TEK

User Reference

THE DSA 601 & DSA 602

DIGITIZING SIGNAL ANALYZERS

Tektronix

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TEK

User Reference

Part No. 070-7250-00
Product Group 47

THE DSA 601 & DSA 602

DIGITIZING SIGNAL ANALYZERS

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

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Instrument Serial Numbers

Each instrument manufactured by Tektronix has a serial number on a panel insert or tag, or stamped on the chassis. The first letter in the serial number 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:

B010000	Tektronix, Inc., Beaverton, Oregon, USA
G100000	Tektronix Guernsey, Ltd., Channel Islands
E200000	Tektronix United Kingdom, Ltd., London
J300000	Sony/Tektronix, Japan
H700000	Tektronix Holland, NV, Heerenveen, The Netherlands

Instruments manufactured for Tektronix by external vendors outside the United States are assigned a two digit alpha code to identify the country of manufacture (e.g., JP for Japan, HK for Hong Kong, etc.).

Tektronix, Inc., P.O. Box 500, Beaverton, OR 97077

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About This Manual

This is the front panel reference manual for the DSA 601 and DSA 602 Digitizing Signal Analyzers. If you are a new user, first read the *DSA 601 and DSA 602 Tutorial* to become familiar with the DSA. Use this User Reference to answer specific questions about operation of the DSA.

The first section, At a Glance, presents quick get-acquainted information and a map of the various menus. Each menu is accompanied by pointers into the detailed second section, In Detail.

Related Manuals

Other manuals that complete the documentation set for the DSA 601 and DSA 602 Digitizing Signal Analyzers are:

- The *DSA 601 and DSA 602 Tutorial* (Tektronix part number 070-7249-00) gives step-by-step instructions that demonstrate basic operation of the DSA.
- The *DSA 601 and DSA 602 QuickStart Package* (U.S.A. Tektronix part number 020-1769-00, European 020-1770-00) is a complete learning laboratory, including a signal generating board and a workbook. A videotape for the *DSA 601 and DSA 602 QuickStart Package* is included with your DSA. These show you how to use the power of the DSA to get the types of measurements you need. The QuickStart Package is available at no charge, but you need to mail in the postage-paid card included with the DSA.
- The *DSA 601 and DSA 602 Programmer Reference* (Tektronix part number 070-7251-00) describes using a computer to control the DSA through GPIB or RS-232-C interfaces.
- The *DSA 601 and DSA 602 Command Reference* (Tektronix part number 070-7252-00) describes the commands used to program the DSA.
- The *DSA 601 and DSA 602 Service Reference* (Tektronix part number 070-7254-00) provides information to maintain and service components of the DSA, and provides a complete board-level description of DSA operation.

