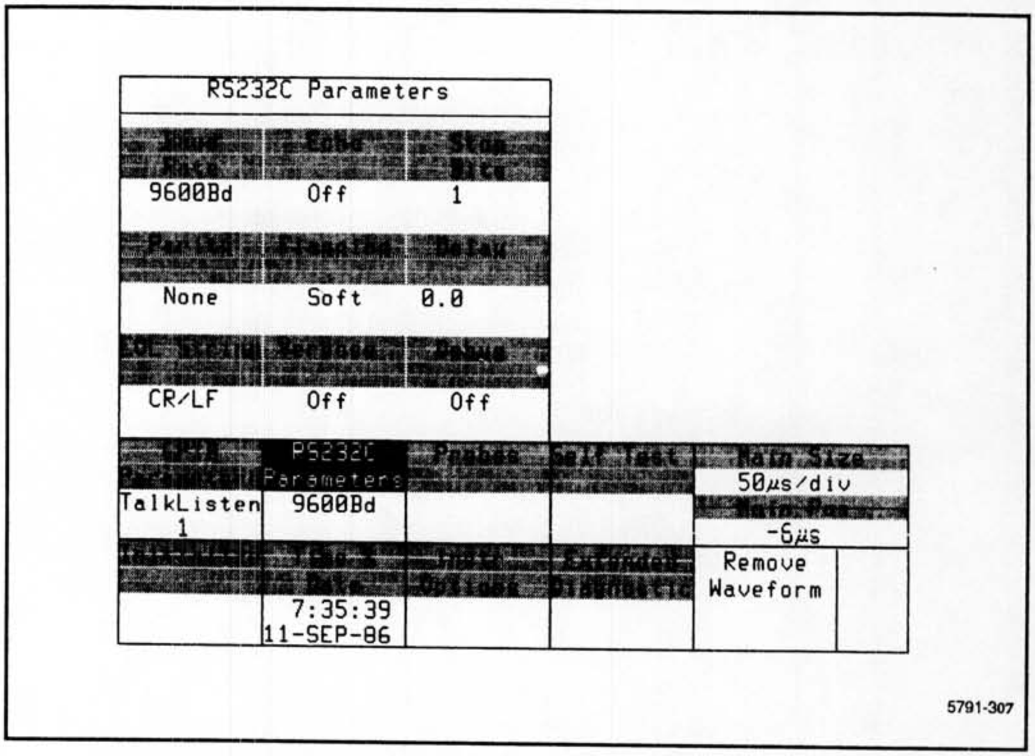

Figure 3-8. Typical RS-232-C settings.

After setting the appropriate items in step three, the interface is ready for operation.

While the **Debug** setting is **"Off"**, you may choose to set **Debug "On."** This allows front panel viewing of the RS-232-C interface input operations via the 11401/11402 screen for program development troubleshooting.

See the earlier explanation of the RS-232-C Pop-up Menu (Section 2) for parameter details. In addition, these parameters are selectable over either interface via device-dependent commands. Refer to the "RS-232-C Command" later in this section in "Command Set".

NOTE

The 11401/11402 transmits and receives 8-bit characters. Accordingly, the word length of the RS-232-C instrument controller should be set to eight bits.

Command Rules

The command set represents the basic vocabulary of the 11401/11402.

The 11401/11402 commands are embedded in the controller's application program and fall into two broad categories: set commands and query commands. Set commands cause the 11401/11402 to change a setting or mode. Queries cause the 11401/11402 to return a setting, mode, measurement, waveform, or instrument status.

A command consists of a group or string of ASCII characters. It consists of four major parts: the header, the (optional) link, the (optional) argument, and the message delimiters (see Fig. 3-9).

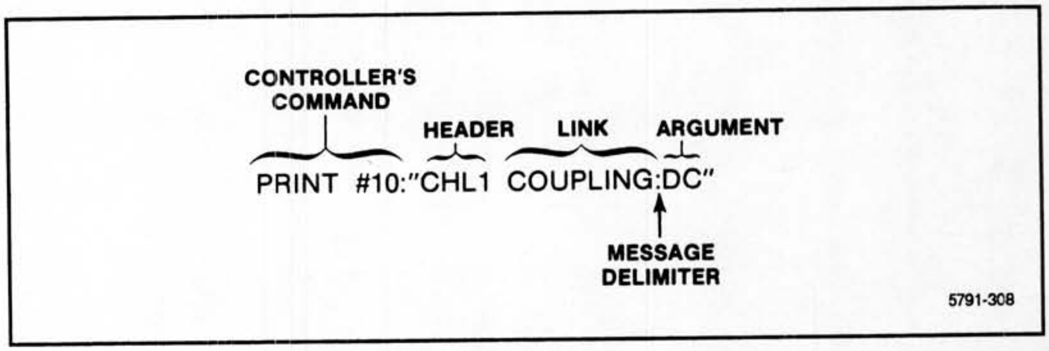

Figure 3-9. 11401/11402 command syntax elements.

The header is a primary command word (function) that encompasses a group of optional functions or links. The argument gives the header and optional links specific qualities, restrictions, or limits. The message delimiters (i.e., **<space>** : , and ;) break the message into understandable segments for the 11401/11402 to process.

NOTE

The command syntax is in BNF (Backus-Naur-Form) notation. This notation is based on individually defined elements or symbols that comprise the rules or productions of the language.

Set commands take the syntactic form:

<header> [<link>][:<arg>][{,<link>:<arg>}...]

Query commands take the syntactic form:

<header>? [<link>][{,<link>}...]

Queries return this general response form:

<header> [<link>][:<arg>][{,<link>:<arg>}...]

Developing Application Programs

Each instrument controller will have some unique message communication requirements for forming and exchanging messages with the 11401/11402. Refer to the appropiate controller's user's manuals for the necessary protocols.

A controller's specific language protocol requirements for sending messages over the GPIB depends on the application programming language and its device I/O driver. Many languages will contain the necessary high-level GPIB I/O driver so that operators need not include low-level interface function calls in their GPIB application programs (unless they want to and have the programming facilities to do so).

Application programs to be used over the RS-232-C interface do not require low-level interface calls. Its message protocol is minimal (flagging) and the necessary interface signals are taken care of by the controller and 11401/11402's RS-232-C device I/O drivers.

Sending Commands to the 11401/11402

Here are some typical 11401/11402 set commands as they would appear in an HP BASIC or IBM BASICA application program for the GPIB. In these examples, it is assumed that "@Et" and "ET%" identify the 11401/11402 assigned to the controller's GPIB port.

TABLE 3-1
Examples of 11401/11402 Set Commands

Command Class	Controller	Program Lines
Channel	HP 200, 300	OUTPUT @Et;"CHL1 SENSITIVITY:1"
	IBM PC*	WRT$ = "CHL1 SENSITIVITY:1" CALL IBWRT(ET%,WRT$)
Timebase	HP 200, 300	OUTPUT @Et;"TBMAIN TIME:1E-6"
	IBM PC*	WRT$ = "TBMAIN TIME:1E-6" CALL IBWRT(ET%,WRT$)
Waveform	HP 200, 300	OUTPUT @Et;"TRACE1 DESCRIPTION:'L1' "
	IBM PC*	WRT$ = "TRACE1 DESCRIPTION:'L1' " CALL IBWRT(ET%,WRT$)
Measurement	HP 200, 300	OUTPUT @Et;"MSLIST PER,FRE"
	IBM PC*	WRT$ = "MSLIST PER,FRE" CALL IBWRT(ET%,WRT$)

TABLE 3-1 (cont)
Examples of 11401/11402 Set Commands

Command Class	Controller	Program Lines
Data Transfer	HP 200, 300	OUTPUT @Et;"ENCDG WAVFRM:ASCII"
	IBM PC*	WRT$ = "ENCDG WAVFRM:ASCII" CALL IBWRT(ET%,WRT$)
Status and Event	HP 200, 300	OUTPUT @Et;"RQS ON"
	IBM PC*	WRT$ = "RQS ON" CALL IBWRT(ET%,WRT$)

*** IBM PC with a National Instruments GPIB interface card.**

Responses from the 11401/11402

Here are some typical 11401/11402 queries and responses as they would appear in an HP BASIC or IBM BASICA application program for the GPIB (the responses appear in bold). In these examples,it is assumed that "@Et" and "ET%" have been assigned address values that identify them with the 11401/11402.

NOTE

Error and warning messages comprise a special class of response and may be sent to a controller manually whenever desired via the EVENT? or automatically with each event occurrence via the GPIB SRQ or the RS-232-C VERBOSE command. Refer to "Errors and Events Handling Information" and "Special RS-232-C I/O Considerations" later in this section for more information.

TABLE 3-2
Examples of 11401/11402 Query Commands

Command Class	Controller	Program Lines/Response
Channel	HP 200, 300	DIM Resp $ [100] OUTPUT @Et;"CHL1? SENSITIVITY" ENTER @Et;Resp$ PRINT Resp$ **CHL1 SENSITIVITY:1.0E+0**
	IBM PC*	WRT$ = "CHL1? SENSITIVITY" CALL IBWRT(ET%,WRT$) RD$=SPACE$(100) CALL IBRD(ET%,RD$) PRINT RD$ **CHL1 SENSITIVITY:1.0E+0**
Timebase	HP 200, 300	DIM Resp $ [100] OUTPUT @Et;"TBMAIN? TIME" ENTER @Et;Resp$ PRINT Resp$ **TBMAIN TIME:1.0E-6**
	IBM PC*	WRT$ = "TBMAIN? TIME" CALL IBWRT(ET%,WRT$) RD$=SPACE$(100) CALL IBRD(ET%,RD$) PRINT RD$ **TBMAIN TIME:1.0E-6**
Waveform	HP 200, 300	DIM Resp $ [100] OUTPUT @Et;"TRACE1? DESCRIPTION" ENTER @Et;Resp$ PRINT Resp$ **TRACE1 DESCRIPTION:"L1"**
	IBM PC*	WRT$ = "TRACE1? DESCRIPTION" CALL IBWRT(ET%,WRT$) RD$=SPACE$(100) CALL IBRD(ET%,RD$) PRINT RD$ **TRACE1 DESCRIPTION:"L1"**

TABLE 3-2 (cont)
Examples of 11401/11402 Query Commands

Command Class	Controller	Program Lines/Response
Measurement	HP 200, 300	DIM Resp $ [100] OUTPUT @Et;"MEAS?" ENTER @Et;Resp$ PRINT Resp$ **MEAS PERIOD:1.0E-3,EQ,FREQ:1.0E+3,EQ**
	IBM PC*	WRT$ = "MEAS?" CALL IBWRT(ET%,WRT$) RD$=SPACE$(100) CALL IBRD(ET%,RD$) PRINT RD$ **MEAS PERIOD:1.0E-3,EQ,FREQ:1.0E+3,EQ**
Data Transfer	HP 200, 300	DIM Resp $ [100] OUTPUT @Et;"WAVFRM?" ENTER @Et;Resp$ PRINT Resp$ ** {WFMPRE? response;CURVE? response}

	IBM PC*	WRT$ = "WAVFRM?"
		CALL IBWRT(ET%,WRT$)
		IBCNT% = 240
		WHILE IBCNT% = 240
		  RD$ = SPACE$ (240)
		  CALL IBRD (ET%,RD$)
		  PRINT RD$;
		WEND
		
		** {WFMPRE? response;CURVE? response}

Status and Event	HP 200, 300	DIM RESP$ [100] OUTPUT @Et;"EVENT?" ENTER @Et;Resp$ PRINT Resp$ **EVENT 400,"System function normal"**
	IBM PC	WRT$ = "EVENT?" CALL IBWRT(ET%,WRT$) RD$ = SPACE$(100) CALL IBRD(ET%,RD$) PRINT RD$ **EVENT 400,"System function normal"**

*** IBM PC with a National Instruments GPIB interface card.**
**** Returns the waveform preamble and data point information. See "WAVFRM?" in the Command Set, later in this section, for details of the response.**

Programming Example

The application program (see Fig. 3-10) shows how the 11401/11402 can be used to execute and transfer a set of simple measurements. There are two versions of the program: one for the GPIB interface and one for the RS-232-C interface. Both examples are written in IBM BASICA for use on an IBM PC configured with a National Instruments (NI) GPIB card and an RS-232-C interface card. It is assumed that the user has already set up the 11401/11402 for correct operation and the intended data to be transferred and has configured the NI GPIB interface hardware/software.

The 11401/11402 GPIB and RS-232-C pop-up menu settings for these examples are as shown, previously, in Figure 3-7 and Figure 3-8. Of course, the IBM® controller must have its ports configured the same way.

```
GPIB:

  1   CLEAR     ,50000!                'BASIC Declarations.
  2   IBINIT1 = 50000!                 'Lines 1 thru 6 must be
  3   IBINIT2 = IBINIT1 + 3            'included in your program.
  4   BLOAD "bib.m",IBINIT1
  5   CALL IBINIT1 (IBFIND,IBTRIG,IBCLR,IBPCT,IBSIC,IBLOC,IBPPC,
      IBBNA,IBONL,IBRSC,IBSRE,IBRSV,IBPAD,IBSAD,IBIST,IBDMA,
      IBEOS,IBTMO,IBEOT,IBRDF,IBWRTF)
  6   CALL IBINIT2 (IBGTS,IBCAC,IBWAIT,IBPOKE,IBWRT,IBWRTA,IBCMD,
      IBCMDA,IBRD,INRDA,IBSTOP,IBRPP,IBRSP,IBDIAG,IBXTRC,IBRDI,
      IBWRTI,IBSTA%,IBERR%,IBCNT%)
  .                                    'Lines 7 thru 99 of National
  .                                    'Instruments GPIB Program
  .                                    'declare global variables.
 99
100   DEV1$ = "ET"
110   CALL IBFIND(DEV1$,ET%)
120   WRT$ = "MSLIST PER,FRE,MAX,PP,RISE,FALL"
130   CALL IBWRT(ET%,WRT$)
140   WRT$ = "MEAS?"
150   CALL IBWRT(ET%,WRT$)
160   MEAS$ = SPACE$(200)
170   CALL IBRD(ET%,MEAS$)
180   PRINT MEAS$
190   END


RS-232:

100   OPEN "COM1:9600,N,8,1" AS #1
110   PRINT #1,"MSLIST PER,FRE,MAX,PP,RISE,FALL"
120   PRINT #1,"MEAS?"
130   LINE INPUT #1,MEAS$
140   PRINT MEAS$
150   END
```

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Figure 3-10. Signal measurement programs.

Command Set

This information begins with a discussion of various command and interface operating conventions. It is followed by the command set description, reserved word abbreviations, and character set.

Command Usage Conventions

The 11401/11402 ASCII Command Set information includes syntax and semantic meaning for all 11401/11402 commands. In this context, an "ASCII command" is a data stream received at the 11401/11402's GPIB or RS-232-C (hereafter, RS-232-C) port.

The syntax and commands contained herein comply with the Tektronix GPIB Codes, Formats, Conventions, And Features Standard. For details of this standard, contact your local Tektronix Field Representative.

Syntax Conventions

There are a number of syntax conventions used throughout the section. Most notably, the syntax is presented in extended BNF (Backus-Naur-Form) notation. The extended BNF symbols used in this section are as follows:

< >	Defined Element
::=	Is Defined As
{ }	Grouping
[ ]	Optional, May Be Omitted
|	Exclusive OR
...	Previous Element May Be Repeated One Or More Times

Globally defined elements are as follows:

<bblock>	::=	Tektronix "Codes & Formats" binary block data. See the CURVE and SET commands in the command set for the binary block format.
<EOI>	::=	End Of Input delimiter. This delimiter terminates a message transmitted to or from the 11401/11402.
<slot>	::=	{L | C | R} . Respectively designates a Left, Center, or Right plug-in compartment (corresponding lower case letters may also be used).

Numeric Arguments:

<NRx> ::= {<NR1> | <NR2> | <NR3>}. Valid range: $1e\text{-}300 \le abs(X) \le 1e\text{+}300$, 15 significant digits maximum.

<NR1> ::= a signed integer value.

<NR2> ::= a floating point value, sans exponent.

<NR3> ::= a floating point value with an exponent.

<ui> ::= unsigned integer value; no leading white space permitted.

Quoted Strings:

<qstring> ::= quoted string data. This element may optionally contain "escaped" data, which provides access to special graphics characters (see Fig. 3-19, Escaped Character Set).

There are many lexical features and restrictions associated with quoted string data:

- Unless otherwise noted in this document, the maximum length of any quoted string is 127 characters, excluding delimiters.

- The 11401/11402 accepts either an apostrophe (') or a quotation mark (") as a valid string delimiter. However, quoted string data returned to the ASCII ports (i.e., query data) will be delimited solely with quotation marks.

- With respect to quoted strings received at the 11401/11402's ASCII ports, the same type of delimiter that opens a quoted string must close that string. Examples:

  "this is a quoted string" and 'so is this.'

  'But this is not a quoted string."

- When transmitting a quoted string to the 11401/11402, it is permissible to mix quotation marks and apostrophes within a string so long as the previous rule above is followed. Thus:

  "this is a 'fine' string" and 'so "is" this.'

- A delimiter may be included within a string by simply repeating the delimiter. Examples:

  "double "" quote" and 'single '' quote'

- A quoted string may not be terminated with an IEEE-488 EOI interface signal. Thus, "test<IEEE-488 EOI> is an invalid string. Also, a carriage return or line-feed embedded within a quoted string does not terminate that string and is considered to be just another character in the string.

- A quoted string may not include an embedded ASCII NULL character (0).

Command Structures

The 11401/11402's ASCII commands are divided into two categories: set commands, which specify an action to be taken, and queries, which return a specified state of the device.

Set Commands

Set commands come in three types: set commands with link arguments, set commands without link arguments, and set commands that have a mix of link and nonlink arguments.

Set Commands With Link Arguments

The syntax of a set command with link arguments is as follows:

<SET_WITH_LINK>	::=	<HDR> <DLM> <LINK_ARG>
<LINK_ARG>	::=	<LINK>: <ARG> [{, <LINK_ARG>}...]
<DLM>	::=	{ASCII space} ... | {,}
<HDR>	::=	command header, as defined in this document
<LINK>	::=	command link, as defined in this document
<ARG>	::=	link argument, as defined in this document

The 11401/11402's ENCDG command is an example of a set command that takes link arguments. The syntax elements of the ENCDG command are as follows:

Header	Link	Argument
ENCDG	WAVFRM SET	ASCII | BINARY ASCII | BINARY

Given the above ENCDG syntax elements and the general syntax of a set command, we find that the following ENCDG set commands are possible (this is not an exhaustive list):

ENCDG WAVFRM:BINARY<EOI>
ENCDG SET:ASCII,WAVFRM:ASCII<EOI>
ENCDG WAVFRM:ASCII,SET:ASCII<EOI>

An important point to note concerning this example is that links may follow a command header in any order.

Set Commands Without Link Arguments

The syntax of a set command without link arguments is as follows:

<SET_NO_LINK>	::=	<HDR> [<DLM> <ARG> [{, <ARG>}...]]
<DLM>	::=	{ASCII space} ... | {,}
<HDR>	::=	command header, as defined in this document
<ARG>	::=	argument, as defined in this document

The 11401/11402's MAINPOS command is an example of a set command that takes no link arguments. The syntax elements of the MAINPOS command look like so:

Header	Link	Argument
MAINPOS		<NRx>

Given the MAINPOS syntax elements and the general syntax of a set command, we find that the following MAINPOS set commands are possible (this is not an exhaustive list):

MAINPOS –1<EOI>
MAINPOS –1.1,–1.2,–1.3,–1.4<EOI>

Set Commands That Mix Link and Nonlink Arguments

This class of set commands are formed by specifying a header, following it with the usual delimiter (space or comma), and then adding comma-delimited link and nonlink arguments in any order.

The SELFCAL command is an example of this case. Its syntax is as follows:

Header	Link	Argument
SELFCAL		FORCE
	MODE	AUTO | MANUAL

Given the above syntax elements, the following SELFCAL set commands are possible:

SELFCAL FORCE<EOI>
SELFCAL MODE:MANUAL,FORCE<EOI>

Queries

In many instances, queries are formed from set commands by simply appending a question mark ('?') to the desired set header and omitting the set command's argument. There are, however, some queries which have no corresponding set commands. Such queries are referred to as "query-only."

The general syntax of a query is as follows:

<QUERY>	::=	<HDR>? [<DLM> <LINK> [{, <LINK>}...]]
<DLM>	::=	{ASCII space...} | {,}
<HDR>	::=	query header, as defined in this document
<LINK>	::=	query link, as defined in this document

Queries Derived From Set Commands With Links

To form a query from a set command that takes link arguments, omit the link's colon (':') and argument. For example, here is a possible list of queries for the ENCDG command (this is not an exhaustive list):

Query Sent To The 11401 Example	11401 Query Response
ENCDG? SET<EOI>	ENCDG SET:BINARY<EOI>
ENCDG? SET,WAVFRM<EOI>	ENCDG SET:ASCII,WAVFRM:ASCII<EOI>
ENCDG? WAVFRM,SET<EOI>	ENCDG WAVFRM:BINARY,SET:ASCII<EOI>

An important point to note concerning this example is that query links may follow a query header in any order.

When query links are omitted (i.e., the command is simply a query header), all links and their current arguments are returned. For example:

Query Sent To The 11401	Example 11401 Query Response
ENCDG?<EOI>	ENCDG WAVFRM:ASCII,SET:ASCII<EOI>

Queries Derived From Set Commands Without Links

To form a query from a set command that takes no link arguments, simply omit the set command's argument. For example, there is only one possible query for the RQS set command, which looks like so:

Query Sent To The 11401	Example 11401 Query Response
RQS?<EOI>	RQS OFF<EOI>

Queries That Have No Corresponding Set Commands

If a query has no corresponding set command (i.e., query-only commands), its syntax is fully specified and explained in this document. An example of such a query is the UPTIME query (syntax: UPTIME?).

NOTE

The response obtained from a query that has no corresponding set command may never be returned to the 11401/11402 as a set command string. Any such attempt always results in a syntax error.

Command Processing Conventions

The following text describes various conventions for processing commands.

- Several 11401/11402 set commands may not be queried. These commands are referred to as "set-only" and are clearly identified in this section.

NOTE

Attempting to query a set-only command always results in a syntax error.

- Several 11401/11402 set commands are structured such that one or more of their link arguments may not be modified. Such links are referred to as "query-only." All such links are clearly identified in this section.

NOTE

Attempting to modify a query-only link argument (via a set command) is not considered to be an error if the link's argument is syntactically valid. In such cases, the 11401/11402 simply ignores the attempted modification of the query-only link. This convention permits query responses that include query-only links to be returned to the 11401/11402 without generating a syntax error.

- The 11401/11402 recognizes alphabetic character input data of either uppercase or lowercase. Thus, the commands "Rqs On" and "rqs ON" are considered to be identical. The 11401/11402 returns only UPPERCASE nondelimited alphabetic data to its ASCII ports.

- Any command reserved word transmitted to the 11401/11402 may be abbreviated up to the minimum ambiguity described later in this section.

- Any combination of set and/or query commands may be concatenated together with a semicolon. Thus:

  RQS OFF<EOI>
  ENCDG? <EOI>
  UPTIME?<EOI>

  may be combined as

  RQS OFF;ENCDG?;UPTIME?<EOI>

- The response to command input containing more than one query is formatted as follows:

  <response>;<response>[{;<response>}...]<EOI>

  Thus, for the command

  RQS ON;RQS?;PROBE NT;PROBE?<EOI>

  the query response is

  RQS ON;PROBE NT<EOI>

- The ASCII interfaces handle <EOI> message termination in the following manner:

  At the RS-232-C port, the 11401/11402 always accepts either a CR, LF, CR/LF, or LF/CR as an input message terminator. The output message terminator is user-selectable and may be either a CR, LF, CR/LF, or LF/CR.

  At the GPIB port, <EOI> is user-selectable and may be either a linefeed or an IEEE-488 EOI interface signal. Once a particular GPIB termination mode has been selected, the 11401/11402 both accepts and transmits that message terminator. (Regardless of which GPIB termination mode has been selected, the 11401/11402 always accepts an IEEE-488 EOI interface signal as an input message terminator.)

  When binary block data is transmitted to the 11401/11402's GPIB or RS-232-C ports, line feeds and carriage returns embedded within the binary block are treated as data bytes, not as message terminators. Once the 11401/11402 begins reading a binary block, linefeeds and carriage returns are not processed as terminators until the byte count of the block is satisfied.

- All command elements received at the 11401/11402's ASCII ports may be optionally preceded by "white space." In this context, a command element is a <HDR>, <LINK>, <ARG>, or a simple punctuation character (',' or ':'). White space has a different definition at each of the 11401/11402's ASCII ports.

  At the RS-232-C port, blanks are always considered to be white space. Furthermore, any linefeeds or carriage returns that precede a <HDR> are also considered to be white space.

  When the 11401/11402's GPIB port is configured for IEEE-488 EOI message termination, GPIB white space is defined to be any combination of blanks, linefeeds, or carriage returns.

  When the 11401/11402's GPIB port is configured for linefeed message termination, GPIB white space is defined to be any combination of spaces or carriage returns.

As an example, the command:

ENCDG WAVFRM : ASCII , SET: BINARY <EOI>

is equivalent to

ENCDG WAVFRM:ASCII,SET:BINARY<EOI>

- The 11401/11402 unconditionally clears its GPIB output buffer when any new input message (set or query command) is received at the GPIB port (no error is reported). No such equivalent action is taken at the RS-232-C port.

This means that the GPIB interface must be talked after each message containing a query or the response will be lost.

- The 11401/11402 unconditionally clears its GPIB output buffer when both the GPIB input and output buffers are simultaneously full. An execution error is also reported (event code 203—I/O buffers full).

  This is not the case for the RS-232-C interface. See the "RS-232-C I/O Errors" paragraph for a list of possible RS-232-C I/O errors.

- With two exceptions, all commands listed in this document are valid for use at both the GPIB and RS-232-C ports. The exceptions are the STBYTE? query, which is not a valid GPIB command, and RQS ON, which is invalid for the RS-232-C interface.

  The LONGFORM, EVENT?, STBYTE?, RQS, and SRQMASK commands are port-dependent. All other 11401/11402 commands are port-independent.

  A port-dependent command modifies or queries data that is not shared between the 11401/11402's I/O ports. A port-independent command modifies or queries data that is shared between the 11401's I/O ports. To illustrate the difference between port-dependent and port-independent commands, suppose that the following preconditions exist:

  a) LONGFORM is ON at both the RS-232-C and GPIB ports.
  b) WAVFRM ENCDG is set to ASCII at both the RS-232-C and GPIB ports.

  Now, suppose that a LONGFORM OFF command is received at the GPIB port and suppose that an ENCDG WAVFRM:BINARY command is received at the RS-232-C port. Once both of these commands have been executed, the following postconditions will exist:

  a) LONGFORM is OFF at the GPIB.
  b) LONGFORM is ON at the RS-232-C.
  c) WAVFRM ENCDG is set to BINARY at both the RS-232-C and GPIB ports.

Talked With Nothing To Say (TWNTS)

If the 11401/11402's GPIB port is talked with the input and output buffers empty, while the 11401/11402 isn't currently processing a GPIB command, it will return a "TWNTS" message to the GPIB port. The message is simply one byte with all eight bits set, followed by <EOI> (i.e., 0FFH<EOI>).

The RS-232-C interface doesn't have a "TWNTS" message. If an external device attempts to read data from the 11401/11402's RS-232-C port while the 11401 has no pending query responses or buffered query responses to process, that device will "hang" the interface (i.e., no further input/output operations will be possible).

Default Values and Units

Where applicable, a command's unit of measure and default values appear with its command description in the command set.

ASCII Interfaces Operating Conventions

The 11401/11402 follows a number of conventions in dealing with the interface operations for processing data and performing related functions.

User Interfaces I/O Synchronization

If a user of the 11401/11402 mainframe wishes to configure his oscilloscope such that the front panel, GPIB port, and RS-232-C port are simultaneously active (i.e., engaged in I/O), then the user is responsible for the sequence of events that occur in the mainframe at any given instant. Under no circumstances will the 11401/11402 attempt to synchronize the order in which a GPIB command, RS-232-C command, or human interface command is executed.

However, the 11401/11402 "tags" all input messages with the identity of the originating entity (GPIB, RS-232-C, or front panel) and correctly returns command queries and SRQ's as appropriate. For example, assume the RS-232-C sends a "DATE?" query to the 11401/11402 at the same time that the GPIB sends an "UPTIME?" query. In this scenario, only the RS-232-C will receive a response for the DATE? query and only the GPIB will receive a response for the UPTIME? query. However, the port that receives its query response first (in this "race" condition) cannot be determined.

I/O Buffer Operations

The lengths of the 11401/11402's GPIB/RS-232-C input and output buffers are shown in Table 3-3.

TABLE 3-3
I/O Buffer Sizes

GPIB INPUT	GPIB OUTPUT	RS-232-C INPUT	RS-232-C OUTPUT
256	1024	1024	1024

Even though the lengths of the primary GPIB and RS-232-C input buffers are fixed, GPIB/RS-232-C programmers should not assume that an input command that exceeds 256/1024 bytes will be errored. On the contrary, except in the case where RS-232-C ECHO is enabled, all GPIB/RS-232-C I/O is unbuffered. What this means is that the 11401/11402 parses input data as soon as it is received at its external ports. Thus, it continuously empties its input buffers while processing commands.

Should an external controller fill the GPIB/RS-232-C input buffers before the 11401/11402 has an opportunity to process their contents, it simply holds off the external controller (via IEEE-488 interface signals or RS-232-C flagging) until the input buffers have been partially emptied.

A similar situation exists with respect to GPIB/RS-232-C output buffers. If a query response fills the 11401/11402's output buffers, the 11401/11402 stops sending data to these buffers until an external controller partially empties (reads) them.

DCL Operating Conventions

The 11401/11402 DCL (Device Clear) and SDC (Selected Device Clear) interface message requirements state that upon receipt of a DCL or SDC message an instrument shall take the following actions to restart device communications:

1. Clear any SRQ (except "power on") and all pending events (except "power on").
2. Clear input and output buffers.
3. Restart device-dependent message processing.
4. Not change any settings or stored data.
5. Not interrupt front panel I/O.
6. Not interrupt non-programmable functions.

In addition, a DCL message received from the RS-232-C port does not affect the processing of device communications on the GPIB, and vice versa.

Special RS-232-C I/O Considerations

RS-232-C Emulation of GPIB Interface Messages

Except for DCL, the 11401/11402's RS-232-C interface does not support GPIB interface messages. To emulate DCL, an RS-232-C device (controller, terminal, etc.) must transmit a break character to the 11401/11402's RS-232-C port.

The interface message capabilities of the RS-232-C port, in comparison to the GPIB port, are given in the table below.

TABLE 3-4
RS-232-C & GPIB Interface Messages

Interface Message	Implemented GPIB Port?	Implemented RS-232-C Port?
GTL	No*	No*
SDC	Yes	No
PPC	No	No
GET	No	No
TCT	No	No
LLO	No*	No*
DCL	Yes	Yes
PPU	No	No
SPE	Yes	No
SPD	Yes	No
UNT	Yes	No
UNL	Yes	No
Talk Addresses	Yes	No
Listen Addresses	Yes	No

*** There is a device-dependent command (FPANEL) available to implement this function over the RS-232-C or GPIB interface.**

Binary Block Data Transfer

When transferring binary block data to the 11401/11402 via the RS-232-C, the following points should be noted:

- Binary block data may not be transmitted to the 11401/11402 when ECHO is ON. Any such attempt to do so causes the input block to be discarded and event code 164 to be posted.
- Binary data transfers should not be used with SOFT flagging unless the user can ensure that the data does not contain XON or XOFF characters. Use of DTR/CTS flagging guarantees correct data transfer.
- All eight bits of a binary block data byte contain meaningful information. To ensure that all eight bits are received from the 11401/11402 (or transmitted to the 11401/11402), an external RS-232-C controller must be configured to receive and transmit eight-bit characters (i.e., set the RS-232-C word length to eight bits). If a controller is incapable of decoding/encoding eight-bit characters, it is incapable of receiving or transmitting 11401/11402 binary block data.

RS-232-C Echo

When echo is enabled, all characters received at the 11401/11402's RS-232-C port are echoed back to the command source that transmitted those characters. RS-232-C echo can be enabled from the 11401/11402's front panel or from the GPIB or RS-232-C ports. To enable echo from the front panel, select the RS-232-C Utility menu and toggle the ECHO selector until ECHO is ON. To enable echo from the GPIB/RS-232-C ports, use this command: RS232 ECHO:ON .

With similar actions, echo can be disabled from the front panel or GPIB/ RS-232-C ports. Of course, the front panel ECHO selector must be toggled OFF and the corresponding GPIB/RS-232-C command is RS232 ECHO:OFF .

When To Use RS-232-C ECHO

An important point to note regarding RS-232-C echo is when to enable this feature and when to shut it off.

Never enable echo when a computer program is transmitting commands to the 11401/ 11402 (e.g., when a BASIC program on a small computer is being used to control the 11401/11402 via the RS-232-C port). The computer program will not expect to see its commands echoed back and the program will fail.

However, when a "dumb" RS-232-C device (e.g., a crt or hardcopy terminal) is connected to the 11401/11402's RS-232-C port, it is quite desirable to enable echo. Once echo is on, each character typed at the "dumb" device is echoed back and, consequently, the device's operator can see what she is typing.

ECHO Features And Limitations

When echo is enabled, several new features and limitations appear:

- The 11401/11402 solicits command input with a ">" prompt. When this prompt appears on an RS-232-C device, enter a valid command and terminate it with a carriage return (CR) or a linefeed (LF).
- Nonprintable ASCII characters are echoed with the following visual representations:

TABLE 3-5
Nonprintable ASCII Character Representations

ASCII Character	Echoed Character
NUL (0)	^@
SOH (1)	^A
STX (2)	^B
. .	.
. .	.
BS (8)	^H*
HT (9)	^I
LF (10)	^J*
. .	.
. .	.
CR (13)	^M*
. .	.
. .	.
DC1 (17)	^Q**
DC2 (18)	^R*
DC3 (19)	^S**
. .	.
. .	.
NAK (21)	^U*
. .	.
. .	.
SUB (26)	^Z
ESC (27)	^[
FS (28)	^\
GS (29)	^]
RS (30)	^^
US (31)	^_
DEL (127)	^?*

*** Only echoed when preceded with a backslash.**
**** Only echoed when soft flagging is disabled.**

- All command input is buffered. This means that a command will not be analyzed or executed until a CR or LF is received at the 11401/11402's RS-232-C port. (As you may recall, RS-232-C I/O is normally unbuffered, which means that each input character is analyzed as soon as it is received at the RS-232-C port.)

Buffering command input has its disadvantages and advantages. The only disadvantage is that no input command may exceed the length of the 11401/ 11402's RS-232-C echo buffer, which is fixed at 256 bytes (characters). Should this buffer overflow before a terminating CR or LF is entered, a command error (event code 163) will be returned and the entire command will be discarded.

The major advantage of command buffering is that before a command is terminated with a CR or LF, it may be edited with any of the following special characters:

CONTROL<R>—Retypes the current input command and places the terminal's cursor at the immediate right of the last character of the command.

CONTROL<U>—Deletes the current command and prompts for a new command.

BACKSPACE—Erases the character immediately to the left of the terminal's cursor. The visual effect of the 11401/11402's erasure algorithm is compatible with crt terminals but not with hardcopy terminals. (Hardcopy users take heart. Once a character has been erased with the backspace key, the entire input command can be retyped with the CONTROL<R> character.)

DEL or RUBOUT—Same functionality as BACKSPACE.

BACKSLASH—"Escapes" the character that immediately follows the backslash. Escaping a character means that the backslash is itself ignored and the character that follows is not interpreted in any way. Use the backslash to place a CR, LF, BACKSPACE, DEL, CONTROL<R>, or CONTROL<U> in a quoted string. To place a backslash itself in a quoted string, enter two consecutive backslashes (e.g., "\\" is interpreted as "\").

RS-232-C VERBOSE Mode

When verbose mode is enabled, each command sent to the 11401/11402 always returns a response of one type of or another. Such I/O behavior is often referred to as a "handshake." When verbose mode is disabled, only valid queries return a response from the 11401/11402.

Verbose mode can be enabled from the 11401/11402's front panel or from the GPIB or RS-232-C ports. To enable this mode from the front panel, select the **RS232C Parameters** Utility menu and toggle the **Verbose** label **On**. To enable verbose mode from the GPIB/RS-232-C ports, use this command: RS232 VERBOSE:ON.

Similarly, verbose mode can be disabled from the front panel or GPIB/RS-232-C ports. Of course, the front panel **Verbose** label must be toggled **Off** and the corresponding GPIB/RS-232-C command is RS232 VERBOSE:OFF .

I/O Behavior: RS-232-C Verbose Mode Enabled

When RS-232-C Verbose mode is enabled, each semicolon or EOI-delimited input command causes the 11401/11402 to return one of the following three responses:

OK—This response is returned for a successfully executed set command.

<QUERY DATA>—This response is returned for a successfully executed query.

EVENT <NR1>[,<qstring>]—This response is returned when the 11401/11402 detects an error while parsing or executing a query/set command. The <NR1> value represents one of the event codes listed in Tables 3-22 through 3-27. The optional <qstring> is an event code description string that describes the numerical event code. The event code description string is only returned when LONGFORM is ON. If more than one error is detected while parsing a particular query or set command, only one EVENT response is returned to the RS-232-C port. All other errors are stacked and may be polled with STBYTE? or EVENT?.

To illustrate I/O behavior when verbose mode is enabled, consider the following table of input commands and their corresponding response(s) from the 11401/11402:

TABLE 3-6
Examples of Verbose Mode Enabled Responses

Input Command(s)	11401/11402 Response
LONGFORM OFF<EOI>	OK<EOI>
INPUT STO1;RS232? BAUD<EOI>	OK;RS232 BAUD:9600<EOI>
JUNK;INIT;INPUT?<EOI>	EVENT 156;OK;INPUT STO1<EOI>
JUNK;INIT<EOI>	EVENT 156;OK<EOI>
RS232? OOPS;INPUT?<EOI>	EVENT 156;INPUT STO1<EOI>
INPUT?<EOI>	INPUT STO1<EOI>
INIT;LONGFORM ON<EOI>	OK;OK<EOI>
LONGFORM<EOI>	EVENT 157,"Syntax error"<EOI>

I/O Behavior: RS-232-C Verbose Mode Disabled

When RS-232-C Verbose mode is disabled, only valid queries cause the 11401/11402 to return any type of data to the RS-232-C. Valid set commands, invalid set commands, and invalid queries will elicit no response from the 11401/11402. The errors associated with invalid commands are not discarded. They are stacked and may be polled at any time. (Refer to "Status and Event Reporting" later in this section for more details.)

To illustrate I/O behavior when verbose mode is disabled, consider the following table of input commands and their corresponding response(s) from the 11401/11402:

TABLE 3-7
Examples of Verbose Mode Disabled Responses

Input Command(s)	11401/11402 Response
INPUT STO1;RS232? BAUD<EOI>	RS232 BAUD:9600<EOI>
JUNK;INIT;INPUT?<EOI>	INPUT STO1<EOI>
JUNK;INIT<EOI>	
RS232? OOPS;INPUT?<EOI>	INPUT STO1<EOI>
INPUT?<EOI>	INPUT STO1<EOI>
INIT<EOI>	

I/O Behavior: Instrument Power-up

If the RS-232-C Verbose mode is enabled at instrument energization, an asynchronous message is written to the RS-232-C port. This message reports either event 401 ("Power on") or, should power up diagnostics fail, event 394 (refer to "Status and Event Reporting" later in this section for more details).

The asynchronous message format is

EVENT <NR1>,<qstring><EOI>

The <NR1> value is the event code of the particular power up event, and <qstring> is the event code description string.

If the RS-232-C Verbose mode is disabled at instrument energization, no asynchronous messages are written to the RS-232-C port. Instead, power up events are stacked in the usual manner (refer to "Status and Event Reporting" later in this section for more details).

RS-232-C DCL

As stated previously, DCL is emulated on the RS-232-C by transmitting a break character to the 11401/11402. After the 11401/11402 has received and internally processed the DCL break, it returns a special message to the external RS-232-C device that handshakes this initial transmission.

The RS-232-C DCL handshake's form is different, depending on whether echo is on or off. When ECHO is ON, the 11401/11402 signals that it has completed processing DCL by echoing a new prompt for command input.

When ECHO is OFF, the 11401/11402 signals DCL completion by sending the following character string out its RS-232-C port:

DCL<EOI>

RS-232-C I/O Errors

The 11401/11402 detects and reports RS-232-C parity, framing, and input buffer overrun errors. An input buffer overrun is said to occur when the 11401's software input buffer or hardware DUART (Dual Universal Asynchronous Receiver/Transmitter) buffer overflows with data (the DUART buffer is 3 bytes deep and is used as temporary storage while the 11401/11402's RS-232-C interrupt handler moves data from the DUART to the software input buffer). In either case, input buffer overrun is caused by improper or nonexistent flagging.

To report RS-232-C errors, the 11401/11402 prints an appropriate error message on its front-panel display and posts one of these events to both the GPIB and the RS-232-C ports:

I/O Error	Event Code
Parity	653
Framing	654
Input Buffer Overrun	655

I/O Error Recovery

To recover from an input buffer overrun, the 11401/11402 takes the following actions:

1. All "incoming" data that caused the input buffer to overflow are discarded

2. If **RS232 ECHO** is **OFF**, unparsed input buffer data is discarded until a nondelimited semicolon or <EOI> character is encountered. Command processing recommences from the point at which the semicolon or <EOI> is found.

If **ECHO** is **ON**, all parsed input data are discarded and the user is reprompted for input.

To recover from a parity or framing error, the 11401/11402 takes one of two actions, depending upon the current state of **ECHO**. If **ECHO** is **OFF**, unparsed input buffer data are discarded until a nondelimited semicolon or <EOI> character is encountered. Command processing recommences from the point at which the semicolon or <EOI> character is found. If ECHO is ON, all unparsed input data are discarded and the user is reprompted for input.

NOTE

When ECHO is OFF, the previously described recovery steps may temporarily cause the 11401/11402 to process incomplete RS-232-C commands. This means that spurious syntax or semantic errors may be reported as a result of an I/O error.

RS-232-C Pin Out and Cable Connections

The 11401/11402's RS-232-C port is configured for full duplex, DCE type communications. Half duplex communications are not supported.

The 11401/11402 RS-232-C pin assignments are listed below.

Pin Number	Pin Name	I/O	Notes
1	Chassis Ground		
2	Transmit Data	I	
3	Received Data	O	
4	Request To Send	I	Ignored by the 11401/ 11402
5	Clear To Send	O	See flagging discussion
6	Data Set Ready	O	Always high
7	Signal Ground		
8	Data Carrier Detect	O	Always high
20	Data Terminal Ready	I	See flagging discussion

Flagging vs CTS and DTR

When SOFT or NONE flagging are selected, the 11401/11402 sets CTS (Clear To Send) high and ignores all DTR (Data Terminal Ready) signal changes.

When HARD flagging is enabled, CTS is normally high. However, if the 11401/ 11402's software input buffer or hardware DUART buffer are in danger of overflowing, CTS is set low until all buffers are suitably emptied.

When HARD flagging is enabled, the 11401/11402 monitors DTR. The 11401/ 11402 transmits no data when DTR is set low (by whatever device is attached to its RS-232-C port). When DTR is set high, data transmission (from the 11401/11402 to an external device) is enabled.

Connecting Two RS-232-C Devices

Connecting two different RS-232-C devices, often made by two different manufacturers, can be frustrating. There is no recipe that will permit the connection to be made "first time, every time." We can, however, offer these insights:

- Read the equipment guide of the device you wish to connect to the 11401/ 11402 and determine which signal lines are ignored, which are output lines, and which are input lines. Determine also whether this device is configured as a DTE or DCE.

- If a DTE device is being attached to the 11401/11402, chances are good that no signal lines must be swapped between the two devices.

- If a DCE device is being connected, at least two signal lines, Transmit Data and Receive Data, must be swapped. If hard flagging is also used in this DCE-to-DCE connection, two more signals (typically, DTR and CTS) are usually swapped (consult your device's equipment guide for exact details).

- When wiring the cable that connects the 11401/11402 to an external device, these "rules of thumb" are useful:

  Pay attention to the input signal requirements of the external device (many devices require a constant high signal at one or more input pins).

  With respect to DCE-to-DCE connections, do not connect the output line of one DCE to the output line of the other. Failure to heed this restriction may damage one or both devices.

  Ensure that the 11401/11402's signal ground is connected to the external device's signal ground.

  Ensure that the 11401/11402's chassis ground is connected to the external device's chassis ground.

Example Cable Connections

Cable connections (see Fig. 3-11) are offered as examples to help connect an RS-232-C device to the 11401/11402. No explanation is provided regarding the logic behind these connections, however, experienced users should find them extremely useful.

CONNECTION: 11401/11402 TO SIMPLE RS-232-C TERMINAL (*)

11401/11402 (DCE) I/O	PIN #	TERMINAL (DTE) PIN #	I/O
	1	1	
I	2	2	O
O	3	3	I
	7	7	

CONNECTION: 11401/11402 TO IBM PC/XT

11401/11402 (DCE) I/O	PIN #	PC/XT (DTE) PIN #	I/O
	1	1	
I	2	2	O
O	3	3	I
I	4	4	O
O	5	5	I
O	6	6	I
	7	7	
O	8	8	I
I	20	20	O

CONNECTION: 11401/11402 TO HP9836 (WITH 98626A INTERFACE CARD)

11401/11402 (DCE) I/O	PIN #	HP9836 (DTE) PIN #	I/O
	1	24	
I	2	12	O
O	3	42	I
I	4	13	O
O	5	44	I
O	6	45	I
	7	48	
O	8	46	I
I	20	14	O

CONNECTION: 11401/11402 TO TEK 4132 (**)

11401/11402 (DCE) I/O	PIN #	TEK 4132 (DCE) PIN #	I/O
	1	1	
I	2	3	O
O	3	2	I
I	4	8	O
O	5	20	I
	7	7	
O	8	4	I
I	20	5	O

(*) THIS CONNECTION, WHICH ASSUMES HARD FLAGGING IS NOT USED, WORKS FOR MANY RS-232-C TERMINALS; INCLUDING, BUT NOT LIMITED TO: HEATH 19, TEK 41XX FAMILY, ANN ARBOR AMBASSADOR FAMILY, AND TELEVIDEO FAMILY.

(**) NOTICE THAT WHEN A DCE-TO-DCE CONNECTION IS MADE, SIGNAL LINES 2 AND 3 ARE SWAPPED. SINCE THE 4132 SUPPORTS HARD FLAGGING, SIGNAL LINES 5 AND 20 ARE CONNECTED AND SWAPPED. ALSO, THE 4132 REQUIRES ITS RTS LINE TO BE DRIVEN HIGH, WHICH IS ACCOMPLISHED BY CONNECTING THE 11401/11402'S DCD LINE TO THE 4132'S RTS LINE.

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Figure 3-11. Examples of RS-232-C connections.

Syntax and Descriptions

The 11401/11402 command set is functionally grouped. The major command groups, by order of appearance, are

Group	Functions Controlled:
CHANNEL	Plug-in parameters
TIMEBASE	Main & Window lengths, scale factors, etc.
TRIGGERING	Main & Window trigger parameters
RECORD POSITION	Main & Window record position
DISPLAY	Front panel screen parameters and placement of user text on screen
CURSOR	Front panel cursors
WAVEFORM/SETTINGS	Waveform and setting creation/modification
DATA TRANSFER	Waveform and settings transfer to/from the 11401/11402
ACQUISITION	Conditional acquisition
MEASUREMENT	11401/11402 measurements
STATUS & EVENT	Event reporting and hardware configuration
EXTERNAL I/O	RS-232-C parameters, hardcopy, and ASCII debug
CALIBRATION	11401/11402 self-calibration
MISCELLANEOUS	Commands that don't fit one of the above groups
DIAGNOSTICS	11401/11402 diagnostics

Of the groups listed above, WAVEFORM/SETTINGS is very important, since it contains commands that create, remove, and store waveforms. Waveforms are created with the TRACE<ui> DESCRIPTION command, waveforms are removed from the display with the REMOVE command, and waveforms are stored with the STORE command.

Once a waveform is created, its timing and amplitude characteristics may be analyzed with the MEASUREMENT commands. It may be positioned vertically with the CHANNEL commands or horizontally with the TIMEBASE and RECORD POSITION commands. Also, it's triggering characteristics may be adjusted with the TRIGGER-ING commands.

There are numerous other uses for the command set, each of which depends upon the needs of the individual user.

An Easy Way To Learn The Command Set

As you will see, the 11401/11402's command set is very large. Attempting to gain familiarity with the entire command set from small BASIC programs written on an RS-232-C or GPIB controller is sometimes tedious and subject to programming errors.

There is a simpler way to learn the command set. Instead of using BASIC on the RS-232-C or GPIB controller, connect an ASCII terminal to the 11401/11402's RS-232-C port. Once connected and properly configured, enable RS-232 ECHO and turn on the RS-232 VERBOSE mode (type "e" and a carriage return, then type "v" and a carriage return).

Now, simply experiment with the command set by typing "set" and "query" commands at the terminal's keyboard. In this way, you can try any command sequence imaginable (binary block formatted data transfers excluded) and immediately find out how the instrument reacts, and what type of errors and warnings it can report.

NOTE

For many commands and their links, detailed definitions and descriptions of corresponding front-panel functions can be found, previously, in the front-panel operation section of this manual.

Once you feel comfortable with the command set and the 11401/11402's operation, you're ready to write useful programs on an actual controller.

Channel Commands

Channel commands set and query the parameters of an 11000-Series vertical channel plug-ins.

Header	Link	Argument	Notes
CH<slot><ui>	AMPOFFSET:	<NRx>	1
	BW:	<NRx>	2
	BWHI:	<NRx>	3
	BWLO:	<NRx>	3
	COUPLING:	AC I DC I OFF	4
	IMPEDANCE:	<NRx>	
	MNSCOUPLING:	AC I DC I VC I OFF	1
	MNSOFFSET:	<NRx>	1
	MNSPROBE:	<qstring>	1,5
	OFFSET:	<NRx>	
	PLSCOUPLING:	AC I DC I VC I OFF	1
	PLSOFFSET:	<NRx>	1
	PLSPROBE:	<qstring>	1,5
	PROBE:	<qstring>	4,5
	PROTECT:	ON I OFF	1
	SENSITIVITY:	<NRx>	
	UNITS:	<qstring>	5
	VCOFFSET:	<NRx>	1
CH<slot>			6
CH			6

Note
1. Link applies only to differential amplifier
2. Link applies only to amplifiers that have no high/low bandwidth function
3. Link applies only to amplifiers that have high/low bandwidth function
4. Link applies only to nondifferential amplifier
5. Query-only link
6. Query-only

CH<slot><ui> Command

The <slot> component of this command header selects a particular plug-in compartment, and the <ui>header component selects a particular plug-in channel. Thus, to set or query any parameter of the third channel of the LEFT vertical plug-in amplifier the command header must appear as "CHL3."

Details of how these Channel command parameters operate is covered in Section 2 "Operating Information".

How Channel Command Parameters Apply

Not all CH<slot><ui> command parameters apply to all 11000-series plug-ins. Hence, parameters fall into four categories:

1. Parameters Common To All 11000-series Plug-ins.
2. Nondifferential Plug-in Parameters.
3. Differential Plug-in Parameters.
4. Bandwidth Parameters

The following Channel command parameter listing is organized into the aforementioned categories.

Parameters:

NOTE

The ranges and valid values for vertical parameters that take numeric arguments are unique to each type of plug-in unit. Therefore, see the appropriate plug-in supplement for setting ranges and valid setting values.

Category 1

IMPEDANCE—sets the channel input impedance, in ohms, to a value indicated by the argument.

SENSITIVITY—sets the specified channel's vertical input sensitivity (gain) to a value indicated by the argument.

UNITS—is a query-only link that returns a quoted string indicating the units of the selected channel.

Category 2

COUPLING—sets the selected channel input coupling to one specified by the argument list.

OFFSET—sets the voltage subtracted from the input signal of the specified channel. OFFSET vertically positions a plug-in signal on the 11401/11402 display.

PROBE—is a query-only link that returns a quoted string indicating what type of probe is currently being used. For example, when a Level 1 TEKPROBE™ is connected, the 11401/11402 returns the quoted string, "Level 1". When a Level 2 TEKPROBE™ is connected, the 11401/11402 returns "Level 2/<probe_type>/<serial_number>". When neither a level two nor level one probe is connected, the query response is "NONE".