Contents

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Revised 9/89

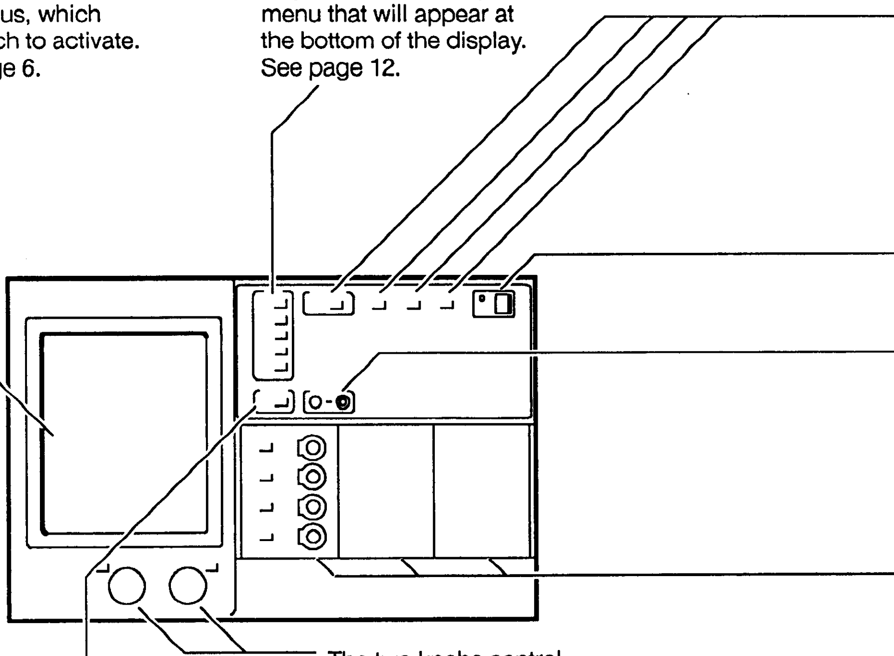
At a Glance

This section presents general operating instructions and a road-map of the menu system. All menus are shown in this section. Once you find a menu of interest, you will be directed to the page in the In Detail section that discusses that feature.

You may want to consult the *DSA 601 and DSA 602 Tutorial* for a complete introduction.

The display shows the waveforms and the menus, which you touch to activate. See page 6.

The major menu buttons let you select the major menu that will appear at the bottom of the display. See page 12.



The **Touch Panel On/Off** button lets you turn off the touch panel so that you can point to the display without inadvertently making menu selections.

The two knobs control many functions of the DSA. You set the knobs to control specific functions when you make menu selections or touch icons. The knobs are described on page 10.

Front Panel and Plug-in Units

The **DIGITIZER** button stops and starts waveform acquisition—see page 36. The **AUTOSET** button sets the DSA parameters for a waveform display—see page 57. The **HARDCOPY** button prints a copy of the display—see page 115.The **ENHANCED ACCURACY** button calibrates the system for greatest accuracy—see page 85.

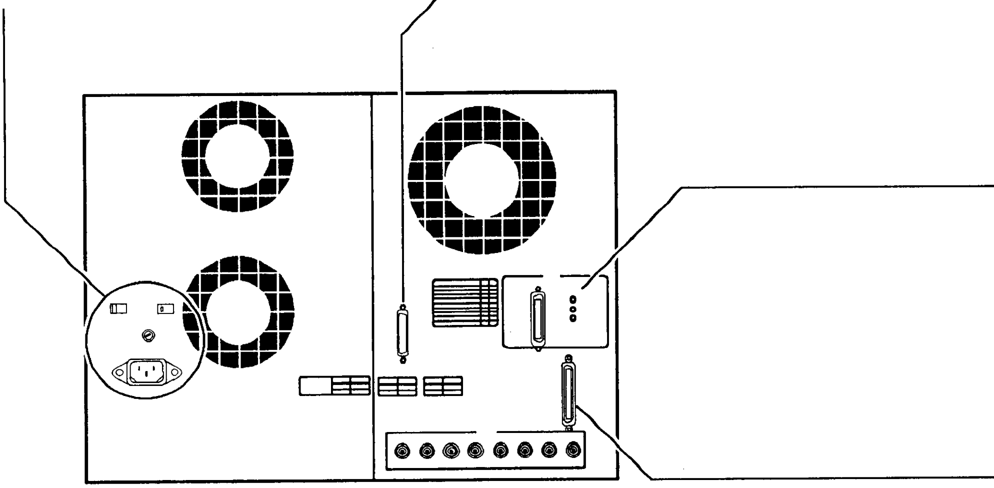
Use the **ON/STANDBY** switch as the power switch once the DSA is installed. See page 165.

The **CALIBRATOR** output provides a known signal for calibrating probes and input cables. See page 173

You install plug-in units or blank covers in the plug-in compartments. See page 155.

Power line controls include the **LINE VOLTAGE SELECTOR SWITCH**, the fuse, the power connector, and the **PRINCIPAL POWER SWITCH.**
See page 165.

The **RS-232-C** connector allows a remote computer to control the DSA through a serial interface.
See page 179.