Category 3

MNSCOUPLING—sets the selected channel's minus differential input coupling as indicated by the argument. When this function is set to OFF or VC, the specified minus input is internally disconnected from its external signal source.

MNSOFFSET—sets the probe offset voltage subtracted from the minus input of the specified channel. If the user attempts to set this function without having an offset-type probe connected, a warning will be reported and the offset value saved until an appropriate probe is connected.

MNSPROBE—this query-only link returns a quoted string indicating what type of probe is currently connected to the minus input of the specified channel. The possible responses are identical to those described for the PROBE link.

PLSCOUPLING—sets the selected channel plus differential input coupling as indicated by the argument.

PLSOFFSET—sets the plus input probe offset voltage of the specified channel.

PLSPROBE—this query-only link returns a quoted string indicating what type of probe is currently connected to the plus input of the specified channel.

PROTECT—sets the SENSITIVITY range of a differential amplifier. When PROTECT is ON, the minimum SENSITIVITY settings are restricted to protect front end hardware circuitry. When PROTECT is OFF, the SENSITIVITY range is not restricted.

VCOFFSET—sets an internal comparison voltage that serves as a plus or minus input signal when either PLSCOUPLING or MNSCOUPLING, respectively, is set to VC. Otherwise, there is no effect.

OFFSET—this link is independent of the nondifferential plug-in unit OFFSET. Differential OFFSET's argument modifies one of the other four differential offset functions (i.e., AMPOFFSET, MNSOFFSET, PLSOFFSET, and VCOFFSET). Just which function is affected depends upon the current input coupling and the type of probes connected to the inputs. See the applicable differential plug-in supplement for further details.

Category 4

BW—sets a plug-in's channel bandwidth to the value specified in the argument. This command link is valid only for plug-ins that do not have the BWHI/BWLO function.

BWHI—sets the specified channel upper bandwidth limit to a value specified by the argument. This is valid only for plug-ins that have the BWHI/BWLO feature.

BWLO—sets the specified channel lower bandwidth limit to a value specified by the argument. This is valid only for plug-ins that have the BWHI/BWLO feature.

Level 2 TEKPROBEs vs Plug-in Parameters

Attaching a Level 2 TEKPROBE™ to an input channel may cause a plug-in to reject coupling or impedance settings that are normally valid for that channel. Consult the appropriate Plug-in supplement to determine which coupling and impedance settings are valid.

Special Plug-in Out-of-Range Considerations

The 11401/11402 normally returns out of range warnings for numerical values that exceed the valid range of a particular instrument setting. These values are not rejected, but are, instead, coerced to appropriate maximum or minimum settings.

Plug-in units, however, do not return warnings for out of range BW, BWHI, BWLO, or IMPEDANCE values. But, they do coerce out of range values to appropriate maximum or minimum settings.

Special 11A33 Plug-in Considerations

The 11A33 is a differential plug-in and several of its parameters interact with one another. Therefore, modifying the value of one parameter might coerce one or more other 11A33 parameters. When such coercion occurs, no warning messages are reported. Also, there are certain circumstances under which parameter "X" is not possible because parameter "Y" is in effect. The following list describes those 11A33 parameters that interact with one another:

- **PROTECT**—interacts with IMPEDANCE and SENSITIVITY. When PROTECT is OFF there are no side effects or restrictions. When PROTECT is ON, SENSITIVITY is restricted from 100 mV to 10 V and IMPEDANCE is restricted to 1 MΩ for 50 Ω (1 GΩ is disallowed). When PROTECT mode is enabled and SENSITIVITY is less than 100 mV, it will be set to 100 mV. If IMPEDANCE is 1 GΩ when PROTECT is enabled, IMPEDANCE will be coerced to 1 MΩ.

- **PLSCOUPLING/MNSCOUPLING**—interact with IMPEDANCE. When either coupling parameter is AC, 1 GΩ IMPEDANCE is disallowed. Otherwise, coupling does not restrict IMPEDANCE. If either parameter is changed to AC when IMPEDANCE is 1 GΩ, IMPEDANCE will be set to 1 MΩ.

- **IMPEDANCE**—interacts with SENSITIVITY, PROTECT, PLSCOUPLING, and MNSCOUPLING. If PROTECT is enabled or one of the coupling settings is AC, then 1 GΩ IMPEDANCE is disallowed regardless of the SENSITIVITY. If PROTECT is disabled, neither coupling is AC, SENSITIVITY is between 100 mV and 10 V, and IMPEDANCE is changed to 1 GΩ; then SENSITIVITY will be changed to 99.5 mV before the IMPEDANCE is changed to 1 GΩ. Take note that setting IMPEDANCE to 1 MΩ or 50 Ω causes no parameter coercion under any circumstances.

- **SENSITIVITY**—cannot coerce anything but may be limited by PROTECT and IMPEDANCE.

Query Information:

The general query form for the Channel command is

CH<slot><ui>?

This query causes the 11401/11402 to return the current parameters/settings of the specified channel for the specified plug-in slot. The information returned is dependent upon the type of amplifier installed in that slot.

NOTE

In the following example query responses it is assumed that the currently loaded plug-in unit has the BWLO/BWHI functions. Hence, a BWLO and a BWHI argument are always shown in the response. However, if an 11000-series plug-in does not have this function, no BWLO/BWHI link will be returned. Instead, the BW link will be returned.

For example, if the plug-in is not a differential amplifier, the query response is

CH<slot><ui> COUPLING:<arg>,OFFSET:<NR3>,BWHI:<NR3>,
BWLO:<NR3>,IMPEDANCE:<NR3>,PROBE:<gstring>,
SENSITIVITY:<NR3>,UNITS:<qstring>

However, if the plug-in is a differential amplifier, the query response is

CH<slot><ui> MNSCOUPLING:<arg>,PLSCOUPLING:<arg>,
PROTECT:<arg>,OFFSET:<NR3>,AMPOFFSET:<NR3>,
BWHI:<NR3>,BWLO:<NR3>,IMPEDANCE:<NR3>,
MNSOFFSET:<NR3>,MNSPROBE:<qstring>,
PLSOFFSET:<NR3>,PLSPROBE:<qstring>,
SENSITIVITY:<NR3>,UNITS:<qstring>,VCOFFSET:<NR3>

Error and Warning Conditions:

An execution warning (event code 550) is issued if arguments are out of range for the AMPOFFSET, OFFSET, PLSOFFSET, MNSOFFSET, VCOFFSET, or SENSITIVITY links.

Attempting to set or query the parameters of plug-in slot that isn't loaded with an 11000 Series amplifier results in an execution error (event code 275).

Attempting to set or query a plug-in channel that doesn't exist results in an execution error (event code 263).

An execution error (event code 272) is returned when an attempt is made to set or query the BWHI or BWLO parameters of a plug-in that doesn't have these functions. This same error is returned when an attempt is made to set or query the BW parameter of a plug-in that supports BWHI/BWLO limits.

An execution error (event code 284) is returned when an attempt is made to set coupling to a setting which is not supported by the currently loaded plug-in. This same error is returned when an attempt is made to set a plug-in channel's coupling to a setting that is normally supported, but is not presently permitted because a Level 2 TEKPROBE™ has been connected to that channel. This error is also returned when an input channel is overloaded and an attempt is made to set coupling to an otherwise valid setting that would worsen the overload.

An execution error (event code 285) is returned when an attempt is made to set a plug-in channel to an impedance value that is normally supported, but which is not presently permitted because a Level 2 TEKPROBE™ has been connected to that channel. This error is also returned when an input channel is overloaded and an attempt is made to set impedance to an otherwise valid value that would worsen the overload.

Attempting to set or query a PLSCOUPLING or MNSCOUPLING parameter for a nondifferential amplifier results in an execution error (event code 272). The same error is returned when an attempt is made to set or query the COUPLING parameter of a differential amplifier.

Attempting to set or query the AMPOFFSET, MNSOFFSET, PLSOFFSET, or VCOFFSET parameters of a nondifferential amplifier results in an execution error (event code 272).

Attempting to query the PLSPROBE or MNSPROBE parameters of a nondifferential amplifier results in an execution error (event code 272). This same error is returned when an attempt is made to query the PROBE parameter of a differential amplifier.

An execution warning (event code 558 or 559) is returned when an attempt is made to change the PLSOFFSET or MNSOFFSET of a differential plug-in and an offset-type probe is not connected to the plus or minus input of the specified channel.

Attempting to set/query the PROTECT parameter of a nondifferential amplifier results in an execution error (event code 272).

When an input signal overloads a plug-in low impedance termination resistor, the plug-in changes its impedance to protect against this condition and reports an internal warning (event code 651).

When a plug-in input signal is overdriven in a way that might distort the displayed signal, an internal warning (event code 652) is reported.

An internal error (event code 308) is returned when a plug-in detects that a Level 2 TEKPROBE™ has been improperly connected to an input channel. This same error is reported when a Level 2 probe is properly connected, but has malfunctioned.

An internal error (event code 397) is returned when a plug-in detects that a requested setting has overflowed an internal digital-to-analog converter (DAC). In this situation, the plug-in reverts to the nearest setting. This error usually indicates failed plug-in hardware.

An internal error (event code 396) is returned when the 11401/11402 detects that communication is no longer possible between the 11401/11402 and a particular plug-in. In this situation, the 11401/11402 may or may not continue to operate, depending upon the type of message that was in progress at the time that communication failure occurred. This error could indicate: failed hardware, a software bug, or that a plug-in was removed from an energized 11401/11402 and plug-in communication was attempted with that empty compartment.

CH<slot>? Query Command

This query-only command returns information regarding all channels of a specific plug-in unit, in the form:

CH<slot>1 <link>:<arg>[{,<link>:<arg>}...];
CH<slot>2 <link>:<arg>[{,<link>:<arg>}...];
.
.
CH<slot>n <link>:<arg>[{,<link>:<arg>}...]

Error and Warning Conditions: Attempting to query a plug-in slot that isn't loaded with an 11000-series amplifier results in an execution error (event code 275).

CH? Query Command

This query-only command returns responses for all plug-ins that support the 11000-series plug-in interface.

The following example demonstrates a CH? query response (this example assumes that the 11401/11402 is configured with plug-in units in each of its slots):

CHL1 <link>:<arg>[{,<link>:<arg>}...];
CHL2 <link>:<arg>[{,<link>:<arg>}...];
.
.
CHLn <link>:<arg>[{,<link>:<arg>}...];
CHC1 <link>:<arg>[{,<link>:<arg>}...];
CHC2 <link>:<arg>[{,<link>:<arg>}...];
.
.
CHCn <link>:<arg>[{,<link>:<arg>}...];
CHR1 <link>:<arg>[{,<link>:<arg>}...];
CHR2 <link>:<arg>[{,<link>:<arg>}...];
.
.
CHRn <link>:<arg>[{,<link>:<arg>}...]

Special Conditions When the 11401/11402 is configured such that some (but not all) of its plug-in units do not support the 11000-series plug-in interface, the CH? query returns channel information for 11000-series plug-ins only.

Error and Warning Conditions: When the 11401/11402 has no 11000-series plug-ins installed, a CH? results in an execution error (event code 274).

Time-Base Commands

Time-base commands establish acquisition scaling and select a time base.

Header	Link	Argument	Notes
TBMAIN	TIME: LENGTH: XINCR:	<NRx> <NRx> <NRx>	 1
TBWIN	TIME: LENGTH: XINCR:	<NRx> <NRx> <NRx>	 1

Note 1: Query-only link.

TBMAIN and TBWIN Commands

TBMAIN—selects the main time base to establish its scaling.

TBWIN—selects the window time base to establish its scaling.

Parameters:

TIME—sets the selected time base, in seconds, to the specified time per division (also called "horizontal scale"). The valid range of both time bases is 500 picoseconds per division to 100 seconds per division, in 1-2-5 step intervals. There are many restrictions on this range. For example, 500 psec/div is only possible when the specified time base record length is 512 points. Also, the window time/div may never exceed the main time/div setting. For a list of horizontal scale restrictions, refer to the operator's information section of this manual.

LENGTH—sets the selected time base to the specified record length, scaled in points per waveform. Valid selections for both time bases are 512, 1024, 2048, 4096, 5120, 8192, 10240 points.

XINCR—this query-only link returns the sample interval of the selected time base. The units are seconds per point.

Computing Time-Base Duration

The sample interval returned via a TBMAIN? XINCR or TBWIN? XINCR can be used to compute the duration, in seconds, of the main or window time base. The computations are:

Main Duration = main_XINCR * (main_LENGTH - 1)

Window Duration = window_XINCR * (window_LENGTH -1)

Duration is an important quantity that specifies the limits of other 11401/11402 parameters (e.g., main time base position).

Query Information

The general query form TBMAIN? or TBWIN? returns all links and their currently selected arguments, in the form:

TBMAIN LENGTH:<NR1>,TIME:<NR3>,XINCR<NR3>
TBWIN LENGTH:<NR1>,TIME:<NR3>,XINCR<NRx>

Error and Warning Conditions:

An execution warning (event code 550) is issued if set arguments are out of range for the TIME or LENGTH links.

An execution error (event code 295) is returned if the selected trace is a Point Accumulate waveform and an attempt is made to increase the time base LENGTH to some value greater than 2048 points.

Triggering Commands

Triggering commands select and define the behavior of the triggering system.

Header	Link	Argument	Notes
TRMAIN	ALEVEL: ANLEVEL: COUPLING: MODE: SLOPE: SOURCE: STATUS: TIHOLDOFF:	<NRx> <NRx>,<units> AC I ACLF I ACHF I DCHF I ACNOISE I DCNOISE I DC AUTO I AUTOLEVEL I NORMAL PLUS I MINUS <qstring> TRG I NOTRG <NRx>	 1 2
WTMODE		MAIN I EVHOLDOFF I TIHOLDOFF	
TRWIN	ALEVEL: COUPLING: EVHOLDOFF: MODE: NLEVEL: SLOPE: SOURCE: STATUS: TIHOLDOFF	<NRx> AC I ACLF I ACHF I DCHF I ACNOISE I DCNOISE I DC <NRx> AUTOLEVEL I NORMAL <NRx>,<units> PLUS I MINUS <qstring> TRG I NOTRG <NRx>	 1 2
TR			3

Note
1. <units> ::= DIVS I VOLTS
2. Query-only link
3. Query-only

TRMAIN Command

TRMAIN selects the main time base trigger to set its parameters.

Parameters:

ALEVEL —when trigger mode is autolevel, ALEVEL sets trigger level to a value specified by the argument.

The units of ALEVEL are percentage and the valid range is 20% to 80%. Refer to "Autolevel Trigger Level Usage" later inthis section of the manual for a discussion of how and when to use ALEVEL.

ANLEVEL—when trigger mode is auto or normal, ANLEVEL sets the trigger level to a value specified by the argument. Since trigger level may be scaled in either DIVS or VOLTS, units must be specified when setting ANLEVEL. Refer to the "Auto/Normal Trigger Level Usage" later inthis section for a discussion of how and when to use ANLEVEL.

COUPLING—sets the trigger to coupling as indicated by the argument.

MODE—sets the trigger mode as indicated by the argument.

SLOPE—sets the trigger slope as indicated by the argument.

SOURCE—sets the source of the trigger to the specified trigger expression, which must be enclosed within a quoted string. Within the quoted string, trigger expression syntax is

```
<TRG_EXPR>      ::=  LINE | {[<OP>] <EXP>}
<EXP>           ::=  {<LC_CHAN> <LC_EXP>} | {<R_CHAN> <R_EXP>}
<LC_CHAN>       ::=  {L | C} <ui>
<R_CHAN>        ::=  R <ui>
<LC_EXP>        ::=  <EMPTY> | {<OP> <LC_CHAN> <LC_EXP>}
<R_EXP>         ::=  <EMPTY> | {<OP> <R_CHAN> <R_EXP>}
<EMPTY>         ::=
<OP>            ::=  + | -
```

See the "Trigger Source Semantics" paragraph for more information.

STATUS—this query-only link returns the trigger status of the main time base. TRG indicates the main time base is triggered. NOTRG indicates that the time base is not triggered.

TIHOLDOFF—sets trigger TIme HOLDOFF to a value as indicated by the argument. The units of this link are seconds and the valid range is 490 nanoseconds (4.9E-7) to 10 seconds.

Query Information:

The general query TRMAIN? returns all links and their currently selected arguments, in the following form:

```
TRMAIN  MODE:<arg>,ALEVEL:<NR3>,COUPLING:<arg>,SLOPE:<arg>,
        SOURCE:<qstring>,ANLEVEL:<NR3>,<units>,STATUS:<arg>,
        TIHOLDOFF:<NR3>
```

Error and Warning Conditions:

An execution warning (event code 550) is returned if set arguments are out of range for ALEVEL, ANLEVEL, or TIHOLDOFF links.

An execution error (event code 288) is returned if improper ANLEVEL units are specified. Refer to the "Auto/Normal Trigger Level Usage" later in this section for complete details.

Improper trigger source expressions also cause the 11401/11402 to return errors and warnings. Refer to the "Trigger Source Semantics" later in this section for complete details.

WTMODE Command

WTMODE sets the Window Triggering MODE to determine how windows are acquired and displayed.

Parameters:

MAIN—(triggered by main) causes the window time base trigger to not be held off, such that the window trigger coincides with the main trigger. The window record may be positioned with respect to the main trigger point.

TIHOLDOFF—(triggered from window/holdoff by time) causes the window time base to be held off for a time equal to the trigger holdoff and the window having received a trigger from the window trigger source. The window record may be positioned with respect to the window trigger point.

EVHOLDOFF—(triggered from window/holdoff by event) causes the window time base to be held off by a number of events. The window record may be positioned with respect to the window trigger point.

Query Information:

The status of WTMODE may be obtained via a WTMODE? query. The currently selected argument is returned in the form:

WTMODE <arg>

Error and Warning Conditions:

When WTMODE is changed from MAIN to TIHOLDOFF or EVHOLDOFF, the 11401 traps chopped window trigger sources. Refer to the "Trigger Source Semantics" paragraph of this section of the syntax manual for more details.

TRWIN Command

TRWIN sets or queries window time base trigger parameters.

Take note that changes to TRWIN parameters do not take effect until WTMODE is set to some value other than MAIN. For example, suppose WTMODE is MAIN and suppose the window trigger slope is changed from plus to minus. In this case, the 11401/11402 stores the new slope value, but does not use it to trigger the window time base. Later, if WTMODE is set to TIHOLDOFF or EVHOLDOFF, the new slope value will be applied to the window trigger.

Parameters:

MODE—sets trigger mode as indicated by the argument.

ALEVEL—when trigger mode is autolevel, ALEVEL sets trigger level to a value specified by the argument. The units of ALEVEL are percentage and the valid range is 20% to 80%. Refer to the" Autolevel Trigger Level Usage" paragraph of this section of the manual for a discussion of how and when to use ALEVEL.

COUPLING—sets trigger coupling as indicated by the argument.

EVHOLDOFF—sets EVents HOLDOFF to a value as indicated by the argument. The range of EVHOLDOFF is 1 to 1E9 events. Take note that a change to EVHOLDOFF takes effect only when WTMODE is set to EVHOLDOFF. When WTMODE is set to MAIN or TIHOLDOFF, a change to EVHOLDOFF is stored and not applied to the trigger until WTMODE is switched to EVHOLDOFF.

NLEVEL—when trigger mode is normal, NLEVEL sets the trigger level of the trigger source to a value specified by the argument. Since normal trigger level may be scaled in either DIVS or VOLTS, units must be specified when setting NLEVEL. Refer to the "Auto/Normal Trigger Level Usage" paragraph of this section of the manual for a discussion of how and when to use NLEVEL.

SLOPE—sets trigger slope as indicated by the argument.

SOURCE—sets the trigger source to the specified trigger expression, which must be enclosed within a quoted string. Refer to "Trigger Source Semantics" later in this section and "TRMAIN Command" earlier in this section for more details.

STATUS—this query-only link returns the trigger status of the window time base. TRG indicates the window time base is triggered. NOTRG indicates that the time base is not triggered.

TIHOLDOFF—sets trigger TIme HOLDOFF to a value as indicated by the argument. The units of this link are seconds and the valid range is 20 nanoseconds (20E-9) to 10 seconds, with the upper limit bounded by main time base duration (see the Time base commands for the way to compute main duration). Take note that a change to TIHOLDOFF takes effect only when WTMODE is set to TIHOLDOFF. When WTMODE is set to MAIN or EVHOLDOFF, a change to TIHOLDOFF is stored and not applied to the trigger until WTMODE is set to TIHOLDOFF.

Query Information:

The general query TRWIN? returns all links and their currently selected arguments, in the following form:

TRWIN MODE: <arg>,ALEVEL: <NR3>, COUPLING: <arg>,
EVHOLDOFF: <NR1>, SLOPE:<arg>, SOURCE: <qstring>,
NLEVEL: <NR3>, <units>, STATUS: <arg>, TIHOLDOFF: <NR3>

Error and Warning Conditions:

An execution warning (event code 550) is returned if set arguments are out of range for ALEVEL, EVHOLDOFF, NLEVEL, or TIHOLDOFF links.

An execution error (event code 288) is returned if improper NLEVEL units are specified. Refer to "Auto/Normal Trigger Level Usage" for complete details.

Improper trigger source expressions also cause the 11401/11402 to return errors and warnings. Refer to "Trigger Source Semantics" for complete details.

TR? Query Command

TR? is shorthand notation for the following command:

TRMAIN?;TRWIN?

The TR? query response is

TRMAIN <link>:<arg>[{,<link>:<arg>}...];
TRWIN <link>:<arg>[{,<link>:<arg>}...]

Take note, the individual TR header is never returned as part of the query response.

Auto/Normal Trigger Level Usage

It is important to describe which units of auto or normal trigger level are accepted by the 11401/11402 in various trigger modes and which units are reported back via the TRM? ANLEVEL and TRW? NLEVEL queries.

In autolevel trigger mode, the 11401/11402 discards any trigger level values set via the ANLEVEL or NLEVEL links—no error is reported. However, in autolevel mode the TRM? ANLEVEL and TRW? NLEVEL queries are useful because they return scaled trigger level values (as opposed to the percentage values returned by TRM? ALEVEL and TRW? ALEVEL). Refer to "Autolevel Trigger Level Usage" of this section of the manual for more details.

In auto or normal mode, trigger level may be set via the ANLEVEL or NLEVEL links. Under the following conditions, the 11401/11402 scales and reports ANLEVEL or NLEVEL in volts:

- Trigger source is a single, possibly inverted, plug-in channel, and
- Trigger coupling is DC, DCHF, or DCNOISE.

Otherwise, the 11401/11402 scales and reports ANLEVEL or NLEVEL in divs.

When the 11401/11402 scales trigger level in volts, users may set ANLEVEL or NLEVEL values in VOLTS or DIVS units. If divs are specified when level is scaled as volts, the 11401/11402 converts the divs value to volts and applies that value to the appropriate trigger. The divs-to-volts conversion formula is as follows:

<# of divs> * trig source channel gain + trig source channel offset

When auto or normal trigger level is scaled in divs, ANLEVEL or NLEVEL may only be specified in divs units. Specifying volts under these conditions is an execution error (event code 288).

For examples, refer to the following table.

TABLE 3-8
11401/11402 Trigger Level Setting

Trig Mode	Trig Coup	Trig Source	Example User Level Set	Action Taken
AUTOLEVEL	DC	L1	NLEVEL:3,DIVS	Value ignored
AUTOLEVEL	DC	L1	NLEVEL:3,VOLTS	Value ignored
AUTO	DCHF	L1+L2	ANLEVEL:3,DIVS	Value ok, no conversion
NORMAL	DCNOISE	C3	ANLEVEL:5,DIVS	Value converted to volts
AUTO	DC	R1	ANLEVEL:2,VOLTS	Value ok, no conversion
NORMAL	AC	L2	NLEVEL:1,VOLTS	- error -
NORMAL	ACLF	L2	NLEVEL:1,DIVS	Value ok, no conversion

The valid range of ANLEVEL or NLEVEL scaled in DIVS is –5 to +5. The valid range of ANLEVEL or NLEVEL scaled in VOLTS is

–5* trig source channel gain + trig source channel offset
to
+5* trig source channel gain + trig source channel offset

Autolevel Trigger Level Usage

In autolevel trigger mode, the ALEVEL link sets trigger level as a percentage of the peak-to-peak value of the trigger source signal. When mode is not autolevel, a change to ALEVEL is stored and subsequently applied to the appropriate trigger when mode is switched to autolevel.

In autolevel mode, any attempt to set trigger level via ANLEVEL or NLEVEL is ignored. However, querying these links is worthwhile since they report the scaled level at which the 11401/1402 controls the Main or Window trigger for the currently specified autolevel percentage. The reported ANLEVEL or NLEVEL scaling is always DIVS.

Trigger Source Semantics

There are a number of constraints associated with trigger source expressions. Those constraints, in no particular order, are as follows:

- The 11401/11402 returns a command error (event code 157) for any trigger expression that does not adhere to the previously listed trigger syntax. Take note that this syntax does not permit RIGHT plug-in channels to be added to (or subtracted from) LEFT or CENTER plug-in channels.

- The Window time base may not be LINE triggered. The 11401/11402 returns an execution error (event code 279) if this constraint is disregarded.

- No trigger channel may be used more than once in a trigger expression. Specifying the same channel more than once (e.g., TRWIN SOURCE: "R1+R1") is an execution error (event code 278).

- The 11A71 plug-in has but one input channel and that channel may never be inverted in a trigger source expression. The 11401/11402 returns an execution error (event code 272) if this constraint is disregarded.

- When a plug-in slot is not loaded with an 11000-series plug-in, it may not be referenced as an 11000-series trigger channel. The 11401/11402 returns an execution error (event code 275) if this constraint is disregarded.

- Referencing a nonexistent 11000-series channel number causes the 11401/11402 to return an execution error (event code 263). As an example, suppose the right slot is loaded with a 2-channel 11000-series plug-in. In this case, attempting to specify TRM SOU:"R3" is illegal.

- When WTMODE is set to TIHOLDOFF or EVHOLDOFF, avoid "chopping" signals between main and window trigger sources. Trigger chop occurs when the Main and Window trigger sources reference channels from the same plug-in(s), but the Window trigger source plug-in channel combination(s) do not exactly match the Main trigger source's corresponding plug-in channel combination(s). That is, each specified plug-in channel signal usage must be exactly the same for both main and Window triggers. Any attempt to chop trigger channels causes the 11401/11402 to return an execution error (event code 244).

  For example:

  Suppose WTMODE is TIHOLDOFF, the Left and Center slots are loaded with two-channel 11000-series plug-ins, and the Window trigger source is defined as "C1+C2". In this case, the only center plug-in channels that can be used in the main trigger source expression are "C1" and "C2", and both of these must be included in the main trigger source expression.

For instance, in this case, TRM SOU:"L2" would be okay, and TRM SOU:"C1+C2+L2" would be okay. But, TRM SOU:"C1+L2" would be a chopped trigger, as would TRM SOU:"C1-C2", or TRM SOU:"C1". This is because these latter Main trigger source expressions don't call for the exact same usage of the center plug-in's channel signals as are used for the Window trigger source expression.

- When WTMODE is set to MAIN, the Window trigger source has no effect on the 11401/11402's window time base and no checks are made to see if the Window and Main trigger sources are chopped. However, when WTMODE is changed from MAIN to TIHOLDOFF or EVHOLDOFF, trigger chop checks are made and if the Window source is incompatible with the Main source, an execution warning is reported (event code 553) and the Window trigger source is set equal to the Main source.

Record Position Commands

Record position commands control main and window (delayed) sweep positioning.

Header	Link	Argument	Notes
MAINPOS		<NRx>	
WIN1POS		<NRx>	
WIN2POS		<NRx>	

MAINPOS, WIN1POS, And WIN2POS Commands

MAINPOS sets or queries the position of the main acquisition record with respect to the Main trigger.The valid range is from –Main Duration to 0 seconds. Refer to the Time base commands for an explanation of Main Duration.

WIN1POS sets or queries the position of the Window 1 record with respect to the window trigger. WIN2POS positions the Window 2 record with respect to the window trigger. The valid range of either command is:

Minimum value (WTMODE is TIHOLDOFF):
– (Window_Holdoff – MAINPOS + Window Duration)

Maximum value (WTMODE is TIHOLDOFF):
Main Duration + MAINPOS – Window_Holdoff

OR

Minimum value (WTMODE is not TIHOLDOFF):
MAINPOS – Window Duration

Maximum value (WTMODE is not TIHOLDOFF):
Main Duration + MAINPOS

NOTE

Window_Holdoff refers to triggered window holdoff, which is returned via a TRWIN? TIHOLDOFF command (refer to "Triggering Commands" for details).

Query Information:

The queries MAINPOS?, WIN1POS?, and WIN2POS? return the currently selected argument, in one of these forms:

MAINPOS <NR3>
WIN1POS <NR3>
WIN2POS <NR3>

Error and Warning Conditions:

An execution warning (event code 550) is issued if the MAINPOS, WIN1POS, or WIN2POS set arguments are out of range.

It should be noted that the valid range of WIN1POS and WIN2POS directly depends upon the current value of MAINPOS. Therefore, changing MAINPOS to a new valid value can cause the current values of either WIN1POS or WIN2POS to be out of range. In such case, the 11401 sets WIN1POS and/or WIN2POS to the closest appropriate endpoint and reports an out of range warning (event code 550) for whichever window position parameter was implicitly adjusted.

Display Commands

Display commands select display mode, number of graticules, and intensity and place text on the display area.

Header	Link	Argument	Notes
DISPLAY	MODE: GRATICULE: INTENSITY:	DOTS | VECTORS DUAL | SINGLE <NRx>	
TEXT	X: Y: STRING:	<NRX> <NRX> <qstring> CLEAR	1

Note 1: Set-only; header and all links are set-only.

DISPLAY Command

Selects the display mode, number of graticules, and intensity.

Parameters:

MODE—enables either dots or vectors type display.

GRATICULE—enables either dual or single display graticules.

INTENSITY—sets the display intensity to a level designated by the argument. The valid range is 0 to 100 percent.

Query Information:

The general query form is DISPLAY?, which returns all links and their currently selected arguments, in the form:

DISPLAY GRATICULE:<arg>,INTENSITY:<NR1>,MODE:<arg>

Error and Warning Conditions:

An execution warning (event code 550) is returned if a set argument is out of range for the INTENSITY link.

An execution error (event code 294) is returned if an attempt is made to change from single to dual graticules when an XY trace is displayed.

TEXT Command

TEXT writes the desired characters (refer to "11401/11402 Character Set" later in this section) to the selected area of the screen.

Parameters:

X—The X coordinate specifies the horizontal position of a character in discrete character cells. The minimum value of X is zero, which corresponds to the left edge of the graticule. The maximum value of X is 49, which corresponds to the right edge of the screen.

Y—The Y coordinate specifies the vertical positioning of a character, in discrete character cells. The minimum value of Y is zero, which corresponds to the top edge of the display graticule. The maximum value of Y is 31, which corresponds to the bottom edge of the graticule.

Thus, the XY coordinate-pair 0,0 represents the left uppermost cell of the display upon which text can be written. The 11401/11402 powers-up with X and Y equal to 0 and 0, respectively.

STRING—specifies text that is to be displayed on the 11401/11402's screen.

Specifying values for the X and Y links determines the coordinates at which the display of <qstring> starts.

User specified text is written sequentially across the display, starting at the last specified X location and proceeding until <qstring> is exhausted, or until the right edge of the display (cell 49) is reached. If the right edge is reached and <qstring> is not exhausted, all remaining characters in <qstring> are truncated.

After TEXT has completed execution, the current values of X and Y point to the character location immediately following the last character of <qstring>. Subsequent TEXT STRING commands, without X and Y specified, will begin at these last values. However, if truncation has occurred, X is set to its maximum value. Should no <qstring> be specified, nothing new will be displayed.

As an example, consider these two commands:

```
TEXT X:0,Y:8,STRING:"Please Setup Trigger"
TEXT STRING:" —Touch RQS Icon When Done"
```

In this example, the first TEXT command displays a string that begins at location 0,8 and ends at location 19,8. The second TEXT command displays a string that begins at location 20,8 and ends at location 46,8.

CLEAR—this argument removes all user-defined text from the screen.

Special Characters

TEXT may be used to display any of the "escaped" characters shown in the 11401 Character Set. For example, the following command writes upper and lower case Pi on the 11401 display:

TEXT STRING:"<ESC>@<ESC>P"

In this example, <ESC> represents the ASCII ESC (escape) character, decimal 27.

TEXT and XY Traces

User text may not be written to the display when an acquired XY trace is active (this restriction does not apply to unacquired XY traces). Furthermore, when user text is on the display and an acquired XY trace is subsequently created, the text will be automatically removed.

Implicit TEXT Removal

In addition to acquired XY trace creation, initialization (via the INIT command), self-test (via the TEST command), and a switch from either dual to single graticules or vice versa (via the DISPLAY command) also cause user defined text to be removed from the display.

Error and Warning Conditions:

An execution warning (event code 550) is issued when the X or Y link arguments are out of range.

An execution error (event code 291) is issued when an acquired XY trace is active and an attempt is made to place TEXT on the display.

Cursor Commands

Cursor commands control the creation and placement of cursors on waveforms.

Header	Link	Argument	Notes
CURSOR	TYPE: REFERENCE: READOUT: XUNIT: YUNIT:	PAIRED | SPLIT | VBARS | HBARS TRACE<ui> ON | OFF AMPS | DIVS | OHMS | SECONDS | VOLTS | WATTS AMPS | DIVS | OHMS | VOLTS | WATTS	 1 1
DOT1ABS	PCTG: XCOORD: XDIV: XQUAL: YCOORD: YDIV: YQUAL:	<NRx> <NRx> <NRx> EQ | LT | GT | UN <NRx> <NRx> EQ | LT | GT | UN	 1 1 1 1
DOT2ABS	PCTG: XCOORD: XDIV: XQUAL: YCOORD: YDIV: YQUAL:	<NRx> <NRx> <NRx> EQ | LT | GT | UN <NRx> <NRx> EQ | LT | GT | UN	 1 1 1 1
DOT1REL	PCTG: XCOORD: XDIV:	<NRx> <NRx> <NRx>	2
DOT2REL	PCTG: XCOORD: XDIV:	<NRx> <NRx> <NRx>	2
H1BAR	YCOORD: YDIV:	<NRx> <NRx>	
H2BAR	YCOORD: YDIV:	<NRx> <NRx>	
V1BAR	XCOORD: XDIV:	<NRx> <NRx>	
V2BAR	XCOORD: XDIV:	<NRx> <NRx>	

Notes
1. Query-only link.
2. Set-only; header and all links are set-only

Cursors and the Selected Trace

All cursor manipulations, including queries, are taken with respect to the currently selected trace. To select a particular trace (assuming more than one trace is displayed on the 11401/11402's front panel), use the SELECT command described later in this section.

Each displayed trace has its own unique set of cursor parameters. Therefore, cursor queries and set commands only access cursor data that pertains to the selected trace. Hence, altering the cursor parameters of the selected trace has **no effect** on any other trace's cursor data.

When no traces are defined, there isn't a default selected trace. Thus, cursor parameters cannot be set or queried. Attempting to do so will result in an execution error (event code 250).

Cursor Positioning Methods

Dot cursors may be horizontally positioned with respect to graticule divisions, percentage of waveform record, or horizontal units of the selected trace. Bar cursors may be horizontally or vertically positioned with respect to graticule divisions or the units of the selected trace.

When cursors are positioned or queried with respect to divisions, use the illustration shown in Figure 3-12 to interpret the dimensions of the 11401/ 11402's single and dual graticules.

CURSOR Command

Selects cursor operation characteristics.

Parameters:

TYPE—selects the cursor type as designated by the argument. Note that SPLIT cursors are not permitted on XY traces. See the Operating Information section for details about the various types of cursors.

REFERENCE—selects the reference trace for the split cursors as designated by the argument. The valid range of <ui> is 1 to 8. Changing the reference to a trace other than the selected trace automatically sets the cursor TYPE to SPLIT.

Unlike other ASCII commands, no error is reported when a valid, undefined trace is selected as the cursor reference trace. For example, if only trace 2 is defined, it is not an error to specify CURSOR REFERENCE:TRACE3. The existence of the reference trace is examined only when the cursor readout is turned on. If the reference does not exist at that time, the 11401/11402 changes the reference to that of the currently selected trace. In this case, cursors are split across the same waveform (see the Note which follows).

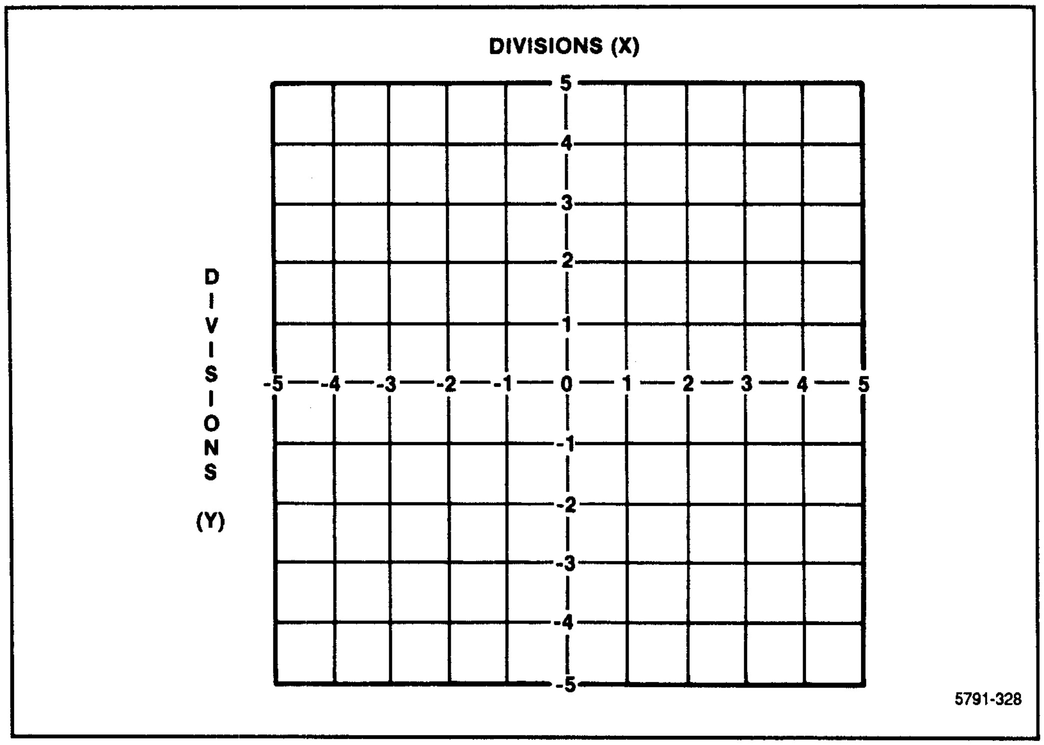

Figure 3-12. Graticule coordinates.

NOTE

It is possible to specify the currently selected trace as a split reference trace. In fact, when a new trace is created, its default split reference is the new trace itself. However, splitting cursors across the same waveform is no different than selecting paired cursors.

READOUT—enables/disables front-panel cursors and corresponding knob readouts. It must be emphasized that READOUT need not be ON to manipulate cursors from the ASCII ports. For example, it is possible to change cursor type and position while the front-panel cursors are OFF. The 11401/11402 will respond to these commands and execute their intended function. Furthermore, queries will return data that reflects these changes. However, when READOUT is OFF, the 11401/11402 will not update the display to show cursor changes made from the ASCII ports.

When FPUPDATE is set to NEVER (refer to "Miscellaneous Commands" later in this section) turning READOUT ON will display front-panel cursors, but not their readouts.

XUNIT—this query-only link returns the horizontal units of the selected trace.

YUNIT—this query-only link returns the vertical units of the selected trace.

Query Information:

The general query form is CURSOR?, which returns all links and their currently selected arguments, in the form:

CURSOR READOUT:<arg>,REFERENCE:<arg>,TYPE:<arg>
XUNIT:<arg>,YUNIT:<arg>

Error and Warning Conditions:

An execution error (event code 251) is issued for a REFERENCE TRACE<ui> link argument when the <ui> component is less than 1 or greater than 8.

An execution error (event code 250) is returned when no traces are defined and an attempt is made to set or query CURSOR parameters.

An execution error (event code 289) is returned when an attempt is made to SPLIT cursors across an XY trace.

DOT1ABS and DOT2ABS Commands

These commands set and query absolute cursor position. In this context, "dot" cursors refer to either split or paired cursors, depending upon the currently selected cursor type. When the cursor type is split, DOT1ABS and DOT2ABS set and query the current split cursor position. When cursor type is not split, DOT1ABS and DOT2ABS set and query the current paired cursor position.

Dot cursors are positioned with respect to the waveform record of the selected trace. Dot cursors may not be positioned off the waveform record.

Parameters:

PCTG—positions the first or second dot cursor as a percentage of waveform record. For example, if the selected trace's record length is 2048 points, the command DOT1ABS PCTG:10 places the first cursor on the 204th waveform point. The valid range is 0 to 100 percent.

XCOORD—positions the first or second dot cursor with respect to horizontal units of the selected trace. When PANZOOM is OFF and the selected trace is acquired, the valid range of XCOORD is listed below:

Selected Trace's Reference Record	Minimum XCOORD	Maximum XCOORD
Main	MAINPOS	MAINPOS + duration
Window 1	WIN1POS	WIN1POS + duration
Window 2	WIN2POS	WIN2POS + duration

Notes
1. See the Time-base commands for details of how duration is computed.
2. See the Record Position commands for details of MAINPOS, WIN1POS, and WIN2POS.

3. When PANZOOM is on, or the selected trace is not acquired, the valid XCOORD range cannot be determined from this information. Instead, refer to "The Range Of Cursor Positioning" later in this section.

XDIV—sets the first or second cursor to the specified X-coordinate divisions position. When PANZOOM is OFF and the selected trace is acquired, the valid range of XDIV is listed below:

Record Length Of Selected Trace	Minimum XDIV	Maximum XDIV
4096 or 8192	–5.12	+3.07
any other length	–5.12	+5.10

NOTE

When PANZOOM is on, or the selected trace is not acquired, the valid XDIV range cannot be determined from this information. Instead, refer to "The Range Of Cursor Positioning" later in this section.

XQUAL—returns a qualifier regarding the accuracy of positioning information returned via an XCOORD or XDIV query. EQ indicates that cursor position is equal to the returned query response. LT indicates that cursor position is less than the returned query response (i.e., the cursor is positioned offscreen low). GT indicates that cursor position is greater than the returned query response (i.e., the cursor is positioned offscreen high). UN indicates that cursor position is completely uncertain (i.e., the cursor is positioned on an unacquired waveform point).

When the selected trace is YT, XQUAL is always EQ because the horizontal position of the cursor is always known. When the selected trace is XY, XQUAL could be EQ, LT, GT, or UN. Just which value is returned depends upon the horizontal component of the underlying waveform data on which the cursor is positioned.

YCOORD—returns the current vertical position of the first or second dot cursor, in the units of the selected trace.

YDIV —this query-only link returns the current vertical position of the first or second dot cursor, in graticule divisions.

YQUAL—returns a qualifier regarding the accuracy of positioning information returned via a YCOORD or YDIV query. Qualifier values have the same meanings as were described for XQUAL, but unlike XQUAL, YQUAL returns all possible qualifiers regardless of whether the selected trace is YT or XY.

When the selected trace is YT, YQUAL depends upon the underlying data on which the cursor is positioned. When the selected trace is XY, YQUAL depends upon the vertical component of the underlying waveform data.

YT vs XY Dot Cursor Positioning

When the selected trace is YT, dot cursors may be positioned via PCTG, XDIV, or XCOORD control.

When the selected trace is XY, dot cursors may only be positioned via PCTG control. Attempting to position dot cursors via XDIV or XCOORD control under these circumstances will lead to unpredictable results.

NOTE

Regardless of whether the selected trace is YT or XY, there are no restrictions on the use or accuracy of any of the dot cursor queries. For example, while it is not possible to position a dot cursor by divisions when the selected trace is XY, an XDIV query (e.g., DOT1ABS? XDIV) does correctly return the current location of the specified cursor.

Query Information:

The general queries DOT1ABS? and DOT2ABS? return all links and their current settings, in the following form:

DOT1ABS PCTG:<NR3>,XCOORD:<NR3>,XDIV:<NR3>,
XQUAL:<arg>,YCOORD:<NR3>,YDIV<NR3>,YQUAL:<arg>

DOT2ABS PCTG:<NR3>,XCOORD:<NR3>,XDIV:<NR3>,
XQUAL:<arg>,YCOORD:<NR3>,YDIV<NR3>,YQUAL:<arg>

Error and Warning Conditions:

An execution warning (event code 550) is issued if the PCTG, XDIV, or XCOORD link arguments would position dot cursors off the waveform record of the selected trace.

An execution error (event code 250) is returned when no traces are defined and an attempt is made to set or query DOT1ABS or DOT2ABS parameters.

DOT1REL and DOT2REL Commands

These commands set dot cursor position. In this context, "relative" position arguments specify an offset from the current cursor position (e.g., one relative DIV means one division to the right of where the cursor is currently located on the display).

When the cursor type is split, DOT1REL and DOT2REL set relative split cursor position. When cursor type is not split, DOT1REL and DOT2REL set paired cursor position.

Parameters:

PCTG—positions the first or second dot cursor as a percentage of the waveform record.

XCOORD—positions the first or second dot cursor with respect to the units of the selected trace.

XDIV—positions the first or second dot cursor in graticule divisions.

Error and Warning Conditions:

An execution warning (event code 550) is issued if the PCTG, XCOORD, or XDIV arguments position dot cursors outside the limits specified for the corresponding DOT1ABS or DOT2ABS links.

An execution error (event code 250) is returned when no traces are defined and an attempt is made to set DOT1REL or DOT2REL parameters.

H1BAR and H2BAR Commands

These commands set and query the absolute horizontal bar cursor position.

Parameters:

YCOORD—positions the first or second horizontal bar cursor with respect to the units of the selected trace. The valid range is listed below:

Selected Trace WFMCALC Mode	Minimum YCOORD	Maximum YCOORD
FAST	gain*(–5.12) + offset	gain*5.10 + offset
HIPREC	VSIZE*(–5.12) + VPOS	VSIZE*5.10 + VPOS

Notes

1. "gain" and "offset" refer to the channel sensitivity and offset (e.g., CHL3? SENSITIVTY,OFFSET) of the acquired channel(s) of the selected trace (see the Channel commands).

2. See the VSIZE, VPOS, and WFMCALC links of the "ADJTRACE<ui>" and "TRACE<ui>" Commands in this section for details of their operation.

3. If the selected trace is composed of more than one acquired channel, and the gains and offsets of the channels are not identical, and WFMCALC mode is FAST, the valid YCOORD range cannot be determined from the above information. Instead, refer to "The Range Of Cursor Positioning" later in this section.

YDIV—positions the first or second horizontal bar cursor in graticule divisions. The valid range is –5.12 (bottom of screen) to +5.10 (top of screen).

Query Information:

The general queries H1BAR? and H2BAR? return all links and their current settings, in the form:

H1BAR YCOORD:<NR3>,YDIV:<NR3>
H2BAR YCOORD:<NR3>,YDIV:<NR3>

Error and Warning Conditions:

An execution warning (event code 550) is issued if YCOORD or YDIV arguments are out of range.

An execution error (event code 250) is returned when no traces are defined and an attempt is made to set H1BAR or H2BAR parameters.

V1BAR and V2BAR Commands

These commands set and query absolute vertical bar cursor position.

Parameters:

XCOORD—positions the first or second vertical bar cursor with respect to the units of the selected trace. When PANZOOM is off and the selected trace is acquired, the valid range is listed below:

Selected Trace's Reference Record	Minimum XCOORD	Maximum XCOORD
Main	MAINPOS	10.22*time_per_div + MAINPOS
Window 1	WIN1POS	10.22*time_per_div + WIN1POS
Window 2	WIN2POS	10.22*time_per_div + WIN2POS

Notes

1. "time_per_div" is TBMAIN TIME for Main waveform records and TBWIN TIME for Window 1 or Window 2 records.

2. See "MAINPOS", "WIN1POS", and "WIN2POS" Commands in this section for details of their operations.

3. When PANZOOM is on or the selected trace is not acquired, refer to "The Range Of Cursor Positioning" later in this section for the valid XCOORD range.

XDIV—positions the first or second vertical bar cursor in graticule divisions. The valid range is –5.12 (left screen edge) to +5.10 (right screen edge).

Query Information:

The general queries V1BAR? and V2BAR? return all links and their current settings, in the form:

V1BAR XCOORD:<NR3>,XDIV:<NR3>
V2BAR XCOORD:<NR3>,XDIV:<NR3>

Error and Warning: Conditions

An execution warning (event code 550) is issued if the XCOORD or XDIV arguments are out of range.

An execution error (event code 250) is returned when no traces are defined and an attempt is made to set V1BAR or V2BAR parameters.

The Range of Cursor Positioning

Under some circumstances, computing the valid range of cursor positioning is very complex and, due to insufficient information, often not possible from the ASCII interfaces. In these circumstances, it is much easier to simply force the 11401/11402 to set cursors to their maximum and minimum values and then, query back current cursor positions. These new positions constitute the valid range of cursors for that particular instrument setup. The following example, which deliberately sets dot cursors far out of range, demonstrates this technique:

```
write "DOT1ABS XCOORD:-1E16"
write "DOT2ABS XCOORD:1E16"
write "DOT1ABS? XCOORD;DOT2ABS? XCOORD"
read minpos, maxpos
```

This method is applicable to both dot and bar cursors, and always works, regardless of current 11401/11402 instrument settings.

Waveform and Settings Commands

Waveform and setting commands select, store, remove, and specify waveform and front-panel setting (FPS) characteristics.

Header	Link	Argument	Notes
WFMSCALING		OPTIONAL I FORCE	
TRACE<ui>	DESCRIPTION: GRTYPE: GRLOCATION: ACCUMULATE: ACSTATE: XUNIT: YUNIT: WFMCALC:	<qstring> LINEAR UPPER I LOWER ON I OFF ENHANCED I NENHANCED SECONDS I DIVS I AMPS I VOLTS I WATTS I OHMS DIVS I AMPS I VOLTS I WATTS I OHMS FAST I HIPREC	 1 1 1 1
ADJTRACE<ui>	PANZOOM: HMAG: HPOSITION: HVPOSOITION: HVSIZE: TRSEP: VPOSITION: VSIZE:	ON I OFF <NRx> <NRx> <NRx> <NRx> <NRx> <NRx> <NRx>	
TRANUM			2
SELECT		TRACE<ui>	
NAVG NENV		<NRx> <NRx>	
AVG ENV		ON I OFF ON I OFF	
STORE	 TRACE<ui>:	FPS<ui> STO<ui>	4
DELETE	 ALL:	STO<ui> I FPS<ui> STO I FPS	4
CLEAR		TRACE<ui> I ALL	3
REMOVE		TRACE<ui> I ALL	3
RECALL		FPS<ui> I FPNEXT	3
SETSEQ		ON I OFF	

Header	Link	Argument	Notes
FPSNUM			2
FPSLIST			2
NVRAM			2
STONUM			2
STOLIST			2

Note
1. Query-only link.
2. Query-only.
3. Set-only.
4. Set-only; header and all links are set-only.

WFMSCALING Command

WFMSCALING controls the global waveform scaling flag. The scaling flag is examined each time a new trace is created via the TRACE<ui> command.

When scaling is set to Optional, traces are created in integer mode, when possible. Integer mode implies that no floating point operations are used to display or position traces. Traces created in integer mode have the fastest display update rates. When a trace cannot be created in this mode and scaling is set to Optional, the 11401/11402 automatically switches to floating point mode to display and position that particular trace. However, subsequently created traces will be created in integer mode if at all possible. When scaling is set to Optional, the 11401/11402 only creates a trace in floating point mode if absolutely necessary.

The following exhaustive list describes those kinds of traces that can be displayed in integer mode:

Trace Description	Example
<slot><ui> (11000-Series plug-in channel)	C3
Average of Plug-in Channels	AVG(L2)
Envelope of Plug-in Channels	ENV(C3)
Inversion of Plug-in Channels	–L3
Addition of Plug-in Channels	L1+C2
Subtraction of Plug-in Channels	R1-C1
Combinations of the above	AVG(L4-R1)

The following partial list describes those traces that cannot be displayed in integer mode:

Trace Description	Trace Type
STO<ui>	Stored
<number>	Scalar
STO<ui> + number	Stored+Scalar
L1 / L3	Any trace using division
R4 * C2	Any trace using multiply
DIFF(C4)	Any trace using floating point function

Note that when WFMSCALING is set to FORCE, all traces, except single channel acquisitions (e.g., L1, C2, R4, etc.), are created in floating point mode.

TRACE<ui> Command

The TRACE command defines a trace and its characteristics. Up to eight traces may be specified with this command. Thus, the range of <ui> is from 1 to 8.

Parameters:

DESCRIPTION—describes the selected trace's source description or origin and which must be within a quoted string of less than or equal to 55 characters.

This link allows the user to define simple, single sourced waveforms, or complex, multi-sourced traces made up of whatever applied inputs, stored traces, and waveform functions the user might desire. The syntax is similar to that of a common desk calculator.

The trace description syntax is

```
<TRA_DESC>      ::=  <Y_EXP> [ vs <X_EXP>] [ on <TIME BASE>]
<Y_EXP>         ::=  <EXP>
<X_EXP>         ::=  <EXP>
<EXP>           ::=  [<UNOP>] <TERM> <ADD_EXP>
<ADD_EXP>       ::=  <EMPTY> | {<ADDOP> <TERM> <ADD_EXP>}
<EMPTY>         ::=
<TERM>          ::=  <FACTOR> <MULT_EXP>
<MULT_EXP>      ::=  <EMPTY> | {<MULOP> <FACTOR> <MULT_EXP>}
<FACTOR>        ::=  <NRx>
<FACTOR>        ::=  <slot><ui>
<FACTOR>        ::=  STO<ui>
<FACTOR>        ::=  ( <EXP> )
<FACTOR>        ::=  <FUNC> ( <LIST> )
<LIST>          ::=  <EXP> <EXP_LIST>
<EXP_LIST>      ::=  <EMPTY> | {, <LIST>}
<FUNC>          ::=  ABS | AVG | DIFF | ENV | EXP | INTG | INTP |
                     LN | LOG | SIGNUM | SMOOTH | SQRT
```

Trace description syntax (cont)

<UNOP>	::=	+ | -
<ADDOP>	::=	+ | -
<MULOP>	::=	* | /
<TIME BASE>	::=	MAIN | WIN1 | WIN2

NOTE

MAIN represents the main time base. WIN1 and WIN2 are the window 1 , and window 2 time base.

If "vs <X_EXP>" is omitted, the trace is YT; otherwise the trace is XY.

If "on <TIME BASE>" is omitted, the time base defaults to MAIN.

An example of a complex trace description could be:

TRACE1 DESCRIPTION:"L1+AVG(C1-C2)"

In this case, the resultant trace will be a combination of the signal from the left channel one amplifier and the average of subtracting the center channel two amplifier signal from the center channel one amplifier signal.

GRTYPE—sets the selected trace's graticule type to LINEAR.

GRLOCATION—positions the selected trace to the upper or lower graticule pair.

ACCUMULATE—enables or disables point accumulate (PA) for the specified trace. There are three restrictions associated with a PA trace:

1. PA and XY traces are mutually exclusive. At most, one of either type of trace may be defined via the TRACE<ui> command.

2. PA may not be enabled when the time base record length is greater than 2048 points.

3. PA may not be enabled if the specified trace is nonacquired (i.e., STORED or SCALAR).

ACSTATE—specifies the calibration conditions under which this trace was created. ENHANCED means the trace was created in the enhanced accuracy state. NENHANCED means the trace was created in the non-enhanced or new-configuration accuracy states. Refer to the Calibration commands for more information.

XUNIT—this query-only link returns the horizontal units of the specified trace.

YUNIT—this query-only link returns the vertical units for the specified trace.

WFMCALC—this query-only link indicates whether or not a trace was created in integer (FAST) or floating point (HIPREC, meaning "high precision") mode. Once a trace is created, it may not be changed from integer to floating point mode, or vice versa.

Query Information:

The TRACE query command syntax is

TRACE<ui>? [<link>[{,<link>}...]]

OR

TRACE?

With respect to a specific trace number, the query form TRACE<ui>? returns all links and their currently selected arguments, in the form:

TRACE<ui> DESCRIPTION:<qstring>,ACCUMULATE:<arg>,
ACSTATE:<arg>,GRLOCATION:<arg>,GRTYPE:<arg>,
WFMCALC:<arg>,XUNIT:<arg>,YUNIT:<arg>

While TRACE? returns information about all currently defined traces:

TRACE<lowest defined trace_#> <link>:<arg>{,<link>:<arg>}...;
TRACE<next lowest defined trace_#> <link>:<arg>{,<link>:<arg>}...;
. .
.
. .
TRACE<highest defined trace #> <link>:<arg>{,<link>:<arg>}

Special XY Trace Conditions

The 11401/11402 does not permit more than one acquired XY trace, or more than two unacquired XY traces to be displayed via the TRACE DESCRIPTION command.

Furthermore, an acquired XY trace may never be displayed simultaneously with an unacquired XY trace, and vice versa.

An acquired XY trace has at least one acquired signal (e.g., L1, R1, etc.). An unacquired XY trace has no acquired components. The following examples demonstrate these conditions:

Acquired XY Trace Description	Unacquired XY Trace Description
"L1 VS L2" "L2 VS C1 ON WIN1"	"STO1 VS STO2" "STO45 VS 200"

In addition to the previously mentioned restrictions on the number and type of XY displayed traces, the scaling modes of the horizontal and vertical components of XY traces must be identical. Thus

<integer> vs <integer>
or
<floating point> vs <floating point>

are valid XY traces. All other combinations are invalid. The following examples illustrate this restriction:

XY Trace Description	Comments
"L3 VS R1"	Valid integer XY trace
"STO1 VS STO8"	Valid floating point XY trace
"L1 VS STO1"	Invalid XY trace
"L1/L2 VS C2"	Invalid XY trace

Error and Warning Conditions:

An execution error (event code 251) is issued for out of range TRACE<ui> headers.

An execution error (event code 269) is returned when an attempt is made to query a nonexistent trace.

An execution error (event code 250) is returned when a TRACE? query is attempted and no traces are currently displayed.

An execution error (event code 264) is returned when an attempt is made to define more than the maximum permissible number of XY traces.

An execution error (event code 295) is returned when an attempt is made to enable point accumulate and the time base record length is greater than 2048 points.

An execution error (event code 296) is returned when an attempt is made to simultaneously define a point accumulate and XY trace.

An execution error (event code 232) is reported when an attempt is made to create an XY trace with incompatible horizontal and vertical scaling modes.

A command error (event code 160) is returned when a trace description exceeds 55 characters, or when a trace description cannot be parsed, due to insufficient stack space.

A command error (event code 157) is returned when an attempt is made to create a purely stored or scalar waveform on Window 1 or 2. For example "C3 + ST01 ON WIN1" is valid while "ST01 ON WIN1" results in a command error.

An execution error (event code 241) is returned when a trace definition would cause the 11401/11402 to acquire more than eight unique plug-in channels. This same error is returned when a trace definition would cause the 11401/11402 to exceed 14 total acquisitions from any source.

A trace description may not include an AVG or ENV function that takes a nonacquired argument (e.g., AVG(STO1) or ENV(1000)). Any attempt to do so returns an execution error (event code 248).

An execution error (event code 240) is returned if an attempt is made to enable point accumulate when the specified trace is nonacquired.

Purely nonacquired trace components may not be created on the WIN1 or WIN2 time bases. A command error (event code 157) is returned when any such attempt is made. Examples:

Allowed Window Trace	Disallowed Window Trace
L1 ON WIN1 L2 + ON WIN2 C3 + ST01 WIN1	ST01 ON WIN1 8 ON WIN2 ST02 + 10 ON WIN1

Other errors that can be returned from syntactically or semantically incorrect trace descriptions include:

Event code	**Error condition**
169	Unsupported function.
257	Illegal stored waveform.
263	Illegal plug-in channel.
270	Referencing a legal, undefined stored waveform.
280	Out of range SMOOTH function argument.

ADJTRACE<ui> Command

This command permits the displayed position of a specified trace to be adjusted without modifying time-base or plug-in parameters.

Parameters:

PANZOOM—enables or disables pan/zoom mode. When ON, selected sections of a displayed trace may be horizontally magnified via the HMAG command. There are two restrictions associated with this link:

1. An XY trace may not have PANZOOM enabled.

2. PANZOOM is always enabled for stored or scalar traces. Attempting to disable PANZOOM for such traces is an error.

HMAG—sets the specified trace's magnification factor when PANZOOM is ON. Attempting to set HMAG when PANZOOM is OFF is an error. The valid mag factors vary with the length of the time base (number of points), as shown in Table 3-9:

TABLE 3-9
HMAG Range

Record Length	**Valid HMAG Value(s)**
512	1
1024	1, 2
2048	1, 2, 4
4096	1, 2, 2.5, 5, 10
5120	1, 2, 2.5, 5,10
8192	1, 2, 2.5, 4, 5, 10, 20
10240	1, 2, 2.5, 4, 5, 10, 20

HPOSITION—sets the specified trace's horizontal position when PANZOOM is ON. Attempting to use the command when PANZOOM is OFF is an error. This command positions a trace in terms of waveform points.

TRSEP—sets the window trace separation of the specified trace. Only under the following conditions may TRSEP be modified (set):

- The specified trace was created on the WIN1 or WIN2 time bases and
- The specified trace was created in integer mode (i.e., WFMCALC is FAST) and
- The specified trace is not XY.

Attempting to set TRSEP under any other conditions is an error.

The valid range of TRSEP is –5 to +5 graticule divisions.

HVPOSITION—sets the graphical position of the horizontal component of the specified XY trace. HVPOSITION may only be modified (set) when the specified trace was created in floating point mode (i.e., WFMCALC is HIPREC). Attempting to set HVPOSITION under any other condition is an error. The valid range of this command is -1E15 to 1E15.

HVSIZE—sets the graphical size of the horizontal component of the specified XY trace. HVSIZE may only be modified (set) when the specified trace was created in floating point mode (i.e., WFMCALC is HIPREC). Attempting to set HVSIZE under any other condition is an error. The valid range of this command is 1E-15 to 1E15.

VPOSITION—sets the vertical graphical position of a YT trace or sets the graphical position of the vertical component of an XY trace. This command may only be modified (set) when the specified trace was created in floating point mode (i.e., WFMCALC is HIPREC). Attempting to set VPOSITION under any other condition is an error. The valid range for this command is –1E15 to 1E15.

VSIZE—sets the vertical graphical size of a YT trace or sets the graphical size of the vertical component of an XY trace. VSIZE may only be modified (set) when the specified trace was created in floating point mode (i.e., WFMCALC is HIPREC). Attempting to set VSIZE under any other condition is an error. The valid range for this command is 1E-15 to 1E15.

Query Information:

The query command forms of ADJTRACE<ui> are

ADJTRACE<ui>? [<link>[{,<link>}...]

OR

ADJTRACE?

With respect to a specific trace number, the query form ADJTRACE<ui>? returns all links and their currently selected arguments, in the form:

ADJTRACE<ui> PANZOOM: <arg>, HMAG: <NR3>, HPOSITION: <NR3>,
HVPOSITION: <NR3>, HVSIZE: <NR3>, TRSTEP: <NR3>,
VPOSITION: <NR3>, VSIZE: <NR3>

For ADJTRACE?, the query returns information about all currently defined traces:

ADJTRACE<lowest defined trace#> <link>:<arg>{,<link>:<arg>}...;
ADJTRACE<next lowest defined trace#> <link>:<arg>{,<link>:<arg>}...;
. .
. .
. .
ADJTRACE<highest defined trace#> <link>:<arg>{,<link>:<arg>}...

Special ADJTRACE Query Responses

As noted previously, there are occasions when it is not possible to set the value of a particular ADJTRACE link, and attempting to do so will cause an error. However, it is always possible to query an ADJTRACE link, regardless of whether or not that same link can be set, and this operation is not an error.

When it is not possible to set an ADJTRACE link, a query of that link always returns a predefined constant value from which the following conclusions may be drawn:

- The query response is meaningless, and
- The query response should not be returned to the 11401/11402 under present circumstances or it will be rejected and an error reported.

Table 3-10 shows what values are returned when it is not possible to set an ADJTRACE link.

TABLE 3-10
ADJTRACE Returned Values

ADJTRACE Link	Constant Query Value
HMAG	-1
HPOSITION	1e16
HVPOSITION	1e16
TRSEP	1e16
VPOSITION	1e16
VSIZE	-1
HVSIZE	-1

An example of this condition would be the situation where a trace where created with this command:

TRACE1 DESCRIPTION:"L1 ON MAIN"

In this case, it is not possible to set the trace separation of trace #1. Hence, the response to an ADJTRACE1? TRSEP query command would be:

ADJTRACE1 TRSEP:1E16

Error and Warning Conditions:

An execution error (event code 251) is issued for out of range ADJTRACE<ui> headers.

An execution error (event code 550) is issued if set arguments are out of range for the HMAG, HPOSITION, TRSEP, VPOSITION, or VSIZE links.

An execution error (event code 269) is returned when an attempt is made to set or query the parameters of a nonexistent trace.

An execution error (event code 250) is returned when an ADJTRACE? is attempted and no traces are currently displayed.

When conditions do not permit HMAG, HPOSITION, TRSEP, VPOSITION, or VSIZE values to be modified (e.g., an attempt is made to set HMAG and PANZOOM is OFF), an execution error (event code 249) is reported.

An execution error (event code 297) is returned when an attempt is made to enable PANZOOM for an XY trace or to enable PANZOOM for a trace created on a window time base.

An execution error (event code 298) is returned when an attempt is made to disable PANZOOM for a stored or scalar trace.

TRANUM? Query Command

TRANUM? returns the number of traces displayed on the 11401/11402's front panel display. This query is most useful when it precedes a TRACE or ADJTRACE? query, since TRANUM's response can be used to determine how many traces will be returned by TRACE or ADJTRACE?.

The query response is

TRANUM <NR1>

When a "TRANUM 0" response is returned, no traces are currently displayed.

SELECT Command

This command is used to define an entity known as the "selected trace". The selected trace is used as a data reference by many measurements (refer to "Measurement Commands" later in this section) and as a cursor reference.

Parameters:

TRACE<ui>—defines the selected trace as indicated by the <ui> argument. The valid <ui> setting range is 1 to 8. However, <ui> can be specified as 0, which is an illegal trace number for most other commands, but under conditions described below in the query information, the 11401/11402 will not generate an error.

Query Information:

SELECT? returns the selected trace value, in the following form:

SELECT TRACE<ui>

Note that in the case where there is no selected trace (i.e., no traces are defined), this query returns SELECT TRACE0. If the SELECT TRACE0 query response is then sent back to the 11401/11402 in a set command, it will be completely ignored and no error will be reported.

Error and Warning Conditions:

An execution error (event code 251) is issued for out of range TRACE<ui> arguments.

An execution error (event code 269) is returned when an attempt is made to select a nonexistent trace.

An execution error (event code 295) is returned when an attempt is made to select a previously defined point accumulate (AA) waveform and the time base of that waveform has been changed to some value greater than 2048 points. In this case, the PA waveform becomes the selected trace, but is displayed in normal YT format, not in PA format.

NAVG Command

For any trace description that contains an average (AVG) function, this command specifies the number of waveform samples that are averaged into the resultant waveform. The valid range is 2 to 4096.

Query Information:

NAVG? returns the current number of averages, in the form:

NAVG <NR1>

Error and Warning Conditions:

An execution warning (event code 550) is returned for out of range values of NAVG.

NENV Command

When conditional acquire mode is set to envelope complete (ENV), this command specifies the number of waveform samples that are to be enveloped before conditional acquisition is satisfied and the digitizer is subsequently stopped. The valid range of NENV is 2 to 4096.

NENV has no effect when conditional acquire mode is not set to envelope complete.

Query Information:

NENV? returns the current number of envelopes, in the form:

NENV <NR1>

Error and Warning Conditions:

An execution warning (event code 550) is returned for out of range NENV values.

AVG Command

AVG modifies the vertical expression component (Y_EXP) of the trace description of the selected trace (see the TRACE<ui> command, in this section).

When the selected trace's vertical description is not enclosed with ENV() and AVG is set ON, that trace's vertical description is enclosed with AVG().

When the selected trace's vertical description is enclosed with ENV() and AVG is set ON, the enclosing ENV() is replaced with AVG().

When the selected trace's vertical description is enclosed with AVG() and AVG is set OFF, the enclosing AVG() is removed.

It is not permissible to set AVG OFF when the vertical description of the selected trace is not enclosed with AVG(). Also, if the selected trace is XY or consists solely of stored and scalar components, AVG may not be set ON.

Examples:

Before Trace	Command	After Trace
AVG(L3)	AVG OFF	L3
R2 ON WIN2	AVG ON	AVG(R2) ON WIN2
ENV(L1-L2)	AVG ON	AVG(L1-L2)
(AVG(L1))	AVG OFF	L1*
AVG (R3)	AVG ON	AVG (AVG(R3))

* Note removal of outer parentheses.

Query Information:

AVG? returns its current setting, in the form:

AVG <arg>

A response of AVG ON means that the selected trace's vertical description is enclosed by AVG(). An AVG OFF response means that it isn't enclosed. However, it must not be assumed that if AVG is OFF that no AVG() function is embedded in the selected trace's vertical description.

Examples:

Trace Description	Query Response
AVG(R1) ON WIN1	AVG ON
AVG(L1+L2)	AVG ON
L1	AVG OFF
AVG(R2)-1000	AVG OFF

Error and Warning Conditions:

An execution error (event code 250) is returned for any attempted set or query of AVG when no traces are defined.

An execution error (event code 248) is returned when the selected trace is XY and an attempt is made to turn AVG ON. The same error is returned if the selected trace is composed only of stored and scalar components and an attempt is made to turn AVG ON.

An execution error (event code 248) is returned when the selected trace's vertical description is not enclosed by AVG() and an attempt is made to turn AVG OFF.

ENV Command

Like AVG, ENV modifies the vertical expression component of the trace description of the selected trace.

When the selected trace's vertical description is not enclosed with AVG() and ENV is set ON, that trace's vertical description is enclosed with ENV().

When the selected trace's vertical description is enclosed with AVG() and ENV is set ON, the enclosing AVG() is replaced with ENV().

When the selected trace's vertical description is enclosed with ENV() and ENV is set OFF, the enclosing ENV() is removed.

It is not permissible to set ENV OFF when the vertical description of the selected trace is not enclosed with ENV(). Also, if the selected trace is XY or consists solely of stored and scalar components, ENV may not be set ON.

Examples:

Before Trace	Command	After Trace
ENV(L3)	ENV OFF	L3
L1 VS L2	ENV ON	- error -
AVG(L1-L2)	ENV ON	ENV(L1-L2)
(ENV(L1))	ENV OFF	L1*

*Note removal of outer parentheses.

Query Information:

ENV? returns its currently selected argument, in the form:

ENV <arg>

A response of ENV ON means that the selected trace's entire vertical description is enclosed by ENV(). An ENV OFF response means that it isn't enclosed. An ENV OFF response does not necessarily mean that an ENV() function is not embedded somewhere within the selected trace's vertical description.

Examples:

Trace Description	Query Response
ENV(C2) VS L2	ENV OFF
ENV(L1+L2)	ENV ON
ENV(L1)	ENV ON
AVG(ENV(R3))	ENV OFF
ENV (L1)*2	ENV OFF

Error and Warning Conditions:

An execution error (event code 250) is returned for any attempted set or query of ENV when no traces are defined.

An execution error (event code 248) is returned when the selected trace is XY and an attempt is made to turn ENV ON. The same error is returned if the selected trace is composed only of stored and scalar components and an attempt is made to turn ENV ON.

An execution error (event code 248) is returned when the selected trace's vertical description is not enclosed by ENV() and an attempt is made to turn ENV OFF.

STORE Command

The STORE command saves or copies a displayed trace to memory, while not removing the displayed trace from the screen. The copied trace is referred to as the "stored waveform" and is accessed via its associated number (STO<ui>). This command also saves front panel settings (FPS) in nonvolatile RAM and references them with an associated number (FPS<ui>).

Parameters:

TRACE<ui>—this link argument stores a copy of the indicated displayed trace into memory and tags it with the number specified. The TRACE<ui> link parameter must be greater than or equal to 1 and less than or equal to 8. The STO<ui> argument parameter must be greater than or equal to 1 and less than or equal to 256.

FPS<ui>—this argument stores current front panel settings and tags them with the specified number. The <ui> value must be greater than or equal to 1 and less than or equal to 10.

STORE TRACE <ui> Side Effects

Copying an active trace over an existing stored waveform destroys the old copy of the stored data. Furthermore, if the "overwritten" stored waveform is a component of one or more active traces, then those traces will display the new stored waveform data and not the old data.

STORE TRACE<ui> Limitations:

a) It is not possible to store an XY trace.

b) An active trace may only be copied over an existing stored waveform if the record lengths (number of points) of the active trace and existing stored waveform are identical.

Error and Warning Conditions:

If insufficient memory exists to make a copy of a trace, an execution error (event code 255) is returned. This same error is returned if insufficient nonvolatile NVRAM exists to store settings.

An execution error (event code 251) is issued for out of range TRACE<ui> arguments.

An execution error (event code 252) is issued for out of range FPS<ui> arguments.

An execution error (event code 257) is issued for out of range STO<ui> arguments.

An execution error (event code 269) is returned when an attempt is made to store a nonexistent trace.

An execution error (event code 282) is returned when an attempt is made to store an XY trace.

An execution error (event code 282) is returned when an attempt is made to copy a trace over an existing stored waveform and the two waveforms do not have equal record lengths. For example, assume the following definitions:

TBMAIN LENGTH:1024
TRACE1 DESCRIPTION:"L1"
STORE TRACE1:STO1
TBMAIN LENGTH:512
TRACE2 DESCRIPTION:"C1"

With these definitions, the following command is illegal:

STORE TRACE2:STO1

DELETE Command

This command deletes a stored waveform or stored front panel setting.

Parameters:

STO<ui>—deletes the specified stored waveform. The <ui> parameter must be greater than or equal to 1 and less than or equal to 256.

FPS<ui>—deletes the specified front panel setting. The <ui> parameter must be greater than or equal to 1 and less than or equal to 10.

ALL—deletes all stored waveforms when the link argument is STO. When the link argument is FPS, ALL deletes all stored front panel settings. No error is reported, nor action taken, when this link is specified, and no waveform or settings are stored in memory.

DELETE Side Effects

Deleting a stored waveform that is a single component of one or more active traces will cause those traces to be removed from the display.

For example, assume the following trace definition:

TRACE2 DESCRIPTION:"STO1"

Now, if STO1 is deleted, TRACE2 will be concurrently removed from the display.

Error and Warning Conditions:

An execution error (event code 257) is issued for out of range STO<ui> arguments.

An execution error (event code 270) is returned when an attempt is made to delete an nonexistent stored waveform.

An execution error (event code 252) is issued for out of range FPS<ui> arguments.

An execution error (event code 273) is returned when an attempt is made to delete an undefined stored settings number. In this context, "undefined" refers to previously deleted settings or to settings that have never been initialized.

An execution error (event code 281) is returned when an attempt is made to delete a stored waveform that is a component of a combination waveform. For example, assume the following trace description:

TRACE1 DESCRIPTION:"STO1 + STO2"

In this case, neither STO1 nor STO2 can be deleted, since they are part of a defined complex waveform. In fact, neither can be deleted until TRACE1 is removed (see the "REMOVE Command" that follows).

CLEAR Command

This command clears displayed traces.

Parameters:

TRACE<ui>—sets the specified trace to null values. The <ui> parameter must be greater than or equal to 1 and less than or equal to 8.

ALL—clears all displayed traces. No error is reported (and no action is taken) if the ALL argument is specified when no traces are defined.

Error and Warning Conditions:

An execution error (event code 251) is issued for out of range TRACE<ui> arguments.

An execution error (event code 269) is returned when an attempt is made to clear a nonexistent trace.

An execution error (event code 283) is returned when an attempt is made to clear a trace that has only stored or scalar waveform components (e.g., TRACE1 DESCRIPTION:"STO3").

REMOVE Command

This command removes displayed traces.

Parameters:

TRACE<ui>—removes a specified trace from the display only. If the specified trace is also stored in memory, the stored waveform is not removed. The <ui> parameter must be greater than or equal to 1 and less than or equal to 8.

ALL—removes all displayed traces. No error is reported (and no action is taken) if the ALL argument is specified when no traces are defined.

Error and Warning Conditions:

An execution error (event code 251) is issued for out of range TRACE<ui> arguments.

An execution error (event code 269) is returned when an attempt is made to remove a nonexistent trace.

RECALL Command

This command recalls stored settings from memory.

Parameters:

FPS<ui>—recalls front panel settings from memory as indicated by the <ui> argument. The valid <ui> range is: 1 to 10.

FPNEXT—recalls the next front panel setting from memory. Settings may not be "sequenced" in this manner unless SETSEQ is ON (refer to the "SETSEQ Command" that follows).

Error and Warning Conditions:

An execution error (event code 252) is issued for out of range FPS<ui> arguments.

An execution error (event code 273) is returned when an attempt is made to recall an undefined stored settings number. In this context, "undefined" refers to previously deleted settings or to settings that have never been initialized.

An execution error (event code 247) is returned when an attempt is made to sequence settings and no settings are defined.

An execution error (event code 246) is returned when an attempt is made to sequence settings and SETSEQ is OFF.

SETSEQ Command

This command enables or disables settings sequencing. Settings are sequenced via the RECALL FPNEXT command, as discussed above.

Query Information:

The SETSEQ? query returns the current state of settings sequencing, in the form:

SETSEQ <arg>

SETSEQ Side Effects:

If SETSEQ is ON and all stored settings are deleted, SETSEQ is implicitly set OFF.

If SETSEQ is OFF and the PROBE command is used to assign the probe tip to sequence settings, SETSEQ is implicitly set ON.

Error and Warning Conditions:

An execution error (event code 247) is returned when an attempt is made to SETSEQ ON and no settings are defined.

FPSNUM? Query Command

This query-only command returns the number of front-panel settings presently stored in non-volatile RAM, in the form:

FPSNUM <NR1>

This query is particularly useful when it precedes the FPSLIST?, since the FPSNUM? response determines how many arguments will be returned by FPSLIST?.

FPSLIST? Query Command

This query-only command returns a list of all front-panel settings stored in non-volatile RAM. When one or more settings are stored, the query response is

FPLIST FPS<ui>:<seq>,<len>[{,FPS<ui>:<seq>,<len>}...]

where <seq> is an unsigned integer that represents the sequence number of the specified stored settings and <len> is an unsigned integer that represents the number of bytes of non-volatile RAM that these settings consumed.

When there are no stored front-panel settings, the query response is

FPSLIST EMPTY

NVRAM? Query Command

This query-only command returns the number of bytes of unallocated non-volatile RAM (NVRAM) in which front-panel settings may be stored, in the form:

NVRAM <NR1>

STONUM? Query Command

This query-only command returns the number of waveforms currently stored in the 11401/11402, in the form:

STONUM <NR1>

This query is particularly useful when it precedes a STOLIST?, since the STONUM? response can be used to determine how many arguments will be returned by STOLIST?.

STOLIST? Query Command

This query-only command returns a list of all waveforms stored in the 11401/ 11402. When one or more waveforms are stored, the response is

STOLIST STO<ui>[{,STO<ui>}...]

When there are no stored waveforms, the response is

STOLIST EMPTY

Data Transfer Commands

Data transfer commands transfer waveform and settings from the 11401/11402 to and from its external interfaces.

Header	Link	Argument	Notes
ENCDG	WAVFRM:	ASCII | BINARY	
	SET:	ASCII | BINARY	
INPUT		STO<ui>	
OUTPUT		STO<ui> | TRACE<ui>	
BYT.OR		LSB | MSB	
WFMPRE	ACSTATE:	ENHANCED | NENHANCED	
	BIT/NR:	<NRx>	3
	BN.FMT:	RI	3
	BYT/NR:	<NRx>	3
	BYT.OR:	LSB | MSB	3
	CRVCHK:	CHKSMO | NONE | NULL	3
	ENCDG:	ASCII | BINARY	3
	NR.PT:	<NRx>	
	PT.FMT:	XY | Y | ENV	
	WFID:	STO<ui> | TRACE<ui>	3
	XINCR:	<NRx>	
	XMULT:	<NRx>	3
	XUNIT:	DIVS | VOLTS | AMPS | WATTS | OHMS | SECONDS	3
	XZERO:	<NRx>	
	YMULT:	<NRx>	
	YUNIT:	DIVS | VOLTS | AMPS | WATTS | OHMS	
	YZERO:	<NRx>	
ABBWFMPRE		ON | OFF	
CURVE		<bblock> | <asc_curve>	4
WAVFRM			1
SET			1
SET		<bblock>	2

Notes
1. Query-only
2. Set-only
3. Query-only link
4. <asc_curve> ::= <NRx>[{,<NRx>}...]

ENCDG Command

This command selects the data encoding that is returned in response to a CURVE? or a SET? (for waveforms and settings). Data encoding is a global parameter and affects both the GPIB and RS-232-C interfaces.

Each data format has certain advantages. ASCII data is human-readable, while binary data is not. However, since the binary data format is more compact, requiring fewer bytes to accomplish the same amount of data encoding, it is faster and, therefore, preferred for large data transfers over the GPIB or RS-232-C interfaces.

Parameters:

WAVFRM—selects the encoding for waveform data output over the external interfaces in response to a CURVE? or WAVFRM? query.

SET—selects the encoding for settings information transferred in response to a SET? query.

Query Information:

The general query form of ENCDG? returns the current encoding format of both links.

ENCDG SET:<arg>,WAVFRM:<arg>

INPUT Command

The INPUT command selects the destination for waveform and preamble data that is input to the 11401/11402 via the WFMPRE (waveform preamble data) and CURVE (waveform point data) commands. At instrument power-up, the default INPUT location is stored waveform number one (STO1). The valid range for the value of <ui> is 1 to 256.

Query Information:

The query form, INPUT? , returns the current input destination for waveform and preamble data:

INPUT STO<arg>

Error and Warning Conditions:

An execution error (event code 257) is issued for out of range STO<ui> arguments.

OUTPUT Command

The OUTPUT command selects the source for waveform and preamble data returned to the ASCII interfaces from a WFMPRE?, CURVE? or WAVFRM? query. At instrument power-up, the default OUTPUT waveform data is STO1. Data is always returned from the waveform location last set by the OUTPUT command.

STO<ui> returns waveform data relating to the user-specified stored waveform, where the range of <ui> is between 1 and 256.

TRACE<ui> returns waveform data relating to a user-specified displayed trace, where the range of <ui> is 1 to 8.

Query Information:

When OUTPUT? specifies a stored waveform, the query response is

OUTPUT STO<arg>

When OUTPUT? specifies an active trace, the query response is

OUTPUT TRACE<arg>

Error and Warning Conditions:

An execution error (event code 257) is issued for out of range STO<ui> arguments.

An execution error (event code 251) is issued for out of range TRACE<ui> arguments.

BYT.OR Command

When binary curve data is transmitted to and from the 11401/11402's ASCII interfaces, each waveform point is represented by a two-byte (two's-complement, 16-bit) integer. BYT.OR specifies the transmission order of each two-byte integer.

When BYT.OR is MSB, the Most Significant Byte of each waveform point precedes the least significant byte of that same point. When BYT.OR is set to LSB, the transmission order is reversed.

The fastest waveform data transfer rate occurs when BYT.OR is LSB.

At power-up, BYT.OR is MSB by default.

Query Information:

The BYT.OR? response is

BYT.OR <arg>

WFMPRE Command

This command sends the waveform preamble for the waveform last selected by the OUTPUT command, or accepts a waveform preamble for the waveform last selected by the INPUT Command. The waveform preamble describes the characteristics of waveform data transferred with the CURVE command. It defines such items as waveform size, scaling, format, etc. required to determine coordinate values and auxiliary information, such as identification strings and units.

All preamble data is ASCII encoded. A waveform preamble consists of the WFMPRE header followed by one or more waveform preamble arguments in any order. Each preamble argument specifies a parameter of the waveform data.

Parameters:

ACSTATE—specifies the calibration conditions underwhich the OUTPUT waveform was created. ENHANCED means the waveform was created in the Enhanced Accuracy state. NONHANCED means the waveform was created in the non-enhanced or new-configuration accuracy states. Refer to "Enhanced Accuracy Commands" later in this section for more information.

BIT/NR—specifies the number of bits per binary waveform point, which is always 16.

BN/FMT—specifies the TEK Codes and Formats binary number format (i.e., the format of binary waveform data returned to and from the 11401/11402). The only possible format is RI, that is, right-justified, 2's complement integers.

BYT.NR—specifies the binary data field width, which is always two bytes per binary waveform point.

BYT.OR—specifies the transmission order of binary waveform data returned from the 11401/11402 via a CURVE?. At the time that preamble data is queried, the information returned by this link is identical to that returned by a BYT.OR? response. Since the BYT.OR command specifies the transmission order of binary waveform data returned to the 11401/11402, this link is ignored when returned to the 11401/11402.

CRVCHK—specifies the type of checksum appended to waveform data returned from the 11401/11402 via a CURVE?. Possible values are

- **CHKSM0**—means that a standard TEK Codes and Formats checksum is ap pended. This is returned when BINARY waveform ENCDG is in effect and OUTPUT specifies a stored waveform location (e.g., STO1).
- **NONE**—means that no checksum is appended. This is returned when ASCII waveform ENCDG is in effect.
- **NULL**—means that an arbitrary zero checksum value is appended. This is returned when BINARY waveform ENCDG is in effect and OUTPUT specifies a displayed waveform location (e.g., TRACE1).

Since binary waveform data returned to the 11401/11402 is accepted, regardless of the validity of its checksum, this link is ignored on input to the 11401/11402.

ENCDG—specifies the encoding of the waveform data returned from the 11401/11402 via a CURVE?. At the time that preamble data is queried, the information returned by this link is identical to that returned by an ENCDG? WAVFRM command. Since the syntax of the CURVE command specifies the type of waveform data returned from an external controller to the 11401/11402, this link is ignored when returned to the 11401/11402.

NR.PT—specifies the number of points in the waveform record received from, or transmitted to, the 11401/11402. Valid selections are 512, 1024, 2048, 4096, 5120, 8192, and 10240.

There are conditions where the 11401/11402 will not return this same range of selections to an external controller. The number of points returned depends upon several factors primarily, the type of trace referenced by the OUTPUT command; and more specifically, by displayed traces with PANZOOM on and a horizontal magnification (HMAG) greater than one.

For example, assume the following conditions:

- Trace 1 is "L1 ON MAIN"
- TBMAIN LENGTH is 2048
- ADJTRACE1 PANZOOM is ON and ADJTRACE1 HMAG is 4
- OUTPUT is set to TRACE1

In this case, WFMPRE? NR.PT returns:

WFMPRE NR.PT:512

PT.FMT—specifies the point format of the waveform data returned from the 11401/11402 via a CURVE?. "Y" implies the waveform is YT, which means one ASCII or binary data point is returned for each point in the waveform record. "XY" implies the waveform is XY and that an X, Y point-pair is returned for each point in the waveform record. "ENV" applies to YT waveforms that are transmitted as maximum-minimum point pairs, maximum point first.

WFID—specifies the Waveform IDentification of the data returned from the 11401/11402 via a CURVE?. At the time that preamble data is queried, the information returned by this link is identical to that returned by OUTPUT?. Since the INPUT command specifies the location at which waveform data is stored in the 11401/11402's RAM, this link is ignored when returned to the 11401/11402.

XINCR—specifies the horizontal sample interval of a YT waveform. This link has no meaning for XY waveform data. The valid range of XINCR is any value greater than or equal to 10 picoseconds per point.

XUNIT—specifies the horizontal units (x-axis) of the waveform data at the time of waveform creation. Notice that if this is an XY waveform, XUNIT actually represents the vertical units of the horizontal component of the waveform.

XMULT—specifies the vertical scale factor, in XUNIT per division, of the horizontal component of an XY waveform. This link has no meaning for YT waveform data.

XZERO—specifies the number of seconds of pre- or post-trigger of a YT waveform. XZERO also specifies the vertical offset of the horizontal component of an XY waveform. The valid range of XZERO is –1E15 to 1E15.

YMULT—specifies the vertical scale factor, in YUNIT per division, of a YT waveform. YMULT also specifies the vertical scale factor, in YUNIT per division, of the vertical component of an XY waveform. The valid range is 1E–15 to 1E15.

YUNIT—specifies the vertical units (y-axis) of the waveform data (YT or XY) at the time of waveform creation.

YZERO—specifies the vertical offset of a YT waveform. YZERO also specifies the vertical offset of the vertical component of an XY waveform. The valid range is –1E15 to 1E15.

XY vs YT Waveforms and the Waveform Preamble

The 11401/11402 does not support stored XY waveforms. Thus XY waveform data cannot be returned to the 11401/11402. It is assumed that only YT data will be returned to the 11401/11402.

Based upon this assumption, the following WFMPRE links are singled out for special treatment when returned to the 11401/11402:

- PT. FMT - only Y or ENV values are valid. An XY value will be coerced to Y and an appropriate warning issued.
- XMULT - ignored, has no meaning for YT data.
- XUNIT - ignored, presumed to be seconds.

WFMPRE Side Effects

Returning WFMPRE data to the 11401/11402 in a command string implicitly deletes any existing stored waveform referenced by the INPUT command. Furthermore, deleting a stored waveform that is a single component of one or more active traces causes those traces to be removed from the display.

Since returning WFMPRE data implicitly deletes the stored waveform referenced by the INPUT command (if any), and since it is not possible to delete a stored waveform that is a component of an active, combination trace (refer to "DELETE Command" earlier in this section), there are situations when it is not valid to return WFMPRE data to the 11401/11402.

As an example, if INPUT references STO3, and TRACE3 is defined to be the difference of STO3 and STO1 (i.e., TRACE3 DESC:"STO3-STO1"), then sending WFMPRE data to the 11401/11402 would result in an invalid attempt to delete a combination component (STO3) of an active trace (TRACE3).

Query Information:

The query form, WFMPRE? , returns all selected waveform preamble arguments, in the form:

```
WFMPRE    ACSTATE:<arg>,BIT/NR:16,BN.FMT:RI,BYT/NR:2,
          BYT.OR:<arg>,CRVCHK:<arg>,ENCDG:<arg>,NR.PT:<NR1>,
          PT.FMT:<arg>,WFID:<arg>,XINCR:<NR3>,XMULT:<NR3>,
          XUNIT:<arg>,XZERO:<NR3>,YMULT:<NR3>,YUNIT:<arg>,
          YZERO:<NR3>
```

Error and Warning Conditions:

An execution error (event code 269) is issued if a WFMPRE? is attempted and OUTPUT references a nonexistent waveform (trace) location.

An execution error (event code 270) is reported if a WFMPRE? is attempted and OUTPUT references a nonexistent stored waveform.

An execution error (event code 255) is reported if WFMPRE data is returned to the 11401/11402 and insufficient memory exists to create a stored waveform record for that preamble.

An execution error (event code 281) is reported and the returned WFMPRE data discarded when such data would cause the implicit deletion of a stored waveform that is a combinatoric component of an active trace.

An execution error (event code 550) is returned for out of range NR.PT, XINCR, XZERO, YMULT, or YZERO arguments.

If WFMPRE data is returned to the 11401/11402 with an XY PT.FMT, it is coerced to Y and an execution warning (event code 559) is reported.

ABBWFMPRE Command

This command enables the abbreviation of the WFMPRE? command response. When ABBWFMPRE is ON, the WFMPRE? response is

```
WFMPRE  ACSTATE:<arg>,NR.PT:<NR1>,PT.FMT:<arg>,
        XINCR:<NR3>,XMULT:<NR3>,XZERO:<NR3>,
        YMULT:<NR3>,YZERO:<NR3>
```

When ABBWFMPRE is OFF, the WFMPRE? response is identical to that previously described in the WFMPRE syntax and semantics.

At power-up, the default setting for ABBWFMPRE is OFF.

Query Information:

The ABBWFMPRE? response is

ABBWFMPRE <arg>

Curve Command

This command sends or accepts unscaled waveform data from the GPIB or RS-232-C interfaces.

The query form of this command retrieves unscaled waveform data from the 11401/ 11402. The OUTPUT command specifies the displayed or stored waveform source from which this data is obtained.

The set form of this command sends unscaled waveform data to the 11401/11402 from an external controller. The INPUT command specifies the location into which stored waveform data is written.

Query Information:

The general query form, CURVE? , returns waveform data, either in ASCII or BINARY format.

The ASCII form is

CURVE <NR1>[{,<NR1>}...]

The number of ASCII data points returned is specified by the NR.PT link of the WFMPRE command. The range of the returned data is –32768 to +32767.

If CURVE? returns data for a YT waveform, then each <NR1> value represents one data point in the waveform record.

If CURVE? returns data for an XY waveform, every two consecutive <NR1> values represent one X,Y coordinate pair in the waveform record (the X-coordinate being the first point of the pair).

The entire ASCII-encoded CURVE? response may be sent back to the 11401/ 11402 as a set command.

The BINARY form is

<BINARY curve>	::=	CURVE <binary block data>
<binary block data>	::=	<bblock>
<bblock>	::=	%<byte_count><bin_point> . . . <checksum>

where

<byte_count>	::=	16-bit binary integer (MSB). This value represents the length (in bytes) of the remainder of the binary block, including the checksum.
<bin_point>	::=	binary data point, in a 2-byte format. The order of transmission is specified by the BYT.OR command.
<checksum>	::=	2's complement of the modulo 256 sum of the preceding byte-count and point data. This is an 8-bit value.

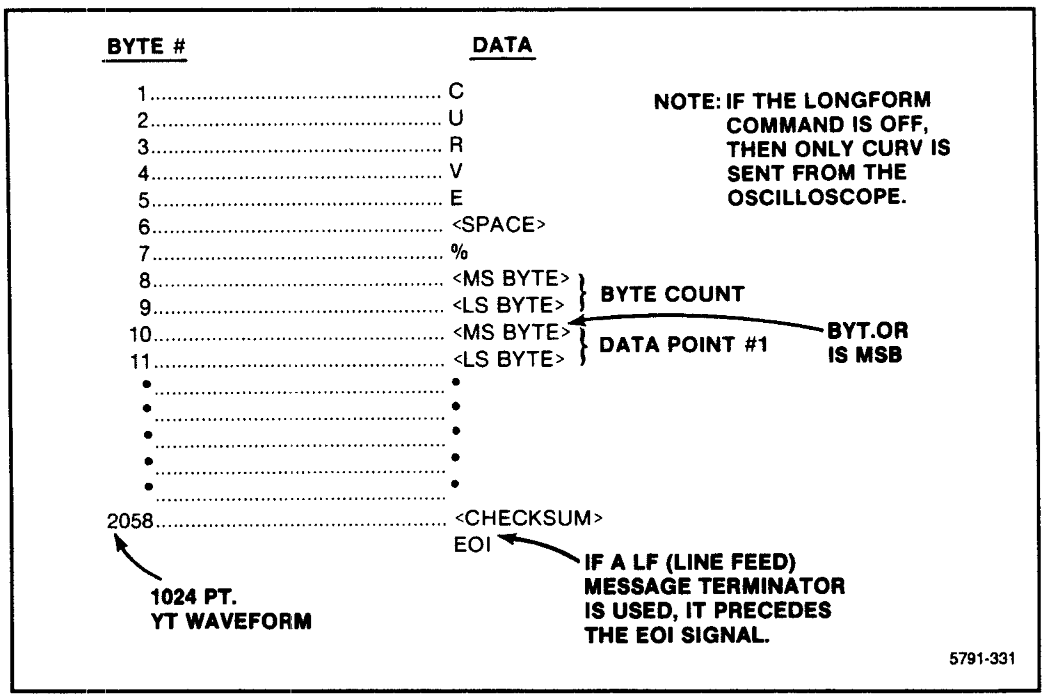

Figure 3-13. Binary transfer operation.

The number of data points returned in bblock is specified by the NR. PT link of the WFMPRE command and the range of the binary data points (<bin_points>) is -32768 to +32767.

If CURVE? returns data for a YT waveform, then each binary point represents one data point in the waveform record.

If CURVE? returns data for an XY waveform, every two consecutive <bin_points> represent one X, Y coordinate pair in the waveform record (the X-coordinate being the first point of the pair).

The entire binary-encoded CURVE? response may be sent back to the 11401 as a set command.

Retrieving and Scaling Waveform Data

In general, waveform data is retrieved from the 11401/11402 through the following sequence:

1. The ENCDG command is used to select the desired waveform encoding.
2. If binary encoding is in effect, the BYT.OR command is used to select the binary data transmission order appropriate for the target RS-232-C/GPIB controller.
3. The OUTPUT command is used to select the stored or displayed waveform that is to be retrieved.
4. Finally, WFMPRE? and CURVE? are used to query the 11401/11402 for the preamble and unscaled data of the OUTPUT waveform.

Notice that once waveform encoding and binary data transmission order are initially established, steps 1 and 2 can be omitted for all succeeding retrievals.

Once retrieved, each unscaled waveform point returned via CURVE? must be scaled with preamble scaling information, before the data can be meaningfully analyzed. For YT waveforms, the scaled coordinate values of each point are calculated with these equations:

X(n) = XZERO + XINCR * n
Y(n) = YZERO + YMULT * data_point_n

where

XZERO, XINCR, YZERO, and YMULT are taken from the preamble.

"n" is the sequence number of the nth retrieved data point. For the purpose of these calculations, "n" ranges from 0 to NR.PT –1.

"data_point_n" is the value of the nth unscaled data point (as retrieved by the CURVE?).

X(n) is the scaled horizontal coordinate of the nth unscaled data point, in XUNITs (typically, seconds).

Y(n) is the scaled vertical coordinate of the nth unscaled data point, in YUNITs (typically, volts).

For XY waveforms, the scaled coordinate values of each X, Y point-pair are calculated with these equations:

X(n) = XZERO + XMULT * data_point_nx
Y(n) = YZERO + YMULT * data_point_ny

where

XZERO, XMULT, YZERO, and YMULT are taken from the preamble.

"n" is the sequence number of the nth retrieved X,Y coordinate pair.

"data_point_nx" is the value of the nth unscaled X-coordinate (as retrieved by the CURVE?).

"data_point_ny" is the value of the nth unscaled Y-coordinate (as retrieved by the CURVE?).

X(n) is the scaled X-coordinate of the nth unscaled X,Y coordinate pair, inXUNITs.

Y(n) is the scaled Y-coordinate of the nth unscaled X,Y coordinate pair, YUNITs.

Overrange, Underrange, and NULL Data Points

Within the range of unscaled data returned via the CURVE?, there are three values that have special meaning:

Value	Meaning
+32767	**Vertical overrange**—these data points are high off screen and are not displayed. They are given this default value in the waveform.
–32767	**Vertical underrange** —these data points are low off screen and are not displayed.They are given this default value in the waveform.
–32768	**NULL point**—data points that haven't been acquired by the 11401/ 11402 and are not displayed. They are given this default value in the waveform.

Returning Waveform Data to the 11401/11402

In general, waveform data is returned to the 11401/11402 via the following sequence:

1. If the waveform data is binary encoded, BYT.OR is used to specify the transmission order of the returned data.
2. The INPUT command is used to select the stored waveform location at which the data will be written.
3. The WFMPRE command is used to return the waveform's preamble to the 11401/11402.
4. Finally, the CURVE command is used to return unscaled waveform data to the 11401/11402.

As the 11401/11402 copies waveform data from the ASCII interfaces to its memory, the number of received data points is compared against the number of data points specified by NR.PT. If more points are sent than the preamble called for, then the excess are discarded and an error is reported. If fewer points are sent than the preamble called for, then the remainder of the INPUT stored waveform is filled out with NULL data points, with no error reported.

It is possible to return waveform data to the 11401/11402 without supplying a preamble. When the 11401/11402 receives such waveform data, the following conventions apply:

- If the INPUT stored waveform exists when "preamble-less" data is received, that data is copied over the existing stored waveform. The preamble of the existing stored waveform is retained as the preamble of the new waveform data.

- If the INPUT stored waveform does not exist, an internal "default" preamble is used to create a new stored waveform and scale the received data. At instrument power up, the default preamble consists of these values:

Preamble Link	Default Value
ACSTATE	ENHANCED
PT.FMT	Y
NR.PT	1024
XINCR	5.0E-7
XZERO	0.0
YMULT	1.5625E-4
YUNIT	VOLTS
YZERO	0.0

When any of these links are returned to the 11401/11402 following power-up, they overwrite and thus, update the corresponding links of the default preamble.

Error and Warning Conditions:

An execution error (event code 270) is reported when a CURVE? is attempted and OUTPUT references a nonexistent stored waveform.

An execution error (event code 269) is reported when CURVE? is attempted and OUTPUT references a nonexistent trace.

A command error (event code 161) is reported and the excess points are discarded when more binary curve data points are returned to the 11401/11402 than were specified via the WFMPRE NR.PT field.

A command error (event code 162) is reported and the excess points are discarded when more ASCII curve data points are returned to the 11401/11402 than were specified via the WFMPRE NR.PT field.

If waveform data is returned to the 11401/11402 and INPUT references a nonexistent stored waveform, the 11401/11402 must first create a stored waveform record for that data before it can be copied from the interfaces to memory. If insufficient memory exists to create the stored record, an execution error (event code 255) is returned and the waveform data is discarded.

An execution warning (event code 552) is reported when binary curve data is returned to the 11401/11402 and a checksum comparison fails. However, the curve data is not discarded. Note that if the returned binary data was created with a NULL checksum, the checksum test is almost certain to fail. Since the returned data isn't discarded, this failure isn't critical.

An execution warning (event code 551) is reported and the waveform is filled out with NULL points when binary curve data returned to the 11401/11402's GPIB port is prematurely terminated (i.e., binary block byte count not satisfied and the data is terminated with a GPIB EOI signal).

Under normal conditions, an even number of binary waveform data bytes will be returned to the 11401/11402 (2 binary bytes per waveform point). Should an odd number of bytes be returned and the checksum comparison not fail, an execution error (event code 555) will be reported and the last (odd) data byte discarded.

WAVFRM? Query Command

This query-only command provides a short-hand notation for issuing the following commands in sequence:

WFMPRE?;CURVE?

When the WAVFRM encoding is ASCII, the WAVFRM? response is

WFMPRE <link>:<arg>[{,<link>:<arg>}...];
CURVE <NR1> [{,<NR1>}...]

When the WAVFRM encoding is BINARY, the WAVFRM? response is

WFMPRE <link>:<arg>[{,<link>:<arg>}...];
CURVE <bblock>

Error and Warning Conditions:

If a WAVFRM? query is attempted and OUTPUT references a nonexistent stored waveform, an execution error (event code 270) is returned.

If a WAVFRM? query is attempted and OUTPUT references a nonexistent trace, an execution error (event code 269) is reported.

SET? Query Command

This query-only command returns the current front panel settings of the instrument.

Note that the 11401/11402 waveform records, waveform preamble data, and ASCII-specific controls (e.g., LONGFORM, RQS, SRQMASK, etc.) are not stored with the normal front-panel settings, and thus are not returned via a SET? command.

Settings are returned to the GPIB or RS-232-C ports in one of the two data formats, depending upon the current setting of the ENCDG SET command, either ASCII or BINARY.

ASCII Encoded Settings

When ENCDG SET is ASCII, the returned settings will be human readable strings (separated by semicolons). However, the ASCII encoded SET? response is not preceded with the "SET" header.

The response form is

{<string>[;<string>...]}

A controller may return these ASCII settings to an instrument at any time by simply sending the human readable strings to the 11401/11402's RS-232-C or GPIB ports, thus restoring these settings to the 11401/11402.

The ASCII encoded SET? response string varies with the number of plug-in units that are loaded in the 11401/11402's compartments and with the number of active traces displayed on the 11401/11402's front panel.

Binary Encoded Settings

When ENCDG SET is BINARY, the settings will be returned to a controller via the following data structure:

SET <bblock>

<bblock>	::=	%<byte_count><settings><checksum>
<byte_count>	::=	16-bit, binary integer; most-significant byte first.
<settings>	::=	binary-encoded data
<checksum>	::=	2's complement of the modulo 256 sum of the preceding byte count and settings data. This is an 8-bit quantity.

Note that, unlike the ASCII encoded SET? response, the binary encoded SET? response is preceded by a "SET" header.

A controller may return these BINARY settings to the 11401/11402 at any time by simply sending the exact same data structure to the 11401/11402's RS-232-C or GPIB ports.