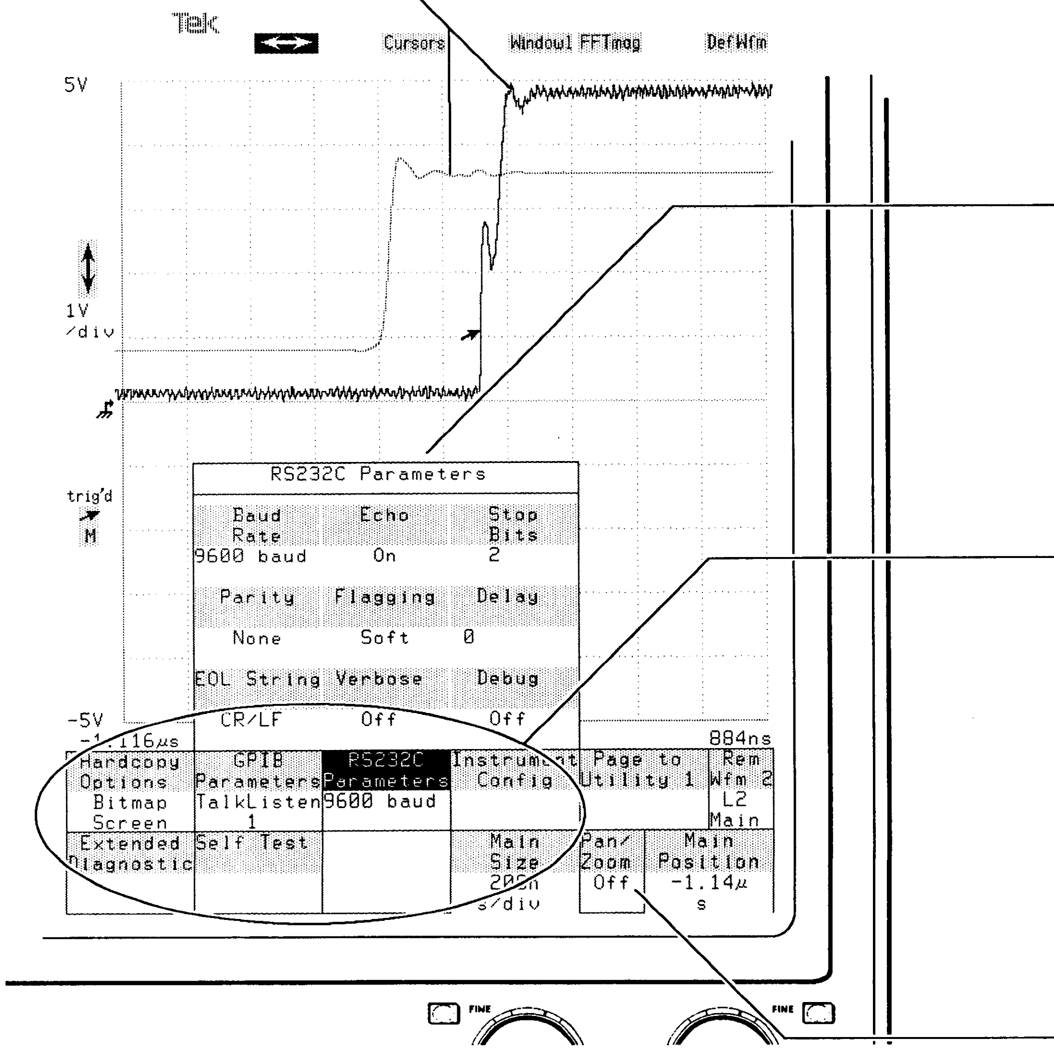


Rear Panel

The **GPIB** connector allows a remote computer to control the DSA through an IEEE STD 488 parallel interface. Three lights show the status of the parallel bus. See page 107.

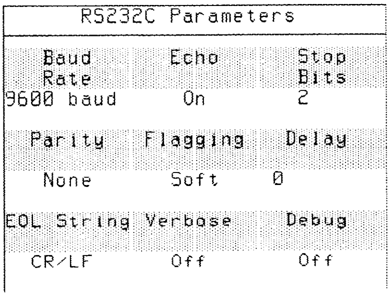
The **PRINTER** connector lets you attach an Epson FX-80 or compatible printer using a Centronics interface. See page 115.