There are two important points to note:

1. The controller must not alter the contents of the returned binary block.

2. To return BINARY settings, the binary block must be preceded with a SET header.

Special Binary Setting Considerations

When binary settings are returned to the 11401/11402 from an external controller, the 11401/11402 performs a checksum comparison of the data received versus the data that was originally sent to the controller. If the checksum comparison is favorable, no further tests of the binary data are performed and the settings are stored as the instrument's current settings.

However, if the checksum fails, event code 108 is reported and the settings are discarded.

Though the checksum provides some assurance of the integrity of the settings data, the checksum comparison is not infallible, and corrupted binary settings data may be passed. In this situation, one of two events can occur:

1. The corrupted binary settings do not cause a software "crash", but the front-panel is set to an unknown, functional state.

2. The corrupted binary settings cause a software "crash" and the only way to recover is to cycle power. When the 11401/11402 recognizes power-up, it will notice that its settings are corrupted and proceed to perform an initialization that uses its factory-set default front-panel settings.

Error and Warning Conditions:

When returned binary settings are prematurely terminated (i.e., binary block byte count is not satisfied and settings are terminated with a GPIB EOI signal), a command error (event code 167) is reported and the settings are discarded.

When binary settings are returned to the 11401/11402 and the binary block byte count exceeds the maximum possible size of any 11401/11402 front-panel settings buffer, a command error (event code 109) is reported and the settings are discarded.

When a binary checksum comparison fails, a command error (event code 108) is reported and the settings are discarded.

Attempting to return binary block data to the 11401/11402 from the RS-232-C port when ECHO is ON is not permitted. Any attempt to do so causes a command error (event code 164) to be reported and the binary data is discarded.

If corrupted binary settings pass the checksum test and subsequently cause a software crash, the 11401/11402 reports an internal warning (event code 658) during instrument power-up.

The data structure of binary settings is different for each version of 11401/11402 firmware. Therefore, the version number is included in each block of settings returned with the SET? query command. If the version number of a block of binary settings sent to the 11401/11402 does not match the instrument's current firmware version, then the settings are discarded and an execution error (event code 239) is reported.

SET Command

This set-only command enables the user to transfer the last selected settings received from the SET? command back to the 11401/11402 in a binary block format. This is a convenient means of resetting the 11401/11402 for a previously defined measurement or test.

Acquisition Commands

Acquisition commands control waveform digitizing.

Header	Link	Argument	Notes
DIGITIZER		RUN | STOP	
CONDACQ	TYPE: FILL: REMAINING:	FILL | AVG | ENV | BOTH | SINGLE | CONTINUOUS <NRx> <NRx>	 1
AUTOSET	 HORIZ: VERT:	START UNDO PERIOD | OFF ECL | PP | TTL | OFF	2 2

Note 1. Query-only link.
2. Set-only argument.

AUTOSET Command

Enables or disables vertical and horizontal autoranging of input signals.

Parameters:

The START argument begins autosetting on the selected trace, however, when no trace selected, the 11401/11402 will sample all plug-in units and autoset the first signal it encounters. Autoset completion is signaled via operation complete event 464.

The UNDO argument cancels the previous autoset and returns the selected trace to its original vertical and horizontal settings assuming a previous autoset has been performed.

HORIZ—enables (PERIOD) or disables (OFF) autoset on the horizontal components of the trace.

VERT—selects one of the following vertical autoset options:

- Off disables autoset on the vertical components of the input signal.
- PP (peak-to-peak) enables autoset on the vertical components of the input signal.
- ECL (emitter-coupled logic) autosets with the vertical aspect referenced to ECL levels.
- TTL (transistor-transistor logic) autosets with the vertical aspect referenced to TTL levels.

Restrictions:

The following types of traces may not be autoset:

- A multi-channel trace (e.g. TRA1 DES: "L1 + L2").

- A WINdow'd trace that has no MAIN "parent", when the main timebase is not triggered.

Query Information:

The general query form, AUTOSET?, returns the current HORIZ and VERT link arguments, in the form:

AUTOSET HORIZ:<arg>, VERT:<arg>

Error and Warning Conditions:

An execution error (event code 231) is reported when an attempt is made to autoset any of the traces described in the previous "Restrictions" paragraph.

An execution warning (event code 554) is reported when no traces are defined, autoset is initiated, and no plug-in input has an amplitude or offset greater than +/-1.0 division on the most sensitive channel gain setting (i.e., no signal source can be found).

An execution warning (event code 561) is reported when the horizontal autoset algorithm does not have a correctly triggered signal. This event occurs when VERT autoset is OFF and the selected trace is not triggered.

An execution warning (event code 562) is reported when the horizontal autoset algorithm cannot correctly calculate the period of the selected trace.

An execution warning (event code 563) is reported when the vertical autoset algorithm detects a signal whose AC component is too large for the least sensitive gain setting of a trace's plug-in channel.

An execution warning (event code 564) is reported when the vertical autoset algorithm detects a signal whose DC component is larger than the offset range of the least sensitive gain setting of a trace's plug-in channel.

DIGITIZER Command

Starts or stops waveform digitization.

Query Information:

The query DIGITIZER? returns the currently selected argument, in the form:

DIGITIZER <arg>

Error and Warning Conditions:

An execution warning (event code 556) is returned if an attempt is made to start the digitizer when no traces are defined, or when no defined traces contain "active" components. An active trace is one that is has at least one component that is currently being digitized (e.g., TRA1 DESC:"L1+500-STO2"), rather than one containing only scalar (e.g., TRA1 DESC:"20") or stored (e.g., TRA2 DESC:"STO3") components.

CONDACQ Command

Selects whether to conditionally acquire waveforms using a single trigger, or upon completion of waveform acquisition.

Completion of any conditional acquire, except a CONTINUOUS acquire, is signaled via operation complete event 450.

Parameters:

TYPE—this link selects the kind of acquisition as determined by the argument and the 11401/11402 immediately begins the selected acquisition.

The FILL argument stops acquisition when all defined traces are the percent (%) complete as specified by the FILL link.

AVG causes the digitizer to continue acquiring until the number of averages specified by the NAVG command have been completed for all traces that include the AVG function in their trace descriptions.

ENV causes the digitizer to continue acquiring until the number of envelopes specified by the NENV command have been completed for all traces that include the ENV function in their trace descriptions.

BOTH causes the digitizer to execute conditional acquisition as if TYPE had been specified as both AVG and ENV. Acquisition does not stop until all averages and envelopes have been acquired for all traces that include the AVG and ENV functions.

SINGLE causes the digitizer to wait for a single trigger from the main time base.

CONTINUOUS causes the digitizer to continually acquire waveforms until commanded to stop.

FILL—this link selects the percent (%) of waveform completion desired. The valid range is 1 to 100 percent.

REMAINING—this query-only link returns a value indicating the current state of a non-SINGLE, active conditional acquisition, as shown in Table 3-11.

TABLE 3-11
REMAINING Conditional States

Acquisition	Information Returned By REMAINING Link
AVG	Averages remaining until acquisition is complete.
BOTH	Averages and Envelopes remaining until acquisition is complete.
CONTINUOUS	Always 0; REMAINING query is not meaningful.
ENV	Envelopes remaining until acquisition is complete.
FILL	Percent Fill remaining until acquisition is complete.
SINGLE	Always 0; REMAINING query is not meaningful.

Query Information:

The query form, CONDACQ?, returns all links and their currently selected arguments in the following form:

CONDACQ FILL:<NR1>,REMAINING:<NR1>,TYPE:<arg>

Error and Warning Conditions:

An execution warning (event code 550) is returned if set arguments are out of range for the FILL link.

An execution error (event code 299) is returned when the ENV or AVG acquisition arguments are specified and no traces include the ENV or AVG function.

An execution error (event code 299) is returned when BOTH conditional acquisition is specified and one of these conditions does not exist:

- At least one trace description includes the AVG function and at least one other trace description includes the ENV function.
- One trace includes both the AVG and ENV functions in its description.

An execution error (event code 299) is returned if conditional acquisition of any type is specified and no traces are defined.

Measurement Commands

Measurement commands execute and query waveform measurements, and set the references for measurements.

The set of selectable 11401/11402 waveform measurements is defined as:

<meas> ::= CROSS | DELAY | FALLTIME | FREQ | MAX | MEAN | MID | MIN | PDELAY | PERIOD | PP | RISETIME | RMS | TTRIG | WIDTH | YTENERGY | YTMNS_AREA | YTPLS_AREA

Header	Link	Argument	Notes
MSYS		ON | OFF	
MSLIST		<meas> | EMPTY	
MSNUM			1
MEAS			1
<meas>			1
REFSET	CURRENT: <meas>:	<meas> <NRx>	2
COMPARE		ON | OFF	
MESIAL		<NRx>	
PROXIMAL		<NRx>	
DISTAL		<NRx>	
REFLEVEL		<NRx>	
BASELINE		<NRx>	
TOPLINE		<NRx>	
DAINT		WHOLE | SINGLE	
SNRATIO		<NRx>	
MSLOPE		PLUS | MINUS	
LMZONE		<NRx>	
RMZONE		<NRx>	
MTRACK		ON | OFF	
TTAVERAGE		<NRx>	
DLYTRACE		TRACE<ui>	

Notes
1. Query only.
2. Set-only link.

The 11401/11402 Measurement Systems

The 11401/11402 has two measurement systems: one for GPIB/RS-232-C interface use and one for front-panel use, via the Measure menu. While these systems have many of the same measurement features, they do operate independently of one another. So, a GPIB or RS-232-C measurement can be made regardless of whether the Measure menu is currently displayed.

NOTE

In the following descriptions, remote measurement commands which have corresponding front-panel commands have only a brief explanation of their functions described here. Detailed explanations of these commands can be found in Section 2 "Operating Information".

Waveform Measurements and the Selected Trace

All waveform measurements are taken with respect to the currently selected trace. To select a particular trace, use the SELECT command described earlier in this section.

MSYS Command

This command turns the measurement system on or off at the front panel display. However, it does not affect the ASCII interfaces' ability to take measurements via the MEAS? or <meas>? commands (see these commands below) when MSYS is OFF.

Turning MSYS ON has the same effect as pressing the front-panel MEASURE button when the Measure menu is not currently displayed or when the menu status area is blank; That is, the currently displayed menu is replaced by the Measure menu and its status readouts.

Turning MSYS OFF has the same effect as pressing the MEASURE button when the Measure menu is active, that is, removing the Measure menu and its status readouts from the menu/status area.

When to use MSYS

Of course, use MSYS when you need to interact with the 11401/11402 at the front panel, as well as over the ASCII interfaces (e.g., device-under-test applications).

However, if maximum GPIB or RS-232-C throughput is essential, turn MSYS OFF. This will free up more 11401/11402 system resources for faster command processing.

Finally, note that if FPUDATE is set to NEVER (refer to the Miscellaneous Commands described later in Section 3), setting MSYS ON is pointless, since the Measure menu is not displayed.

Query Information:

The query form, MSYS? , returns the last selected argument in the form:

MSYS <arg>

MSLIST Command

This command generates a measurement list of up to six measurements (from the set of selectable 11401/11402 measurements defined above) which the 11401/ 11402 will continuously execute while in the Measure major menu mode (refer to "Operating Information" for detailed descriptions of these measurements).

Each newly specified list clears and replaces any previously stored list.

Query Information:

The query form, MSLIST? , returns the latest measurement list containing each selected measurement's name (up to 6), in the form:

MSLIST <meas>[{,<meas>}...] | EMPTY

The <meas> argument is a previously selected measurement name, while the EMPTY argument is returned when no measurements have been selected.

Note that the measurements returned by this query are specified via the MSLIST set command or by operator selection from the front panel Measure menu.

Error and Warning Conditions:

When more than six measurements are specified via MSLIST, an execution error (event code 286) is returned and the input measurement list is truncated.

MSNUM? Query Command

This query-only command returns the number of items in the current MSLIST, and is most useful in determining the variable dimension for a MSLIST? response.

The response form is

MSNUM <NR1>

If the current MSLIST is EMPTY, the query response is MSNUM 0.

MEAS? Query Command

This query-only command executes the selected measurement list and returns their scalar values, or EMPTY, if none were specified.

The response form is

MEAS <meas>:<NR3>,<qual>[{,<meas>:<NR3>,<qual>}...] | EMPTY

<meas> denotes a measurement name in the measurement list.

<qual> returns a qualifier or value that are ASCII characters having meanings that relate to the completeness of the underlying waveform data. Completeness refers to whether or not the underlying data contains nulls, overrange values, or underrange values. The <qual> argument can also return an indication as to whether or not an error occurred during measurement calculations. These qualifiers are

LT—indicates the true measurement value is less than the value given.

GT—indicates the true measurement value is greater than the value given.

UN—indicates the true measurement value is uncertain and the returned value is not reliable. This qualifier is returned for any of these conditions:

- A timing measurement (e.g., RISETIME) is attempted and the selected trace contains null (unacquired) points within the specified measurement zone.
- The selected trace is ENVeloped (e.g., TRA1 DESC: "ENV(L1)"), contains combinations of ENVeloped components (e.g., TRA1 DESC: "ENV(C3) + L4"), or contains stored component(s) created from an ENVeloped trace and any of the following measurements are attempted:

FALLTIME	FREQ	PERIOD	RISETIME
WIDTH	YTENERGY	YTPLS_AREA	YTMNS_AREA

Given the same selected trace conditions, the MEAN and RMS measurements are also qualified with UN when the measurement data interval (DAINT) is set to SINGLE. Setting DAINT to WHOLE removes the UN qualifier (providing, of course, that the selected trace does not contain null points.)

EQ—indicates the true measurement value is equal to the value given.

ER—indicates an error occurred while calculating this value, rendering the result meaningless. This qualifier is returned for any of these conditions:

- The selected trace is XY or point accumulate and any measurement is attempted.
- A FREQ or PERIOD measurement is attempted and no period can be found within the specified measurement zone.
- A MEAN, RMS, YTPLS_AREA, YTMNS_AREA, or YTENERGY measurement is attempted and DAINT is SINGLE and no period can be found within the specified measurement zone.
- A CROSS measurement is attempted and REFLEVEL does not fall within the specified measurement zone.
- A RISETIME measurement is attempted and the measurement system cannot compute a valid proximal time, followed by a valid distal time, within the specified measurement zone.
- A FALLTIME measurement is attempted and the measurement system cannot compute a valid distal time followed by a valid proximal time, within the specified measurement zone.
- A WIDTH measurement is attempted and two mesial crossings of opposite slope cannot be found within the specified measurement zone.
- No traces are defined on the 11401/11402's display (i.e., there is no selected trace) and any measurement is attempted.
- A PDELAY measurement is attempted and only one trace is defined (PDELAY requires at least two traces on the screen).

Signaling Operation Complete

Since TTRIG measurement calculations can consume a considerable amount of time, successful completion of a MEAS? containing a TTRIG measurement is signaled via an operation complete event (event code 463). No other measurements require or report an operation complete event.

Special Conditions

If the MSLIST is not EMPTY and there is no selected trace, MEAS? returns a list of meaningless measurement values. Each returned value is flagged with an ER qualifier.

<meas>? Query Command

This query-only command executes the specified measurement and returns its value with the appropriate accuracy qualifier.

The response form is

<meas> <NR3>,<qual>

<meas> is the selected measurement (from the set of 11401/11402 measurements) and <qual> is as described in the MEAS? command.

For example, to return the frequency of the currently selected trace, use this query:

FREQ?

The response will be

FREQ <NR3>,<qual>

Signaling Operation Complete

As in the MEAS? command, the TTRIG measurement can consume a considerable amount of time and is the the only measurement that generates an operation complete event upon successful completion.

REFSET Command

Sets the reference value for measurements. References are used when measurements are returned in comparison mode.

Parameters:

CURRENT—causes the measurement to be executed and the resultant value stored as the measurement reference.

<meas>—sets the reference for the specified measurement (again, from the set of 11401/11402 measurements) to a user-defined value. The valid range is any <NRx> value between -5.0E+20 and 5.0E+20.

Query Information:

REFSET? returns the reference values for all measurements.

REFSET <meas>:<NR3>[{,<meas>:<NR3>}...]

Signaling Operation Complete

Successful completion of a REFSET CURRENT:TTRIG command signals an operation complete event (event code 463). This is the only REFSET computation for which an operation complete event is generated.

Error and Warning Conditions:

An execution error (event code 290) is returned when a CURRENT reference cannot be computed. The conditions that cause CURRENT reference calculation failures are the same as those that cause MEAS? to return an ER qualifier (see above).

An execution Warning (event code 550) is returned for out of range arguments.

COMPARE Command

This command enables or disables comparison between a measurement and a reference from the REFSET command.

When COMPARE is ON, comparison measurements are enabled and measurement queries return values equal to an actual measurement value minus its reference value.

When COMPARE is OFF, the measurement query returns the current value of the measurement.

Query Information: The query form, COMPARE?, returns the last selected argument.

COMPARE <arg>

Measurement Parameters and the Selected Trace

The remaining measurement commands describe parameters that directly affect the 11401/11402's waveform measurement calculations by setting measurement boundaries or references. These measurement parameter commands include:

MESIAL, PROXIMAL, and DISTAL level values
REFLEVEL for signal reference levels
TOPLINE and BASELINE level values
DAINT for data interval reference
SNRATIO for signal-to-noise ratios
MSLOPE for the measurement crossing slope
LMZONE and RMZONE for measurement zones
MTRACK for continual measurement tracking
TTAVERAGE for trigger-to-trigger measurements

Note that each displayed trace has a unique set of these measurement parameters with the exception of TTAVERAGE which applies to all traces. Also, the commands that set or query these parameters only access the parameters of the "selected trace." Thus, modifying the measurement parameters of the selected trace has no effect on the measurement parameters of other traces.

If no traces have been defined (thus no selected trace), attempting to set or query these measurement parameters will result in an execution error (event code 250).

MESIAL Command

The MESIAL (middle) reference level sets the vertical end points of the waveform period for MEAN, RMS, PERIOD, FREQ, WIDTH, and DELAY measurements under all circumstances, and sets period end points for YTMNS_AREA, YTPLS_ARA, and YTENERGY measurements when the data interval (DAINT) is set to SINGLE. The valid range is from 0 to 100 percent.

Query Information:

The query form, MESIAL? , returns the mesial value last set.

MESIAL <NR3>

Error and Warning Conditions:

An execution warning (event code 550) is returned for out of range MESIAL arguments.

An execution error (event code 250) is returned when there is no selected trace and an attempt is made to query or set MESIAL.

PROXIMAL Command

The PROXIMAL (near to point of origin) reference level is set for RISETIME and FALLTIME measurements. The valid range is from 0 to 100 percent.

Query Information:

The query form, PROXIMAL?, returns the proximal value last set.

PROXIMAL <NR3>

Error and Warning Conditions:

An execution warning (event code 550) is returned for out of range arguments.

An execution error (event code 250) is returned when there is no selected trace and an attempt is made to query or set PROXIMAL.

DISTAL Command

The DISTAL (far from point of origin) reference level is set for RISETIME and FALLTIME measurements. The valid range is from 0 to 100 percent.

Query Information:

The query form, DISTAL? , returns the distal value last set.

DISTAL <NR3>

Error and Warning Conditions:

An execution warning (event code 550) is returned for out of range arguments.

An execution error (event code 250) is returned when there is no selected trace and an attempt is made to query or set DISTAL.

REFLEVEL Command

Selects the signal reference levels for CROSS, YTPLS_AREA, YTMNS_AREA, and YTENERGY measurements. The valid range is any legal <NRx> value.

Query Information:

The query form, REFLEVEL? , returns the reference level last set.

REFLEVEL <NR3>

Error and Warning Conditions:

An execution error (event code 250) is returned when there is no selected trace and an attempt is made to query or set REFLEVEL.

BASELINE Command

Sets the selected waveform's vertical baseline level for measurements. BASELINE levels are calculated by using a histogram method and the vertical axis scale factors. The valid range is any legal <NRx> value.

BASELINE and MTRACK are interdependent. When MTRACK is ON, attempting to set measurement BASELINE is futile, since the 11401/11402 will calculate its own baseline value and overwrites any user-specified value. It is only possible to set BASELINE when MTRACK is OFF.

Query Information:

The query form, BASELINE? , returns the baseline value last set.

BASELINE <NR3>

Error and Warning Conditions:

An execution error (event code 250) is returned when there is no selected trace and an attempt is made to query or set BASELINE.

TOPLINE Command

Sets the selected waveform's top vertical level for a measurement. The valid range is any legal <NRx> value.

TOPLINE and MTRACK are interdependent. When MTRACK is ON, attempting to set measurement TOPLINE is futile, since the measurement system calculates its own TOPLINE value and overwrites any user-supplied value. It is only possible to set TOPLINE when MTRACK is OFF.

Query Information:

The query form, TOPLINE? , returns the topline value last set.

TOPLINE <NR3>

Error and Warning Conditions:

An execution error (event code 250) is returned when there is no selected trace and an attempt is made to query or set TOPLINE.

DAINT Command

Sets the data interval for measurements to the WHOLE measurement interval or to a SINGLE period of the waveform, as bounded by the measurement zone.

For example, if DAINT were set to WHOLE and an RMS? is executed, the 11401/11402 would use the whole measurement interval within the measurement zone to compute the RMS value. However, if DAINT were set to SINGLE, only one period would be used to compute RMS.

The MEAN, RMS, YTENERGY, YTMNS_AREA, and YTPLS_AREA measurements return values that depend upon the current setting of DAINT.

Note: all measurements which are queried and depend upon DAINT return an ER qualifier if DAINT is SINGLE and no period can be found.

Query Information: DAINT? returns the data interval last selected.

DAINT <arg>

Error and Warning Conditions: An execution error (event code 250) is returned when there is no selected trace and an attempt is made to query or set DAINT.

SNRATIO Command

Sets the signal-to-noise ratio for reducing the impact of noise on measurements. The valid range is from 1 to 99.

Query Information: SNRATIO? returns the signal-to-noise ratio last set.

SNRATIO <NR3>

Error and Warning Conditions: An execution warning (event code 550) is returned for out of range arguments.

An execution error (event code 250) is returned when there is no selected trace and an attempt is made to query or set SNRATIO.

MSLOPE Command

Sets the crossing slope for the CROSS measurement.

Query Information: The query form, MSLOPE? , returns the crossing slope last set

MSLOPE <arg>

Error and Warning Conditions: An execution error (event code 250) is returned when there is no selected trace and an attempt is made to query or set CROSS.

LMZONE Command

Sets the left measurement zone limiter (% of waveform record). This zone is used as a reference in measurements. The valid range is from 0 to 100 (percent).

Query Information:

The query form, LMZONE? , returns the left measurement zone limiter value last set.

LMZONE <NR1>

Error and Warning Conditions:

An execution warning (event code 550) is returned for out of range arguments.

An execution error (event code 250) is returned when there is no selected trace and an attempt is made to query or set LMZONE.

RMZONE Command

Sets the right measurement zone limiter (% of waveform record). This zone is used as a reference in measurements. The valid range is from 0 to 100 (percent).

Query Information:

The query form, RMZONE? , returns the right measurement zone limiter value last set.

RMZONE <NR1>

Error and Warning Conditions:

An execution warning (event code 550) is returned for out of range arguments.

An execution error (event code 250) is returned when there is no selected trace and an attempt is made to query or set RMZONE.

MTRACK Command

Turns measurement tracking on or off. If ON, histograms are calculated and used to set TOPLINE and BASELINE. If OFF, the user sets those parameters.

Query Information:

The query form, MTRACK? , returns the current state of measurement tracking.

MTRACK <arg>

Error and Warning Conditions:

An execution error (event code 250) is returned when there is no selected trace and an attempt is made to query or set MTRACK.

TTAVERAGE Command

Sets the number of averages for the trigger-to-trigger measurement (TTRIG). The value set applies to all traces. This command may be set to one of the four values shown in Table 3-12.

TABLE 3-12
TTRIG Measurement Operation

Value	Semantics
1	Single-shot mode.
10	Averaged 10 times before a final value is reported.
100	Averaged 100 times before a final value is reported.
1000	Averaged 1000 times before a final value is reported.

Query Information:

TTAVERAGE? returns the currently selected value for averaging the TTRIG measurement.

TTAVERAGE <NR1>

Error and Warning Conditions:

An execution warning (event code 550) is returned for out of range TTAVERAGE arguments.

DLYTRACE Command

DLYTRACE selects a delayed trace for the PDELAY measurement. This command's <ui> argument must be greater than or equal to 0 (zero) and less than or equal to 8. In the special case of a 0<ui> argument, the delayed trace is ignored (treated as a NOP).

Take note that the DLYTRACE command must not be used to specify a delayed trace number that is identical to the currently selected trace. That is to say, proper operation of the PDELAY measurement requires two unique traces: the selected trace and a second, "delayed" trace, which is specified with DLYTRACE.

Query Information:

DLYTRACE? returns the currently selected argument, in the form:

DLYTRACE TRACE<ui>

When there is no delayed trace (i.e., less than two traces are displayed on the screen), DLYTRACE TRACE0 is returned.

Error and Warning Conditions:

An execution error (event code 251) is returned for out of range TRACE<ui> arguments.

An execution error (event code 250) is returned when there is no selected trace and an attempt is made to query or set DLYTRACE.

An execution error (event code 233) is returned when an attempt is made to specify the currently selected trace as the PDELAY delayed trace.

Special PDELAY Considerations

PDELAY measures the absolute time between the mesial crossings of the currently selected trace (referred to here as the primary trace) and a user-specified delayed trace.

While changing the measurement parameters (MESIAL, TOPLINE, etc.) of the primary trace is straightforward, changing the measurement parameters of the delayed trace requires a bit more effort. To accomplish this task, first use the SELECT command to specify the delayed trace as the currently selected trace. Modify the measurement parameters of this trace as necessary and then re-SELECT the primary trace. At this point, PDELAY can be used to measure the time between the mesial crossings of the primary and delayed trace.

For example, suppose it was desired to measure the PDELAY between TRACE2 and TRACE4 and suppose the required MESIAL values of these two traces were 40% and 45%, respectively. The following commands produce the desired measurement:

```
SELECT TRACE2
MESIAL 40            /* Specify primary trace's MESIAL value        */
DLYTRACE TRACE4      /* Specify primary trace's delayed trace       */
SELECT TRACE4        /* Temporarily change selected trace           */
MESIAL 45            /* Specify delayed trace's MESIAL value        */
SELECT TRACE2        /* Re-SELECT primary trace                     */
PDELAY?              /* Measure PDELAY between TRACE2 & TRACE4
                      * Primary trace is TRACE2.
                      * Delayed trace is TRACE4.
                      */
```

Status and Event Commands

Status and Event commands control the reporting of the 11401/11402's operating status to an external controller or device.

Header	Link	Argument	Notes
RQS		ON I OFF	
SRQMASK	ABSTOUCH: CALDUE: CMDERR: EXERR: EXWARN: IDPROBE: INERR: INWARN: OPCMPL: USER:	ON I OFF ON I OFF ON I OFF ON I OFF ON I OFF ON I OFF ON I OFF ON I OFF ON I OFF ON I OFF	
STBYTE			1
EVENT			1
ID			1
IDPROBE			1
PIVERSION			1
CONFIG			1
UID	MAIN: LEFT: CENTER: RIGHT:	<qstring> <qstring> <qstring> <qstring>	2 2 2 2

Notes
1. Query-only.
2. <qstring> argument may not exceed 10 characters; longer strings are truncated.

RQS Command

RQS is a port-specific command that controls how the 11401/11402 responds to "events" detected during instrument operation.

At the GPIB, this command controls whether or not the 11401/11402 asserts SRQ when a noteworthy event occurs. When RQS is ON and a defined condition occurs within the 11401/11402 (e.g., syntax error), the 11401/11402 asserts SRQ and sets the RQS bit (bit 7) of the status byte stored in the 11401/11402's GPIB serial poll register. When RQS is OFF, the 11401/11402 does not assert SRQ. The EVENT? responses (see below) still report all events. The instrument will power up in RQS ON state.

For the RS-232-C interface, this command has no effect and the 11401/11402 generates an error if an attempt is made to set RQS ON. Therefore, this command only allows GPIB programs that operate under RQS OFF to be used via the RS-232-C port. For a detailed description of how RQS affects the 11401/11402's event reporting, refer to "Status and Event Reporting" later in this section.

Query Information:

The query form, RQS? , at the GPIB port, returns the RQS argument last selected, in the form:

RQS <arg>

An RQS? issued from the RS-232-C port always returns RQS OFF.

Error and Warning Conditions:

A command error (event code 157) is returned when an attempt is made to turn RQS ON at the RS-232-C port.

SRQMASK Command

Whether RQS is ON or OFF, this port-specific command permits a GPIB/ RS-232-C programmers to enable or disable the reporting of selected classes (see parameters) of events.

Parameters:

ABSTOUCH—front-panel screen touch or RS-232/GPIB ABSTOUCH occurred, event code 451.

CALDUE—instrument calibration due, event codes 465-472.

CMDERR—command error, event codes 100-199.

EXERR—execution error, event codes 200-299.

EXWARN—execution warning, event codes 500-599.

IDPROBE—plug-in unit probe ID button press, event code 457.

INERR—internal error, event codes 300-399.

INWARN—internal warning, event codes 600-699.

OPCMPL—operation complete, event codes 460-464.

USER—RQS icon touch, event code 403. This SRQMASK also controls whether or not the RQS icon is displayed. Refer to "Status and Event Reporting" later in this section for more details.

At instrument power-up, all SRQMASKs, except ABSTOUCH, IDPROBE and USER, are ON.

Query Information:

The general query form, SRQMASK? , returns all masks and their current arguments, in the form:

SRQMASK ABSTOUCH: <arg>, CALDUE:<arg>,CMDERR:<arg>,
EXERR:<arg>,EXWARN:<arg>,IDPROBE:<arg>,INERR:<arg>,
INWARN:<arg>,OPCMPL:<arg>,USER:<arg>

INITialize Side Effects

The INIT command turns the GPIB and RS-232-C USER SRQMASKs Off, which means that the RQS icon will be removed from the front panel (assuming it was displayed when INIT was executed).

STBYTE? Query Command

This query-only command mimics a GPIB serial poll at the RS-232-C port, thus permitting an RS-232-C controller to "read" the status byte value of the current RS-232-C event.

The response form is

STBYTE <NR1>

<NR1> is an event status byte. Refer to "Status and Event Reporting" later in this section for more information.

Error and Warning Conditions:

STBYTE? exists solely to support event reporting at the RS-232-C interface and may not be used from the GPIB port. Attempting to use this query from the GPIB will result in a command error (event code 157).

EVENT? Query Command

This query-only command returns more detailed information about the event reported in the last GPIB serial poll or RS-232 STBYTE? query. It also provides a mechanism for the controller to get information about events when the device's RQS assertion capability has been disabled. The event is cleared when the event code is reported.

The exact response depends upon whether or not the LONGFORM command is ON or OFF.

When LONGFORM is ON, the EVENT? response contains the event code and a quoted string describing the code/event:

EVENT <NR1>,<qstring>

When LONGFORM is OFF, the EVENT? response is only the event code:

EVENT <NR1>

Refer to "Status and Event Reporting" later in this section for a detailed discussion of events and a listing of event codes.

ID? Query Command

This query-only command returns several classes of identifying information about the device, thus aiding determination of system configurations. Each class of information is comma-delimited and includes these items:

- Instrument model number
- Tek Codes and Formats version number
- Executive processor (EXP) software version number
- Display processor (DSY) software version number
- Digitizer processor (DIG) software version number

The 11401 response form is

ID TEK/11401,V81.1,DIG/<NR2>,DSY/<NR2>,EXP/<NR2>

The 11402 response form is

ID TEK/11402,V81.1,DIG/<NR2>,DSY/<NR2>,EXP/<NR2>

IDPROBE? Query Command

This query-only command identifies the last probe ID button pressed by the front-panel operator.

The response form is

IDPROBE <slot><ui>

The argument <slot> identifies the plug-in compartment, while <ui> identifies the channel of the probe ID button last pressed.

In the case where no probe ID button has been pressed, this query returns IDPROBE L0. This response reflects the consecutive numbering scheme for plug-in channels, from 1 to "n" (i.e., low to high), with a returned channel value of 0 indicating that the IDPROBE? received nonstandard plug-in and channel information.

Special Conditions

Differential amplifier plug-ins have two signal inputs per channel and thus, two probes per channel. One probe is referred to as a "plus" probe and the other as a "minus" probe. However, pressing an ID button on a plus or minus differential probe results in the same IDPROBE? response.

PIVERSION? Query Command

This query-only command returns identifying information about the software/ firmware version numbers of all 11000-series plug-ins currently installed, thus aiding determination of system configurations.

The response form is

PIVERSION LEFT:"<ver#>",CENTER:"<ver#>",RIGHT:"<ver#>"

The 11401/11402 will return "N/7K" for the version number of plug-in compartments that are empty.

CONFIG? Query Command

This query-only command returns identifying information about the plug-in names, thus aiding determination of system configurations.

The response form is

CONFIG LEFT:"<name>",CENTER:"<name>",RIGHT:"<name>"

If a particular plug-in compartment is empty, its name is returned as "N/7K".

UID Command

The Unit IDentification command sets or queries the serial numbers of the 11401/ 11402, and its plug-ins. When setting a UID value, no serial number may exceed 10 characters. Serial numbers that exceed 10 characters are truncated and no error is reported.

The setting of this command is, typically, disabled by a factory-set internal hardware strap. If setting serial numbers is desired, authorized service personnel should refer to the 11401/11402 Service Manuals for details. However, serial numbers may always be queried, regardless of the strap setting.

Query Information:

The general query response depends upon the number of 11000-series plug-ins that are loaded in the 11401/11402's plug-in compartments. When all compartments are loaded, the query is

UID MAIN:<qstring>,LEFT:<qstring>,CENTER:<qstring>,RIGHT:<qstring>

Otherwise, if a given compartment is not loaded with an 11000-series plug-in unit, the corresponding link for that compartment is omitted.

Error and Warning Conditions:

An execution error (event code 292) is returned when an attempt is made to set or query the serial number of a plug-in compartment that is not loaded with an 11000-series plug-in.

An execution error (event code 243) is returned when the hardware strap is disabled and an attempt is made to modify a serial number.

External I/O Interface Commands

External input and output commands manipulate the 11401/11402's GPIB, RS-232-C, and Centronics I/O ports.

Header	Link	Argument	Notes
RS232	BAUD: DELAY: ECHO: EOL: FLAGGING: PARITY: STOPBITS: VERBOSE:	<NRx> <NRx> ON I OFF CR I CRLF I LF I LFCR SOFT I HARD I OFF ODD I EVEN I NONE <NRx> ON I OFF	
COPY	 PRINTER: FORMAT:	ABORT START PIN8 I PIN24 DRAFT I HIRES I REDUCED	1 1
DEBUG	GPIB: RS232:	ON I OFF ON I OFF	

Note
1. Set-only argument.

RS-232-C Command

Sets or queries RS-232 interface parameters.

NOTE

See "Special RS-232-C I/O Considerations" earlier in this section for related information.

Parameters:

BAUD—selects the baud rate for the RS-232-C interface port. Both transmit and receive baud rates are set by this command. The valid rates are 110, 150, 300, 600, 1200, 2400, 4800, 9600, and 19200.

DELAY—sets the minimum delay from receipt of an RS-232-C query to its response. This command allows an RS-232-C controller time to prepare to receive the response from a query before the response is transmitted. The argument represents the minimum delay in seconds, with minimum granularity of 20 milliseconds. The valid range is from 0 to 60 seconds.

ECHO—turns RS-232-C echo on or off. When echo is on, all characters received from the RS-232-C port are echoed. When echo is off, input characters are not echoed.

FLAGGING—controls input and output flagging over the RS-232-C port. When flagging is turned OFF, the 11401/11402 does not respond to any transmission control on output and does not send any transmission control on input.

When SOFT flagging is enabled, the 11401/11402 stops transmitting data any time it receives an XOFF (DC3) character and the instrument sends an XOFF character when it's input buffer is 3/4 full. The 11401/11402 begins transmitting data again when it receives an XON (DC1) character and it sends XON when its input buffer is 1/4 full.

Notice that there are potential conflicts when using soft handshaking with binary data transfers, since binary data may contain XON and XOFF characters. Generally, binary data transfers should not be used with soft handshaking unless the user can be sure that the data does not contain XON or XOFF characters.

When HARD flagging is selected, the 11401/11402 uses the DTR (Data Terminal Ready) and CTS (Clear to send) lines to control data transmission. On output, the instrument transmits data only when DTR is asserted. When DTR is not asserted, the instrument stops transmitting data. On input, the 11401/11402 asserts CTS until the input buffer is 3/4 full. Then it unasserts CTS to stop transmission from an external controller. CTS remains unasserted until the input buffer is 1/4 full, at which time CTS is asserted again to restart transmission.

PARITY—selects the parity used for all RS-232-C data transfers. The 11401/ 11402 generates the selected parity on output and checks all input against the selected parity. When parity is ODD or EVEN, and an input parity error is detected, an internal error warning (event code 653) is returned. When parity is NONE, no input parity error checks are performed and no output parity is generated.

STOPBITS—selects the number of transmission stops bits sent with each character to identify the end of data for that character. Valid selections are 1, 1.5, or 2 stop bits.

EOL—selects the type of End Of Line string that terminates each query transmitted from the 11401/11402 to its RS-232-C port. Possible EOL string selections include:

CR	→	Carriage Return
LF	→	Line Feed
CRLF	→	CR followed by a LF
LFCR	→	LF followed by a CR

VERBOSE—sets whether the 11401/11402 returns error and warning messages when they occur (RS232 VERBOSE:ON), or whether the 11401/11402 must be queried for event messages.

Query Information:

The general query form, RS232? , returns all links and their currently selected arguments, in the form:

RS232 BAUD:<NR1>,DELAY:<NR3>,ECHO:<arg>,EOL:<arg>,
FLAGGING:<arg>,PARITY:<arg>,STOPBITS:<NR2>,
VERBOSE:<arg>

Error and Warning Conditions:

An execution warning (event 550) is issued if set arguments are out of range for the BAUD, DELAY, or STOPBITS links.

COPY Command

Transmits a copy of the front panel display to the 11401/11402's PRINTER (Centronics) port.

Completion of the copy operation is signaled with operation complete event 462.

Parameters:

START—initiates a copy of the front-panel display. COPY START may be abbreviated to simply COPY (i.e., COPY without arguments is identical to the command "COPY START"). Take note that if a second COPY command is sent to ET before a prior COPY has been completely queued for output, the second command aborts the prior COPY.

ABORT—dequeues all queued COPY requests and aborts any COPY operation currently in progress. Completion of the ABORT operation is signaled via an operation complete event (event code 458).

FORMAT—selects the output format produced by COPY [START]. Choices are HIRES, DRAFT, and REDUCED. HIRES copies are approximately 8.5 inches by 11 inches and, as the name suggests, yield the greatest front-panel detail of the three possible formats. DRAFT copies are similar to HIRES copies except that no overstriking is used to depict front-panel intensified regions. REDUCED copies are much smaller than DRAFT or HIRES copies and show absolutely no front-panel intensified regions.

PRINTER—selects the target printer. PIN8 selects a printer that supports the standard EPSON command set. Examples of such printers include the Tektronix 4644 and EPSON EX-800. PIN24 selects a printer that supports the extended EPSON command set (often referred to as a "letter quality" dot matrix printer). The EPSON LQ-1500 is an example of such a printer.

Query Information:

The general query form, COPY? , returns all links and their currently selected arguments, as follows:

COPY FORMAT: <arg>, PRINTER:<arg>

Error and Warning Conditions:

When a COPY command is attempted and either a printer is not connected to the PRINTER port or the currently connected printer is offline, an execution error (event code 287) is returned and no copy is made.

When multiple COPY [START] commands cause a copy operation to be aborted, an execution warning (event code 557) is reported.

If COPY ABORT is attempted and there is nothing to abort, an execution warning (event code 558) is reported.

DEBUG Command

This command copies input data from the selected interface to the front panel display for program development troubleshooting. The incoming ASCII commands are displayed in the 11401/11402's "Error/Message" area (top two lines of the screen).

With DEBUG ON, artificial delays are inserted in the input stream to prevent commands from rapidly scrolling off the display. This does reduce the GPIB and/or RS-232-C throughput to some degree.

Unprintable input data (e.g., control characters, CR and LF) are displayed in snoopy mode (i.e., two- or three-character mnemonics that represent nonprinting ASCII control characters). A GPIB EOI interface signal is displayed as "<EOI>".

An input message terminator causes the front-panel Error/Message area to be cleared when the next input command is received.

If an error occurs during input, the erroneous item is displayed first, followed by the event code describing that type of error (refer to "Status and Event Reporting" later in this section), in the form:

<EVENT ddd>...

where ddd is the numeric (decimal) event code. Further command input is flushed until a synchronizing delimiter is encountered.

GPIB or RS-232 DCL commands clear the front-panel Error/Message area. A DCL command, itself, is displayed as "<DCL>...".

Binary settings and binary curve data are not displayed when DEBUG mode is enabled. However, ASCII curve data (waveform transmissions) are displayed.

Parameters:

RS232—enables or disables the debug function for this interface.

GPIB—enables or disables the debug function for this interface.

Query Information:

The general query form, DEBUG? , returns all links and their currently selected arguments.

DEBUG GPIB:<arg>,RS232:<arg>

INITialize Side Effects

The INIT command disables both GPIB and RS-232-C debug, assuming either was enabled.

Enhanced Accuracy Commands

These commands initiate the 11401/11402's Enhanced Accuracy feature and report on their various conditions.

Header	Link	Argument	Notes
SELFCAL		FORCE	1
	MODE:	AUTO | MANUAL	
CALSTATUS			2
MCALCONSTANTS	<UI>:	<NRx>	
CCALCONSTANTS	<UI>:	<NRx>	
LCALCONSTANTS	<UI>:	<NRx>	
RCALCONSTANTS	<UI>:	<NRx>	

Notes
1. Set-only argument
2. Query-only link.

SELFCAL Command

Selects the mode of Enhanced Accuracy or forces Enhanced Accuracy to occur.

Parameters:

The FORCE argument causes the 11401/11402 to immediately perform its Enhanced Accuracy procedures. Successful completion of Enhanced Accuracy is signaled via operation complete event 461.

MODE—selects whether Enhanced Accuracy is performed AUTOmatically, when it is due, or upon user initiation with the FORCE argument under the MANUAL mode.

Enhanced Accuracy Sequence of Operations

There are two major levels of accuracy: Enhanced, Not-Enhanced.
The 11401/11402 returns optimal measurements and settings in the enhanced state.

At power-up, checks are made to determine if any resident plug-ins have been installed since the last power up. Also, checks are made to determine if the 11401/11402 nonvolatile RAM contains corrupted digitizer constants. If either condition exists, the 11401/11402 enters the new-configuration state and posts event 466 indicating such. Then, it performs a partial Enhanced Accuracy of all plug-ins and the digitizer, as necessary. Successful completion of this operation generates an operation complete event (code 461).

If partial Enhanced Accuracy isn't required at power-up, then the 11401/11402 enters a 20 minute warm-up state.

After warmup there are several steps that must be executed to take the 11401/ 11402 and its plug-ins to Enhanced Accuracy.

How the 11401/11402 attains the Enhanced Accuracy state is discussed, in detail, in Section 2 "Operating Information" earlier in this manual. However, Figure 3-14 gives a conditional flow diagram of possible Enhanced Accuracy conditions, and the event codes each reports.

Query Information:

The general query form, SELFCAL? , returns the currently selected argument.

SELFCAL MODE:<arg>

Error and Warning Conditions:

An internal error (event code 330) is returned if Enhanced Accuracy is initiated (automatically or manually) and subsequently fails.

An execution error (event code 242) is returned if Enhanced Accuracy is FORCEd before the 20-minute power-up warmup period elapses.

Enhanced Accuracy Side Effects

If Enhanced Accuracy fails and its mode is auto, the 11401/11402 sets Enhanced Accuracy mode to manual. This action prevents the 11401/11402 from perpetually initiating Enhanced Accuracy in a vain attempt to calibrate the instrument to Enhanced Accuracy standards.

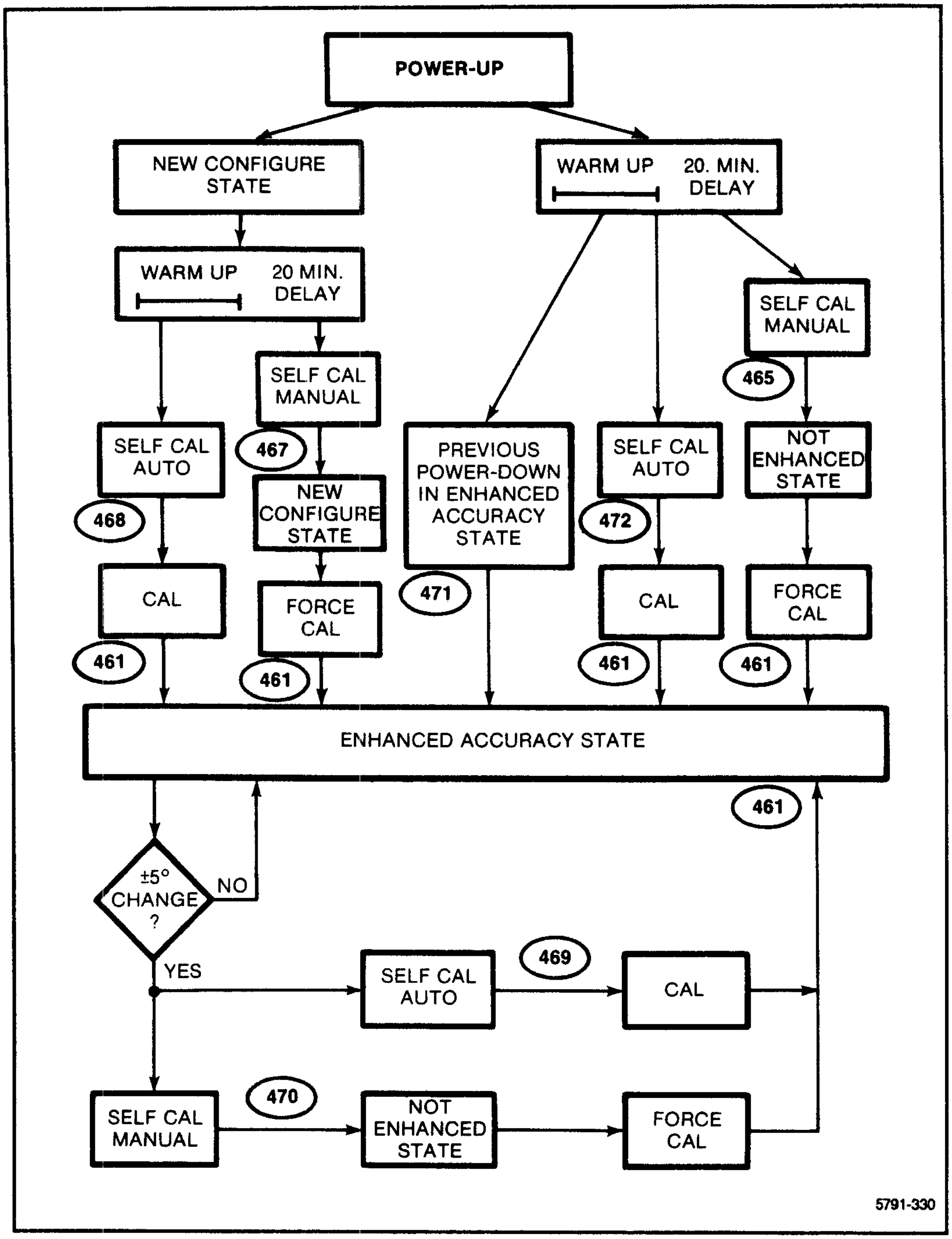

Figure 3-14. Enhanced Accuracy Conditions and Reported Events.

CALSTATUS? Query Command

This query-only command returns the Ehhanced Accuracy status condition of the mainframe and its plug-ins.

The response to the CALSTATUS? query is

CALSTATUS <state>

where <state> ::= ENHANCED | NENHANCED | NEWCONFIG

MCALCONSTANTS Command

This command sets or queries the mainframe Enhanced Accuracy constants.

Parameters:

<ui>—specifies which constant is to be set or queried. The <NRx> argument specifies what value the constant is to be assigned.

Thus, to set the 10th mainframe Enhanced Accuracy constant to 48, the following command would be used:

MCALCONSTANTS 10:48

Usage Notes:

1. Enhanced Accuracy constants may only be set when an internal 11401/11402 hardware strap is enabled by authorized service personnel. However, the constants may be queried regardless of the state of the hardware strap.
2. The valid range of the <ui> link is one to X, where "X" depends upon the current version of installed firmware. Out of range values cause the paired argument value to be ignored, and return an error to the originating port.
3. The valid range of the <NRx> argument is –2 raised to the 31st power (-2^{31}) to 2 raised to the 31st power minus one (2^{31}-1). Out of range values are truncated; no errors are reported.

Query Information:

The general query form, MCALCONSTANTS? , returns the specified mainframe Enhanced Accuracy constants and their current values, in the form:

MCALCONSTANT <ui>:<NR1>[{,<ui>:<NR1>}...]

Error and Warning Conditions:

When the hardware strap is disabled and an attempt is made to set mainframe Enhanced Accuracy constants, an execution error (event code 243) is returned and the set command ignored.

An execution error (event code 205) is reported when <ui> set values are out of range.

CCALCONSTANTS, LCALCONSTANTS, and RCALCONSTANTS Commands

These commands set or query 11000-series plug-inEnhanced Accuracy constants. The CCALCONSTANTS command manipulates the center plug-in constants, while the LCALCONSTANTS and RCALCONSTANTS commands manipulate the left and right plug-in unit constants, respectively.

Parameters: <ui>—specifies which constant is to be set or queried. The <NRx> argument specifies what value the constant is to be assigned.

Usage Notes: Thus, to set the 12th Enhanced Accuracy constant of the center plug-in to 800, the following command would be used:

CCALCONSTANTS 12:800

1. Calibration constants may only be set when an internal 11401/11402 hardware strap is enabled by authorized service personnel. However, the constants may be queried regardless of the state of the hardware strap.
2. The valid range of the <ui> link is plug-in dependent.
3. The valid range of the <NRx> argument is also plug-in dependent.

Query Information: The general query forms, CCALCONSTANTS?, LCALCONSTANTS?, and RCALCONSTANTS?, return all Enhanced Accuracy constants of the specified plug-in, in the forms:

CCALCONSTANTS <ui>:<NR3>[{,<ui>:<NR3>}...]
LCALCONSTANTS <ui>:<NR3>[{,<ui>:<NR3>}...]
RCALCONSTANTS <ui>:<NR3>[{,<ui>:<NR3>}...]

Error and Warning Conditions: When the hardware strap is disabled and an attempt is made to set plug-in Enhanced Accuracy constants, an execution error (event code 243) is returned and the set command is ignored.

An execution error (event code 275) is returned when an attempt is made to query or set the Enhanced Accuracy constants of a plug-in slot that is not loaded with an 11000-series plug-in.

Miscellaneous Commands

This category of commands performs a variety of functions which are helpful to the user.

Header	Link	Argument	Notes
DSYMENU			2
FPANEL		ON | OFF	
ABSTOUCH		{<NRx>,<NRx>} | CLEAR	
INIT			1
LONGFORM		ON | OFF	
DATE		<qstring>	
TIME		<qstring>	
UPTIME			2
POWERON			2
PROBE		NT | NTAUTO | SETSEQ	
SPEAKER		ON | OFF	
DEF		<qstring>,<qstring>	1
UNDEF		<qstring> | ALL	1
FEOI			1
FPUPDATE		ON | OFF | NEVER	
PATH		ON | OFF	

Notes
1. Set-only.
2. Query-only.

DSYMENU? Query Command

This query-only command returns the name of the major menu currently active on the 11401/11402's front panel display.

Possible query responses are shown in Table 3-13.

TABLE 3-13
Displayed Menus

Response	Major Menu Displayed
DSYMENU CURSOR	Cursor
DSYMENU MEAS	Measurements
DSYMENU TRIGGER	Trigger
DSYMENU UTILITY	Utility
DSYMENU STORE_RECALL	Store_Recall
DSYMENU WAVFRM	Waveform
DSYMENU ALL_WAVFRM	Paged Waveform Menu
DSYMENU NONE	Blank Major Menu

The "NONE" response indicates that some major menu's status area is blank. The situation occurs when a major menu button/icon is pushed/selected twice in succession without any other intervening major menu selection.

FPANEL Command

The command FPANEL OFF functionally mimics the GPIB RWLS state and FPANEL ON mimics the GPIB LOCS state.

When FPANEL if OFF, the front panel is said to be locked out and only the RQS icon and the plug-in probe ID buttons are still operable, given they are enabled via their normal operational means (i.e., SRQMASK USER:ON and SRQMASK IDPROBE:ON, respectively).

When FPANEL is ON, all front panel controls are operable, assuming the "TOUCH PANEL ON/OFF" button is "ON".

By default, FPANEL is ON at 11401/11402 power-up.

The FPANEL command is valid for use at both the GPIB and RS-232-C ports.

The FPANEL command has no connection whatsoever with the TOUCH PANEL (ON/OFF) button on the 11401/11402's front panel. The difference between the two is as follows:

- FPANEL provides a mechanism to lock out the 11401/11402 front panel controls (i.e., knobs, buttons, screen touches) from the ASCII interfaces. There is no front panel equivalent of this function.
- The TOUCH PANEL ON/OFF button only locks out front panel screen touches. There is no ASCII command that mimics this function. However, the ABSTOUCH command could be used to "touch" this button from the ASCII interfaces.

Query Information:

The query form, FPANEL? , returns the currently selected argument, in the form:

FPANEL <arg>

ABSTOUCH Command

ABSTOUCH mimics a touch to the 11401/11402's touch panel or front-panel buttons, thus activating it. This command permits the user to access all front panel functions from either the GPIB or RS-232-C interfaces.

ABSTOUCH can not be used to touch a plug-in channel button or a plug-in probe ID button.

The argument denotes the X,Y location of a particular touch-panel cell or front-panel button. Touch panel coordinates are described in Figure 3-15.

The 11401/11402's button coordinates are listed Table 3-14.

TABLE 3-14
Front-Panel Button Coordinates

Button Name	X,Y Coordinates
Waveform	11,0
Trigger	11,1
Measure	11,2
Store/Recall	11,3
Utility	11,4
Touch Panel	11,5
Digitizer Run/Stop	11,6
Autoset	11,7
Hardcopy	11,8
Enhanced Accuracy	11,9

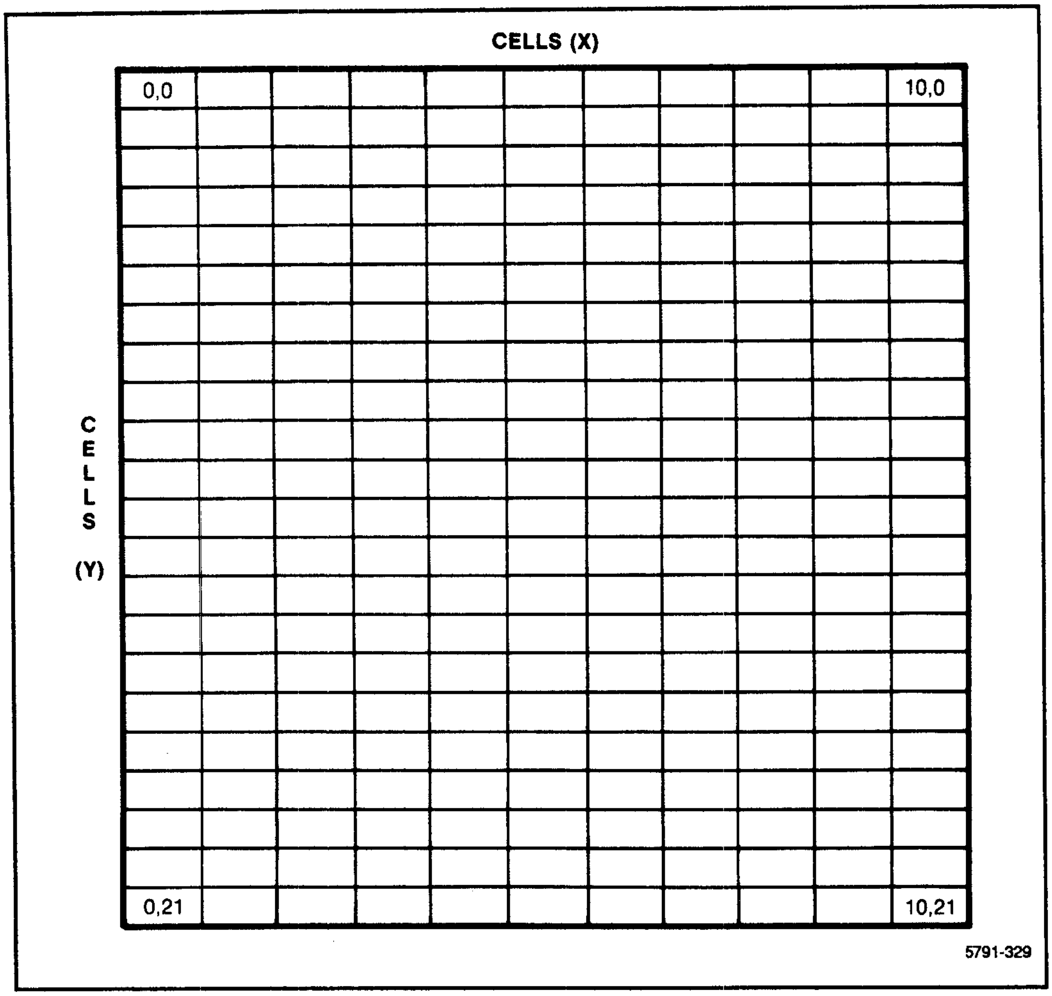

Figure 3-15. Touch-panel coordinates.

Front-Panel Lockout vs ABSTOUCH

ABSTOUCH always works, regardless of whether the FPANEL command is OFF (front-panel lockout), or the TOUCH PANEL button is set to OFF (touch panel disabled).

Query Information:

Whenever a front-panel touch occurs, regardless of whether it originates from the ABSTOUCH command or from an actual front-panel touch, that touch's coordinates are stored in a 20-deep FIFO (First In, First Out) buffer. The contents of the FIFO buffer can be read at any time via the ABSTOUCH? query. The query response is as follows:

ABSTOUCH <NR1>,<NR1>

The first <NR1> value returned by this query represents the x-coordinate of the oldest touch stored in the FIFO buffer. The second <NR1> value represents the y-coordinate of that same touch.

When the FIFO is empty (no touches buffered), ABSTOUCH? returns:

ABSTOUCH -1, -1

When more than 20 touches accumulate, (i.e., the FIFO overflows), the oldest buffered touch is discarded and the newest touch is placed at the end of the FIFO.

ABSTOUCH CLEAR unconditionally empties the FIFO.

Error and Warning Conditions:

An execution error (event code 205) is issued when ABSTOUCH arguments do not fall within the range of the touch panel grid.

Asynchronous Notification

If the ABSTOUCH SRQMASK is ON, every front-panel touch is reported via event code 451.

User-Defined Menus

The TEXT and ABSTOUCH commands can be used to place user-defined menus on the 11401/11402 display. As an example, suppose it was desirable to create a menu in the middle of the graticule area that, when touched by a front-panel operator, caused the selected trace's RMS measurement to be displayed. Assume the desired menu looks like this:

RMS

The following GPIB-specific program creates this menu, waits for a front-panel touch in the menu area, and then displays the RMS measurement:

```
/* Create menu
 * <ESC>  is the ASCII ESC char, decimal 27
 * <DEL>  is the ASCII DEL char, decimal 127
 */
TEXT CLEAR, Y: 9, X: 17, STR: "<ESC>w<ESC>z<ESC>z<ESC>z<ESC>z<ESC>z"
TEXT STR: "<ESC>z<ESC>z<ESC>z<ESC>z<ESC>z<ESC>z<ESC>z<ESC>z<ESC>v"
TEXT Y: 10, X: 17, STR: "<ESC><DEL>", X: 31,STR: "<ESC><DEL>"
TEXT Y: 11, X: 17, STR: "<ESC><DEL>", X: 31,STR: "<ESC><DEL>"
TEXT Y: 12, X: 17, STR: "<ESC><DEL>", X: 31,STR: "<ESC><DEL>"
TEXT STR: "<ESC>w<ESC>z<ESC>z<ESC>z<ESC>z<ESC>z"
TEXT Y: 13, X: 17, STR: "<ESC>x<ESC>z<ESC>z<ESC>z<ESC>z<ESC>z"
TEXT STR: "<ESC>z<ESC>z<ESC>z<ESC>z<ESC>z<ESC>z<ESC>z<ESC>z<ESC>u"
TEXT Y: 11, X: 23, STRING: "RMS"

/* Turn on ABSTOUCH SRQMASK, clear stale front-panel touches */
SRQMASK ABSTOUCH: ON; ABSTOUCH CLEAR
loop:
    wait(gpib srq)
    ABSTOUCH?
    if (abstouch coordinates in RMS menu area) then
      break
end loop
MSLIST RMS; MSYS ON
```

INIT Command

This set-only command initializes the oscilloscope to its factory-assigned default parameters/settings. With respect to the ASCII interfaces, INIT has these effects:

- GPIB and RS-232-C debug are disabled.
- The GPIB and RS-232 USER SRQMASKs are turned OFF. This action removes the RQS icon, assuming it was displayed.
- All pending events, except "Power On" are discarded.
- GPIB RQS is turned ON
- User Text is removed from the front-panel display.

For more details, refer to "Initialize Function" in "Operating Information".

LONGFORM Command

This command has three major functions:

1. LONGFORM enables or disables abbreviated query responses.
   When LONGFORM is ON, all command reserved words are returned in their fully unabbreviated form (refer to Table 3-17 for the abbreviation information). When LONGFORM is OFF, reserved words are returned fully abbreviated.

   As an example, assume the following commands are sent to the 11401/ 11402:

   ENCDG SET:BINARY,WAVFRM:ASCII
   LONGFORM ON; ENCDG?; LONGFORM OFF; ENCDG?

   The query response from this example looks like so:

   ENCDG SET:BINARY,WAVFRM:ASCII;ENC SET:BIN,WAV:ASC

   NOTE

   LONGFORM has no effect upon abbreviated reserved words received at the 11401/ 11402's RS-232-C/GPIB ports. The 11401 always accepts correctly abbreviated reserved words regardless of the state of LONGFORM.

2. LONGFORM controls the response returned by EVENT? query. When LONGFORM is ON, the response to an EVENT? query contains a numeric event code as well as a brief text string explaining the event code. When LONGFORM is OFF, the EVENT? query response is just an event code. Refer to "EVENT? Query Command" earlier in this section for more details.

3. LONGFORM controls the RS-232 VERBOSE response when an error is returned to the RS-232-C port. When LONGFORM is ON, the response contains both a numeric event code and an event description string. When LONGFORM is OFF, the response is simply an event code.

By default, both the RS-232-C and the GPIB have LONGFORM enabled at 11401/ 11402 power-up.

Query Information:

LONGFORM? returns the currently selected argument, in the form:

LONGFORM <arg>

DATE Command

Sets the date on the 11401/11402's internal calendar. Within the quoted string argument, proper date syntax is

"<DD>-<MON>-<YY>",

where:

<DD>	::=	day of the month
<MON>	::=	first three letters of the month
<YY>	::=	last two digits of the year

Query Information: DATE? returns the calendar's date day, month, and year, in the form:

DATE <qstring>

Error and Warning Conditions: An execution error (event code 265) is returned if an illegal date value is specified or if the specified syntax is incorrect.

TIME Command

Sets the time-of-day on the 11401/11402's clock. Within the quoted string argument, proper time syntax is

"<HH>:<MM>:<SS>",

where:

<HH>	::=	hours in 24-hour format
<MM>	::=	minutes of the hour
<SS>	::=	seconds of the minute

Query Information: TIME? returns the clock's time in hours, minutes, and seconds, in the form:

TIME <qstring>

Error and Warning Conditions: An execution error (event code 265) is returned if an illegal time value is specified or if the specified syntax is incorrect.

UPTIME? Query Command

This query-only command returns the total number of hours the 11401/11402 has been powered-up.

The query response is

UPTIME <NR3>

POWERON? Query Command

This query returns the total number of times the 11401/11402 has been powered up.

The query response is

POWERON <NR1>

PROBE Command

PROBE selects the function to be performed when an 11000-series plug-in probe ID button is pressed.

The NT argument indicates that a New Trace is to be created or an existing trace is to be selected when a probe ID button is pressed. This means that when no displayed trace description contains the plug-in channel of the pressed probe ID, a new trace is created that contains only the channel of the pressed probe ID. Otherwise, the 11401/11402 will select the next trace containing the pressed probe ID channel.

The NTAUTO argument operates the same as NT, except that trace creation occurs via AUTOSET.

The SETSEQ argument indicates that a button press causes the next set of stored front panel settings to be recalled from memory. Repeated button presses cause the 11401/11402 to cyclically recall all stored settings.

Probe ID Button Press Events

A system event (event code 457) is reported to the GPIB and RS-232-C interfaces for every probe ID button press with the IDPROBE SRQMASK:ON. The description string of this event contains the name of the specific plug-in slot and probe ID pressed. Therefore, if the user wishes to know which probe ID button was pressed, he must have the LONGFORM command "ON" so that the response to EVENT? also contains the description string (refer to "LONGFORM and EVENT? Commands" earlier in this section).

The Effects of Front-Panel Lockout

When the 11401/11402's front-panel controls are locked out via the FPANEL command, a probe ID button loses its NT, NTAUTO, or SETSEQ functionality.

However, even when the front panel is locked out, a system event (event 457) is still reported to the RS-232-C/GPIB ports when the IDPROBE SRQMASK is enabled. This feature permits an RS-232-C/GPIB programmer to negate the functionality of a probe ID button press and still retain the capacity to determine when a human operator presses a probe button.

Side Effects

If PROBE is assigned to SETSEQ and all front panel settings are subsequently deleted, PROBE is reassigned to NT.

When PROBE is assigned to SETSEQ, the SETSEQ function (refer to "SETSEQ Command" earlier in this section) is set to "ON", if it isn't already.

Query Information:

PROBE? returns the currently selected argument in the form:

PROBE <arg>

Error and Warning Conditions:

An execution error (event code 247) is returned if an attempt is made to assign probes to SETSEQ and no settings are defined.

SPEAKER Command

Enables or disables the 11401/11402's audio response.

Query Information:

SPEAKER? returns the currently selected argument, in the form:

SPEAKER <arg>

DEF Command

DEF provides a mechanism that permits one string to be substituted for another (i.e., to define a new word for the 11401/11402's vocabulary). DEF's first argument (a quoted string) is referred to as a "logical name". DEF's second argument (also a quoted string) is called an "expansion string".

Whenever the 11401/11402 encounters a user-defined logical name (sans quotes) within some input command, the logical name is replaced by its expansion string and the input command is reparsed from the point at which string replacement occurred.

As an example, suppose we wished to create a new query that returned all possible information about the main and window time bases. Let's say that we wanted to call this query "TBASE?". To create TBASE? using DEF, we would use the following command:

```
DEF "TBASE?","TBMAIN?;TBWIN?"
```

To use this new query, simply send the following command to the 11401/11402:

```
TBASE?
```

When TBASE? next appears in the 11401/11402's input buffer, it will be replaced with the string TBMAIN?;TBWIN?, which will then be parsed as two queries in the 11401/11402's repertoire of standard commands.

Besides synthesizing new commands, DEF can be used to:

- Alter the 11401/11402's GPIB/RS-232-C reserved words to suit the preferences of an individual user. For example, suppose you don't like the syntax of the ID? query and would prefer to use FIRMWARE? instead. To effect such a change, simply use this logical name:

  ```
  DEF "FIRMWARE?","ID?"
  ```

- Substitute a short, user-defined string for a very long sequence of concatenated commands. The short string minimizes the overhead that occurs when sending a long string of commands over the 11401/11402's I/O buses and also minimizes the tedium and errors associated with repeatedly typing long commands.

DEF Usage:

- Quoted string input is exempt from logical name substitution.
- The first character of a logical name must be alphabetic. There are no other restrictions placed on logical names.

- An expansion string may not be null (e.g., ""). Also, the first character of an expansion string can not be any one of these:

carriage return	(Octal 15)
colon	(:)
comma	(,)
linefeed	(Octal 12)
semicolon	(;)
space	(Octal 40)

  Otherwise, there are no other restrictions placed on expansion strings.

- Logical name recognition is caseless. As an example, suppose a logical name is defined like so:

  DEF "Xy","rs232?;tbmain?"

Given this logical name, the 11401/11402 will recognize XY, xy, and xY as being equivalent to the original "Xy" logical name definition.

- Recursive DEF logical names are acceptable only when recursion occurs to right of an unquoted semicolon. All other recursive definitions are illegal. Here are examples that demonstrate this restriction.

Acceptable Recursion	Unacceptable Recursion
DEF "z","tbmain?;z" DEF "j","abstouch 3,10;j"	DEF "z","z?" DEF "j","text j"

  Of course, recognition of a valid recursive logical name does cause the 11401/11402 to enter an infinite command processing loop. This means that once a recursive logical name is transmitted to the 11401/11402, the 11401/11402 will no longer respond to command input until a DCL signal is sent to the port that received the recursive logical name.

- The logical names and expansion strings created with the DEF command are not stored in nonvolatile RAM. Therefore, when the 11401/11402 is turned off, or when diagnostics are executed via the TEST command, all user-defined logical names and expansion strings are lost.

DEF Examples:

- DEF "SL1:4?","CHL1? SENS;CHL2? SENS;CHL3? SENS; CHL4? SENS"

  This DEF equates "SL1:4?" with an expansion string that causes the 11401/11402 to return the sensitivity settings of channels one through four of the Left plug-in.

- DEF "Init 2 Traces","REMOVE ALL;TRA1 DES:'L1'; TRA2 DES:'L2'"

  This DEF equates "Init 2 Traces" with a series of commands that causes the 11401/11402 to remove all currently displayed traces and then display traces derived from the first two channels of the left plug-in unit.

- DEF "A","AUTOSET"

  This DEF simply shortens the AUTOSET reserved word to a single letter. Given this DEF, it is now possible to autoset input signals via this simple command:

  A START

DEF Hints:

- Avoid redefining the single characters R, L, and C. These characters represent plug-in slots in the 11401/11402's CH command. Once R, L, or C are redefined, they lose their significance as slot designators and the CH<slot><ui> commands always return a syntax error.

- Be careful when redefining any of the reserved words listed in Table 3-17 (Reserved Words). When reserved words are replaced with user-defined logical names, they lose their significance as command verbs. However, if there are certain reserved words that you have no intention of using, then no harm is done by substituting your definitions for those reserved words.

Predefined Logical Names

Each time the 11401/11402 powers-up, several useful logical names are automatically created and placed in it's definition tables (refer to Table 3-15).

TABLE 3-15
Predefined Logical Names

Logical Name	Expansion String	Effect
e	RS232 ECHO:ON	enables RS-232-C echo
v	RS232 VERBOSE:ON	enables RS-232-C verbose mode

Error and Warning Conditions:

An execution error (event code 267) is returned if either the logical name or expansion string are not legally defined (e.g., logical name does not begin with an alphabetic character).

An execution error (event code 268) is returned if unacceptable DEF recursion is detected.

An execution error (event code 266) is returned if an expansion string overflows the 11401/11402's internal expansion buffer. (It takes quite a bit of work to cause this buffer to overflow. Basically, the only way to do it is to chain logical names from "right to left" without using recursion.)

UNDEF Command

UNDEF removes a single logical name from the 11401/11402's list of logical names or removes ALL previously defined logical names.

The <qstring> argument removes a single logical name.

As an example, suppose a logical name is defined with the following command:

```
DEF "INFO?","TIME?;DATE?;UPTIME?;POWERON?;UID?;CONFIG?"
```

Now, to remove INFO? from the list of defined logical names, use this command:

```
UNDEF "INFO?"
```

The ALL argument removes all previously defined logical names. No error is reported (and no action is taken) if the ALL argument is specified when no logical names are defined.

Error and Warning Conditions:

An execution error (event code 271) is returned if UNDEF's quoted string argument is not defined in the 11401/11402's current list of logical names.

FEOI Command

This set-only command forces the 11401/11402 to output the <EOI> delimiter for any pending query response. If there are no pending queries, no action is taken and no error is reported. FEOI can be used to force an <EOI> delimiter into a recursive query or to artificially separate a string of queries that have been joined with semicolons.

As an example, suppose a recursive logical name has been created that causes the 11401/11402 to continuously output a MAX measurement. If it is desirable to terminate each MAX? with <EOI>, the following logical name could be used for that purpose:

```
DEF "RMAX","MAX?;FEOI;RMAX"
```

FPUPDATE Command

FPUPDATE permits a GPIB/RS-232-C user to control when front-panel display readouts are updated following set command execution.

When FPUPDATE is ON, the front-panel display is updated after successful completion of each set command. FPUPDATE ON is better thought of as FPUPDATE "always". However, the necessity of maintaining backward compatibility with older versions of 11401/11402 firmware precludes changing ON to ALWAYS.

When FPUPDATE is OFF, the front-panel display is updated only under the following circumstances:

- DCL or SDC is received at the 11401/11402's ASCII ports, or
- a syntactically or semantically incorrect query/set command is received at the 11401/11402's ASCII ports, or
- a set or query command is successfully executed and the 11401/11402 input buffer from which the command was read is empty.

FPUPDATE OFF is better thought of as FPUPDATE "on empty input buffer." However, the necessity of maintaining backward compatibility with older versions of the 11401/11402 firmware precludes changing OFF to EMPTY.

With the exception of data written to the display via the DEBUG and TEXT commands, FPUPDATE NEVER suppresses all front-panel updates under all circumstances. Furthermore, in the NEVER state, axis labels are removed and the Blank major menu is displayed. These two actions prevent as much "stale" data as possible from being displayed on the frontpanel. But do note that knob readouts are not removed and any ensuing changes to instrument parameters are not reflected in the knob readouts. In the NEVER state, be aware that instrument operation is quite confusing for front-panel operators. Knobs are still functional, but their knob readouts are not. Major menus may be selected with the major menu buttons, but the new selection is not shown. The keypad popup menu may be selected, but data entered is not echoed on the display. Knob assignments may be changed via icon selections, but no change in knob readout occurs. Refer to "FPUPDATE Usage" that follows.

FPUPDATE Usage

If the maximum command through put is of paramount importance, then set FPUP-DATE to NEVER. In this mode, 11401/11402 processing resources are not used to update the front-panel display and RS-232-C/GPIB set commands are executed with maximum efficiency. Do note, however, that when a controller puts the 11401/11402 inthe FPUPDATE NEVER stat front-panel controls become essentially useless and their functionality can only be regained by cycling instrument power or changing FPUPDATE t o ON/OFF. WhenFPUPDATE transitions from NEVER to ON or OFF, axis labels are restore front-panel display is updated to reflect current instrument conditions. RS-232-C/GPIB programmers who choose to operate in FPUPDATE NEVER mode will be wise to terminate their applications with an FPUPDATE ON or OFF command.

If command throughput efficiency and concurrent front-panel updates are required, turn FPUPDATE OFF. In this mode, display readouts are updated to match current instrument conditions only when the 11401/11402 has no more input data to process.

If an application requires that 11401/11402's display readouts exactly match each set command sent to the instrument, then turn FPUPDATE ON. As an example, it makes sense to turn FPUPDATE ON prior to executing a recursive logical name that repeti tively sets the 11401/11402 parameters. If FPUPDATE was set OFF prior to placing the 11401/11402 in this type of command processing loop, then the 11401/11402's display readouts would not be updated until the recursive loop was halted via DCL.

Unlike FPUPDATE NEVER, all front-panel controls remain fully functional when FPUPDATE is ON or OFF.

By default, FPUPDATE is OFF at power-up.

Side Effects

In the NEVER state, take note that:

- Setting MSYS ON is pointless, since the measure major menu is not displayed.
- Setting CURSOR READOUT ON displays front-panel cursors, but not their front-panel readouts.

Query Information:

FPUPDATE? returns the currently selected argument, in the form:

FPUPDATE <arg>

Path Command

PATH provides a mechanism to remove the headers and links that are normally returned in an 11401/11402 query response. The following demonstrates example PATH usage:

PATH	QUERY	RESPONSE
ON	MAX?	MAX <NR3>, <qual>
OFF	MAX?	<NR3>, <QUAL>
ON	CHL3? OFFSET	CHL3 OFFSET: <NR3>
OFF	CHL3? OFFSET	<NR3>
ON	FPUPDATE?	FPUPDATE <arg>
OFF	FPUPDATE?	<arg>
ON	AUTOSET?	AUTOSET HORIZ: <arg>, VERT: <arg>
OFF	AUTOSET?	<arg>, <arg>

By default, PATH is ON at power-up.

Special PATH Considerations And Exceptions

- PATH does not affect an ASCII or BINARY SET? query response. Headers and links are returned regardless of PATH's value.
- PATH has no effect on the 11401/11402's response at the RS-232-C port when VERBOSE is ON.
- When PATH is OFF, only the headers of the DIAG? and FPSLIST? queries are removed. Links are always returned for these queries.
- The query data returned when PATH is OFF is not suitable as the 11401/11402 command input and will generate error(s) when returned to the instrument. Therefore, if a query response is to be returned to 11401/11402, ensure that PATH is ON prior to querying the instrument (this requirement does not apply to SET? query).

Query Information:

PATH? returns the currently selected argument, in the form:

PATH <arg>

Diagnostic Commands

Diagnostic commands invoke self-test or extended-test diagnostics.

Header	Link	Argument	Notes
TEST		[XTND]	1
DIAG			2

Notes
1. Set-only.
2. Query-only.

TEST Command

TEST invokes self-test or extended-test diagnostic tests. TEST without arguments initiates self-test diagnostics. TEST with argument XTND initiates extended-test diagnostics.

When the 11401/11402 receives the TEST command, the instrument goes through a pseudo power-down sequence, performs the diagnostic testing requested, and then performs a pseudo power-up sequence, regardless of whether errors were found or not. Completion of diagnostic testing is signaled via return of one of the following two events to the GPIB and RS-232-C ports:

Event Code	Explanation
460	Self- or extended-test diagnostics were completed successfully.
394	Self- or extended-test diagnostics were completed and failed.

In the event that diagnostics fail, a GPIB/RS-232-C controller may obtain specific failure information via the DIAG? query.

Testing for Diagnostics Completion at the GPIB Port

If RQS is ON when TEST is executed, the 11401/11402 signals diagnostics completion by asserting SRQ and reporting either event 394 or 460. Thus, the simplest method available to monitor completion of TEST consists of:

1. Turn RQS ON (assuming it's not already).

2. Execute TEST [XTND].

3. Wait for an SRQ interrupt.

If waiting for an interrupt is not possible (due to GPIB controller limitations) or desirable, another monitoring method is available that works regardless of whether RQS is ON or OFF. This method relies upon the fact that the 11401/11402's GPIB serial poll register may be read even when the instrument is pseudo powered down.

During diagnostics testing, the 11401/11402 sets the busy bit (DIO5) of the serial poll register. When diagnostic testing is complete, the busy bit is reset. Thus, a continuous serial poll can be used to monitor diagnostics completion.

Testing for Diagnostics Completion at the RS-232-C Port

At the RS-232-C port, there is no SRQ signal line and thus, SRQ is not asserted when diagnostics are complete. However, there are two methods to check for completion of diagnostics.

The first method relies upon the RS-232 VERBOSE feature (see the RS-232-C command). When VERBOSE is ON, the 11401/11402 handshakes every command sent to its RS-232-C port and also asynchronously reports when instrument power-up of any type has occurred. The asynchronous message reported at power-up depends upon whether LONGFORM is ON or OFF (see the LONGFORM command). The message reported looks like this:

EVENT <NR1>[,<qstring>]<EOI>

The <NR1> value represents a power up event code, which is either 460 or 394, following execution of TEST. The optional <qstring>, which is only returned when LONGFORM is ON, describes the power up event. A user need only perform a "read" of the RS-232-C interface to get this message.

The second, less reliable, method is to simply enter a "busy wait" loop (or "sleep", if your controller has such a feature) following the transmission of the TEST command to the 11401/11402. The busy wait must consume enough time such that when the loop exits, the 11401/11402 is powered back up and ready to receive new commands. Note that RS-232 VERBOSE is initially set to OFF, if this method is used.

Side Effects

TEST destroys all stored waveforms and all logical names and expansion strings (see DEF command). TEST also resets the TEXT X and Y coordinates to zero and removes all user TEXT from the front-panel display. All other instrument settings are restored from nonvolatile RAM following execution of TEST.

Error and Warning Conditions:

Since TEST causes a pseudo power-down that destroys the contents of the 11401/11402's I/O buffers, attempting to append a set or query command to TEST is futile and causes the 11401/11402 to report a command error (event code 157). In this situation, TEST is ignored, but all commands appended to TEST are processed normally. The following text demonstrates the proper syntax for concatenating commands with the TEST command:

Acceptable TEST Usage	Unacceptable TEST Usage
[{<cmd>;}...]TEST [XTND]	[{<cmd>;}...]TEST [XTND];<cmd>

DIAG? Query Command

This query returns pass/fail information from the most recent invocation of Self- or Extended-Test diagnostics.

It should be noted that unless diagnostics are bypassed via hardware straps, the 11401/11402 always performs Self-Test when its power switch is turned on. Thus, following instrument energization and before TEST [XTND] is ever invoked, DIAG? returns pass/fail information pertaining to instrument energization diagnostics.

Query Response When Diagnostics Pass

When self- or extended-test diagnostics passes, the DIAG? response depends upon whether or not missing (optional) hardware made it impossible to perform a complete set of tests. The format of the DIAG? response is

DIAG PASSED:"<omitted>"

where <omitted> ::= NONE | <omitted_test>[{,<omitted_test>}...]

NONE means that no tests were omitted. Otherwise, a comma-delimited list of omitted tests is returned by DIAG?.

Query Response When Diagnostics Fail

When Self- or Extended-Test Diagnostics fails, the DIAG? response is

DIAG FAILED:"<failed>"

where <failed> ::={<failed_test> | <omitted_test>}[{,<failed>}...]

Query Response When Diagnostics are Bypassed

If Self-Test is bypassed at the time that the 11401/11402's power switch is turned on, the instrument energization DIAG? response is

DIAG BYPASSED

Abbreviating Reserved Words

When transmitting a reserved word to the 11401/11402's ASCII ports, the first three letters of each reserved word must generally be specified before the reserved word can be recognized. In the few cases where two reserved words begin with the same letters, more than three letters may be required to distinguish between them.

Any leading substring of the full reserved word will be accepted as input, so long as the minimum string is given.

Examples:

What follows is a table of valid commands that are shown with and without reserved word abbreviations. The left side of the table specifies a command in which no is abbreviation occurs. The right side of the table specifies the same command in its most abbreviated form.

TABLE 3-16
Command Abbreviation Comparison

Nonabbreviated Command	Fully Abbreviated Command
TRACE1 DESCRIPTION:"L1"	TRA1 DES:"L1"
DIGITIZER STOP	DIG STOP
TBMAIN? LENGTH	TBM? LEN
BASELINE?;TOPLINE?;DISTAL?	BAS?;TOP?;DIST?
DISPLAY MODE:VECTORS	DISP MOD:VEC
TRMAIN TIHOLDOFF:1e-2;TRMAIN?	TRM TIH:1e-2;TRM?

TABLE 3-17
Reserved Words and Abbreviations

ABBwfmpre	CURSor	FPSNum	MINUs
ABOrt	CURVe	FPUpdate	MNScoupling
ABStouch		FREquency	MNSOffset
AC	DAInt		MNSProbe
ACCumulate	DATE	GPIb	MODe
ACHf	DC	GRAticule	MSB
ACLf	DCHf	GRLocation	MSLIst
ACNoise	DCNoise	GRType	MSLOpe
ACState	DEBug	GT	MSNum
ADJtrace	DEF		MTRack
ALEvel	DELAy	H1Bar	MSYs
ALL	DELete	H2Bar	
ALL_Wavfrm	DEScription	HARd	NAVg
AMPoffset	DIAg	HBArs	NENV
AMPS	DIGitizer	HIPrec	NENHanced
ANLevel	DISPlay	HIRes	NEVer
ASCii	DISTal	HMAg	NEWconfig
AUTO	DIVS	HORiz	NLEvel
AUTOLevel	DLYtrace	HPOsition	NONe
AUTOSet	DOT1Abs	HVPosition	NORmal
AVG	DOT2Abs	HVSize	NOTrg
	DOT1Rel		NR.pt
BASeline	DOT2Rel	ID	NT
BAUd	DOTs	IDProbe	NTAuto
BINary	DRAft	IMPedance	NUL1
BIT/nr	DSYmenu	INErr	NVRam
BN.fmt	DUAL	INIt	
BOTh		INPut	ODD
BW	ECHo	INTensity	OFF
BWHi	ECL	INWarn	OFFSet
BWLo	EMPty		OHMs
BYPassed	ENCdg	LCAlconstants	ON
BYT.or	ENHanced	LEFt	OPCmpl
BYT/nr	ENV	LENgth	OPTional
	EOL	LEVel	OUTput
CCAlconstants	EQ	LF	
CALDue	EVEN	LFCr	PAIred
CALStatus	EVENT	LINear	PANzoom
CENter	EVHoldoff	LMZone	PARity
CH	EXErr	LONgform	PASsed
CHKsm0	EXWarn	LOWer	PATh
CLEar		LSB	PCTg
CMDerr	FAIled	LT	PDElay
COMpare	FALltime		PERiod
CONDacq	FASt	MAIn	PIN8
CONFig	FEOi	MAINPos	PIN24
CONTInuous	FIL1	MANual	PIVersion
COPy	FLAgging	MAX	PLSCoupling
COUpling	FORMat	MCAlconstants	PLSOffset
CR	FORce	MEAN	PLSProbe
CRLf	FPAnel	MEAS	PLUs
CROss	FPNext	MESial	POWeron
CRVchk	FPS	MID	PP
CURRent	FPSList	MIN	PRInter

TABLE 3-17 (cont)
Reserved Words and Abbreviations

PROBe	SNRatio	TRSep	WFId
PROTect	SOFt	TRWin	WFMpre
PROXimal	SOUrce	TTAverage	WFMCalc
PT.fmt	SPEaker	TTL	WFMScaling
	SPLit	TTRig	WHOle
RCAlconstants	SRQMask	TYPe	WIDth
READout	STARt		WIN1Pos
RECall	STAtus	UID	WIN2Pos
REDuced	STByte	UN	WTMode
REFErence	STO	UNDEF	
REFLevel	STOList	UNDO	X
REFset	STONum	UNIts	XCOord
REMAining	STOP	UPPer	XDIv
REMove	STOPBits	UPTime	XINcr
RI	STORe	USEr	XMUlt
RIGht	STORE_Recall	UTIlity	XQUal
RISetime	STRing		XTNd
RMS		V1Bar	XUNit
RMZone	TBMain	V2Bar	XY
RQS	TBWin	VBArs	XZEro
RS232	TESt	VC	
RUN	TEXt	VCOffset	Y
	TIHoldoff	VECtors	YCOrd
SEConds	TIMe	VERBose	YDIv
SELect	TOPline	VERt	YMUlt
SELFcal	TR	VOLts	YQUal
SENsitivity	TRAce	VPOsition	YTMns_area
SET	TRANUm	VSIze	YTP1s_area
SETSeq	TRG		YTEnergy
SINgle	TRIgger	WATts	YUNit
SLOpe	TRMain	WAVfrm	YZEro

11401/11402 Character Set

ASCII Character Set

The character set shown in the following table is the 11401/11402's ASCII character set, which comprises the set of nonescaped characters that may be displayed on the 11401/11402's front-panel display.

TABLE 3-18
ASCII Character Set

	0	1	2	3	4	5	6	7
0	0 NU	16 DL	32	48 0	64 @	80 P	96 `	112 p
1	1 SH	17 D1	33 !	49 1	65 A	81 Q	97 a	113 q
2	2 SX	18 D2	34 "	50 2	66 B	82 R	98 b	114 r
3	3 EX	19 D3	35 #	51 3	67 C	83 S	99 c	115 s
4	4 ET	20 D4	36 $	52 4	68 D	84 T	100 d	116 t
5	5 EQ	21 NK	37 %	53 5	69 E	85 U	101 e	117 u
6	6 AK	22 SY	38 &	54 6	70 F	86 V	102 f	118 v
7	7 BL	23 EB	39 '	55 7	71 G	87 W	103 g	119 w
8	8 BS	24 CN	40 (	56 8	72 H	88 X	104 h	120 x
9	9 HT	25 EM	41)	57 9	73 I	89 Y	105 i	121 y
A	10 LF	26 SB	42 *	58 :	74 J	90 Z	106 j	122 z
B	11 VT	27 EC	43 +	59 ;	75 K	91 [	107 k	123 {
C	12 FF	28 FS	44 ,	60 <	76 L	92 \	108 l	124 |
D	13 CR	29 GS	45 -	61 =	77 M	93]	109 m	125 }
E	14 SO	30 RS	46 .	62 >	78 N	94 ^	110 n	126 ~
F	15 SI	31 US	47 /	63 ?	79 O	95 _	111 o	127 [illegible]

Escaped Character Set

The character set shown in the following table is the 11401/11402's escaped character set. Escaped characters are formed by concatenating an ASCII escape character (decimal 27) with some other ASCII character, as shown in the tables in this section. As an example, if we permit "<ESC>" to represent an escape character, then the following 11401/11402 GPIB/RS-232-C command will place an integral math symbol on the 11401/11402's display:

TEXT STRING:"<ESC>d"

TABLE 3-19
Escaped Character Set

	0	1	2	3	4	5	6	7
0	0 Ä	16 Ñ	32 Norm Inten	48	64 Π	80 π	96 ↓	112 …
1	1 ä	17 ñ	33 Bright	49	65 α	81 θ	97 ↑	113 Ä
2	2 Ö	18 ¿	34 Dim	50	66 γ	82 ρ	98 →	114
3	3 ö	19 ¡	35	51	67 δ	83 Σ	99 ←	115
4	4 Ü	20 Ã	36	52	68 Δ	84 τ	100 ∫	116
5	5 ü	21 ã	37	53	69 ε	85 υ	101 ÷	117
6	6 à	22 À	38	54	70 φ	86 ν	102 •	118
7	7 è	23 Õ	39	55	71 Γ	87 ω	103 √	119
8	8 á	24 õ	40	56	72 Θ	88 χ	104 ¬	120
9	9 é	25 É	41	57	73 ι	89 ξ	105 ±	121
A	10 Å	26 Ø	42	58	74 ψ	90 ζ	106 ≠	122
B	11 å	27 ø	43	59	75 κ	91 Φ	107 ≤	123
C	12 Æ	28 Œ	44	60	76 λ	92 Λ	108 ≥	124
D	13 æ	29 œ	45	61	77 μ	93 Ψ	109 ©	125
E	14 ç	30 Ç	46	62	78 η	94 σ	110 ®	126
F	15 ß	31 ∞	47	63	79 Ω	95 Ξ	111 ≈	127

Status and Event Reporting

The following information describes the status and event reporting systems for both the GPIB and RS-232-C ports. The 11401/11402 implements both a status and an event reporting system for the GPIB. The first system is the Service Request (SRQ) function defined by IEEE-488, which provides a mechanism for reporting a single byte of general status information. A second system, defined by Tektronix GPIB Codes, Formats, Conventions and Features Standard, is the EVENT? query. This query provides more detailed information about the instrument's status, that is, the event that has occurred.

Similar status and event reporting systems exist for RS-232-C controllers and devices.

Figure 3-16 functionally describes the 11401/11402's ASCII status reporting system and summarizes its major elements. These elements will be discussed in the following text.

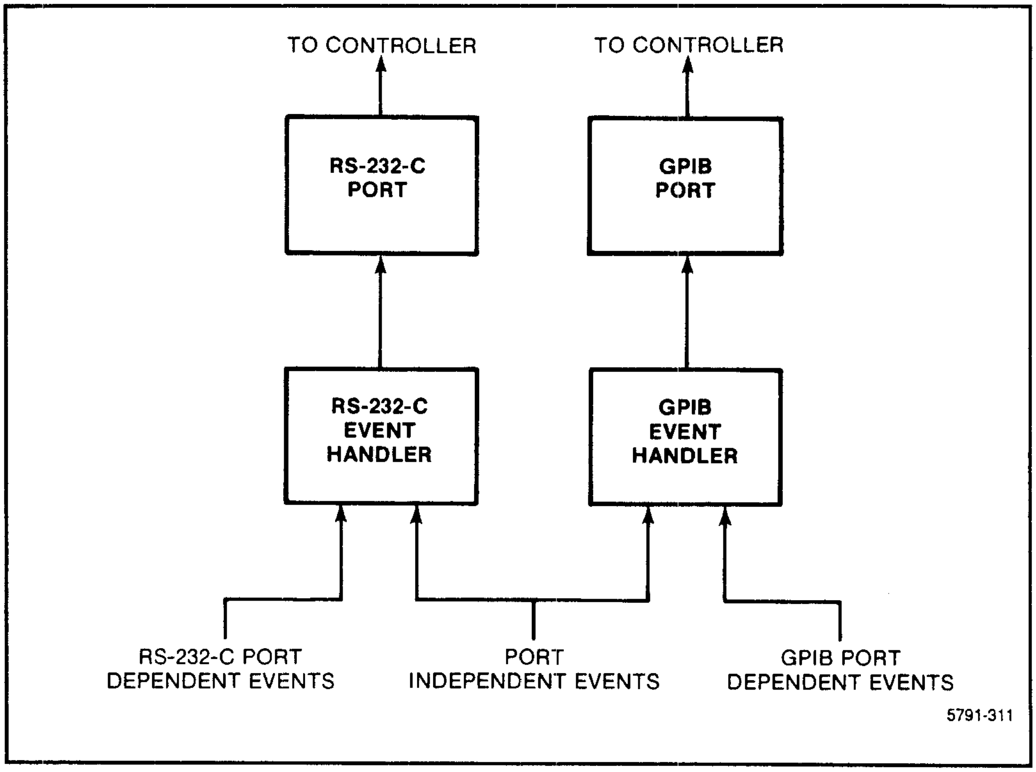

Figure 3-16. ASCII status reporting system block diagram.

Service Request Concepts

The IEEE-488 Service Request function (SRQ) permits a device to asynchronously request service from a GPIB controller whenever the device detects some noteworthy "event". A GPIB controller services the request by serial polling each active device on the bus. A device responds to the serial poll by placing an 8-bit status byte on the bus. The controller determines which device asserted SRQ by serially reading each devices status byte and examining bit 7 (see Fig. 3-17). If a particular device has requested service, bit 7 of its status byte is set. Otherwise, bit 7 is clear (see Fig. 3-18 and Table 3-20).

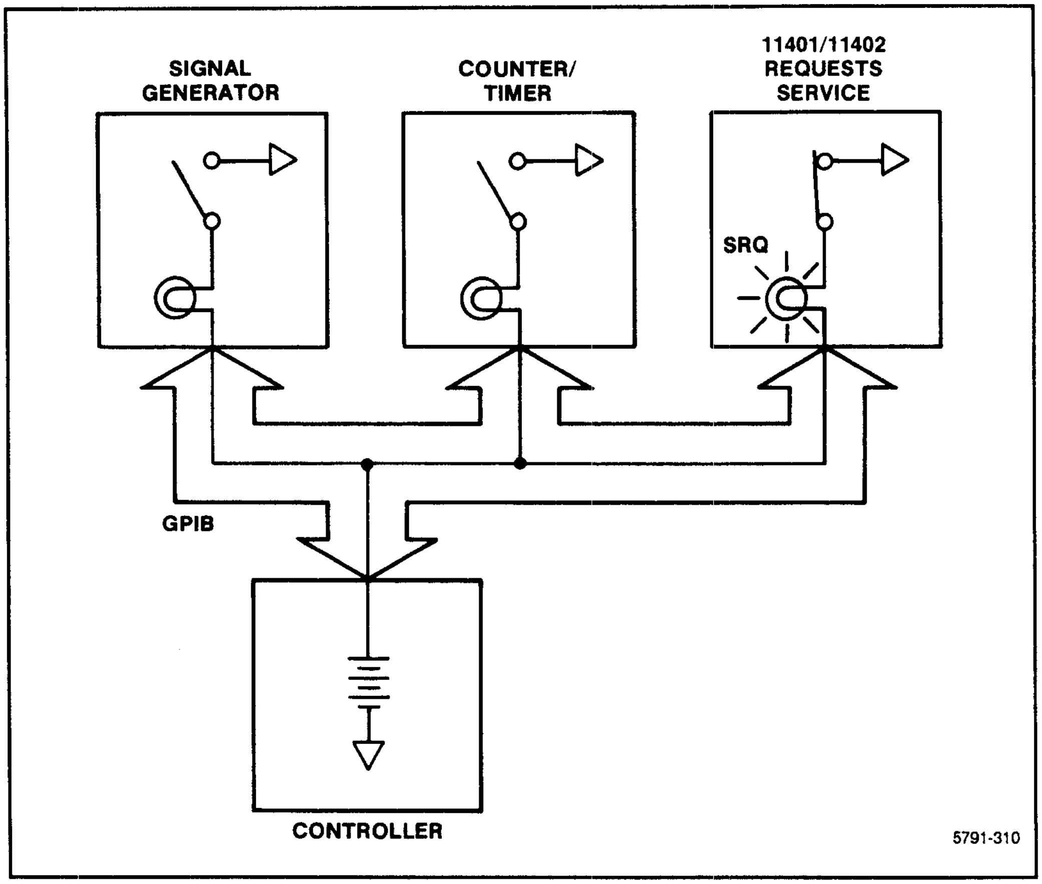

Figure 3-17. A controller can recognize an 11401/11402 service request.

Only broad, general information is returned in an 11401/11402 status byte. The 11401/11402 does, however, maintain an event code for each status byte read by a controller. This code provides detailed information about the event that originally caused service to be requested.

As an example, the 11401/11402 has a single status byte for command errors. Yet, for this same status byte, there is a long list of event codes that describe command errors ranging from "syntax error" to "checksum error" to "invalid string input."

A controller always has the option of reading or ignoring a status byte's corresponding event code. The event code reporting system will be discussed in detail following the discussion of the status byte reporting system.

As will be shown later, the 11401/11402 provides a similar mechanism whereby an RS-232-C controller or device may also read status bytes and event codes.

Status Byte Definition

The following figure shows the significance of the individual bits in an 11401/ 11402 status byte.

DIO BIT #	8	7	6	5	4	3	2	1
BIT VALUE	Ø	R	E	B	S	S	S	S

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Figure 3-18. Status byte definition.

In the preceding figure, bit 8 is the most significant bit of the status byte, and DIO is an IEEE-488 abbreviation for "Data Input Output."

Moving from left to right, notice that DIO8 is always unasserted (i.e., bit DIO8 is always 0). DIO7 is the RQS (request service) bit (R). As previously explained, this bit is set when the 11401/11402 requests service. DIO6 (E) is the error bit (E) and is asserted when an internal or external error condition generates an event. DIO5 (B) is the busy bit and is asserted only when the 11401/11402's diagnostics are in progress (refer to the Diagnostics commands for details). DIO4 through DIO1 are system status bits (S). The state of these four bits vary with the type of event that the 11401/11402 reports.

System Status Conditions

Taken as a whole, the numerical value of bits DIO1-DIO8 signal a unique system status condition. System status conditions are divided into two categories, abnormal (DIO6 set) and normal (DIO6 clear).

There are five abnormal conditions defined:

1. **Command Error**—reported when a message cannot be parsed or lexically analyzed.

2. **Execution Error**—reported when a message is parsed but cannot be executed.

3. **Internal Error**—reported when the 11401/11402 or one of its plug-in units malfunctions.

4. **Execution Warning**—reported when the 11401/11402 is operating, but the user should be aware of potential problems.

5. **Internal Warning**—reported when the 11401/11402 indicates that a problem has been detected. The instrument remains operational, but the problem should be corrected.

There are also five normal conditions defined:

1. **No Status To Report**—reported when there is no event or device dependent status to report.

2. **Power On**—reported when the 11401/11402 has finished its power on sequence. This action lets the controller know that the 11401/11402 just came to life.

3. **Operation Complete**—tells the controller that a time-consuming task has been completed.

4. **User Request**—reported when one of the following three front-panel actions is performed by the 11401/11402's operator:

   a) Selection of the 11401/11402's RQS icon.

   b) Pressing the ID button on a probe attached to a plug-in channel.

   c) The display or any of its front-panel buttons is "touched." The touch may be initiated by a front-panel operator or by the ABSTOUCH com mand.

5. **Calibration Due**—reported when self-calibration is to be performed.

Table 3-20 is a list of the binary and decimal codes that correspond to the previously described conditions.

TABLE 3-20
11401/11402 Status Bytes

Condition	BINARY DIO	BINARY 8765	BINARY 4321	DECIMAL RQS ON	DECIMAL RQS OFF
Abnormal:					
Command Error		0R10	0001	97	33
Execution Error		0R10	0010	98	34
Internal Error		0R10	0011	99	35
Execution Warning		0R10	0101	101	37
Internal Warning		0R10	0110	102	38
Normal:					
No Status To Report		0000	0000	0	0
Power On		0R00	0001	65	1
Operation Complete		0R00	0010	66	2
User Request		0R00	0011	67	3
Calibration Due		0R00	0110	70	6

NOTE

DIO7, shown as "R", is asserted when specifically enabled via the device dependent RQS command. Otherwise, the "R" bit is 0 (zero).

RQS Command

RQS only affects status and event reporting at the GPIB port. It has two major affects:

1. It controls bit DIO7 of the status byte. The command "RQS ON" enables DIO7 assertion. The command "RQS OFF" disables assertion for all conditions except "Power On." At instrument power-up, RQS is ON at the GPIB port and OFF at the RS-232-C port.

2. This command also controls whether or not the 11401/11402 is permitted to request service from a GPIB controller. The command "RQS OFF" disables service requests. The command "RQS ON" enables service requests.

RQS vs GPIB Service Requests

When RQS is ON, the occurrence of a new event (for example, an Internal Warning caused by input channel overload) will cause the 11401/11402 to assert the SRQ signal line. A GPIB controller may then interrogate the 11401/11402 via an IEEE-488 serial poll and obtain a status byte that describes the event that occurred.

When RQS is OFF, no new event will cause the 11401/11402 to assert SRQ, except Power On. Thus, a GPIB controller will not be asynchronously informed (via SRQ) that an event has occurred. In this situation, a controller may still interrogate the 11401/11402 via an IEEE-488 serial poll to read the most recent status byte from the 11401/11402's serial poll register.

RQS vs RS-232-C Service Requests

With respect to the RS-232-C interface, there is no SRQ signal line. Therefore, service requests are never reported asynchronously to the RS-232-C port. In fact, RQS is always OFF at the RS-232-C port.

Since RS-232-C RQS is always off, no new instrument event will cause the 11401/11402 to request service. That is, no asynchronous messages are sent to the controller. Therefore, an RS-232-C controller is required to query (poll) the 11401/11402 to determine the latest status condition that has occurred in the instrument.

To that end, an STBYTE? query is provided to permit RS-232-C controllers to read the status byte of the most recent event reported to the RS-232-C port (refer to"STBYTE? Command" earlier in this sectionfor its syntax and semantics).

SRQMASK Command

Whether RQS is ON or OFF, there may be occasions when a GPIB/RS-232-C programmer wishes to disable event reporting for a specific class of system conditions. To that end, the SRQMASK command is provided to disable (mask off) user-selected events. See the SRQMASK command (in the command set) for a list of maskable events and the command's syntax.

Event Code Reporting

The second part of the 11401/11402 status reporting system is event code reporting. 11401/11402 event messages merely expand the description of the status condition reported by the status byte, in order to more clearly specify the status condition, i.e., event, that has occurred.

GPIB and RS-232-C controllers may read event codes generated by the 11401/ 11402 by using the device dependent EVENT? query command. The response to an EVENT? is either:

EVENT <NR1>

- or -

EVENT <NR1>,<qstring>

<NR1> represents the numerical value of an event code, and <qstring> is a quoted string that describes the returned event code.

The response that includes the quoted description string is returned only when the LONGFORM command is ON.

Refer to "EVENT? Command" and "LONGFORM Command" earlier in this section for related information.

Event Codes

Tables 3-22 through 3-27 list the 11401/11402's event codes and event code description strings for all event classes.

It should be noted that formatting symbols (refer to Table 3-21) are included in some of the event code description strings found in Tables 3-22 through 3-27.