Selected waveform and unselected waveform. Axis labels and readouts apply to the selected waveform. Waveforms can be selected by touching them.
See page 225..

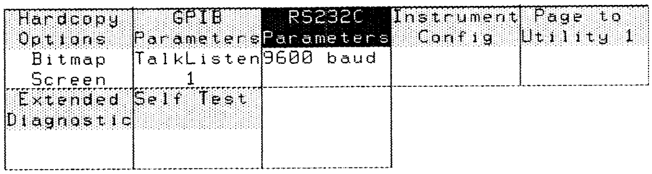


Display and Touch Panel

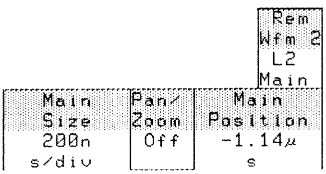
The display shows the output of the DSA, such as waveforms and measurement information. The display is combined with the touch panel to provide a touch menu system. Touch the selectors that are displayed in the various menus to execute those items. Each menu selector has a shaded top portion that names the selector, and a lower portion that shows the current status of the parameter that the selector controls.



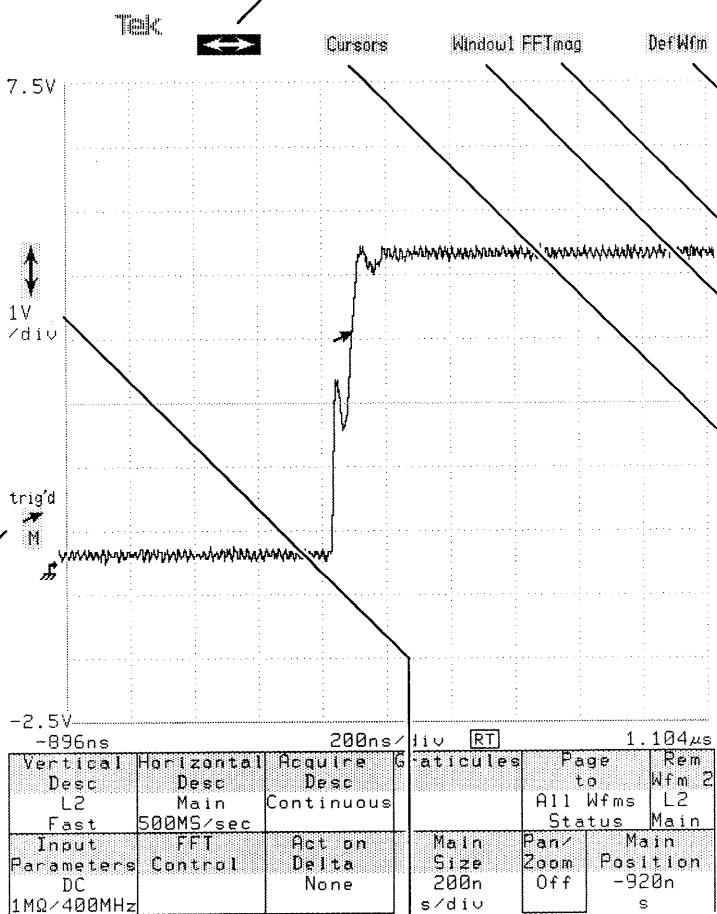
A pop-up menu provides a temporary dialog to let you set specific parameters. This is the **RS232C** pop-up menu, which is accessed by touching the **RS232C** selector in the Utility 2 major menu.



Several different major menus are available. You display and use the major menus by pressing the major menu buttons. This is the Utility 2 major menu. Touch the **RS232C** selector to display that pop-up menu. See page 12 for a description of the various major menus.



The Knob Menu always shows the parameters the knobs are currently assigned to control (top two selectors). You can also use the knob menu to remove waveforms from the display. You can touch the knob labels to see the Keypad Menu, which lets you enter a numeric value for any knob-controlled parameter. See page 10.