Each formatting symbol is introduced with a percent sign (%). The symbols indicate substitution of variable information in the "template" or generic descriptions whenever LONGFORM is ON. The template descriptions provide a basic description that is used for all possible (actual) conditions that might occur.

Thus, when LONGFORM is ON and the 11401/11402 receives an EVENT? query for some event described with a template description, the 11401/11402 actually returns a description string for the specific event encountered.

For example:

The command setting "CHL1 OFFSET:5000" results in an execution warning.

The resultant event code received by the controller (and its description string, as found in Table 3-23) with **LONGFORM OFF** would be:

Returned Event Code	Event Code Table Description
EVENT 550	550 EXERR 98 34 %A out of range – limit set

However, with **LONGFORM ON**, the actual message returned to the controller would be

EVENT 550,"OFFSET out of range – limit set"

The formatting symbols and their meanings are shown in Table 3-21, below.

TABLE 3-21
Formatting Symbols

Symbol	Expand With The:
%a	plug-in channel number or simple integer value.
%A	argument name.
%b	plug-in slot designator, in the form: L, R, or C.
%B	plug-in slot, in the form: LEFT, RIGHT, or CENTER.
%M	mainframe calibration fault string. If no mainframe fault occurred, %M is replaced with "PASS". Otherwise, %M is replaced with a short string that describes what caused mainframe calibration to fail. Possible fault strings include: A/D Out Of Specification A/D Quantizer 1 A/D D/A Converter A/D Quantizer 2 Positive A/D Quantizer 2 Negative Main Time Interpolator Window Time Interpolator Main Fine Holdoff Window Fine Holdof

TABLE 3-21 (cont)
Formatting Symbols

Symbol	Expand With The:
%P	plug-in slot list. If the mainframe cal fails, plug-in cal is not performed and %P is replaced with "NA." If mainframe cal passes and plug-in calibration passed for all slots, %P is replaced with "Pass." Otherwise, %P is replaced with a comma-delimited list of plug-in slots, in the following format: <slot><dd> Where <slot> is L, R, or C and <dd> is a two-digit hex number whose first digit is currently unused and always set to zero. The four bits of the second hex digit encode which channels failed cal. Example lists: LO3, CO8 (L1, L2, and C4 failed) R05 (R1 and R3 failed)
%t	trigger cal fault list. If mainframe cal fails, trigger cal is not performed and %t is replaced with "NA." If mainframe cal passes and both main and window trigger cal pass for each plug-in slot, %t is replaced with "Pass." Otherwise, %t is replaced with a comma-delimited list of failures, in the following format: <trigger><slot> Where <trigger> is M or W, denoting the failed trigger (Main or (Window), and <slot> is L, R, or C, denoting which plug-in failed during trigger cal. Example lists: ML,WC,WR MC
%T	time, formatted as "X minutes and Y seconds." If X is 0, then 'X minutes' is omitted. If Y is 0, then 'Y seconds' is omitted.
%?	event code value.

TABLE 3-22
Command Errors

Event Code	SRQMASK	Status Byte RQS ON	Status Byte RQS OFF	Event Code Description String
108	CMDERR	97	33	Checksum error in binary block transfer
109	CMDERR	97	33	Illegal byte count value on a binary block transfer
154	CMDERR	97	33	Invalid number input
155	CMDERR	97	33	Invalid string input
156	CMDERR	97	33	Symbol not found
157	CMDERR	97	33	Syntax error
160	CMDERR	97	33	Expression too complex
161	CMDERR	97	33	Excessive number of points in binary CURVE data input
162	CMDERR	97	33	Excessive number of points in ASCII CURVE data input
163	CMDERR	97	33	No input terminator seen
164	CMDERR	97	33	Binary block input not allowed with ECHO ON
167	CMDERR	97	33	Insufficient data to satisfy binary block byte count
168	CMDERR	97	33	Unsupported constant
169	CMDERR	97	33	Unsupported function

TABLE 3-23
Execution Errors

Event Code	SRQMASK	Status Byte RQS ON	Status Byte RQS OFF	Event Code Description String
203	EXERR	98	34	I/O buffers full
205	EXERR	98	34	%A out of range—value ignored
224	EXERR	98	34	Function not available in selected plugin range
233	EXERR	98	34	Delayed trace must not be the selected trace
231	EXERR	98	34	Autoset - not functional with this waveform type
232	EXERR	98	34	That XY waveform has incompatible components
239	EXERR	98	34	Improper version number
240	EXERR	98	34	Can't accumulate nonacquired waveform
241	EXERR	98	34	Too many acquisitions
242	EXERR	98	34	Enhanced Accuracy available after %T

TABLE 3-23 (cont)
Execution Errors

Event Code	SRQMASK	Status Byte RQS ON	—OFF	Event Code Description String
243	EXERR	98	34	That function is disabled by a hardware strap
244	EXERR	98	34	%B plugin channel(s) used differently in main and window sources
246	EXERR	98	34	Can't sequence settings
247	EXERR	98	34	No settings defined
248	EXERR	98	34	Misuse of AVG/ENV function
249	EXERR	98	34	Illegal use of trace positioning function
250	EXERR	98	34	No traces defined
251	EXERR	98	34	Illegal trace number
252	EXERR	98	34	Illegal stored settings number
255	EXERR	98	34	Out of memory
257	EXERR	98	34	Illegal stored waveform number
263	EXERR	98	34	Illegal channel number
264	EXERR	98	34	No further XY waveforms may be defined
265	EXERR	98	34	Illegal DATE/TIME
266	EXERR	98	34	DEF expansion overflow
267	EXERR	98	34	Illegal DEF string
268	EXERR	98	34	Illegal DEF recursion
269	EXERR	98	34	No such trace
270	EXERR	98	34	No such stored waveform
271	EXERR	98	34	No such DEF
272	EXERR	98	34	That function is not supported by this plugin
273	EXERR	98	34	No such FPS
274	EXERR	98	34	No appropriate 11K plugins loaded
275	EXERR	98	34	%B slot not loaded with appropriate 11K plugin
278	EXERR	98	34	Plugin channel used more than once in trigger source
279	EXERR	98	34	Line trigger not available for window trigger source
280	EXERR	98	34	Invalid smooth argument
281	EXERR	98	34	Can't delete active stored waveform
282	EXERR	98	34	Can't store trace
283	EXERR	98	34	Can't clear nonacquired waveform
284	EXERR	98	34	Requested coupling for channel %a not available on %B plugin
285	EXERR	98	34	Requested input impedance for channel %a not available on %B plugin

TABLE 3-23 (cont)
Execution Errors

Event Code	SRQMASK	Status Byte RQS ON	OFF	Event Code Description String
286	EXERR	98	34	Too many measurements specified
287	EXERR	98	34	Hardcopy absent or off line
288	EXERR	98	34	Inappropriate trigger level units
289	EXERR	98	34	Split cursors not permitted on XY trace
290	EXERR	98	34	Current reference measurement failed
291	EXERR	98	34	TEXT not permitted when acquired XY trace is active
292	EXERR	98	34	%B slot not loaded with 11K plugin
293	EXERR	98	34	Misuse of 11K plugin.
294	EXERR	98	34	Dual graticules not permitted with XY trace
295	EXERR	98	34	Record length too long for Point Accumulate waveform
296	EXERR	98	34	Point Accumulate and XY waveforms are mutually exclusive
297	EXERR	98	34	Pan zoom may not be enabled
298	EXERR	98	34	Pan zoom may not be disabled
299	EXERR	98	34	CONDACQ function not available

TABLE 3-24
Internal Errors

Event Code	SRQMASK	Status Byte RQS ON	OFF	Event Code Description String
308	INERR	99	35	Bad level 2 probe checksum on channel %b%a
327	INERR	99	35	DIG probe compensation failed
328	INERR	99	35	DIG plugin calibration failed
329	INERR	99	35	DIG deskew failed
330	INERR	99	35	Enhanced accuracy failed. Mainframe: %M. Plugin: %P. Trigger: %t.
394	INERR	99	35	Test completed and failed
395	INERR	99	35	General DIG failure detected (code=%a)
396	INERR	99	35	%B plug-in communication failure
397	INERR	99	35	Internal DAC overflow on channel %a of %B plugin
398	INERR	99	35	Invalid DIG table ID detected
399	INERR	99	35	Invalid DIG field ID detected

TABLE 3-25
System Events

Event Code	SRQMASK	Status Byte RQS ON	Status Byte RQS OFF	Event Code Description String
400	—	-0	0	System function normal
401	—	65	1	Power on
403	USER	67	3	Front panel RQS icon selected
450	OPCMPL	66	2	Conditional acquire completed
451	ABSTOUCH	67	3	Abstouch
457	IDPROBE	67	3	Probe %a ID button pressed on %B plugin
458	OPCMPL	66	2	Hardcopy aborted
460	OPCMPL	66	2	Test completed and passed
461	OPCMPL	66	2	Enhanced accuracy completed and passed
462	OPCMPL	66	2	Hardcopy complete
463	OPCMPL	66	2	Measurements complete
464	OPCMPL	66	2	Autoset complete
465	CALDUE	70	6	Warmup complete - calibration due
466	CALDUE	70	6	New configuration - partial enhanced accuracy occurring
467	CALDUE	70	6	Warmup complete with new configuration-calibration due
468	CALDUE	70	6	Warmup complete with new configuration-automatic ehanced accuracy occurring.
469	CALDUE	70	6	Temperature change - automatic enhanced accuracy occurring
470	CALDUE	70	6	Temperature change - calibration due
471	CALDUE	70	6	Warmup complete- enhanced accuracy in effect
472	CALDUE	70	6	Warmup complete - automatic enhanced accuracy occurring

TABLE 3-26
Execution Warnings

Event Code	SRQMASK	Status Byte RQS ON	Status Byte RQS OFF	Event Code Description String
550	EXWARN	101	37	%A out of range—limit set
551	EXWARN	101	37	Insufficient data to satisfy binary block byte count
552	EXWARN	101	37	Checksum error in binary block transfer
553	EXWARN	101	37	Window trigger source set equal to main trigger source
554	EXWARN	101	37	Autoset - no signal detected
555	EXWARN	101	37	Binary curve odd data byte discarded
556	EXWARN	101	37	No active acquisitions—digitizer remains stopped
557	EXWARN	101	37	Hardcopy aborted
558	EXWARN	101	37	Nothing to abort
559	EXWARN	101	37	XY PT. FMT not permitted - Y assumed
561	EXWARN	101	37	Autoset - trigger search failed
562	EXWARN	101	37	Autoset - horizontal search failed
563	EXWARN	101	37	Autoset - ac signal too large
564	EXWARN	101	37	Autoset - dc signal too large

TABLE 3-27
Internal Warnings

Event Code	SRQMASK	Status Byte RQS ON	Status Byte RQS OFF	Event Code Description String
651	INWARN	102	38	Input channel %a overload on %B plugin
652	INWARN	102	38	Input channel %a overdrive on %B plugin
653	INWARN	102	38	RS-232-C input parity error
654	INWARN	102	38	RS-232-C input framing error
655	INWARN	102	38	RS-232-C input buffer overrun
656	INWARN	102	38	Internal table search failed
657	INWARN	102	38	Nonvolatile RAM completely reset
658	INWARN	102	38	Nonvolatile RAM front panel settings lost; instrument ID data retained
659	INWARN	102	38	Cannot report unknown error code (%?)
660	INWARN	102	38	Digitizer stopped — time base settings exceed available acquisition memory.

System Event Handling

Status bytes and event codes combine to represent common instrument system events (see Fig. 3-16).

The system events that are generated by the 11401/11402 are handled as either "port dependent" or "port independent" events.

Port Dependent Events

A port dependent event is generated when any of the following system status conditions occur:

- Command Error
- Execution Error
- Execution Warning

Port dependent events are returned only to the port responsible for the event. For example, if the 11401/11402 detects a command error in an RS-232-C device dependent command, the event associated with the error will be returned only to the RS-232-C port.

Port Independent Events

Informally, a port independent event is any event that cannot be classified as port dependent. Port independent events are always returned to both the RS-232-C and GPIB controllers. Formally, a port independent event is generated when any of the following system status conditions occur:

- Internal Error
- Internal Warning
- Power On
- Operation Complete
- User Request
- Calibration Due

System Event Handling Priorities

Since more than one event may occur before a GPIB or RS-232-C controller can respond to a service request, the 11401/11402 uses the priorities shown in Table 3-28 to report events.

TABLE 3-28
Event Priorities

Priority	Event Class
1	Power On
2	Command Error
2	Execution Error
2	Execution Warning
2	Internal Error
2	Internal Warning
2	Calibration Due
2	Operation Complete
2	User Request
3	No Status To Report

RS-232-C Event Handling

Figure 3-19 shows a block diagram of the RS-232-C event handler. The event handler consists of two software registers and a LIFO (Last In First Out) buffer.

Within the block diagram, "SB" is an abbreviation for "status byte" and "EC" is an abbreviation for "event code".

When a new event is passed to the event handler, the 11401/11402 checks to see if the event's SRQMASK is OFF. If it is, then the event is discarded. However, if it is ON, then the 11401/11402 checks to see if the current status byte register is empty or has "no status to report". If it is empty, then the event handler latches the new status byte and event code into the current status byte and event code registers. Once this latched state is entered, all subsequent events are stacked in a 40-event LIFO buffer. Should a new event cause the LIFO buffer to overflow, the oldest event in the buffer is discarded.

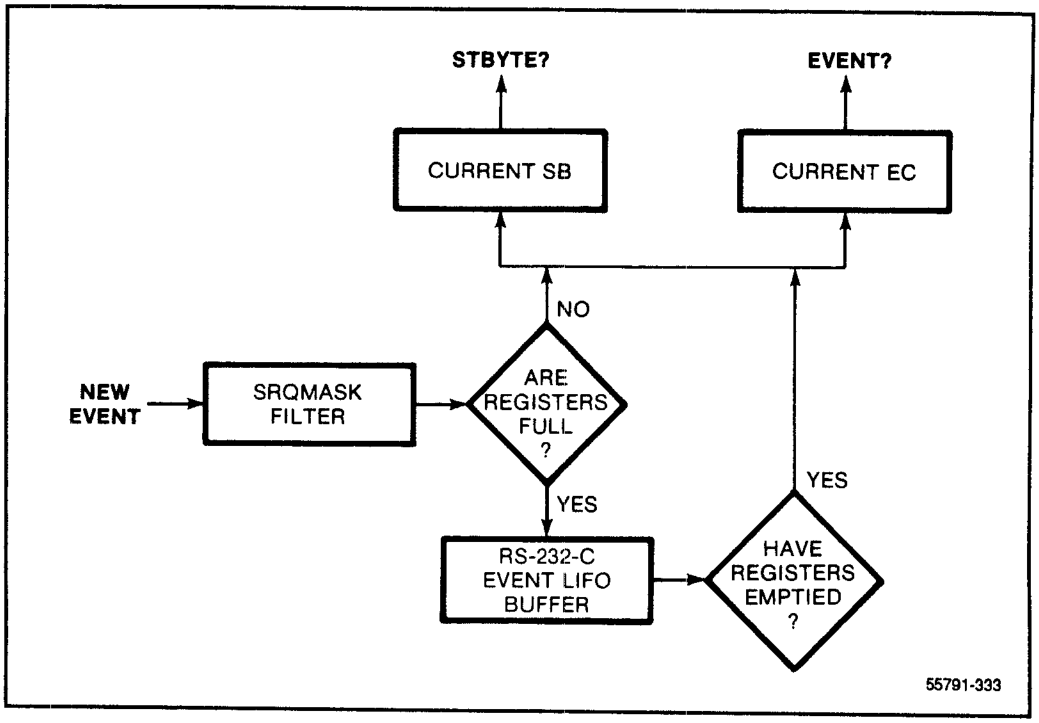

Figure 3-19. RS-232-C event handling.

Reading the RS-232-C Current Event Registers

An RS-232-C STBYTE? Query Command returns the contents of the "current status byte"register. This is a nondestructive read.

An RS-232-C EVENT? Query Command returns the contents of the "current event code" register and, assuming the LIFO buffer is not empty, pops the top LIFO event into the current status byte and event code registers. If the buffer is empty, the current status byte is changed to "No Status To Report" and event code 400 is written to the current event code register. In effect, EVENT? causes the RS-232-C event handler to update its software registers and make the next event (if any) available for subsequent STBYTE? or EVENT? queries.

GPIB Event Handling

Figure 3-20 shows a block diagram of the GPIB event handler. This event handler consists of two software registers, a LIFO buffer, and the IEEE-488 Serial Poll register (a hardware register).

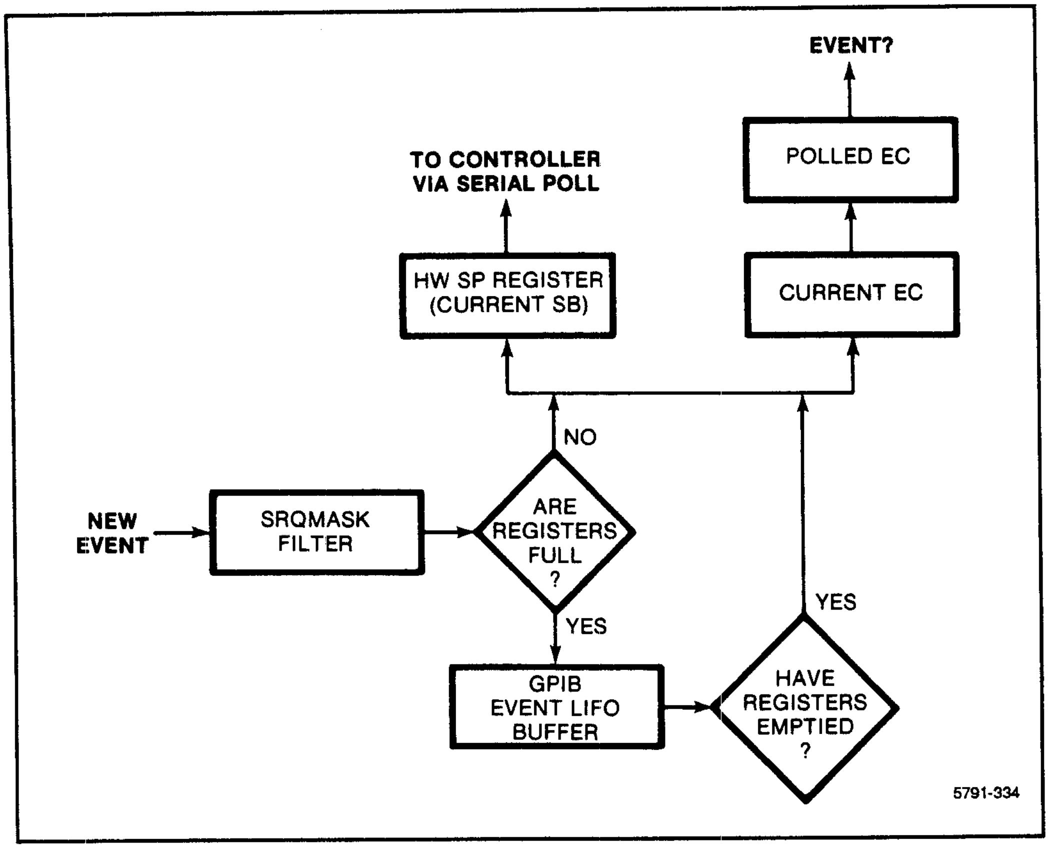

Figure. 3-20. GPIB event handling.

At all times, the contents of the hardware serial poll register are identical to the contents of the software "Current Status Byte" register described for the RS-232-C event handler.

Operation of the GPIB event handler depends upon whether GPIB RQS is ON or OFF.

Event Reporting when GPIB RQS is OFF

When GPIB RQS is OFF, the polled event code register is not used when a new event is passed to the event handler. If the event's SRQMASK is OFF, then the event is discarded. However, if it is ON, then the 11401/11402 checks to see if the current status byte register is empty or has "no status to report". If it is empty, then the event handler latches the new status byte and event code into the hardware serial poll register and current event code register. Once this latched state is entered, all subsequent events are stacked in a 41-event LIFO buffer. Should a new event cause the LIFO buffer to overflow, the oldest event in the buffer is discarded.

Notice that when GPIB RQS is OFF, the GPIB event handler behaves virtually the same as the RS-232-C event handler, with the exception that the current status byte is stored in a hardware register and not in a software register.

Reading the GPIB Current Event Registers when RQS is OFF

An IEEE-488 serial poll permits a GPIB controller to read the contents of the 11401/11402's hardware serial poll register, which, as was previously mentioned, is identical to the Current Status Byte. This is a nondestructive read. There is no device-dependent command provided to read the hardware serial poll register.

A GPIB EVENT? query command returns the contents of the Current Event Code register and, assuming the LIFO buffer is not empty, pops the top LIFO event into the Current Status Byte and Event Code registers. If the buffer is empty, the Current Status Byte is changed to "No Status To Report" and event code 400 is written to the Current Event Code register. In effect, EVENT? causes the GPIB event handler to update its hardware and software registers, and make the next event (if any) available for subsequent serial polls or EVENT? queries.

An important point to stress is that when RQS is OFF, only EVENT? updates the event handler's software and hardware registers. Repeated serial polls simply return the same status byte value.

Event Reporting when GPIB RQS is ON

When a new event is passed to the event handler, the same operations as with GPIB RQS OFF are executed. The only difference is that bit 7 of the new event's status byte is set, thus causing the 11401/11402 to assert SRQ after writing the status byte to the serial poll register.

Note that when GPIB RQS is ON, the Polled Event Code Register is significant. At power up or whenever RQS is turned ON, this register is initialized with event code 0, which is referred to as the NULL event. The event code description string of the NULL event is

"RQS is ON...status byte pending"

Reading the GPIB Current Event Registers when RQS is ON

When GPIB RQS is ON, it is the IEEE-488 serial poll (not EVENT?) that causes the event handler to update its event registers.

When the 11401/11402 asserts SRQ, an external controller must first serial poll the 11401/11402 to read the status byte of the system event that just occurred. The 11401/11402 responds to the serial poll by moving the Current Event Code register contents into the Polled Event Code register. The 11401/11402 next checks for pending events in the LIFO buffer. If found, the 11401/11402 moves the top event's status byte into the Hardware Serial Poll register, thus updating it and causing the 11401/11402 to generate another SRQ. At the same time, the top event's event code is moved into the Current Event Code register, thus updating it. However, if no events are pending in the LIFO buffer, the 11401/11402 moves a status byte into the Hardware Serial Poll register that indicates "No Status To Report", and its corresponding event code 400 is moved into the Current Event Code register. No SRQ is generated under these conditions.

If a controller follows up the serial poll with an EVENT?, the 11401/11402 returns the contents of the Polled Event Code register and reinitializes it to the NULL event. Then, at the next serial poll, the 11401/11402 again moves the contents of the updated Current Event Code register into the Polled Event Code register. This operation assures that the status byte and the polled event code correspond to one another.

In summary, when RQS is ON, keep these important points in mind:

1. EVENT? returns the contents of the Polled Event Code register.

2. The proper sequence for reading event registers is to first serial poll the 11401/11402 and then, if more information is desired, follow up with the EVENT?.

3. When the EVENT? returns the NULL event, the 11401/11402 is signaling that a new event has occurred and its status byte must first be polled before its event code can be queried. Adhering to point two will obviate this problem.

4. If more than one event is pending and the 11401/11402 is serial polled twice with no intervening EVENT?, the event code associated with the first polled status byte is lost.

Enabling the RQS Icon via the USER SRQMASK

One of the SRQMASK command's maskable events is the USER initiated "Request for Service." When the GPIB and/or RS-232 USER SRQMASKs are set to ON, the 11401/11402 displays an RQS icon on its front panel. This icon permits the front-panel operator to request service from an external controller. When both USER SRQMASKs are OFF, the icon is not displayed. Since both USER masks are OFF by default at When initially displayed, the icon is not highlighted and is said to be "unselected." When a front-panel operator touches an unselected RQS icon, the icon is highlighted and an event 403 (Front panel RQS icon pressed) is reported to whichever ASCII port has the USER SRQMASK enabled.power-up, the RQS icon is not visible at that time.

In the highlighted state, the icon is said to be "selected." Once selected, all subsequent icon touches are ignored. The icon regains its functionality when it returns to the unselected state.

The RQS icon transitions from selected to unselected under any one of these circumstances:

- The GPIB USER SRQMASK and RQS are ON and a GPIB controller serial polls (and thereby clears) the status byte associated with event code 403.

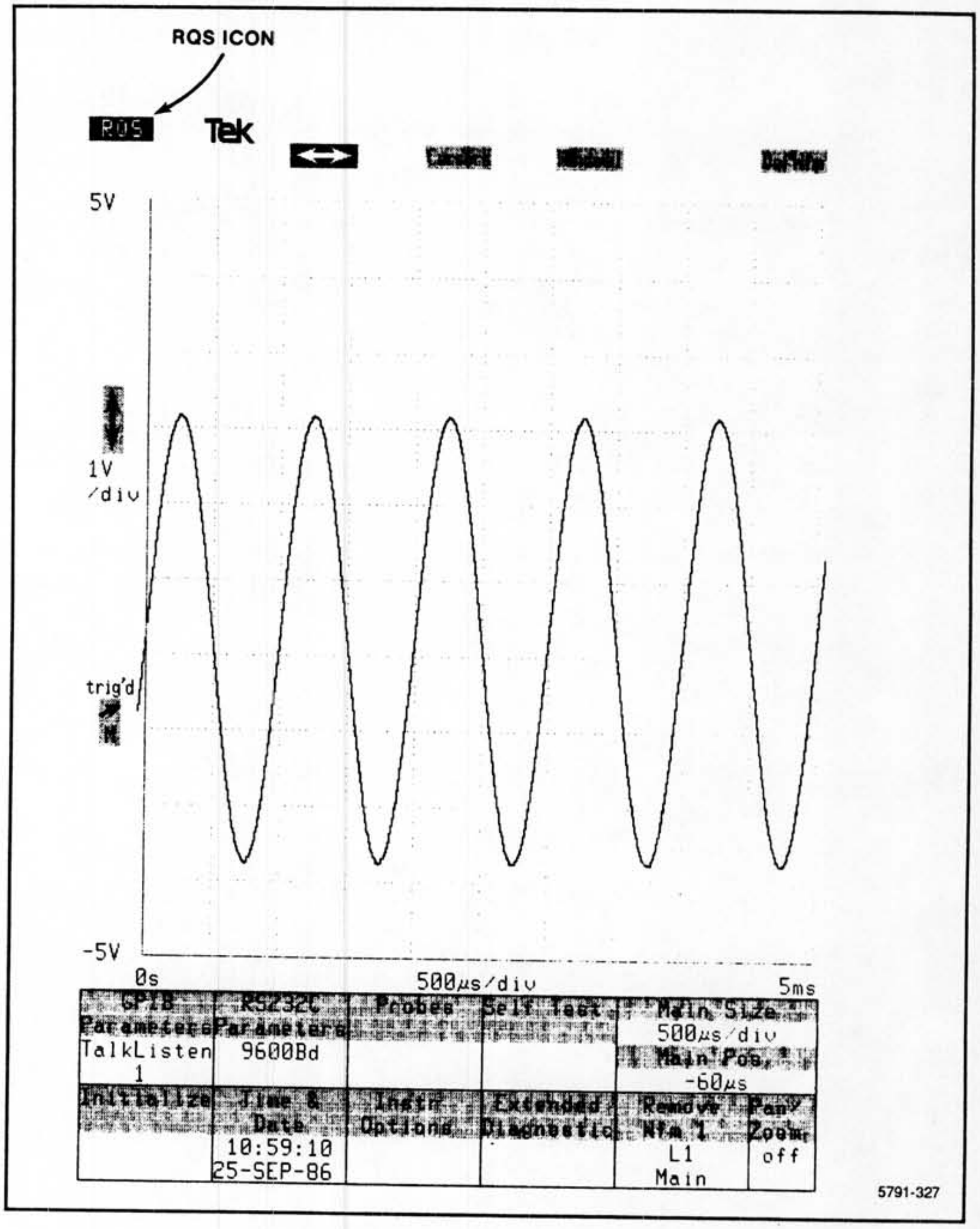

Figure 3-21. RQS icon on the front-panel display.

- The GPIB USER SRQMASK is ON and RQS is OFF and a GPIB controller uses EVENT? to read (and thereby clear) event code 403 from the GPIB event stack.
- The RS-232 USER SRQMASK is ON and an RS-232-C controller uses EVENT? to read event code 403.
- The GPIB USER SRQMASK is ON and event code 403 is discarded from the GPIB stack. This situation arises when a GPIB controller does not query the GPIB event stack and subsequent 11401/11402 events cause the stack to overflow. When event code 403 is discarded, the front-panel user is informed of this fact by this message:

  Request for external service ignored

  If the RS-232 USER SRQMASK is ON and the above scenario is repeated at the RS-232-C port, the 11401/11402 takes the same actions as it did for the GPIB interface.
- The GPIB USER SRQMASK is ON and DCL or SDC is received at the GPIB port. In this situation, all pending events (including event 403) are cleared.

  For the same reasons, RS-232 DCL has the same effect (assuming the RS-232 USER SRQMASK is ON).

Events Reported at Instrument Energization

When the 11401/11402's power switch is turned on, diagnostic testing is automatically executed (unless bypassed by qualified service personnel via hardware straps). At the completion of diagnostics, control is passed to the 11401/11402's nondiagnostic firmware and the ASCII interfaces are activated. One of the first tasks performed following interface activation is to report power up status. If diagnostics passed (or were bypassed), the 11401/11402 reports power on (event 401). If diagnostics failed, then that is reported (event 394). Specific diagnostic failure information can be obtained via DIAG? (refer to "Diagnostic Commands" earlier in this section).

Following the power up status report, the integrity of the 11401/11402's non-volatile RAM (NVRAM) is checked and if found to be unsatisfactory, one of the following events is reported:

- Event 657—NVRAM was completely reinitialized and all stored settings (if any) were discarded. This event is typically reported when the NVRAM battery fails.

- Event 658—This is the same as event 657, except that the Mainframe link of the UID command (refer to "UID Command" earlier in this section), the number of instrument energizations (refer to "POWERON? Command" earlier in this section), and the length of time the 11401/11402 has been powered up (refer to "UPTIME? Command" earlier in this section) are not reinitialized from the factory settings. This event is typically reported when bad settings are passed to the 11401/11402 from an external ASCII interface and a software crash ensues. In this case, event 658 is reported when the 11401/11402 is subsequently powered-down and then back -up.

Programming Applications

The following text lists a number of useful application programs for the GPIB and RS-232-C ports.

These examples are for use with the IBM PC-XT-AT (R) and the HP 200 and 300 Series (R) computers configured with a GPIB and a RS-232-C interface. These programs are written in IBM BASICA and HP BASIC.

Configuration for Example Programs:

HP GPIB

Mode:	TalkListen
Address:	1
Terminator:	EOI
Debug:	Off

HP RS-232

Baud:	9600
Echo:	Off
Stop Bits:	1
Parity:	Even
Flagging:	Hard
Delay:	0
EOL:	LF
Verbose:	Off
Debug:	Off

IBM GPIB

Mode:	TalkListen
Address:	1
Terminator:	EOI
Debug:	Off

IBM RS-232

Baud:	9600
Echo:	Off
Stop Bits:	1
Parity:	None
Flagging:	None
Delay:	0
EOL:	CR
Verbose:	Off
Debug:	Off

Utility Programs:

These are some common operations that are performed from the external interface:

- Taking Measurements
- Storing and Recalling Front Panel Settings
- Binary Waveform Transfer Into An Array
- An SRQ Handler
- String Transfer to the 11401 Screen

The following programs demonstrate these utilities on popular instrument controllers.

NOTE

In these examples, it is assumed that "@Et" and "ET%" identify the 11401/11402 assigned to the controller's GPIB or RS-232-C ports.

HP 200 & 300 Series Controllers

Taking Measurements

GPIB:

```
10 DIM Meas$[200]
20 ASSIGN @Et TO 701;EOL "<LF>" END
30 OUTPUT @Et;"MSLIST PER,FRE,MAX,PP,RISE,FALL"
40 OUTPUT @Et;"MEAS?"
50 ENTER @Et;Meas$
60 PRINT Meas$
70 END
```

RS-232-C:

```
10 DIM Meas$[200]
20 CONTROL 9,3;9600
30 CONTROL 9,4;3+0+8+16
40 ASSIGN @Et TO 9
50 OUTPUT @Et;"MSLIST PER,FRE,MAX,PP,RISE,FALL"
60 OUTPUT @Et;"MEAS?"
70 ENTER @Et;Meas$
80 PRINT Meas$
90 END
```

Store and Recall Front-Panel Settings

GPIB:

```
10 DIM Setting$[5000]
20 ASSIGN @Et TO 701;EOL "<LF>" END
30 OUTPUT @Et;"ENCDG SET:BINARY;SET?"
40 ENTER @Et USING "-K";Setting$
50 DISP "press CONTINUE to reset the front panel"
60 PAUSE
70 OUTPUT @Et;Setting$
80 END
```

RS-232-C:

```
 10 DIM Setting$[5000]
 20 CONTROL 9,3;9600
 30 CONTROL 9,4;3+0+8+16
 40 ASSIGN @Et TO 9
 50 OUTPUT @Et;"ENCDG SET:BINARY;SET?"
 60 ENTER @Et USING "#,5A,W";Header$,Bytcnt
 70 ALLOCATE Set$[Bytcnt]
 80 ENTER @Et USING "-K";Set$
 90 OUTPUT Setting$ USING "5A,Y,K";Header$,Bytcnt,Set$
100 DEALLOCATE Set$
110 DISP "press CONTINUE to reset the front panel"
120 PAUSE
130 OUTPUT @Et;Setting$
140 END
```

Binary Waveform Transfer into an Array

GPIB:

```
10 ASSIGN @Et TO 701;EOL "<LF>" END
20 ASSIGN @Etbin TO 701;FORMAT OFF
30 OUTPUT @Et;"LONGFORM ON"
40 OUTPUT @Et "SELECT?"
50 ENTER @Et;Trace$
60 OUTPUT @Et;"ENCDG WAVFRM:BIN;BYT.OR MSB;OUTPUT "&Trace$[8]
70 OUTPUT @Et;"CURVE?"
80 ENTER @Et USING "#,7A,W";Header$,Bytcnt
90 Nr_pt = (Bytcnt-1)/2
100 ALLOCATE INTEGER Curve(1:Nr_pt)
110 ENTER @Etbin;Curve(*)
120 ENTER @Et USING "B";Cksum
130 PRINT Curve(*)
140 DEALLOCATE Curve(*)
150 END
```

RS-232-C:

```
10 CONTROL 9,3;9600
20 CONTROL 9,4;3+0+8+16
30 ASSIGN @Et TO 9
40 ASSIGN @Etbin TO 9;FORMAT OFF
50 OUTPUT @Et;"LONGFORM ON"
60 OUTPUT @Et;"SELECT?"
70 ENTER @Et;Trace$
80 OUTPUT @Et;"ENCDG WAV:BIN;BYT.OR MSB;OUTPUT "&Trace$[8]
90 OUTPUT @Et;"CURVE?"
100 ENTER @Et USING "#,7A,W";Header$,Bytcnt
110 Nr_pt = (Bytcnt-1)/2
120 ALLOCATE INTEGER Curve(1:Nr_pt)
130 ENTER @Etbin;Curve(*)
140 ENTER @Et USING "B";Cksum
150 PRINT Curve(*)
160 DEALLOCATE Curve(*)
170 END
```

SRQ Handler

GPIB:

```
 10 DIM Event$[100]
 20 ASSIGN @Et TO 701;EOL "<LF>" END
 30 ON INTR 7 GOSUB Poll
 40 ENABLE INTR 7;2
 50 OUTPUT @Et;"SRQMASK USER:ON;RQS ON"
 60 DISP "press RQS icon on 11401"
 70 GOTO 70
 80 POLL: Stat = SPOLL(701)
 90   OUTPUT @Et;"EVENT?"
100   ENTER @Et;Event$
110   PRINT Stat,Event$
120   ENABLE INTR 7
130   RETURN
140 END
```

RS-232-C:

```
 10 DIM Event$[100]
 20 CONTROL 9,3;9600
 30 CONTROL 9,4;3+0+8+16
 40 ASSIGN @Et TO 9
 50 OUTPUT @Et;"SRQMASK USER:ON"
 60 DISP "press RQS icon on 11401"
 70 GOSUB Poll
 80 GOTO 70
 90 Poll: OUTPUT @Et;"STBYTE?"
100   ENTER @Et;Stat$
110   Stat = VAL(Stat$[8])
120   IF (Stat=0) THEN 170
130   OUTPUT @Et;"EVENT?"
140   ENTER @Et;Event$
150   PRINT Stat,Event$
160   GOTO 90
170   RETURN
180 END
```

String Transfer to the 11401/11402 Screen

GPIB:

```
10 DIM Text$[100]
20 ASSIGN @Et TO 701;EOL "<LF>" END
30 INPUT "TEXT: ",Text$,"LOCATION: ",X,Y
40 OUTPUT @Et;"TEXT X:";X;",Y:";Y;",STRING:'"&Text$&"'"
50 END
```

RS-232-C

```
10 DIM Text$[100]
20 CONTROL 9,3;9600
30 CONTROL 9,4;3+0+8+16
40 ASSIGN @Et TO 9
50 INPUT "TEXT: ",Text$,"LOCATION: ",X,Y
60 OUTPUT @Et;"TEXT X:";X;",Y:";Y;",STRING:'"&Text$&"'"

70 END
```

IBM PC/XT/AT Controller

Taking Measurements

GPIB:

```
  1 CLEAR    ,50000!             'BASIC Declarations.
  2 IBINIT1 = 50000!             'Lines 1 thru 6 must be
  3 IBINIT2 = IBINIT1 + 3        'included in your program.
  4 BLOAD "bib.m",IBINIT1
  5 CALL IBINIT1 (IBFIND,IBTRIG,IBCLR,IBPCT,IBSIC,IBLOC,,IBPPC,,
    IBBNA,IBONL,IBRSC,IBSRE,IBRSV,IBPAD,IBSAD,IBIST,IBDMA,
    IBEOS,IBTMO,IBEOT,IBRDF,IBWRTF)
  6 CALL IBINIT2 (IBGTS,IBCAC,IBWAIT,IBPOKE,IBWRT,IBWRTA,IBCMD,
    IBCMDA,IBRD,INRDA,IBSTOP,IBRPP,IBRSP,IBDIAG,IBXTRC,IBRDI,
    IBWRTI,IBSTA%,IBERR%,IBCNT%)
  .                              'Lines 7 thru 99 of National
  .                              'Instruments GPIB Program
  .                              'declare global variables.
 99
100 DEV1$ = "ET"
110 CALL IBFIND(DEV1$,ET%)
120 WRT$ = "MSLIST PER,FRE,MAX,PP,RISE,FALL"
130 CALL IBWRT(ET%,WRT$)
140 WRT$ = "MEAS?"
150 CALL IBWRT(ET%,WRT$)
160 MEAS$ = SPACE$(200)
170 CALL IBRD(ET%,MEAS$)
180 PRINT MEAS$
190 END
```

RS-232-C:

```
100 OPEN "COM1:9600,N,8,1" AS #1
110 PRINT #1,"MSLIST PER,FRE,MAX,PP,RISE,FALL"
120 PRINT #1,"MEAS?"
130 LINE INPUT #1,MEAS$
140 PRINT MEAS$
150 END
```

Store and Recall Front-Panel Settings

GPIB:

```
 1 CLEAR     ,50000!           'BASIC Declarations.
 2 IBINIT1 = 50000!            'Lines 1 thru 6 must be
 3 IBINIT2 = IBINIT1 +  3      'included in your program.
 4 BLOAD "bib.m",IBINIT1
 5 CALL IBINIT1  (IBFIND,IBTRIG,IBCLR,IBPCT,IBSIC,IBLOC,IBPPC,
   IBBNA,IBONL,IBRSC,IBSRE,IBRSV,IBPAD,IBSAD,IBIST,IBDMA,
   IBEOS,IBTMO,IBEOT,IBRDF,IBWRTF)
 6 CALL IBINIT2  (IBGTS,IBCAC,IBWAIT,IBPOKE,IBWRT,IBWRTA,IBCMD,
   IBCMDA,IBRD,INRDA,IBSTOP,IBRPP,IBRSP,IBDIAG,IBXTRC,IBRDI,
   IBWRTI,IBSTA%,IBERR%,IBCNT%)
 .                             'Lines 7 thru 99 of National
 .                             'Instruments GPIB Program
 .                             'declare global variables.
99
100 DIM SETTING$(100)
110 DEV1$ = "ET"
120 CALL IBFIND(DEV1$,ET%)
130 WRT$ = "ENCDG SET:BINARY;SET?"
140 CALL IBWRT(ET%,WRT$)
150 I=0
160 IBCNT% = 255
170 WHILE IBCNT% = 255
180   SETTING$(I) = SPACE$(255)
190   CALL IBRD(ET%,SETTING$(I))
200   I=I+1
210 WEND
220 INPUT "PRESS <RETURN> TO RESET THE FRONT PANEL ",DUMMY$
230 EOI% = 0 : CALL IBEOT(ET%,EOI%)
240 FOR J=0 TO I-2
250   CALL IBWRT(ET%,SETTING$(J))
260 NEXT J
270 EOI% = 1 : CALL IBEOT(ET%,EOI%)
280 CALL IBWRT(ET%,SETTING$(I-1))
290 END
```

RS-232-C:

```
100 DIM SETTING$(100)
110 OPEN "COM1:9600,N,8,1" AS #1
120 PRINT #1,"ENCDG SET:BINARY;SET?"
130 WHILE EOF(1) : WEND
140 I=0
150 WHILE NOT EOF(1)
160   SETTING$(I) = INPUT$(LOC(1),#1)
170   I=I+1
180 WEND
190 INPUT "PRESS <RETURN> TO RESET THE FRONT PANEL ",DUMMY$
200 FOR J=0 TO I-1
210   PRINT #1,SETTING$(J);
220 NEXT J
230 END
```

Binary Waveform Transfer into an Array

GPIB:

```
  1 CLEAR     ,50000!                  'BASIC Declarations.
  2 IBINIT1   = 50000!                 'Lines 1 thru 6 must be
  3 IBINIT2   = IBINIT1 + 3             'included in your program.
  4 BLOAD "bib.m",IBINIT1
  5 CALL IBINIT1    (IBFIND,IBTRIG,IBCLR,IBPCT,IBSIC,IBLOC,IBPPC,
    IBBNA,IBONL,IBRSC,IBSRE,IBRSV,IBPAD,IBSAD,IBIST,IBDMA,
    IBEOS,IBTMO,IBEOT,IBRDF,IBWRTF)
  6 CALL IBINIT2 (IBGTS,IBCAC,IBWAIT,IBPOKE,IBWRT,IBWRTA,IBCMD,
    IBCMDA,IBRD,INRDA,IBSTOP,IBRPP,IBRSP,IBDIAG,IBXTRC,IBRDI,
    IBWRTI,IBSTA%,IBERR%,IBCNT%)
  .                                   'Lines 7 thru 99 of National
  .                                   'Instruments GPIB Program
  .                                   'declare global variables.
 99
100 DIM CURVE%(10240)
110 DEV1$ = "ET"
120 CALL IBFIND(DEV1$,ET%)
130 WRT$ = "LONGFORM ON;SELECT?"
140 CALL IBWRT(ET%,WRT$)
150 TRACE$ = SPACE$(100)
160 CALL IBRD(ET%,TRACE$)
170 WRT$ = "ENCDG WAV:BIN;BYT.OR LSB;OUTPUT "+MID$(TRACE$,8)
180 CALL IBWRT(ET%,WRT$)
190 WRT$ = "CURVE?"
200 CALL IBWRT(ET%,WRT$)
210 HEADER$ = SPACE$(7)
220 CALL IBRD(ET%,HEADER$)
230 HIGH$ = SPACE$(1) : LOW$ = SPACE$(1)
240 CALL IBRD(ET%,HIGH$) : CALL IBRD(ET%,LOW$)
250 BYTCNT% = CVI(LOW$+HIGH$)-1
260 NRPT = BYTCNT%/2
270 CALL IBRDI(ET%,CURVE%(0),BYTCNT%)
280 CKSUM$ = SPACE$(1)
290 CALL IBRD(ET%,CKSUM$)
300 FOR I=0 to NRPT-1
310   PRINT CURVE%(I);
320 NEXT I
330 END
```

RS-232-C:

```
100 REM  ***********************************************
110 REM  BASIC MUST BE INVOKED WITH A LARGE COMM BUFFER
120 REM  ***********************************************
130 DIM CURVE%(10240)
140 OPEN "COM1:9600,N,8,1" AS #1
150 PRINT #1,"LONGFORM ON;SELECT?"
160 LINE INPUT #1,TRACE$
170 PRINT #1,"ENCDG WAV:BIN;BYT.OR LSB;OUTPUT "+MID$(TRACE$,8)
180 PRINT #1,"CURVE?"
190 HEADER$ = INPUT$(7,#1)
200 HIGH$ = INPUT$(1,#1) : LOW$ = INPUT$(1,#1)
210 BYTCNT = CVI(LOW$+HIGH$)
220 NRPT = (BYTCNT-1)/2
230 FOR I=0 TO NRPT-1
240   CURVE%(I) = CVI(INPUT$(2,#1))
250  PRINT CURVE%(I);
260 NEXT I
270 LINE INPUT #1,CKSUM$
280 END
```

SRQ Handler

GPIB:

```
1 CLEAR    ,50000!           'BASIC Declarations.
2 IBINIT1 = 50000!           'Lines 1 thru 6 must be
3 IBINIT2 = IBINIT1 + 3      'included in your program.
4 BLOAD "bib.m",IBINIT1
5 CALL IBINIT1(IBFIND,IBTRIG,IBCLR,IBPCT,IBSIC,IBLOC,IBPPC,
  IBBNA,IBONL,IBRSC,IBSRE,IBRSV,IBPAD,IBSAD,IBIST,IBDMA,
  IBEOS,IBTMO,IBEOT,IBRDF,IBWRTF)
6 CALL IBINIT2(IBGTS,IBCAC,IBWAIT,IBPOKE,IBWRT,IBWRTA,IBCMD,
  IBCMDA,IBRD,INRDA,IBSTOP,IBRPP,IBRSP,IBDIAG,IBXTRC,IBRDI,
  IBWRTI,IBSTA%,IBERR%,IBCNT%)
.                             'Lines 7 thru 99 of National
.                             'Instruments GPIB Program
.                             'declare global variables.
99
```

```
100 REM  ********************************
110 REM  AUTO SERIAL POLL MUST BE ENABLED
120 REM  ********************************
130 DEV1$ = "ET"
140 CALL IBFIND(DEV1$,ET%)
150 WRT$ = "SRQMASK USER:ON;RQS ON"
160 CALL IBWRT(ET%,WRT$)
170 PRINT "PRESS RQS ICON ON 11401"
180 INTR% = &H800
190 CALL IBWAIT(ET%,INTR%)
200 GOSUB 220
210 GOTO 190
220 CALL IBRSP(DEV%,STAT%)
230   WRT$ = "EVENT?"
240   CALL IBWRT(ET%,WRT$)
250   EVENT$ = SPACE$(50)
260   CALL IBRD(ET%,EVENT$)
270   PRINT STAT%,EVENT$
280   RETURN
290 END
```

RS-232-C:

```
100 OPEN "COM1:9600,N,8,1" AS #1
110 PRINT #1,"SRQMASK USER:ON"
120 PRINT "PRESS RQS ICON ON 11401"
130 GOSUB 150
140 GOTO 130
150 PRINT #1,"STBYTE?"
160   LINE INPUT #1,STAT$
170   STAT = VAL(MID$(STAT$,8))
180   IF (STAT=0) THEN 230
190   PRINT #1,"EVENT?"
200   LINE INPUT #1,EVENT$
210   PRINT STAT,EVENT$
220   GOTO 150
230   RETURN
240 END
```

String Transfer to the 11401/11402 Screen

GPIB:

```
  1 CLEAR    ,50000!              'BASIC Declarations.
  2 IBINIT1 = 50000!              'Lines 1 thru 6 must be
  3 IBINIT2 = IBINIT1 + 3         'included in your program.
  4 BLOAD "bib.m",IBINIT1
  5 CALL IBINIT1 (IBFIND,IBTRIG,IBCLR,IBPCT,IBSIC,IBLOC,IBPPC,
    IBBNA,IBONL,IBRSC,IBSRE,IBRSV,IBPAD,IBSAD,IBIST,IBDMA,
    IBEOS,IBTMO,IBEOT,IBRDF,IBWRTF)
  6 CALL IBINIT2(IBGTS,IBCAC,IBWAIT,IBPOKE,IBWRT,IBWRTA,IBCMD,
    IBCMDA,IBRD,INRDA,IBSTOP,IBRPP,IBRSP,IBDIAG,IBXTRC,IBRDI,
    IBWRTI,IBSTA%,IBERR%,IBCNT%)
                                 'Lines 7 thru 99 of National
  .                              'Instruments GPIB Program
  .                              'declare global variables.
  .
 99
100 DEV1$ = "ET"
110 CALL IBFIND(DEV1$,ET%)
120 INPUT "TEXT: ",TEXT$
130 INPUT "LOCATION: ",X,Y
140 WRT$ = "TEXT X:"+STR$(X)+",Y:"+STR$(Y)+",STRING:'"+TEXT$+"'"
150 CALL IBWRT(ET%,WRT$)
160 END
```

RS-232-C:

```
100 OPEN "COM1:9600,N,8,1" AS #1
110 INPUT "TEXT: ",TEXT$
120 INPUT "LOCATION: ",X,Y
130 PRINT #1,"TEXT X:"+STR$(X)+",Y:"+STR$(Y)+",STRING:'"+TEXT$+"'"
140 END
```

System Performance Considerations

The following information provides an overview of performance elements that need the user's attention for optimal system results.

Know Your System

Getting optimum system performance will depend upon a number of factors that can be addressed. First you must be very familiar with your system requirements. What are your objectives for the measurement system, and what are the components of your system?

Once you have decided what you want from your system, then you must determine what you can expect from your chosen system.

The first step is to know your system. Become very familiar with your controller, with each measurement instrument and data recorder, and with your chosen software (i.e., operating system, device drivers, etc,)

Next, decide whether the GPIB or RS-232-C interface will suit your data transfer application needs.

A good way to gain answers to many of these questions is to carefully study each of your system documents. In particular, learn all about your instruments' command vocabularies and data formats (e.g., ASCII and binary). Then look at how they buffer data and execute commands. This will give you direct information, or at least clues, to what are the fastest and most efficient software and hardware configurations for your application.

The 11401/11402 GPIB and RS-232-C information from the earlier portion of this section should give you all the reference data that you need to determine its contribution to your system performance.

These are just a few things you need to learn about your system. The better you know the features and capabilities of your instruments, the better prepared you'll be to write efficient application programs.

In the following text, we'll look at how you might estimate a system's performance and what can be done to enhance that performance. The discussion assumes you are familiar with the basic terminology and concepts of test and measurement systems.

Estimating System Performance

There are five major components that comprise the overall system performance picture (see Fig. 3-22). The sum of these components is the total time required to execute your intended function (application program).

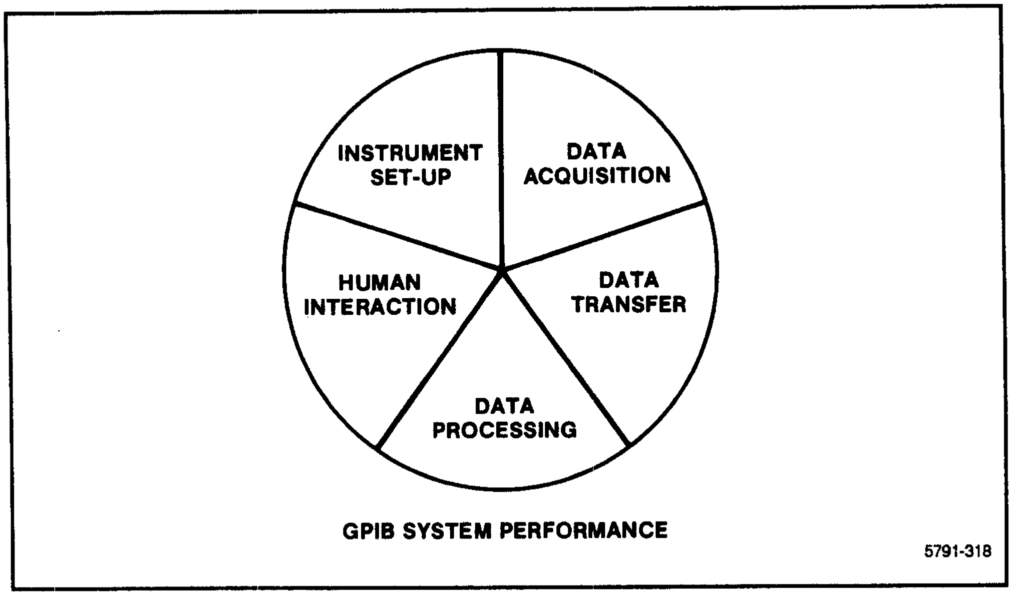

Figure 3-22. System performance elements.