Touch the trigger icon to assign the knobs to adjust the trigger level. If the DSA is not triggered, **!not!** appears above the word **trig'd**.
See page 199.

Touch the vertical icon to assign the knobs to adjust the waveform vertical size and position. See page 215.

Icons

↔ Touch the horizontal icon to assign the knobs to adjust the waveform horizontal size and position. See page 125.

DefWfm Touch the define waveform icon to display a pop-up menu that lets you define a new waveform to be displayed. See page 219.

FFTmag Touch the FFT magnitude icon to display the magnitude of the frequency spectrum of the selected waveform. See page 87.

Window1 Touch the window icon to create a new waveform that represents an enlarged portion of another waveform. See page 231.

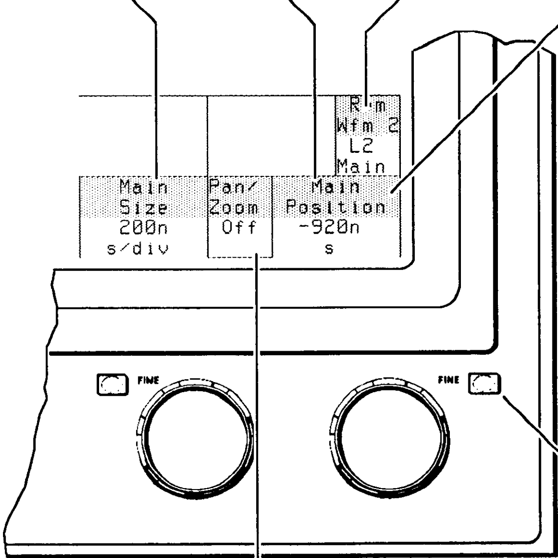
Cursors Touch the cursors icon to display bar or dot cursors for measurements of waveform values. See page 71.

Icons are always available, regardless of the major menu that is displayed.

The knob labels always show the knob assignments, the parameters that the knobs will control. The bottom half of each knob label shows the current value of the parameter. When you turn a knob, you will see the current value change, and you will see the change on the display and on any displayed menus that show the parameter.

This selector lets you remove a waveform from the display. First select the waveform you want removed by touching it, then touch this selector. A pop-up menu will ask you to verify the removal. See page 219.

Touch either knob label to display the Keypad Menu for that parameter.

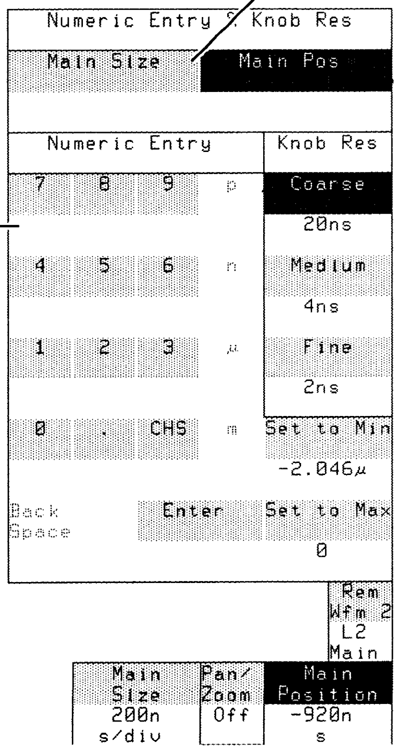


Touch the **FINE** button to change knob resolution. The **FINE** label is lighted when the knob resolution is set to Fine.

The **Pan/Zoom** selector lets you expand any part of a waveform using horizontal magnification. See page 127. When the knobs are assigned to vertical size and offset, this selector may change to provide more vertical control. See page 216.