For example, a data logging system generally spends little time setting up the instrument, and doesn't require operator intervention. Most of the time is spent acquiring and transferring the data. In contrast, a production test system may spend less time acquiring data and spend more time processing data and interacting with the operator. Each situation will result in a different focus for estimating and optimizing system performance.

1. Instrument Set-up Time

The first factor can be divided into two parts: the time required to decode and execute a setting command, and the time required for new settings to stabilize.

The time it takes to decode and execute a single 11401/11402 command is usually small, but if a command initiates a complex or lengthy instrument operation, it can increase the setup time. For instance, some commands require the 11401/ 11402 to check to see if any of the associated settings have been changed prior to its initiation. If it finds any, then it must load the new settings into the hardware.

The second part of the setup time is settling time. This is the time it takes the instrument to settle to the specified setting.

For example, in autoranging (i.e., Autoset) the vertical size, the instrument takes a reading, tests for under- or over-voltage conditions, steps the range up or down, and takes another reading. Several passes might have to be made until the correct range is determined. When the reading is within the newly indicated range of the input, the process stops.

Remember, a change in test conditions can cause a significant change in the set-up times.

2. Data Acquisition Time

The second factor is the time required to take a desired sample of your input source (11401/11402 selected waveform). This is the acquisition time (see Fig. 3-23).

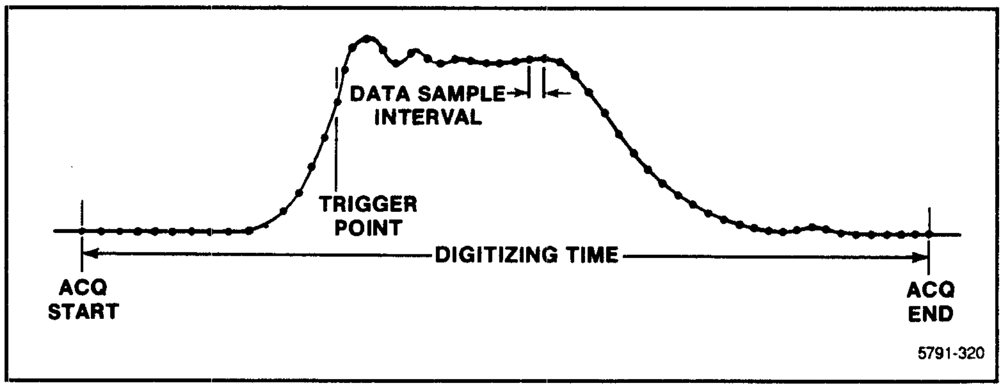

Figure 3-23. Data acquisition time components.

For real-time mode digitizing (single-pass sampling), the significant factors affecting the digitizing time are the waveforms frequency and repetition rate, and the 11401/11402's sweep sampling rate and record length.

For equivalent-time sampling, digitizing time is determined by the number of samples that are required to completely represent your desired data, and the input signal's repetition rate. In addition, if you require other operations (e.g., averaging or enveloping) to be performed on the digitized waveform data, then this also increases the data acquisition time.

The 11401/11402 will sample the incoming waveform every 50 nanoseconds (minimum 10 ps between each sample/data point for a single-channel acquisition.), whether the 11401/11402 is currently in real-time (slow sweep rate) or in equivalent-time (fast sweep rate) mode. Sampling more than one input signal will effectively slow the digitizing rate.

3. Data Transfer Time

The third factor is the time it takes to move the data from one instrument to another. This time includes two major parameters; the number of bytes that are transferred, and the time it takes to transfer each byte.

The number of bytes transferred depends on the message being transferred (number of characters) and the message's data format (e.g., ASCII or binary). The transfer rate is dependent upon the capability of the slowest device addressed on the GPIB bus (see Fig. 3-24), or just the data transfer rate of the 11401/11402 and the other connected device for RS-232-C transfers.

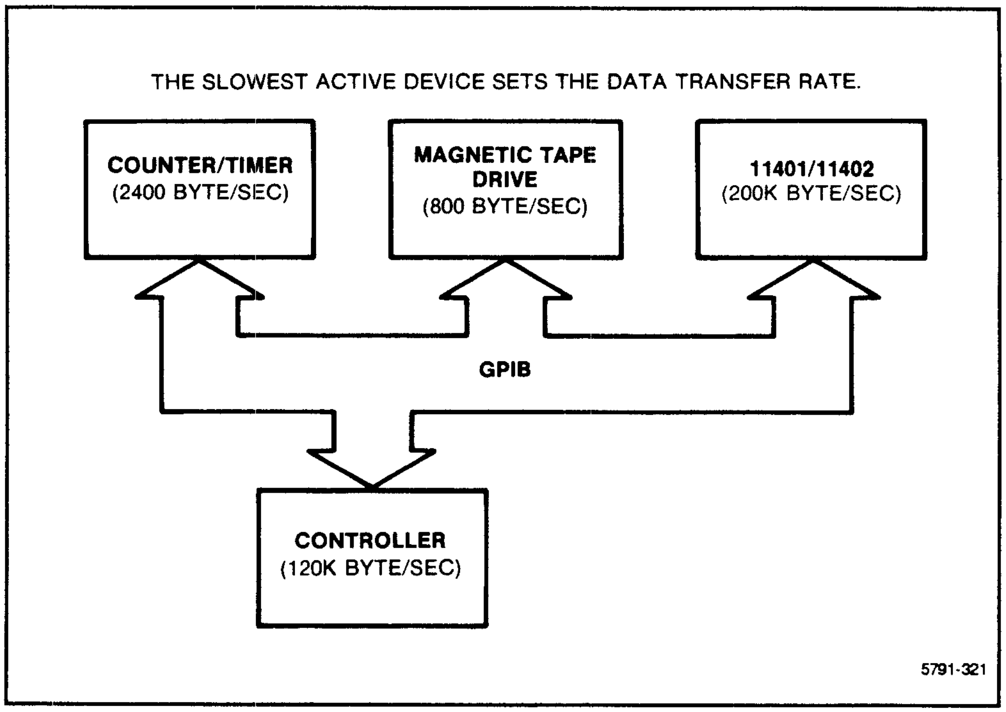

Figure 3-24. System limitations on data transfer rates.

Understanding the processing of GPIB and RS-232-C I/O (input and output) statements is the key to estimating data transfer times.

The execution of GPIB I/O statements consists of five parts: statement overhead, buffer overhead, addressing sequence, data overhead and unaddressing sequence (see Fig. 3-25).

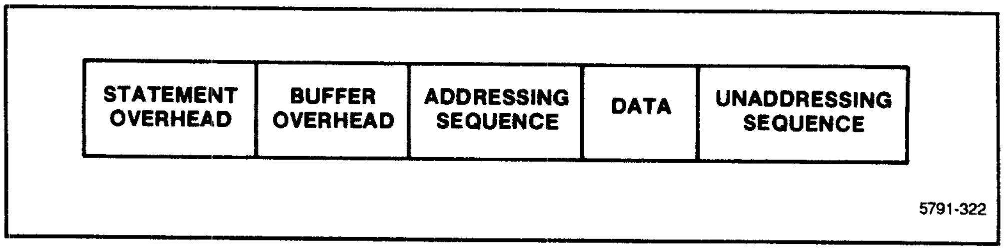

Figure 3-25. Data transfer time components.

These events occur in different order, depending on whether you are dealing with an input or an output operation (see Fig. 3-26).

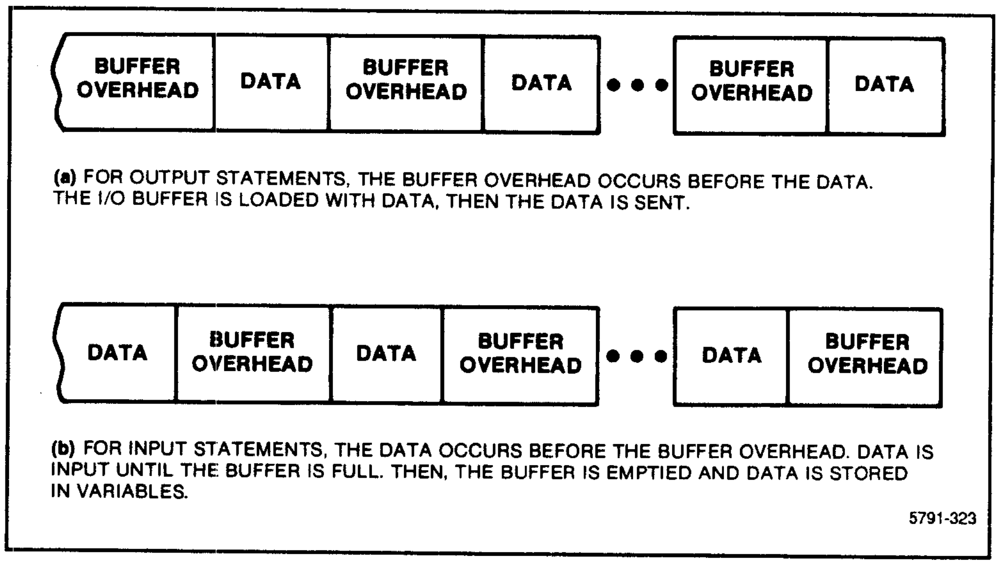

Figure 3-26. Data input and output operations.

For example, statement overhead is the first processing performed when an output statement is executed (see Fig. 3-25). It consists of the time it takes to evaluate the statement's I/O functions and other expressions, and then the statement clauses (11401/11402 commands).

Next, the output statement's data I/O path is setup, and an output buffer is allocated.

The time required to fill or empty the buffer is the buffer overhead. The time required for buffer overhead depends on the amount of data in the I/O buffer and the type of data; string or numeric; ASCII or binary.

The addressing sequence is the first activity on the interface bus. During this period, the 11401/11402 is talk or listen addressed. This time period is dependent upon the data handshaking rate of the slowest device connected to the bus.

The data overhead is the time when device-dependent data is actually being transferred between the 11401/11402 and another device. Again, this time is dependent on the data transfer rate of the slowest device on the bus, and the amount and type (e.g., numeric arrays are a little faster than an equivalent number of scalar variables) of data being transferred. This includes the spaces and formatting characters (i.e., EOI, EOM, etc.) for each message. The total data burst time is the number of bytes being transferred divided by the data transfer rate (in bytes/second).

At the end of the data transfer messages, the controller will usually perform an unaddressing sequence that untalks and unlistens all instruments on the GPIB to assure a clear bus for the next transfer. This usually consists of the controller sending the untalk and unlisten addresses for each instrument on the bus.

The execution of RS-232-C I/O statements consists of five parts, somewhat similar to the GPIB. The parts are statement overhead, buffer overhead, start message, data overhead and stop message.

The RS-232-C statement and buffer overhead consists of the same elements as the GPIB.

The start and stop message time consists of the start bit and the stop bit(s).

The data overhead time has similar components to the GPIB, except only a sender and one receiver's data transmission rates are pertinent.

However, since the data is sent in serial fashion over the interface, there is additional time required to convert information from serial-to-parallel, for input data, and from parallel-to-serial, for output data (see Fig. 3-27). Hence, RS-232-C throughput tends to be less than for GPIB communication.

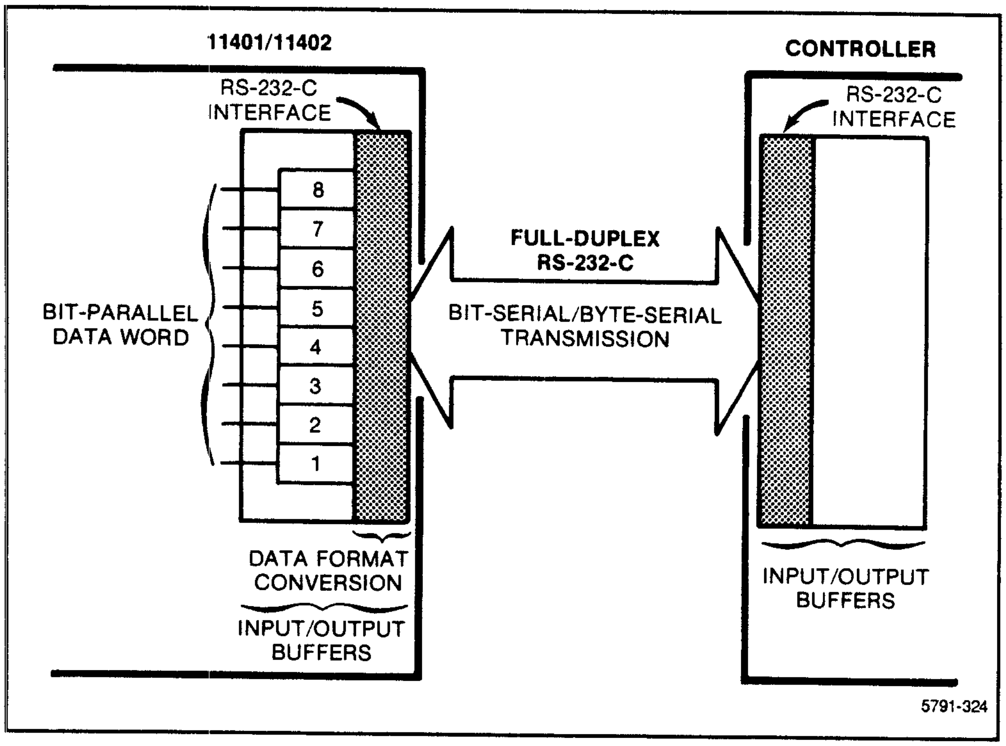

Figure 3-27. 11401 RS-232-C data transfer.

4. Data Processing Time

The fourth factor is the time required to manipulate the acquired data to obtain a desired result.

The processing time is comprised of the time it takes the 11401/11402 to manipulate the data, plus whatever time is required by the controller to further process the data (if any). The 11401/11402 can deliver raw, semi-processed, or even completely processed data, depending upon the requirements of the application. The processing speed of the 11401/11402 is dependent upon the type or complexity of operation or task that is being performed, and the programming language used (high-level vs low-level).

Since processing time is difficult to estimate, often, the only practical way to estimate it is by direct measurement. The real-time clock in the user's controller can be used for timing such measurements.

5. Human Interaction Time

The fifth major factor is determined by whatever operator intervention is required to enter test parameters, or to make adjustments to a device-under-test (DUT).

This factor can easily become the largest part of a system's total operating time. Direct measurement of this parameter is the best method of determining what your overhead time is.

Optimizing System Performance Factors

Instrument Setup

The key to improving instrument setup time is to either reduce the number of setting changes or reduce the time required for the instrument to execute the setting changes. The following suggestions can help you optimize your setup time:

1. Group the tests that use common settings.
2. Set your ranges explicitly. Generally, autoranging (AUTOSET command) takes more time.
3. Set up instruments that require more settling time first. While they're settling, you can be setting up other devices.
4. Use internal setting storage. Resetting takes more time.
5. Use low-level (i.e., low byte count and less complex) commands if they're provided. For example, set LONGFORM OFF for abbreviated responses to queries. This can significantly reduce your byte count.

Data Acquisition

Reducing data acquisition time requires careful attention to the detail in setting up the acquisition. The following suggestions should be helpful:

1. Faster digitizing can be achieved by increasing the repetition rate of the input signal (if possible), or by decreasing the sweep speed (if time resolution isn't critical).
2. Use an operation-complete SRQ interrupt instead of waiting on the acquisition to finish, thus you can continue processing.

Data Transfer

Two major areas of improvement can be addressed for optimizing data transfer time. The first is to the system configuration, and the second is to the programs that control the transfer.

The following suggestions are for optimizing the system configuration:

1. Choose instruments that have an optimum transfer rate, as near to the bus capacity as possible.

2. If your controller has more than one GPIB port, use frequently interacting devices on one bus, or put faster devices together on one bus.

3. Use direct-memory access (DMA) transfers whenever possible, and keep the faster instruments on this bus.

4. Be sure to unaddress slow devices when they're not required in the transfer.

5. Again, if you have two ports, put a device-under-test (DUT) on one bus, and the test equipment on the other bus. Then, if the DUT has an error or malfunction, it won't affect the test equipment.

The following suggestions are for optimizing transfer program parameters:

1. Choose the most efficient I/O statements that your controller provides. In most cases, high-level commands are fastest, except where long strings are encountered. Then use low-level transfer commands (if provided).

2. Minimize bus traffic by reducing the number of bytes being sent. This can be done by abbreviating command names, deleting unnecessary spaces, and omitting unnecessary zeros.

3. Minimize buffer overhead. This can be done by defining buffer size (usually possible for most controllers) to accommodate the entire data transfer. You may also store the data within a string variable. That's because string variables store data directly from the I/O buffer, thus reducing overhead time.

4. Use binary block data transfers, if possible. Binary data is a little more complicated to handle than ASCII data, but binary transfers tend to be much faster since they involve fewer bytes than an equivalent ASCII transfer.

Data Processing

Faster data processing times are a result of faster algorithms and distributed processing. The following suggestions should prove helpful:

1. Evaluate your choice of algorithms to assure the most efficient operations for the application and system configuration you have.

2. Use implied array operations instead of FOR loops in your controller programs. This allows numeric operations to be performed much faster. The implied array operation creates temporary arrays to perform the implicit operation (e.g., add a scalar to the array) rather than an element-by-element operation.

3. Select the data type carefully for your controller programs. Decide whether integer, short floating-point, or long floating-point operations can be done together, rather than doing mixed-mode operations that require conversion from one format to another. This takes additional time.

4. Evaluate your measurement needs to identify what data processing is most effectively done by which device. In other words, should the 11401/11402 perform a given function on a waveform, or perhaps the controller is better suited to quickly perform a given function.

Human Interaction

Human interaction can be the hardest component of system performance to improve. The best advice is to avoid human interaction as much as possible. However, the following suggestions should be helpful whenever interaction is required.

1. Use programmable interfaces and switches to route signal connections wherever possible. This would include programmable relay scanners, multi-function interfaces, and signal multiplexers.

2. Keep the user interface as simple as possible. The 11401/11402 is especially designed for this purpose. User menus are quick and easy to use, so you can make changes fast. There is also a soft keypad for convenient setting changes. There are also complete error message and interrupt facilities, plus debug capability to help pin-point trouble areas quickly.

Optimizing Performance

The following describes the specific optimizations that increase 11401/11402 RS-232-C GPIB performance (optimizations are listed in no particular order of importance and not all optimizations apply to all applications):

- Purchase the GPIB DMA (refer to Section 5 "Instrument Options", Option 4D). The DMA significantly increases GPIB throughput when 11401/11402 transfers binary data to an external controller (i.e. binary waveform or settings data). The DMA also increases GPIB throughput for ASCII data transferred to an external controller, but the performance improvement is not as large.

  The GPIB DMA has no effect on RS-232-C throughput.

- Turn MSYS OFF. If RS-232-C/GPIB efficiency is of paramount concern, never execute with MSYS ON.

- Set PATH OFF. This action decreases the amount of data transmitted from the 11401/11402 to anexternal controller and slightly decreases the instrument's internal execution overhead.

- If a particular set command and/or query is repetitively transmitted to the 11401/11402, encode that set/query as a logical name (via the DEF command) and send the logical name instead of the set/query. Assuming the logical name is shorter than the set/query sequence, the following advantages are realized:

  - GPIB/RS-232-C interface traffic is reduced.

  - GPIB/RS-232-C controller execution overhead is reduced.

  - 11401/11402 execution overhead is reduced since fewer data input interrupts are processed.

- With regard to measurements, keep waveform record lengths at the minimum possible value. With the exception of the TTRIG measurement, measurement efficiency is inversely proportional to record length.

  If long record lengths cannot be avoided, it is still possible to optimize measure ment performance by shrinking the left and right measurement zones to include only the waveform data of interest. Better performance is obtained when fewer data points are included between the left and right zones.

- When working with the conditional acquisition of averaged or enveloped wave forms (CONDACQ TYPE: {AVG | ENV}), minimize the total number of averages or envelopes necessary for a given application.

- When working with settings and waveform data, binary data formats are trans ferred to and from the 11401/11402 in considerably less time than the corresponding ASCII data formats.

- When transferring binary waveform data from 11401/11402 to an external controller, BYT. OR LSB generate the fastest transfer rates. Of course, if the external controller's memory architecture is designed for MSB data, LSB may not be desirable.

- If an application makes more than one measurement, use MSLIST and MEAS? query as opposed to individual <meas>? queries since multiple <meas>? queries require the instrument to compute multiple waveform histograms. However, MEAS? query computes one histogram for the entire measurement list.

  Input: MSLIST MEAN, RMS, FREQ; MEAS?
  Not : MEAN?; RMS?; FREQ?

- The fastest method of creating an averaged or enveloped trace is to include the AVG()/ENV() function within a trace description.

  Input: TRACE1 DESCRIPTION: "AVG(L1)"
  Not : TRACE1 DESCRIPTION: "L1"; AVG ON

  Input: TRACE1 DESCRIPTION: "ENV (L1)"
  Not : TRACE1 DESCRIPTION: "L1"; ENV ON

- When you are executing GPIB applications, configure the11401/11402 for operation in EOI termination mode (not the EOI/LF termination mode) since EOI/LF requires more input data checking by the 11401/11402. If your GPIB controller is incapable of asserting EOI with the last byte of every message transmitted to the 11401/11402, or if your controller requires that a linefeed be appended to every message transmitted from the 11401/11402 to the controller, this optimization is inappropriate.

- When sending TEXT to the 11401/11402 display, send as much data as possible within one quoted string.

  Input: TEXT X:3, STRING: "Test No. 10"
  Not : TEXT X:3, STRING: "Test", X:9, "No. 10"

- If your application doesn't need floating point waveforms, don't use them (i.e., set WFMSCALING OPTIONAL).

- Don't use AUTOLEVEL triggering if your application doesn't require it (since AUTOLEVEL uses a trigger search to maintain a specified trigger lever). Any change to vertical or horizontal waveform parameters has the potential to activate the trigger search, which diminishes set command throughput until a new trigger is found.

- Don't use triggered windows (i.e., set WTMODE MAIN) if your applications don't require them (since triggered windows force periodic updates of all window positions). These updates, which do not occur when WTMODE is MAIN, diminish set command throughput.

- If front-panel updates are unimportant, set FPUPDATE to NEVER at the beginning of you application. Executing with FPUPDATE NEVER dramatically increases set command throughput.

  To restore front-panel updates at the end of your application, set FPUPDATE OFF.

- If your application cannot execute without front-panel updates, the following actions minimize the total number of updates that occur:

  - Set FPUPDATE OFF (avoid using FPUPDATE ON).

  - At the beginning of the application, execute this command sequence:

    INIT; ABSTOUCH 11,0

  The above sequence places the BLANK major menu on the 11401/11402 display. When the BLANK major menu is displayed the overhead associated with front-panel updates is greatly reduced.

  - Use semicolons to concatenate as many set commands together as practical.

```
Input: INIT;MSLIST PP, RMS; AUTOSET START <EOI>
Not  : INIT <EOI>
       MSLIST PP, RMS <EOI>
       AUTOSET START <EOI>
```

  When FPUPDATE is OFF, each EOI-terminated set command triggers a front-panel update (assuming the ET GPIB/RS-232 input buffers are empty).

Specifications

This section contains the performance, electrical, environmental, and physical characteristics of the 11401/11402 Digitizing Oscilloscopes.

The 11401 and 11402 Vertical System Specifications are also included in this section.

Contents

Specifications

The performance and electrical characteristics listed in Table 4-1 and Table 4-2 apply when the following conditions are met: (1) Adjustment of the instrument must have taken place at an ambient temperature between +18° and +28° C, (2) the instrument is allowed a 20-minute warmup period, (3) specifications are valid at an ambient temperature of 0° to 50° C, unless otherwise stated, (4) the instrument must be in an environment that meets the limits described in Table 4-8.

The 11401/11402 Vertical System specifications are listed in Tables 4-3 through 4-7.

Environmental characteristics are listed in Table 4-8 and physical characteristics are listed in Table 4-9.

Mainframe Performance Characteristics and Electrical Specifications

TABLE 4-1
Performance Characteristics

Characteristic	Performance Requirement
VERTICAL SYSTEM	
Acquisition Sources	The signals from the Left, Center, and Right compartments may be acquired.
Equivalent Time Bandwidth: System	Depends on plug-in amplifier. Refer to Table 4-2, 11401/11402 System Bandwidth, for specification valid over the full operating environmental conditions.
Equivalent Time Step Response	
Risetime: System	Depends on Plug-in amplifier. Refer to Table 4-2, 11401/11402 System Bandwidth/Risetime, for specification valid over the full operating environmental conditions. The advertised rise times are calculated from bandwidth (tr=0.35/BW), not measured.
Acquisition Window	Full Scale = ±5.10 divisions. Typically, the graticule area overlaps the acquisition window one for one.

TABLE 4-1 (cont)
Performance Characteristics

Characteristic	Performance Requirement
VERTICAL SYSTEM (cont)	
Vertical Acquisition/Display Resolution Mapping	
One Graticule	100 acquired points per division, 50 displayed pixels per division.
Two Graticules	100 acquired points per division, 25 displayed pixels per division.
Enhanced Accuracy	Also see Tables 4-4 through 4-7.
Warmup	Warmup occurs for the first 20 minutes following power-on. Accuracy is not specified during warmup.
Enhanced	Enhanced Accuracy follows the Self-Test warmup period, and can be initiated either by pressing the ENHANCED ACCURACY button on the front panel. Or, the user can select the Enhanced Accuracy to occur automatically. Enhanced Accuracy can also be invoked over the GPIB or RS-232-C. The Enhanced Accuracy state is indicated by an EA symbol on the screen. If the instrument is in the Enhanced Accuracy state when turned OFF, the instrument will return to the Enhanced Accuracy state following the next power-on and warmup, providing the configuration remains the same and the temperature returns to within 5° C of the previous temperature.

TABLE 4-1 (cont)
Performance Characteristics

Characteristic	Performance Requirement
VERTICAL SYSTEM (cont)	
Not-Enhanced	A change in the instrument temperature of 5° C from the startup temperature will cause the Enhanced Accuracy state to lapse to not-enhanced. The not-enhanced accuracy state is typically one-half that of the Enhanced Accuracy state. That is, to determine the typical not-enhanced accuracy multiply the Enhanced Accuracy figure by 2.
New Configuration	After a new plug-in is installed in the instrument, the oscilloscope system accuracy is not specified until the Enhanced Accuracy Self-Test is performed on this New Configuration, after warmup.

TABLE 4-1 (cont)
Performance Characteristics

Characteristic	Performance Requirement
SAMPLER AND DIGITIZER	
Internal Clock	Crystal-controlled reference oscillator.
A/D Converter	Two-stage flash converter with 10-bit resolution.
Sample Rate Selection	Sample intervals are internally determineed based upon the number of active plug-in signals, the Record Length, and Record Duration. Actual sample interval will always be an integer multiple of 50 ns. Equivalent time sampling allows the effective sample intervals to be as small as 10 ps.
Record Lengths	Standard Record Lengths follow a 1-2-5 sequence and fill ~102% of the 10-division display graticule. The standard Record Lengths are 512, 1024, 2048, 5120, and 10240 points. In addition, two binary Record Lengths may be selected, 4096 and 8192 points. These binary Record Lengths fill only~82% of the display graticule area.
Digitizer Memory	Standard acquisition memory is 16k words. This allows a single 10240-point record to be acquired single shot.

TABLE 4-1 (cont)
Performance Characteristics

Characteristic	Performance Requirement
TIME BASE	
Sample Rate	
Single Channel	Any single channel from the Left, Center, or Right compartment may be acquired at a maximum sample rate of up to (20 Msample/second).
Two Channel	Any combination of two channels from Left, Center, or Right compartment may be acquired at a sample rate of up to 5 Msample/second.
Three Channel	Any combination of three channels from Left, Center, or Right compartments may be acquired at up to a sample rate of 2.5 Msample/second.
Simultaneous Sampling	Three signals, one from each of the three plug-in compartments, are sampled simultaneously.
Record Interval (Effective Sample Interval)	10 ps to 2 s (as determined by Record Duration and Record Length) in a 1-2-5 sequence.
Record Duration	5.11 ns to 1023 s. Time per division is 0.5 ns to 100 s, in a 1-2-5 sequence.

TABLE 4-1 (cont)
Performance Characteristics

Characteristic	Performance Requirement
TRIGGER	
Trigger Sources	Two independent trigger circuits, Main and Window, can derive their triggers from the Left, Center, or Right plug-in compartments. Main and Window triggers may have the same source or independent sources. The trigger sources may be fixed on any given channels. Main may also be triggered from the ac line.
Trigger Modes	
Auto	Auto triggering will occur if approximately 60 ms elapses from the last trigger event. Main only.
Normal	Triggering will occur upon valid trigger events only.
Auto Level	Automatically establishes the level for the trigger source. A new trigger level is searched such that triggering may occur if 60 ms elapses from the last trigger event. The Main time base free runs in the absence of a triggering signal.
Trigger Level	The trigger level and slope can be set independently for the Main and Window triggers.
Range	±Full Scale.
Resolution	0.1% of full scale.
Hysteresis	Either Normal or Noise-Reject may be selected. Trigger Sensitivity is altered by this selection.

TABLE 4-1 (cont)
Performance Characteristics

Characteristic	Performance Requirement
TRIGGER (cont)	
Trigger Coupling and Sensitivity	For each coupling configuration, the minimum peak-peak signal amplitude required for stable triggering.
Holdoff	Holdoff is the calibrated time during which no trigger events can be accepted.
Minimum Holdoff	
Main	500 ns or less.
Window	20 ns or less.
Maximum Holdoff	
Main	10 seconds.
Window	1024 seconds.
Minimum Resolution (Main and Window)	Holdoff can be set in 500 ps increments.

TABLE 4-1 (cont)
Performance Characteristics

Characteristic	Performance Requirement
TRIGGER (cont)	
Main Record Positioning	Position of the Main Record with respect to the trigger point of the Main Record.
Pre-trigger	The maximum amount of pre-trigger is the duration of the Main Record.
Post-trigger	The maximum amount of post-trigger is the duration of the Main Record.
Resolution	One Main Record point.
Windows	In addition to the Main Record, one or two Window Records may be acquired and displayed. The Window Records may be of a different record length and may have a smaller time/division than the Main Record. However, if two Window Records are acquired they must have the same record length and Time/division.
Windowed Record Positioning	Window Records are positioned relative to their common Trigger Point, and may be positioned relative to the Main Record's trigger point.
Window Position Range (No holdoff)	Relative to the Main Record trigger point, negative position equal to the time between the main trigger point and the beginning of the Main Record plus the Window duration (Main Position – Window Duration), to a positive position equal to the time between the Main Record trigger point and the end of the Main Record (Main duration + Main Position).
Window Position Resolution	One Window Record Sample interval.
Window Position Range	Relative to the Main Record trigger point, negative position equal to the time between the trigger and the beginning of the Main Record, to a positive position equal to the time between the Main Record trigger and the end of the Main Record.

TABLE 4-1 (cont)
Performance Characteristics

Characteristic	Performance Requirement
TRIGGER (cont)	
Windowed Record Pos (cont)	
Window Position Range (Holdoff by Time)	Relative to the Window Record trigger point, negative position equal to the time between the Window Holdoff time and the beginning of the Main Record plus the Window duration [–(Window Holdoff – Main Position + Window Duration)], to a positive position equal to the time between the Window Holdoff and the end of the Main Record [Main Duration + Main Position – Window Holdoff].
Pre-Trigger	The maximum amount of pre-trigger occurs when the Window Record is positioned to the beginning of the Main Record.
Post-Trigger	The maximum amount of post-trigger occurs when the Window Record is positioned to the end of the Main Record.
Window Position Resolution	One Window Record sample interval.
Window Position Range	Relative to the Window Record trigger point, negative position equal to the time between the window trigger and the beginning of the Main Record, to a positive position equal to the time between the Window Record trigger and the end of the Main Record.
Measured Window Position Readout	The time between the Main Record trigger and the Window Record trigger is numerically displayable with up to 50 ps resolution. This time is equal to the set Window Holdoff Time plus the time between the expiration of the Window Holdoff to the Window Record trigger.

TABLE 4-1 (cont)
Performance Characteristics

Characteristic	Performance Requirement
TRIGGER (cont)	
Windowed Record Pos (cont)	
Window Position Range (Holdoff by Events)	Relative to the Window Record trigger point, negative position equal to the time between the main trigger point and the beginning of the Main Record plus the window Duration (Main Position – Window Duration), to a positive position equal to the time between the Main Record trigger point and the end of the Main Record (Main Duration + Main Position).
Pre-Trigger	The maximum amount of pre-trigger occurs when the Window Record is positioned to the beginning of the Main Record.
Post-Trigger	The maximum amount of post-trigger occurs when the Window Record is positioned to the end of the Main Record.
Event Source	Same as the Window trigger source.
Maximum Event Count	1 billion events.
Measured Window Position Readout	The time between the Main Record trigger and the Window Record trigger (corresponding to the nth event) is numerically displayable with up to 50 ps resolution.
Precision Time Measurement	The time between the Main trigger and the Window trigger can be measured precisely, even with a single trigger event. Repetitive events can be averaged for more accuracy.
Time Interval Range	20 ns to 1000 s.

TABLE 4-1 (cont)
Performance Characteristics

Characteristic	Performance Requirement
DISPLAY	
CRT	9-inch diagonal, monochrome, magnetic deflection crt. Vertical raster orientation. Nominal screen size of 6.16 inches vertically by 4.80 inches horizontally.
Phosphor	P31.
Video Resolution	552 horizontal by 704 vertical displayed pixels.
Character Display	Character cell is 10 (H) by 16 (V) pixels.
Character Matrix	55 columns by 44 lines.
Character Height	Minimum character height is 0.10 inch (upper case).
Waveform Display	
Graticule Area	Graticule characteristics determined by firmware.
Display Calibration	
Vertical Scale	The Vertical Scale is normally calibrated in volts per division. The range of volts/ div will depend upon the specific plug-in installed. Special purpose plug-ins may use a different scale factor such as Amps/div.
Horizontal Scale	The Horizontal Scale is normally calibrated in Time per division. The digitizer time base will support Time/div from 500 ps to 100 seconds. If an X-Y waveform is displayed, the Horizontal Scale may take on dimensions similar to the Vertical Scale.

TABLE 4-1 (cont)
Performance Characteristics

Characteristic	Performance Requirement
INPUTS AND OUTPUTS	
Human Interface	
Touch Panel	A matrix of 22 rows by 11 columns across the face of the crt correspond to illuminated nomenclature and objects displayed on the crt. Touching the crt with a finger or similar object interrupts an infrared beam and activates the selected function.
Knobs	The functions of two rotating knobs depend upon the specific mode of operation of the mainframe. The knob functions are labeled on the crt, with the minimum and maximum limits shown in the **Numeric Entry and Knob Res** pop-up menu.
Electrical Outputs	Calibrator Output bnc and Probe hook driven only at calibration time (Utility major menu, **Probes** pop-up menu.)
Probe Calibration	
Output Voltage	Provides up to ±10 V used in calibrating dc gain of probes.

TABLE 4-1 (cont)
Performance Characteristics

Characteristic	Performance Requirement
POWER	
AC Line Power	
Voltage	Selected by rear-panel LINE VOLTAGE SELECTOR. Voltage ranges apply for waveform distortion which reduces the peak line voltage 5% below the true peak sine wave value.
Fuse Rating	6 A, 250 V, normal blow.

TABLE 4-2
Electrical Specifications

Characteristic	Performance Requirement
SAMPLER AND DIGITIZER	
A/D Converter	
Linearity	Measured with Signal Averaging enabled. Compression or expansion of a center screen 2-division signal positioned anywhere vertically within the graticule ≤ 2 LSBs. (2 LSBs of 200 LSBs=1%)
TIME BASE	
Sample Rate Accuracy	100 ps+0.002% of measurement interval.
TRIGGER	
Trigger Coupling and Sensitivity	
DC Coupled	0.50 division from dc to 50 MHz, increasing to 1.5 division at 500 MHz.
Noise-Reject Coupled	1.2 divisions or less from dc to 50 MHz, increasing to 3 divisions at 500 MHz.
AC Coupled	0.5 divisions from 60 Hz to 50 MHz increasing to 1.5 division at 500 Mhz.
HF REJ Coupled	0.65 divisions from dc to 30 kHz
LF Rej Coupled	0.65 divisions from 80 kHz to 50 MHz, increasing to 1.5 division at 500 MHz.
Windowed Record Positioning	
Window Position Accuracy	100 ps +0.002% of position
Maxium Event Frequency	150 MHz.
Precision Time Measurement	
Single-Trigger Precision	200 ps (10 ps with 1000 averages)
Accuracy	250 ps +0.002% of measurement interval when > 6 div signal, < 3 ns risetime, and measured at the 50% signal point.

TABLE 4-2 (cont)
Electrical Specifications

Characteristic	Performance Requirement
POWER	
AC Line Power	
Ranges	90 to 132 V rms 180 to 250 V rms.
Line Frequency	48 Hz to 440 Hz.
Power Consumption	320 W maximum.
Line Current (Max)	4.6 A rms at 50 Hz, 90 V line, with 5% clipping.

VERTICAL SYSTEM SPECIFICATIONS

The overall system bandwidth and rise time specifications for the 11401/11402 mainframes, combined with the currently available plug-ins, are shown in Table 4-3. Tables 4-4 through 4-7 list deflection factor and offset accuracy specifications for each plug-in and recommended probe.

TABLE 4-3
11401/11402 System Bandwidth/Calculated Risetime[1]

Plug-in	Vertical Sensitivity	11401 Mainframe	11402 Mainframe
11A32	≥10mV/div	350 MHz/1.0ns	400 MHz/0.9ns
	5mV-9.95mV/div	300 MHz/1.2ns	350 MHz/1.0ns
	2mV-4.98mV/div	250 MHz/1.4ns	250 MHz/1.4ns
	1mV-1.99mV/div	200 MHz/1.8ns	200 MHz/1.8ns
11A33	2mV - 10 V/div	150 MHz/2.3ns	150MHz/2.3ns
	1mV - 1.99 mV	120 MHz/2.9ns	120 MHz/2.9ns
11A34	≥10mV/div	300 MHz/1.2ns	300 MHz/1.2ns
	5mV-9.95mV/div	250 MHz/1.4ns	250 MHz/1.4ns
	2mV-4.98mV/div	200 MHz/1.8ns	200 MHz/1.8ns
	1mV-1.99mV/div	150 MHz/2.3ns	150 MHz/2.3ns
11A52	≥10mV/div	500 MHz/0.7ns	600 MHz/0.6ns
	5mV-9.95mV/div	350 MHz/1.0ns	400 MHz/0.9ns
	2mV-4.98mV/div	250 MHz/1.4ns	250 MHz/1.4ns
	1mV-1.99mV/div	200 MHz/1.8ns	200 MHz/1.8ns
11A71	all V/div	500 MHz/0.7ns	1000 MHz/0.35ns

[1]Rise time calculated =0.35/Bandwidth.

TABLE 4-4
11A32/11A34 Enhanced DC Accuracy[1], Either Polarity
(with the 11401/11402 Mainframe)

Without Probes

Deflection Factor	ΔV DC Accuracy	DC Balance	DC Offset Accuracy
1mV to 99.5mV/div	±(0.9% + 0.012div)	±(1mV + 0.10div)	±(0.20% + 0.5mV)
100mV/div to 995mV/div	±(0.9% + 0.012div)	±(10mV + 0.10div)	±(0.25% + 5mV)
1V/div to 10V/div	±(0.9% + 0.012div)	±(100mV + 0.10div)	±(0.25% + 50mV)

With P6134 10X Probe calibrated from 11401/11402 Calibrator output

Deflection Factor	ΔV DC Accuracy	DC Balance	DC Offset Accuracy
10mV/div to 995mV/div	±(0.9% + 0.012div)	±(7mV + 0.10div)	±(0.25% + 5mV)
1V/div to 9.95V/div	±(0.9% + 0.012div)	±(70mV + 0.10div)	±(0.25% + 50mV)
10V/div to 100V/div	±(0.9% + 0.012div)	±(0.7V + 0.10div)	±(0.25% + 0.5V)
Probe Tip TC term	100ppm/°C		

With P6231 10X Probe calibrated from 11401/11402 Calibrator output

Deflection Factor	ΔV DC Accuracy	DC Balance	DC Offset Accuracy
10mV/div to 995mV/div)	±(1.0% + 0.012 div)	±(5mV + 0.10div)	±(0.2% + 2mV)
≥1V/div	±(1.0% + 0.012 div)	±(50mV + 0.10div)	±(0.2% + 2mV)
Probe Tip TC term	100ppm/°C		

[1]For absolute dc accuracy of single-point measurements using Offset, add the DC Offset Accuracy, DC Balance, and ΔV DC Accuracy terms. Apply the ΔV DC Accuracy only to the difference between the graticule center setting and the measurement point.

TABLE 4-5
11A33 Enhanced DC Accuracy[1], Either Polarity

Without Probes

Volts/Div	ΔV DC Accuracy	DC Balance	DC Offset Accuracy	VC Accuracy
1mV to 99.5mV	±(0.9% + 0.01div)	±(0.5m V+ 0.10div)	±(0.25% + 0.7m V)	±(0.15% + 0.6m V)
100mV to 995mV	±(0.9% + 0.01div)	±(5m V+ 0.10div)	±(0.30% + 7m V)	±(0.20% + 6m V)
1V to 10 V	±(0.9% + 0.01div)	±(50m V+ 0.10div)	±(0.30% + 70m V)	±(0.20% + 60m V)

With P6135 Probe Set calibrated from 11401/11402 Calibrator output

Volts/Div	DC Accuracy	DC Balance	DC Offset Accuracy	VC Accuracy
10mV to 995mV	±(0.9% + 0.01div)	±(5.0m V+ 0.10div)	±(0.30% + 7mV)	±(0.20% + 6m V)
1V to 9.95V	±(0.9% + 0.01div)	±(50m V + 0.10div)	±(0.30% + 70m V)	±(0.20% + 60m V)
10V to 100V	±(0.9% + 0.01div)	±(0.5V + 0.10div)	±(0.30% + 0.7V)	±(0.20% + 0.6m V)
Probe Tip TC term	100ppm/°C	na	na	na

With One P6231 Probe calibrated from 11401/11402 Calibrator output

Volts/Div	DC Accuracy	DC Balance	DC Offset Accuracy	VC Accuracy
10mV to 995mV	±(1.0% + 0.01div)	±(5m V+ 0.10div)	±(0.30% + 7mV)	±(0.20% + 6.0m V)
≥1V	±(1.0% + 0.01div)	±(50m V + 0.10div)	±(0.30% + 70m V)	±(0.20% + 60.0m V)
Probe Tip TC term	100ppm/°C			

With One P6231 Probe calibrated from 11401/11402 Calibrator output

Volts/Div	Probe Offset Accuracy
10mV to 995mV	±(0.20% + 2.0m V)
≥1V	±(0.20% + 2.0m V)

[1]For absolute dc accuracy of single-point measurements using Offset, add the DC Offset Accuracy, DC Balance, and ΔV DC Accuracy terms. Apply the ΔV DC Accuracy only to the difference between the graticule center setting and the measurement point.

TABLE 4-6
11A52 Enhanced DC Accuracy[1], Either Polarity
(with the 11401/11402 Mainframes)

Without Probes

Deflection Factor	ΔV DC Accuracy	DC Balance	DC Offset Accuracy
1mV/div to 99.5mV/div	±(0.8% + 0.01div)	±(0.2mV + 0.10div)	±(0.15% + 0.4mV)
100mV/div to 995mV/div	±(0.8% + 0.01div)	±(2mV + 0.10 div)	±(0.20% + 4mV)
1V/div to 10V/div	±(0.8% + 0.01div)	±(20mV + 0.10div)	±(0.20% + 40mV)

With P6231 10X Probe calibrated from 11401/11402 Calibrator output

Deflection Factor	ΔV DC Accuracy	DC Balance	DC Offset Accuracy
10mV/div to 995mV/div	±(0.9% + 0.01div)	±(2mV + 0.10div)	±(0.15% + 2mV)
≥1V/div	±(1.0% + 0.01div)	±(20mV + 0.10div)	±(0.15% + 2mV)
Probe Tip TC term	100ppm/°C		

[1]For Absolute dc accuracy of single-point measurements using Offset, add the DC Offset Accuracy, DC Balance, and ΔV DC Accuracy terms. Apply the ΔV DC Accuracy only to the difference between the graticule center setting and the measurement point.

TABLE 4-7
11A71 Enhanced DC Accuracy[1], Either Polarity
(with the 11401/11402 Mainframes)

Without Probes

Deflection Factor	ΔV DC Accuracy	DC Balance	DC Offset Accuracy
10mV/div to 1V/div	±(0.7% + 0.03div)	±0.2div	±(0.40% + 0.01div)

With P6231 10X Probe calibrated from 11401/11402 Calibrator output

Deflection Factor	ΔV DC Accuracy	DC Balance	DC Offset Accuracy
100mV/div to 1V/div	±(1.4% + 0.03div)	±0.2div	±(0.15% + 2mV)
Probe Tip TC term	100ppm/°C		

[1]For absolute dc accuracy of single-point measurements using Offset, add the DC Offset Accuracy, DC Balance, and ΔV DC Accuracy terms. Apply the ΔV DC Accuracy only to the difference between the graticule center setting of 0.0 and the measurement point.

Environmental and Physical Characteristics

TABLE 4-8
Environmental Characteristics

Characteristics	Information
Temperature (External Ambient)	
Operating	0° to +50° C.
Nonoperating	–40° to +75° C.
Operating and Nonoperating	Meets MIL-T-28800C, Type III, Class 5, tested per paragraph 4.5.5.1.3.and 4.5.5.1.4. **NOTE** *Loss of non-volatile memory and clock information may occur if temperature goes below 40°C.*
Humidity	
Operating and Nonoperating	Up to 95% Relative Humidity, at up to +50° C. Exceeds MIL-T-28800C, Type III, Class 5, tested per paragraph 4.5.5.1.2.2. (5 days humidity with temperature cycling.)
Altitude	
Operating	To 4.5 km (15,000 ft).
Nonoperating	To 15 km (50,000 ft).
Operating and Nonoperating	Meets MIL-T-28800C, Type III, Class 5.
Vibration	
Operating, Plug-ins not installed in Mainframe	0.015 inches total displacement from 10 Hz to 55 Hz, 75 minutes total. Meets MIL-T-28800C, Sec. 4.5.5.3.1, Type III, Class 5.

TABLE 4-8 (cont)
Environmental Characteristics

Characteristics	Information
Shock	
Nonoperating, Plug-ins not installed in Mainframe.	30 g's, half sine, 11 ms duration, 18 shocks total. Meets MIL-T-28800C, Sec. 4.5.5.4.1, Type III, Class 5, Equipment not operating.
Bench Handling	
Operating, Plug-ins installed or not installed	Drop from 10 cm (4 inch) tilt, or 45°, whichever is less. (Tilt not to exceed balance point.) Meets MIL-T-28800C, Sec. 4.5.5.4.3, Type III, Class 5.
Packaged Product Vibration and Shock	
Vibration and Bounce of Packaged Product, Plug-ins not installed.	Meets ASTM D999-75, Method A, Para. 3.1, (NSTA Proj. 1A-B-1).
Drop of Packaged Product, Plug-ins not installed.	Meets ASTM D775-61, Method 1, Para 5. (NSTA Proj. 1A-B-2).
Electromagnetic Compatibility (Plug-ins or optional blank panels installed in all plug-in compartments).	
United States	Meets the following requirements of MIL-STD-461B: CE-03 Part 4, Curve 1, CS-01 Part 7, CS-02 Part 4, CS-06 Part 5, RE-02 Part 7, RS-01 Part 4, RS-02 Part 5, RS-03 Part 7, (limited to 1 GHz) Meets FCC Part 15, subpart J, Class A.
Germany	Meets VDE 0871/6.78, Class B.

TABLE 4-9
Physical Characteristics

Characteristics	Information
Weight (instrument without plug-ins)	20 kg (44 lbs).
Overall Dimensions	
Benchtop	See Figure 4-1.
Rackmount	See Figure 4-2.
Ventilation	Safe operation temperature maintained by forced air circulation. Automatic resetting thermal cutout protects instrument from over-heating.
Finish	Blue-vinyl painted pebblegrain material on aluminum cabinet.

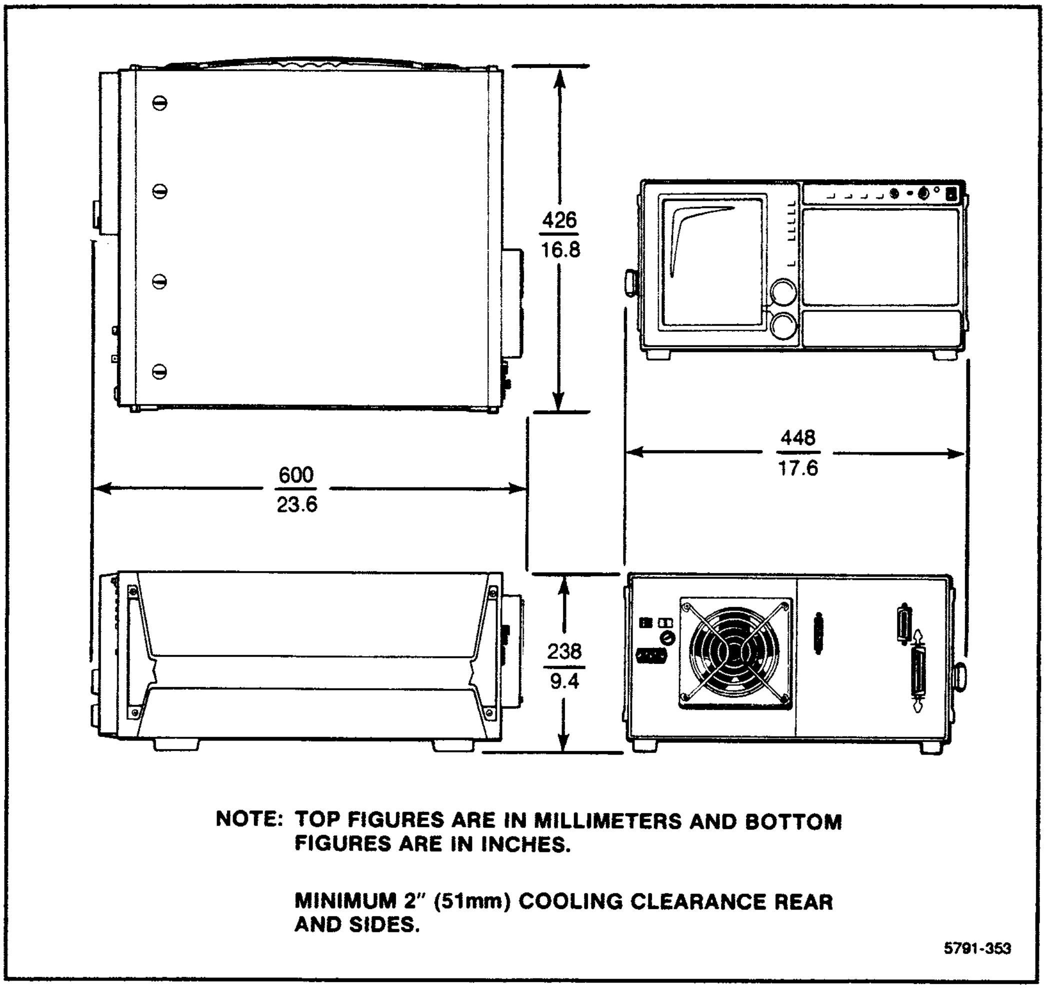

Figure 4-1. Benchtop 11401/11402 dimensional drawing.

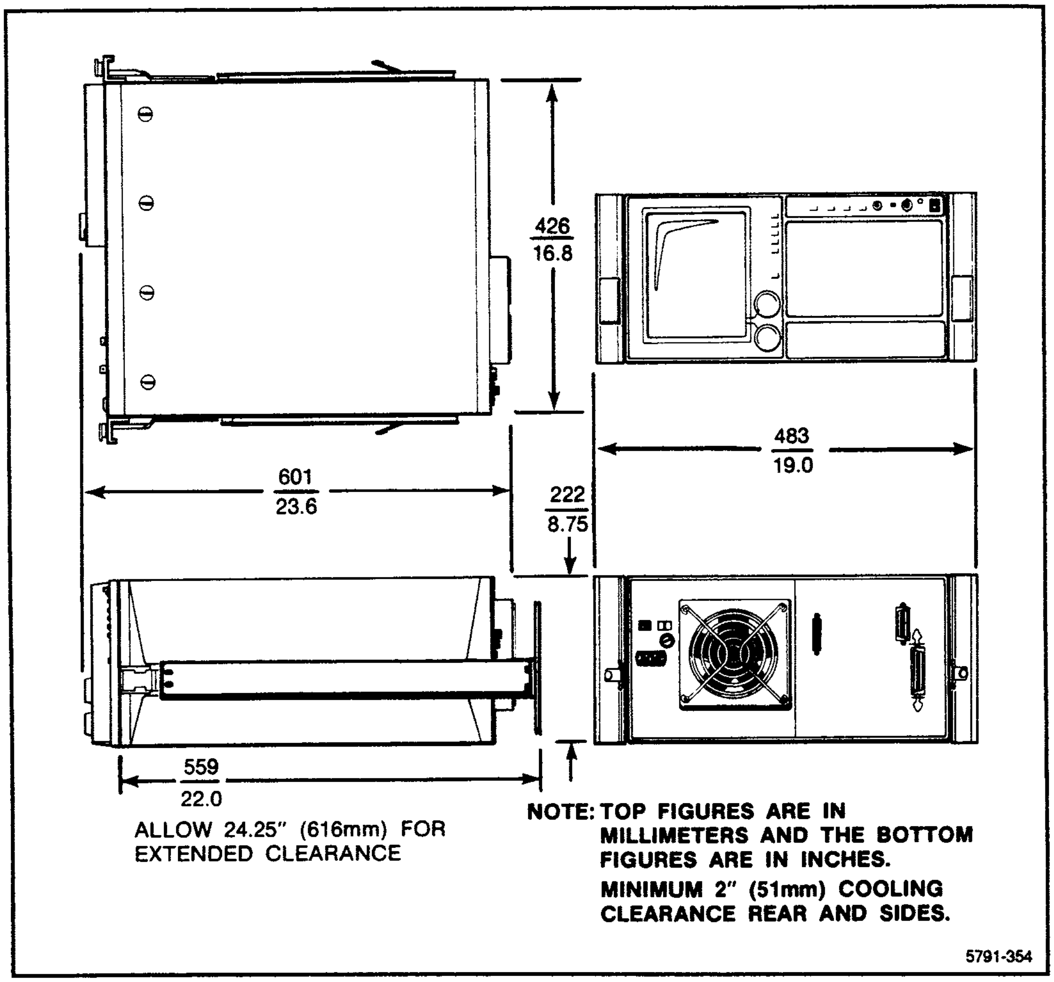

Figure 4-2. Rackmount 11401/11402 dimensional drawing.

Instrument Options

This section contains information on options available for the 11401/11402 Digitizing Oscilloscopes. An Option Information Locator table is included to help you find specific information in this manual.

Contents

Instrument Options

Your instrument may be equipped with one or more instrument options. A brief description of each available option is given in the following discussion. Refer to Table 5-1 and the Contents for the location of option information. For further information and prices of instrument options, see your Tektronix Products catalog or contact your Tektronix Field Office

WARNING

To avoid electric shock hazard, operating personnel must not remove the protective instrument covers. Component replacement and internal adjustments must be made by qualified service personnel only.

List of Options

Option 1C

Option 1C adds eight bnc connectors to the front- and rear-panels so that signals may be internally routed directly between the two panels. This is especially useful for rackmounted applications. This option can be added at any time.

Option 1R

Option 1R adds slide rails and rackmounting hardware to convert the benchtop instrument to a standard 19-inch rackmount version. This option can be added at any time.

Option 2D

Option 2D expands total waveform memory from 44K to 100K points for storage of waveform records. This option can be added at any time.

Option 4D

Option 4D increases GPIB transfer speed as much as ten times. Improves the overall throughput of the oscilloscope system, especially the transmission of waveform and measurement data. This option can be added any time.

Option A1

Replaces the standard power cord with the Universal European 220 V type power cord.

Option A2

Replaces the standard power cord with the United Kingdom 240 V type power cord.

Option A3

Replaces the standard power cord with the Australian 240 V type power cord.

Option A4

Replaces the standard power cord with the North American 250 V type power cord.

Option A5

Replaces the standard power cord with the Switzerland 240 V type power cord.

TABLE 5-1
Option Information Locator

Option	Location in Manual		Information
	Section	Heading	
Option 1C (Provides back to front to connectors)	5 Instrument Options	Option 1C	Gives brief description of Option 1C.
Option 1R (Provides rack-mount hardware)	1 Installation	Rackmounting	Gives brief description of Option 1R.
	5 Instrument Options	Option 1R	Gives brief description of Option 1R.
Option 2D (Provides memory expansion)	5 Instrument Options	Option 2D	Gives brief description of Option 2D.
Option 4D (Provides increased GPIB data transfer speed)	5 Instrument Options	Option 4D	Gives brief description of Option 4D.
Option A1 (Provides Universal European power cord)	1 Installation	Power-Cord Information Table 1-2	Lists details of Option A1.
	5 Instrument Options	Option A1	Gives brief description of Option A1.
	Appendix A	Power-Cord Options	Lists Option A1.

TABLE 5-1 (cont)
Option Information Locator

Option	Location in Manual: Section	Location in Manual: Heading	Information
Option A2 (Provides United Kingdom power cord)	1 Installation	Power-Cord Information Table 1-2	Lists details of Option A2.
	5 Instrument Options	Option A2	Gives brief description of Option A2.
	Appendix A	Power-Cord Options	Lists Option A2.
Option A3 (Provides Australian power cord)	1 Installation	Power-Cord Information Table 1-2	Lists details of Option A3.
	5 Instrument Options	Option A3	Gives brief description of Option A3.
	Appendix A	Power-Cord Options	Lists Option A3.
Option A4 (Provides North American power cord)	1 Installation	Power-Cord Information Table 1-2	Lists details of Option A4.
	5 Instrument Options	Option A4	Gives brief description of Option A4.
	Appendix A	Power-Cord Options	Lists Option A4.
Option A5 (Provides Switzerland power cord)	1 Installation	Power-Cord Information Table 1-2	Lists details of Option A5.
	5 Instrument Options	Option A5	Gives brief description of Option A5.
	Appendix A	Power-Cord Options	Lists Option A5.

Appendix A—Accessory List

Standard Accessories

The following standard accessories are included in each instrument package. To obtain replacements, refer to a Tektronix Products catalog or contact your local Tektronix Field Representative.

11401/11402 Introduction manual
11401/11402 User's Reference manual
Power Cord (North American 120 V)

Supported Accessories

- Tek 4644, Epson EX800, Epson FX80, Epson RX80, IBM ProPrinter

This is the default printer for the instrument. It supports a number of screen formats. The driver should work with any Epson compatible 8-pin impact printer.

Note that and Epson RX80 and the IBM ProPrinter will only work for the HIRES format.

- Epson LQ500, Epson LQ1000, NEC P6, NEC P7

This instrument supports the Extended Epson command set for 24-pin dot matrix printers. The print of the HIRES format on one of these printers is slightly smaller than that of the Tek 4644 and takes about two minutes to complete (vs. 6.5 minutes).

The printer driver in the 11401/11402 will support the following formats:

HIRES—Designed for impacts printers with a limited range of grey scaling. It intensifies normal print and changes bright on normal text and icons to inverse video.

DRAFT—Designed for faster full-size printouts. It sacrifices grey scale capability and highlighting information in order to double speed.

REDUCED—Generates a quarter-size low resolution printout, requires less time to format, and occupies a smaller amount of buffer space. Three or more prints can be sooled in less than a minute.

Optional Accessories (not included)

These optional accessories have been selected from our catalog specifically for your instrument. They are listed as a convenience to help you meet your measurement needs. For detailed information and prices, refer to a Tektronix Products catalog or contact your local Tektronix Field Representative.

11401/11402 Service Reference Manual
Blank panel (plug-in)
2 meter GPIB cable
10 foot RS-232-C cable
10 foot Centronics cable

Recommended Accessories

Hardcopy Unit: Tektronix 4644 Dot Matrix Printer
Tektronix Rack Instrument Cart, Model R217

Power-Cord Options

Also refer to Section 5 "Instrument Options".

Option A1-Universal European 220 V power cord
Option A2-United Kingdom 240 V power cord
Option A3-Australian 240 V power cord
Option A4-North American 250 V power cord
Option A5-Switzerland 240 V power cord

Appendix B—Algorithms

Waveform Functions

Digitized waveforms are represented as a sequence of 16 bit integer numbers. Three numbers from the possible range of –32,768 to 32,767 were chosen to represent invalid data points. The value –32,768 represents unacquired data points, –32,767 represents data values below the dynamic range of the Digitizer, and +32,767 represents data values above the dynamic range of the Digitizer. When a waveform function encounters one of these three data values, it generally passes the invalid data value as its output. All waveform function algorithms assume the existence of data other than these 3 data values, unless specifically noted. These invalid values are referred to elsewhere in this manual as "Null", "Underrange", and "Overrange".

Average

$Avg_1(n) = W(n)$

$Avg_p(n) = Avg_{p-1}(n) + [W(n) - Avg_{p-1}(n)]/D$

$D = 2^{INT(\log_2(1.443 * p))}$

$1.443 = 1.0/Ln(2)$

INT = Integer portion of argument

for $1 < p \leq NA$

$Avg_p(n) = Avg_{p-1}(n) + [W(n) - Avg_{p-1}(n)]/NA$

for $p > NA$

where

$W(n)$ = nth input data point

n = index into the array of data points

p = pass number for Avg function

NA = total number of Avg passes specified

Envelope

$Env_1(n) = W(n)$

$Env_p(n) = \text{Minimum of } [Env_{p-1}(n), W(n), W(n+1)]$

for n is even (0,2,4,...,M-2)

$Env_p(n) = \text{Maximum of } [Env_{p-1}(n), W(n-1), W(n)]$

for n is odd (1,3,5,...,M-1)
for p>1

where
W(n) = nth input data point
n = index into the array of data points
p = pass number for Env function
M = record length in points

Smooth

Ideally, the waveform is convolved with a square pulse of width (w) in points, centered about time zero.

As implemented, each new waveform point is derived by computing the average value of the corresponding point of the original waveform and (w-1)/2 points on either side of it. Near the ends of the waveform, up to (w-1)/2 nonexistent points beyond the ends are requried for averaging. The nonexistent points are given the value of the corresponding end points.

This method of extending the waveform ends is arbitrary, so the results within a pulse width of the ends must be interpreted accordingly. Actual data which may exist beyond the ends would probably give a different result, but the data is unknown.

$$Smooth(n) = 1/w * \left[\sum_{m=0}^{n+h} W(m) + (h-n) * W(0) \right]$$

for n<h

$$Smooth(n) = 1/w * \left[\sum_{m=n-h}^{n+h} W(m) \right]$$

for $h \le n \le M-1-h$

$$\text{Smooth}(n) = 1/w* \left[\sum_{m=n-h}^{M-1} W(m) + (M-1-n)\ T\ W(M-1)\right]$$

for n> M–1–h

where

w = smoothing interval width in number of points
W(n) = nth input data point
n = index into array of data points
h = half interval = (w–1)/2
m = index into array of data points
M = record length in points

Natural Logarithm

Ln – natural logarithm

For example: Ln(2.0) = 0.69315

Implemented as the standard mathematical equivalent by the 80287 math coprocessor and supporting routines.

Exponential

Exp – e^x

For example: Exp(1.0) = 2.71828

Implemented as the standard mathematical equivalent by the 80287 math coprocessor and supporting routines.

Logarithm

Log – logarithm base 10

For example: log(10.0) = 1.0

Implemented as the standard mathematical equivalent by the 80287 math coprocessor and supporting routines.

Square Root

Sqrt – square root

For example: Sqrt(9.0) = 3.0

Implemented as the standard mathematical equivalent by the 80287 math coprocessor and supporting routines.

Integrate

Intg(0) = 0

$$\mathrm{Intg}(n) = \left[1/2\ w(0) + \sum_{m=1}^{n-1} W(m) + 1/2\ W(n) \right] * I$$

for $1 \le n \le M-1$

where
W(n) = nth input data point
n = index into the array of data points
I = time interval between successive waveform points
m = index into array of data points
M = record length in points

Differentiate

Diff(0) = [W(1)–W(0)]/I

Diff(n) = [W(n+1)–W(n–1)]/(2 * I)

for $1 \le n < M-1$

Diff(M–1) = [W(M–1)–W(M–2)]/I

where
W(n) = nth input data point
n = index into the array of data points
I = time interval between successive waveform points
M = record length in points

Absolute Value

For all W(n)

Abs(n) = W(n)

for W(n)≥0

Abs(n) = –W(n)

for W(n)<0

where
W(n) = nth input data point
n = index into the array of data points

Signum

Signum(n) = 1.0

for W(n)>0

Signum(n) = 0.0

for W(n) = 0

Signum(n) = –1.0

for W(n)<0

where
W(n) = nth input data point
n = index into the array of data points

Interpolate

Interpolate fills in unacquired data between two acquired data points. Let ℓ = index of the acquired data point preceding the unacquired section of data (to the left of that section). Let r = index of the acquired data point after the unacquired section of data (to the right).

$$\mathrm{Intp}(n) = W(\ell) + \left[\frac{W(r) - W(\ell)}{r - \ell} \right] * (n-\ell)$$

for all n ; $\ell \geq 0$ and $r \leq M-1$

Intp(n) = W(r)

for all n if ℓ<0 and $r \leq$ M–1

Intp(n) = W(ℓ)

for all n if $\ell \geq$0 and $r >$ M–1

Intp(n) = W(n)

otherwise

where
W(n) = nth input data point
n = index into the array of data points
M = record length in points

Standard Measurement Functions

Most Standard Measurements are performed using common measurement parameters. These parameters are defined under "Standard Measurement Functions" in Section 2 "Operating Information".

Max

The maximum digitized (or calculated) data point in the measurement zone of the waveform record. Overrange and Underrange are treated as any other valid points. The result qualifier is used to note any such condition; Null is ignored. If the whole waveform is Null, this function is qualified as undefined.

Min

The minimum digitized (or calculated) data point in the measurement zone of the waveform record. Overrange and Underrange are treated as any other valid point. The result qualifier is used to note any such condition; Null is ignored. If the whole waveform is Null, this function is qualified as undefined.

Mid

In general,

mid = (max + min)/2

Overrange and Underrange are treated as any other valid point. The qualifier is used to note any such condition; Null is ignored. If the whole waveform is Null, this function is qualified as undefined.

Peak-Peak

In general,

peak-peak = max - min

Overrange and Underrange are treated as any other valid point. The qualifier is used to note any such condition; Null is ignored. If the whole waveform is Null, this function is qualified as undefined.

Mean

If the waveform magnitude takes on n discrete values W_j in the data interval, the mean magnitude is:

$$\text{Mean} = \sum_{j=m}^{j=n-1} \frac{[W_{j+1} + W_j]}{2 * (n-m)}$$

for n=m; mean=Wn

where W_m & W_n are the measured time interval end points.

The summation extends over the interval of time corresponding to one period when **Data Interval** is set to one period, or the entire measurement zone when **Data Interval** is set to entire zone.

RMS

If the waveform magnitude takes on n discrete values W_j in the data interval, the rms magnitude is:

$$\text{rms} = \sum_{j=m}^{j=n-1} \frac{[W_{j+1}^2 + W_j^2]^{1/2}}{2 * (n-m)}$$

where W_m & W_n are the measured time interval end points.

The summation extends over the interval of time corresponding to one period when **Data Interval** is set to one period, or the entire measurement zone when **Data Interval** is set to entire zone.

Rise Time

1. Find the first point in the measurement zone that is less than the proximal value, searching from left to right.
2. From this point, find the first proximal crossing and note the time, t_p.
3. From the proximal crossing, examine points increasing in time, looking for the distal crossing updating t_p if subsequent proximal crossings are found.
4. Once the distal crossing has been found, note the time, t_d.
5. rise = $t_d - t_p$

   Linear interpolation between vertical points and between time intervals is necessary to determine the times, t_p and t_d, when the proximal and distal values do not correspond to acquired data. This algorithm results in finding the two closest crossings of t_p and t_d with the same slope.

Fall Time

1. Find the first point in the measurement zone that is greater than the distal value, searching from left to right.
2. From this point, find the first distal crossing and note the time, t_d.
3. From the distal crossing, examine points increasing in time, looking for the proximal crossing updating t_d if subsequent distal crossings are found.
4. Once the proximal crossing has been found, note the time, t_p.
5. fall = $t_p - t_d$.

   Linear interpolation between vertical points and between time intervals is necessary to determine the times, t_p and t_d when the proximal and distal values do not correspond to acquired data. This algorithm results in finding the two closest crossings of t_p and t_d with the same slope.

Period

1. Establish a histogram for the measurement zone.

2. Determine the topline and baseline from the histogram or use the user set parameters when **Tracking** is off.

3. Calculate the vertical level for mesial.

   mesial = [(m%/100) ∗ (topline - baseline)] + baseline

4. Search for mesial crossing, stopping on +SNR. If found this is P–CROSS. +SNR = Signal/Noise Ratio level above the Mesial level.

5. Search for mesial crossing stopping on –SNR. If found this is N–CROSS. –SNR = Signal/Noise Ratio level below the Mesial level.

6. If (P_CROSS < N_CROSS)
   M1_CROSS = P_CROSS
   M1_SLOPE = POS
   M2_CROSS = N_CROSS
   M2_SLOPE = NEG

ELSE
   M1_CROSS = N_CROSS
   M1_SLOPE = NEG
   M2_CROSS = P_CROSS
   M2_SLOPE = POS

7. If (M1_SLOPE == POS)
   Search from M2_CROSS for mesial crossing stopping on +SNR

ELSE

   Search from M2_CROSS for mesial crossing, stopping on –SNR.

   If a crossing is found this is M3_CROSS

8. Period = M3_CROSS – M1_CROSS

Frequency

1. Find the first period within the measurement zone. Refer to the "Period" algorithm earlier in this appendix.

2. Frequency = 1/period.

Width

1. Establish histogram for the measurement zone.

2. Determine the topline and baseline from the histogram or use the user set parameters when **Tracking** is off.

3. Calculate the vertical level for mesial.

4. Search for mesial crossing, stopping on +SNR. If found this is P_CROSS. +SNR = Signal/Noise Ratio level above the Mesial level.

5. Search for mesial crossing, stopping on –SNR. If found this is N_CROSS. –SNR = Signal/Noise Ratio level below the Mesial level.

6. If (P_CROSS < N_CROSS)
   M1_CROSS = P_CROSS
   M1_SLOPE = POS
   M2_CROSS = N_CROSS
   M2_SLOPE = NEG

ELSE
   M1_CROSS = N_CROSS
   M1_SLOPE = NEG
   M2_CROSS = P_CROSS
   M2_SLOPE = POS

7. Width = M2_CROSS – M1_CROSS

Delay

1. Establish a histogram for the measurement zone.

2. Determine topline and baseline values from the histogram or use the user set parameters when Tracking is off.

3. Calculate the vertical level for the Mesial percentage setting, relative to topline and baseline.

4. Find the first mesial crossing and note the time, t_{m1}.

5. From this mesial crossing, search to the right until the end of the measurement zone (i.e., Right Limit), updating t_{m2} for every mesial crossing.

6. delay = $t_{m2} - t_{m1}$.

Main to Window Trigger Duration

For the Single triggered mode (default):
the Digitizer hardware measures the time between the Main time base trigger and the Window time base trigger.

For an averaged result:
the Digitizer sums the specified number of single trigger sweeps then divides the total by the specified number of averages.

Area + & -- Computations

If m and n are the interval end points, then:

$$\text{area} + = \sum_{j=m}^{n-1} ([\text{abs}(w_{j+1} - \text{ref}) + \text{abs}(w_j - \text{ref})]/2) * h\_i$$

For one point (n=m), area + = 0.

$$\text{area} - = \sum_{j=m}^{n-1} ([(w_{j+1} - \text{ref}) + (w_j - \text{ref})]/2) * h\_i$$

For one point (n=m), area - = 0.

where
abs is the absolute value function
h_i is the horizontal increment between two adjacent points.

Energy Computation

If m and n are the interval end points, then:

$$\text{energy} + = \sum_{j=m}^{n-1} ([w_{j+1}^2 + w_j^2]/2) * h\_i$$

For one point (n=m), energy = 0.

where
h_i is the horizontal increment between two adjacent points.

XY Energy Computation

$$\int_{t_0}^{t_1} y(t)\, x(t)\, dt$$

where

$t_1 - t_0$ = one period of X

y(t) = Y input signal (current)
x(t) = X input signal (voltage)
dt = time per point of X and Y (must be equal)

XY Area Computation

$$\int_{x_0}^{x_1} y\,(t)\, dx$$

$$\int_{t_0}^{t_1} y(t)\, [dx(t)/dt]\, dt$$

where

$t_1 - t_0$ = one period of X

y(t) = Y input signal
x(t) = X input signal
dt = time per point of X and Y (must be equal)

Cross

1. Find the first reference level crossing.
2. Check to see if the slope is correct. If so, interpolate to find the corresponding crossing time. If not then look for next reference level crossing.
3. Continue until found or out of data.

Linear interpolation between vertical points and between time intervals is necessary to determine the exact crossing time, t_c, when the reference level value does not correspond to acquired data.

Appendix C—Glossary

A

Acquire An operation that converts an analog signal to a series of stored digitized values (e.g., a waveform record).

Address, primary A selectable value that identifies a unique GPIB configured device and enables a controller to differentiate between specific devices connected to the bus.

Algorithm A step-by-step procedure (either written or equation) to achieve a specific result.

Annotation A displayed measurement indicator (e.g., the intensified portion of a waveform, horizontal bars, vertical bars, dotted lines, etc.).

Argument A variable whose value determines the value of a function.

Argument (N) One of several arguments, identified by number N.

ASCII American Standard Code for Information Interchange.

Asynchronous Relating to data transmissions which are not synchronized through a system clock.

Auto Level Automatically establishes the trigger level on a trigger signal, and free runs the time base counter in the absence of a triggering signal.

AUTOSET Front-panel pushbutton that automatically scales and positions the selected waveform (vertically and horizontally) for a nominal waveform display on the screen.

Average The Average function is selected either from the **Acquire Description** pop-up menu or from the **Vertical Description** pop-up menu, and is used to remove random noise from a signal to present a better display of the actual waveform.

B

Baseline — The bottom of a pulse reference used for pulse parameter calculations.

Binary block — Tektronix-specified format for binary transmissions: %<byte count><data value><data value>...<data value><checksum>.

BNF — Backus-naur form, a way of structuring elements of syntax.

C

Channel Select — Allows control of individual components of the vertical description (e.g., L1+L2, etc.), when the vertical size and position icon is selected. The **Chan Sel** label is displayed in the lower right corner of the menu/status area.

Conditional Acquire — Starting and stopping the acquisition process with user-selected criteria from the **Acquisition Description** pop-up menu.

Continuously digitized — When waveform data is regularly entered into a memory, and when such data entry causes the memory to lose or discard the oldest data as it receives new data, the waveform is said to be continuously digitized.

Controller — A computer that controls the action of one or more peripheral devices.

Cross — A measurement function that measures the time from the first waveform point to the waveform point after the Left Limit where the waveform first crosses the Reference level with the specified slope polarity.

Crossing Level — The point at which a waveform crosses a predetermined measurement level (e.g., Mesial, Reference, etc.).

Cursor — A dot which can be moved anywhere on a displayed waveform to tell the 11401/11402 to measure some property of the waveform at that point, or to begin or end a time measurement at that point.

D

Data Interval — Determines what measurement zone data will be measured. It can be toggled between the first complete period and the whole measurement zone segment.

Data Point Fill — When all memory locations are used to store waveform data, a data point fill is said to have occurred.

DCE — Data communication equipment.

DCL — Device Clear.

Debug — Copies input data from either GPIB or RS-232-C interface to the front-panel display for program development troubleshooting.

Default — The state to which a function returns when no selection is made.

DefWfm — Define waveform. When you touch the DefWfm label the 11401/11402 will display the **Vertical Description** pop-up menu, which allows you to define a waveform.

Delay — Time between mesial levels on two different waveforms.

Deskew — To restore the original phase to a delayed signal.

Digitize — Converts an analog measurement of a physical variable into a numerical value to express the quantity in digital form.

Distal — Farthest from a reference point. As used in the 11401/11402, the ending measurement point for timing measurements.

DMA — Direct memory access.

DTE — Data terminal equipment.

Dual-Graticules — See Split-Screen Display.

E

Enhanced Accuracy The oscilloscope system accuracy state following a 20-minute warmup of the specific mainframe/plug-in configuration. Indicated by display of **EA** on screen. Continues until system temperature changes 5° C.

Envelope The locus of the instantaneous peak values of an alternating waveform which indicates the variation in amplitude undergone by that waveform.

EOI End of Input delimiter.

EWP Executive waveform processor, comprised of an Intel 80286 Microprocessor and an 80287 Numeric Processor Extension.

F

Falltime Time between Distal and Proximal points on a waveform's falling edge.

Flash Converter The type of A/D converter used in the 11401/11402.

Frequency The reciprocal of the time between Mesial levels on successive rising or falling edges of a waveform.

G

Generic Amplifier Plug-in A plug-in that provides basic operations, such as coarse and fine control of vertical sensitivity through the mainframe, and two or more input impedance and coupling modes (e.g., 11A32 and 11A34).

GPIB General Purpose Interface Bus (see IEEE Standard 488-1978).

Graticule Vertical and horizontal lines displayed on the screen in a crosshatch pattern which provide for visual waveform measurements with the axis scale factors. This instrument can display one or two graticules on the screen.

H

Handshaking	The exchange of predetermined logic signals which control data transfers between connected devices.
Hardcopy	A front-panel button that, when pressed, signals a line printer to produce a complete copy of the screen display.
Hard Flagging	A protocol for handshaking data transfers over the RS-232-C interface. This protocol uses signal line transitions to start and stop message transmissions.
Header	The first part of a message/command containing the root function.
Holdoff	Time, after a trigger signal, that must elapse before the trigger circuit will accept another trigger signal.
Holdoff Events	Window trigger occurrences.
Horizontal Bar Cursors	Two full-screen horizontal bars that can be positioned vertically to set the measurement points.
Horizontal Description	The source of the horizontal component of the display, e.g., main time base, window time base, XY, or YT display mode, etc.

I

Icon	A selectable graphic symbol, displayed on the screen, that represents an action or part of a waveform.
IEEE Standard 488-1978	The Institute of Electrical and Electronic Engineers Standard for digital interfacing between programmable instruments.
Intensity Levels	Information is displayed on the screen with four levels of brightness; off, low, medium, and high. Typically, the currently selected function label and the selected waveform will be indicated with the high intensity level. Screen displayed items shown at medium intensity are usually selectable and items at low intensity are not selectable. Only valid functions, based on the state of the instrument, are selectable.
Interrupt	A controller recognizes an event signal from an external device (e.g., 11401) and breaks its program flow in order to act on the event.

K

Knob Resolution — The amount of change that occurs for each detent of the Control knobs. Coarse, Medium, and Fine resolution are selectable through the **Numeric Entry and Knob Res** pop-up menu.

L

Label — Selectable functions displayed on the screen.

Left Zone Boundary — One of two vertical bars displayed on the screen, that designate a zone in which a measurement is calculated.

Link (Argument) — A subfunction of the primary (header) function, which links the function to an assigned specific value or condition.

Ln — Natural logarithm (base e).

Log — Logarithm (base 10).

M

Main Record — The number of data points that represents a signal acquired with the Main time base.

Main —›Win Trig Time — Time between the main trigger point and the window trigger point.

Major Menu — A menu that appears in the menu/status area at the bottom of the screen. Major menus appear when any MENUS button is pushed, or when the Cursor label at the top of the screen is touched.

Max — The maximum voltage a waveform reaches in the Measurement Zone.

Mean — The mean vertical value of one cycle of a waveform, or of all the waveform within the Measurement Zone.

Measurement Parameter — A limit or specific waveform point used to define measurements.

Measurement Tracking A facility of the measurement systems that causes the measurement parameters to follow fluctuations in a waveform's vertical size and position. Tracking is normally on but can be turned off for some measurements.

Measurement Zone The area between the Left and Right Zone Boundary cursors (vertical bars).

Menu/Status Area The bottom part of the screen that is reserved for major menu displays.

Mesial Closest to the vertical midpoint of a waveform; the median point for timing measurements.

Mid The median waveform value within the Measurement Zone.

Min The minimum waveform value within the Measurement Zone.

N

In a numeric series of 1, 2, 3...n, the extreme number indicated by n is called the n^{th} term.

Non-volatile RAM Memory; memory storage that can retain information in the absence of external power.

Numeric Keypad Screen-displayed "keys" for numeric value input, located in the **Numeric Entry and Knob Res** pop-up menu.

NVRAM See Non-volatile RAM.

P

Pan/Zoom A temporary method of expanding and searching the entire record without affecting time-base settings such as size or position.

Parameter Measurement references that are used to obtain a result (e.g., Baseline, Topline, Proximal, Mesial, Distal, Left Zone Boundary, Right Zone Boundary, etc.).

Period The time between Mesial levels on successive rising or falling edges of a waveform.

Pixels Picture elements; data points that compose a screen image.

Point Accumulate Mode An acquisition mode that displays samples as they are acquired and that accumulates samples on the display until reset. It is intended for displaying infrequent, but repetitive, events by gradually building a picture of the waveform.

Polling, serial A sequential addressing of devices connected to the GPIB to determine which devices are requesting service.

Pop-up menu A temporary menu that appears in the waveform display area and provides additional selection of a category of items and functions.

Port An external access connection to the instrument interface (e.g., GPIB or RS-232-C).

PP (also Peak_Peak) The maximum waveform value minus the minimum waveform value.

Probe Calibration A Utility function that calibrates a selected channel's probe for vertical accuracy. The probe is then automatically deskewed (to equalize propagation time) against an internal reference signal.

Probe Compensation A manual adjustment performed on a selected probe that improves its low-frequency response. This function is available after the probe has been calibrated.

Proximal Closest point or reference level.

Q

Query A type of 11401 command that requests a specified condition or status of the instrument.

R

Record Length The number of data points assigned to display a waveform.

Reserved A GPIB/RS-232-C command set word specifically defined for the 11401/11402.

Right Zone One of two vertical bars displayed on the screen, that designate a zone in which measurement is calculated.

Boundary

Risetime The time between a waveform's Proximal and Distal points.

RMS The root-mean-square vertical value of the waveform over one cycle or over the entire

Measurement Zone.

RQS The "request service" command enables or disables the 11401's ability to actuate the service request (SRQ) line of the GPIB.

RS-232-C Electronics Industries Association standard for interfacing between data terminal equipment and data connection equipment employing serial data interchange.

S

Sample Interval An exact time interval between all samples in a waveform record. This acquisition parameter results from the choices of horizontal scale (time/div) and record length.

Scalar A real number, not a vector.

SDC Selected Device Clear.

Selected Waveform The waveform displayed at medium intensity (all other Main time base waveforms are displayed at low intensity) on which all measurements are performed and for which all status is displayed.

Sequence Setting Provides the facility to easily sequence through previously stored front-panel settings.

Signum A waveform function that returns the sign (+, –, or 0) of each vertical value in a waveform record..

Single Trigger An acquisition mode that displays a waveform based on a single sweep of a time base. This is often referred to as a single-shot acquisition.

Slope Inclination of signal on which trigger will be produced (+ or –).

Smooth A waveform function that replaces each point of a stored waveform with the averaged value of a specified number of points on either side and displays the result.

S/N Ratio The ratio of the signal level to the noise level of a waveform. User-set value for some measurements.

Soft Flagging A protocol for handshaking data transfers over the RS-232-C interface. This protocol uses characters to start and stop message transmissions.

Source Description Origin of signal (e.g., L1 for channel 1 in the left vertical compartment or Main for the main time base).

Split-Screen Display A display with two graticules; upper and lower.

SRQ A service request is initiated by the 11401 in response to some internal event, in order to call this event to the attention of an external controller connected to the GPIB interface.

Standby An instrument condition in which all usual dc power is turned off leaving only a pilot dc supply in operation. This condition occurs when the front-panel ON/STANDBY switch is set to the STANDBY position. Switch to STANDBY before installing or removing plug-ins.

T

Terminator, message A predefined character (value) sent over the interface, or a hardware line signal which ends a message and allows execution to begin.

Toggle To switch alternately between two functions (e.g., on and off).

Topline The top of a pulse reference used for pulse parameter calculations. (See Baseline.)

Touch Panel The system that senses touches of the display screen and correlates them with displayed items. When the TOUCH PANEL ON/OFF button is set to off, the Touch Panel ignores screen touches.

Tracking An operating mode in which the measurement parameters follow the changing waveform data.

Trigger Holdoff Stops valid trigger pulses from starting a time-base sweep for a user-set period of time or number of trigger events (Window time base only).

U

Undefined When a measurement beyond the range of the instrument is requested, the result will be undefined.

Uptime The number of hours the instrument has been powered-up.

V

Verbose — Enables the instrument's RS-232-C interface to asynchronously return system events messages without a query from the controller.

Vertical Bar Cursors — Two full-screen vertical bars that can be positioned horizontally to set the measurement points.

Vertical Description — The source of the vertical signal, e.g, L1+R1 (Left plug-in channel 1, plus Right plug-in channel 1).

W

Waveform Label — Typically, a descriptive name assigned to a waveform and displayed on the screen (e.g., the labels displayed in the major menu area when in **All Wfms Status** mode of the Waveform major menu).

Waveform Record — A timed sequence of digital values (data points) stored in memory.

Width — The time between mesial levels on successive edges of a waveform.

Window — Part of a display selected for close examination, and expanded to permit such examination.

Window Holdoff — The amount of time or events the Window trigger is held off (locked-out) with reference to the Main trigger.

X

XY — Horizontal versus vertical .

Y

YT — Amplitude (voltage) versus time.

Errors, Warnings, and Messages

Errors, warnings, and other messages are displayed at the top of the Waveform Display area whenever an illegal operation or system event occurs. Displayed error or warning messages describe the problem and may indicate an action taken by the instrument. The errors, warnings, and messages are listed alphabetically in the Table of Errors, Warnings, and Messages.

The distinction between an error message and a warning message is:

- **Errors**—The instrument cannot do the requested operation.
- **Warnings**—The instrument performs the operation but warns you that the results may be corrupted or meaningless.

Other system messages are of two basic types:

- **Prompts**—Some user action is requested so the instrument can complete a task.
- **Notices**—The status of an operation is displayed for the user's information. No action is required.

Clearing a Message

Errors, warnings and messages can be cleared (removed from the screen) by touching the Touch Screen anywhere or by pushing any front panel button. When the error or warning message is cleared, the message area will return to its usual function.

Table of Errors, Warnings, and Messages

External interface errors, warnings, and messages are listed in tables under "Event Code Reporting" in Section 3 "GPIB and RS-232-C Interfaces".

Message	Meaning
Autoset— ac signal too large	**Warning.** The vertical autoset algorithm detected a signal whose ac component is too large for the least sensitive gain setting of a waveform's plug-in channel.
Autoset — dc signal too large	**Warning.** The vertical autoset algorithm detected a signal whose dc component is larger than the offset range of the least sensitive gain setting of a waveform's plug-in channel.
Autoset— horizontal search failed	**Warning.** The horizontal autoset algorithm could not correctly calculate the period of the selected waveform.

Table of Errors, Warnings, and Messages (cont)

Message	Meaning
Autoset —no signal detected	**Warning.** Autoset was attempted when no waveforms were defined and no plug-in input amplitude exceeded +/- 1.0 division on the most sensitive channel gain setting (i.e., no signal source could be found).
Autoset— not functional with this waveform type	**Error.** Autoset is not functional with all waveform types, specifically: • A multi-channel waveform (e.g., L1+ L2) • A window'd waveform that has no main time base "parent," when the main time base is untriggered.
Autoset — trigger search failed	**Warning.** The horizontal autoset algorithm does not have a correctly triggered signal. Occurs when autoset's Amplitude option is Off and the selected waveform is not triggered.
Avg out of range —limit set	**Warning.** A value was entered for the parameter that was outside the allowed range. The limit value, nearest the entered value, is used.
Bad level 2 probe checksum on channel (*name*)	**Error.** The plug-in detected a bad or improperly connected level 2 TEKPROBE®.
Center plug-in channel(s) used differently in main and window sources	**Error.** The Window Holdoff mode was set to events or time, and Main and Window trigger sources included different channels from the same plug-in. This results in chopped trigger sources, which are not allowed.

Table of Errors, Warnings, and Messages (cont)

Message	Meaning
Center plug-in communications failure	**Error.** The mainframe was unable to communicate with the compartment. Likely causes are a hardware failure or removal of the plug-in with instrument power on.
Connect probe to Calibrator and restart operation	**Error.** Probe calibration was attempted but no calibration signal was found. Likely causes are that the selected channel's probe is not connected to the CALIBRATOR, the probe is defective, or the CALIBRATOR has a hardware fault.
Cursor positioning out of range—limit set	**Warning.** A value was entered for the parameter that was outside the allowed range. The limit value, nearest the entered value, is used.
DIG deskew failed	**Error.** The digitizer detected an internal error during the deskew operation. Two consecutive failures would indicate that the instrument should be referred to a qualified service person.
DIG plug-in calibration failed	**Error.** The digitizer detected an internal error during plug-in calibration. Two consecutive failures indicate that the instrument should be referred to a qualified service person.
DIG probe compensation failed	**Error.** The digitizer detected an internal error during probe compensation. Two consecutive failures indicate that the instrument should be referred to a qualified service person.
Digitizer stopped—timebase settings exceed available acquisition memory	**Error.** A Digitizer setting was attempted that exceeded the bounds of a time base parameter. Try a less extreme value for the last attempted setting.
Distal out of range—limit set	**Warning.** A value was entered for thepar-ameter that was outside the allowed range. The limit value, nearest the entered value, is used.

Table of Errors, Warnings, and Messages (cont)

Message	Meaning
Dsy Intensity out of range—limit set	**Warning.** A value was entered for the parameter that was outside the allowed range. The limit value, nearest the entered value, is used.
Enhanced accuracy available after (*delay period*)	**Notice.** The ENHANCED ACCURACY button was pressed before the 20-minute power-up warmup period had elapsed. You will be prompted when the warmup is complete if the Enhanced Accuracy mode is manual and the configuration has changed.
Enhanced accuracy completed and passed	**Notice.** Enhanced Accuracy was completed without any faults.
Enhanced accuracy failed. Mainframe: (*subsystem*) Plug-in: (*list*). Trigger: (*trigger fault*).	**Error.** Enhanced Accuracy was attempted and it failed. "Subsystem" is replaced with either the name of the subsystem that failed, or PASS if no mainframe faults occurred. In the event of mainframe failure, "list" and "trigger fault" are replaced with NA. If no plug-in channel or trigger signals fail, "list" and "trigger fault" are replaced with PASS. Otherwise, if plug-in channel faults occured, "list" is replaced with a list of failed plug-ins, in this format: <slot><dd> where <slot> is L, R, or C and <dd> is a two-digit hex number. The first digit is always zero and the second digit is a binary-weighted value that encodes which channels failed (e.g., "R03" means right plug-in channels 1 and 2 failed) If trigger faults occurred, "trigger fault" is replaced with a list of failed triggers, in this format: <trigger><slot> where <slot> is L, R, or C and <trigger> is M or W. Note that failed plug-ins can be replaced when the power is off. Mainframe service should be referred to qualified service personnel.

Table of Errors, Warnings, and Messages (cont)

Message	Meaning
Env out of range—limit set	**Warning.** A value was entered for the parameter that was outside the allowed range. The limit value, nearest the entered value, is used.
Events Holdoff out of range—limit set	**Warning.** A value was entered for the parameter that was outside the allowed range. The limit value, nearest the entered value, is used.
Expression too complex	**Error.** The entered vertical trace description either exceeded 55 characters or the instrument could not resolve its complexity.
Front panel locked out	**Warning.** A front-panel operation was attempted while the front panel was locked out. The lockout was due to instrument power-up or calibration processes, or to an explicit external interface (i.e., GPIB or RS-232-C) command.
Function not available in selected plug-in range	**Error.** Probe Calibration was attempted when a differential amplifier's input gain was restricted from 0.1V/Div to 10V/Div. In this restricted range, probe calibration cannot be performed.
General DIG failure detected (*code number*)	**Error.** An internal error was detected in the Digitizer. No other error was suitable. Refer the instrument to a qualified service person.
GPIB Address out of range—limit set	**Warning.** A value was entered for the parameter that was outside the allowed range. The limit value, nearest the entered value, is used.
Hardcopy aborted	**Warning.** The HARDCOPY button was pushed a second time while the screen was still "frozen." This aborts the requested hardcopy.

Table of Errors, Warnings, and Messages (cont)

Message	Meaning
Hardcopy absent or off line	**Error.** The HARDCOPY button was pushed while the printer was off line or disconnected. No copy is made.
Hardcopy complete	**Notice.** The requested hardcopy is complete.
Horz Mag out of range—limit set	**Warning.** A value was entered for the parameter that was outside the allowed range. The limit value, nearest the entered value, is used.
Horiz Pos Gr out of range—limit set	**Warning.** A value was entered for the parameter (graphic position) that was outside the allowed range. The limit value, nearest the entered value, is used.
Illegal DATE/TIME	**Error.** An illegal date or time value was specified.
Input channel (*number*) overdrive on (*compartment*) plug-in	**Warning.** The signal to the specified plug-in channel was being clipped (distorted).
Input channel (*number*) overload on (*compartment*) plug-in	**Warning.** The signal to the specified plug-in channel was overloading the input termination resistor. Input impedance of the channel is changed to protect the resistor.
Internal DAC overflow on channel (*number*) of (*compartment*) plug-in	**Error.** The last attempted plug-in control operation (e.g., setting offset) caused a plug-in DAC (digital/analog converter) to exceed its allowed range. So, push the ENHANCED ACCURACY button. After the Self-Tests pass, reattempt the control operation. If the error still occurs, refer the problem to a qualified service person.
Invalid number input	**Error.** Numerical input was beyond the range of the floating point processor.

Table of Errors, Warnings, and Messages (cont)

Message	Meaning
Invalid smooth argument	Error. A value was entered for the smooth waveform function that was outside the allowed range. The vertical description is discarded and no new waveform is displayed.
Left Limit out of range—limit set	Warning. A value was entered for the parameter that was outside the allowed range. The valid range value, nearest the entered value, is used.
Left plug-in channel(s) used differently in main and window sources	Error. The Window Holdoff mode was set to events or time, and Main and Window trigger sources included different channels from the same plug-in. This results in chopped trigger sources, which are not allowed.
Left plug-in communications failure	Error. The mainframe was unable to communicate with the compartment. Likely causes are a hardware failure or removal of the plug-in with instrument power on.
Main Pos out of range—limit set	Warning. A value was entered for the parameter that was outside the allowed range. The limit value, nearest the entered value, is used.
Main Size out of range—limit set	Warning. A value was entered for the parameter that was outside the allowed range. The limit value, nearest the entered value, is used.
Main Record Len out of range—limit set	Warning. A value was entered for the parameter (record length) that was outside the allowed range. The limit value, nearest the entered value, is used.
Mesial out of range—limit set	Warning. A value was entered for the parameter that was outside the allowed range. The limit value, nearest the entered value, is used.

Table of Errors, Warnings, and Messages (cont)

Message	Meaning
Misuse of AVG/ENV function	**Error.** Average or Envelope was invoked on a purely stored or scalar displayed waveform. These functions can be used only on waveforms that include an actively acquired channel.
New configuration — partial enhanced accuracy occurring	**Notice.** The instrument powered up with one or more plug-ins that were not previously brought to the Enhanced Accuracy state in this mainframe.
No active acquisitions—digitizer remains stopped	**Warning.** An attempt was made to start the digitizer with no active acquisitions. Scalar and stored waveforms are not actively acquired.
No further XY waveforms may be defined	**Error.** An attempt was made to display more than the allowed number of XY waveforms. Only one live XY waveform or two stored or scalar XY waveforms can be displayed at one time.
No more waveforms permitted	**Error.** A plug-in channel or probe ID button was pressed to add another waveform to the display when eight waveforms were already displayed. Up to eight waveforms can be displayed at one time.
Nonvolatile RAM completely reset	**Warning.** At power-up, a failure of the battery back-up power for the non-volatile RAM was detected. When a battery failure occurs, the instrument initializes the RAM with factory default settings.
Nonvolatile RAM front panel settings lost; instrument ID data retained	**Warning.** At power-up, the instrument detected corrupted data in the stored front panel settings. The stored settings are replaced with the factory default setting. Non-volatile RAM is not initialized as it is when the back-up battery fails. A bad transfer of front-panel settings over an ASCII interface is a probable cause.

Table of Errors, Warnings, and Messages (cont)

Message	Meaning
Out of memory	**Error.** A function was attempted when there was a lack of either Executive or Waveform memory space. Removing one or more previously stored waveforms will free Waveform memory. Shortening the record lengths of acquired waveforms will free Waveform memory.
Panzoom may not be disabled	**Error.** An attempt was made to turn Pan/Zoom off with a scalar or stored waveform selected.
Percent Fill out of range—limit set	**Warning.** A value was entered for the parameter that was outside the allowed range. The limit value, nearest the entered value, is used.
Point Accumulate and XY waveforms are mutually exclusive	**Error.** An attempt was made to simultaneously display an XY waveform and a Point Accumulate waveform.
Press ENHANCED ACCURACY again to confirm request	**Prompt.** After pressing the ENHANCED ACCURACY button once under valid conditions, a second confirming push of the button is requested to activate Enhanced Accuracy.

Table of Errors, Warnings, and Messages (cont)

Message	Meaning
Probe cal complete. Deskew {passed | FAILED}. Perform probe compensation procedure. Touch menu entry to continue.	**Prompt**. Probe calibration and deskew are complete. Whether or not deskew passed or failed is indicated in the prompt. The follow ing conditions can cause a deskew failure: • An ungrounded probe • Incorrect plug-in channel impedance • More than one probe attached to the calibrator If deskew repeatedly fails, then contact a qualified service person for assistance.
Probe calibration error	**Error**. Calibration of the selected probe failed. The probe is not calibrated.
Proximal out of range—limit set	**Warning**. A value was entered for the parameter that was outside the allowed range. The limit value, nearest the entered value, is used.
Request for external service ignored	**Warning**. Your touch of the RQS icon was ignored by the external controller. Touch the icon again to signal the controller.
Right Limit out of range—limit set	**Warning**. A value was entered for the parameter that was outside the allowed range. The valid range value, nearest the entered value, is used.
Right plug-in channel(s) used differently in main and window sources	**Error**. The Window Holdoff mode was set to events or time, and Main and Window trigger sources included different channels from the same plug-in. This results in chopped trigger sources, which are not allowed.

Table of Errors, Warnings, and Messages (cont)

Message	Meaning
Right plug-in communications failure	**Error.** The mainframe was unable to communicate with the compartment. Likely causes are a hardware failure or removal of the plug-in with instrument power on.
RS-232 Baud out of range—limit set	**Warning.** A value was entered for the parameter that was outside the allowed range. The limit value, nearest the entered value, is used.
RS-232 Delay out of range—limit set	**Warning.** A value was entered for the parameter that was outside the allowed range. The limit value, nearest the entered value, is used.
RS-232 input buffer overrun	**Warning.** The instrument's RS-232-C input buffer overflowed. This was likely caused by improper or nonexistent external controller flagging.
RS-232 input framing error	**Warning.** A framing error occurred while transferring data to the instrument. The transfer is completed and the received data is retained, although it may be unsound.
RS-232 input parity error	**Warning.** A parity error occurred while transferring data to the instrument. The transfer is completed, and the received data is retained, although it may be unsound.
S/N Ratio out of range—limit set	**Warning.** A value was entered for the parameter that was outside the allowed range. The limit value, nearest the entered value, is used.
Temperature change — automatic enhanced accuracy occurring	**Notice.** The instrument's internal temperature has changed 5° C and the accuracy mode is automatic. The instrument's accuracy state is not-enhanced. Enhanced Accuracy operations begin immediately.

Table of Errors, Warnings, and Messages (cont)

Message	Meaning
Temperature change — Press ENHANCED ACCURACY	**Prompt.** The instrument's internal temperature has changed 5° C and the Enhanced Accuracy mode is manual. The instrument's accuracy is not-enhanced. Press the ENHANCED ACCURACY button to achieve Enhanced Accuracy.
That function is not supported by this plugin	**Error.** A command misused an 11K sub-generic plug-in. For example, specifying the input of the 11A71 as an inverted trigger source is possible but the plug-in hardware can not perform the operation.
That XY waveform has incompatible components	**Error.** An attempt was made to create an XY waveform with mixed waveform scaling modes (e.g., an integer waveform plotted against a floating point waveform).
Time Holdoff out of range—limit set	**Warning.** A value was entered for the parameter that was outside the allowed range. The limit value, nearest the entered value, is used.
Too many acquisitions	**Error.** An attempt was made to acquire more than eight unique plug-in channels (e.g., L1+L2+L3+L4+R1+R2+R3+ R4+C1) or more than 14 acquisitions from any of up to eight unique channels. For example, two Windows on the main waveform L1+L2+L3+C1 constitutes 12 acquisitions.
Trace Sep out of range—limit set	**Warning.** A value was entered for the parameter that was outside the allowed range. The limit value, nearest the entered value, is used.

Table of Errors, Warnings, and Messages (cont)

Message	Meaning
Trig Level out of range—limit set	**Warning.** A value was entered for the parameter that was outside the allowed range. The limit value, nearest the entered value, is used.
Trigger source incomplete—no changes made	**Error.** An incomplete trigger source description was entered. The existing trigger source is used.
Vertical Mag out of range—limit set	**Warning.** A value was entered for the parameter that was outside the allowed range. The limit value nearest the entered value, is used.,
Vertical Pos out of range—limit set	**Warning.** A value was entered for the parameter that was outside the allowed range. The limit value, nearest the entered value, is used.
Warmup complete — enhanced accuracy in effect	**Notice.** The 20-minute power-up warmup is complete and the configuration has not changed so the previous cal constants are used to resume Enhanced Accuracy.
Warmup complete — Press ENHANCED ACCURACY	**Prompt.** The 20-minute power-up warmup is complete, the Enhanced Accuracy mode is manual and the instrument is in the not-enhanced accuracy state, possibly due to a configuration change since the power was last on.
Warmup complete with new configuration—automatic enhanced accuracy occurring	**Notice.** The 20-minute power-up warmup is complete, the Enhanced Accuracy mode is automatic and the instrument has a different plug-in configuration since the last power-up occurred. Enhanced Accuracy operations begin immediately.

Table of Errors, Warnings, and Messages (cont)

Message	Meaning
Warmup complete with new configuration — Press ENHANCED ACCURACY	**Prompt.** The 20-minute power-up warmup is complete, the Enhanced Accuracy mode is manual and the instrument has a different plug-in configuration since the last power-up occurred. Press the ENHANCED ACCURACY button to bring the instrument to the Enhanced Accuracy state.
Win Record Len out of range—limit set	**Warning.** A value was entered for the parameter (record length) that was outside the allowed range. The limit value, nearest the entered value, is used.
Window 1 Pos out of range—limit set	**Warning.** A value was entered for the parameter that was outside the allowed range. The limit value, nearest the entered value, is used.
Window 2 Pos out of range—limit set	**Warning.** A value was entered for the parameter that was outside the allowed range. The limit value, nearest the entered value, is used.
Window Size out of range—limit set	**Warning.** A value was entered for the parameter that was outside the allowed range. The limit value, nearest the entered value, is used.
Window trigger source set equal to Main trigger source	**Warning.** The Window trigger source was set equal to the Main trigger source when the Window Holdoff Mode was changed from no holdoff to holdoff by events or time. This occurs whenever both trigger descriptions use different channels from the same plug-in. The latter case results in chopped trigger signals, which are not allowed.

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By
Artek Media

Artek Media
1042 Plummer Cir. SW
Rochester, MN 55902

Manuals@artekmedia.com

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