Knobs, Knob Menu, and Keypad Menu

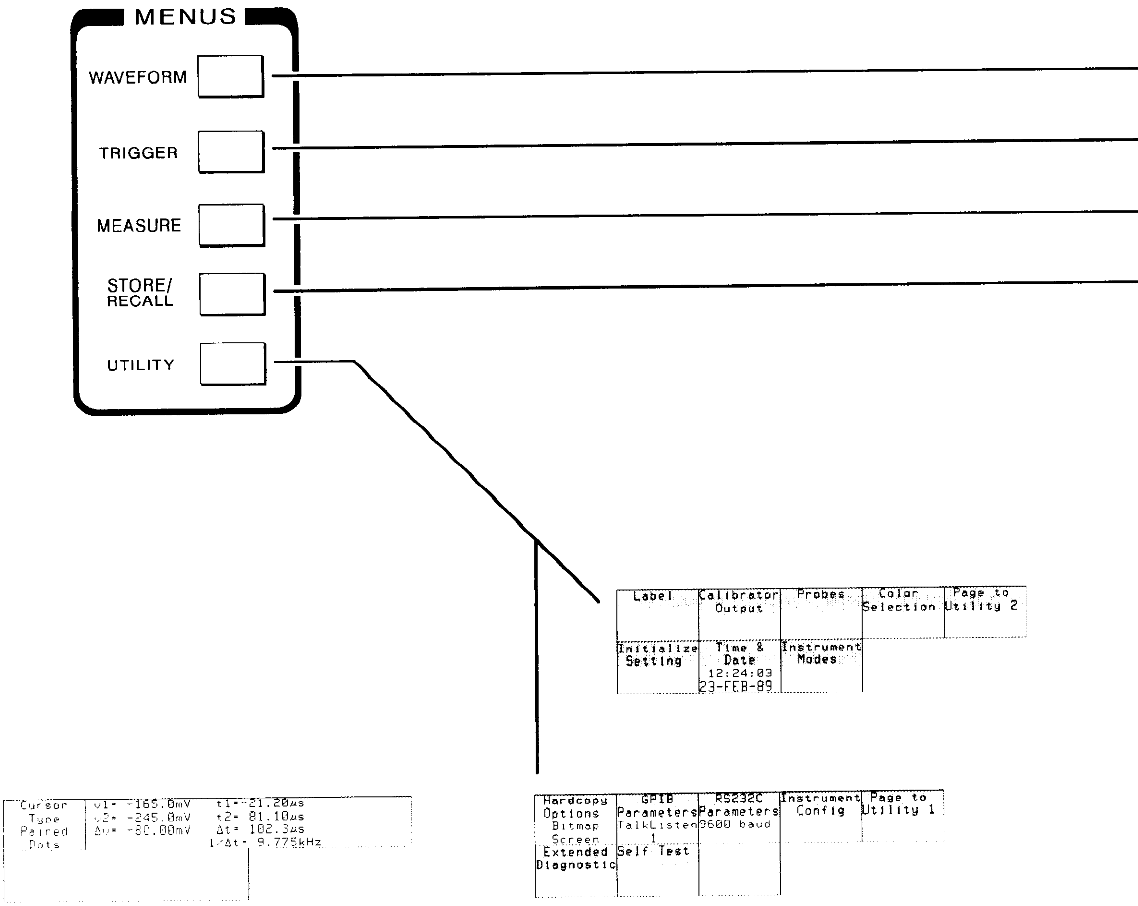
If you touch the wrong knob label by accident, the top two selectors let you choose the other knob parameter for Keypad Menu manipulation.



You can use the Keypad Menu to enter a numeric value for your parameter instead of turning the knob until the parameter is set. Touch number selectors as if you were typing the number, and end your entry by touching the **Enter** selector. **CHS** changes the sign of your number; **Back Space** lets you correct errors. The **p** (pico), **n** (nano), μ (micro), and **m** (milli) selectors let you scale your number.

The **Coarse**, **Medium**, and **Fine** selectors affect the knob resolution. When set to coarse, each knob click represents a greater change than when set to medium or fine.

The **Set to Min** and **Set to Max** selectors let you quickly set a parameter to either extreme of its range of adjustment.



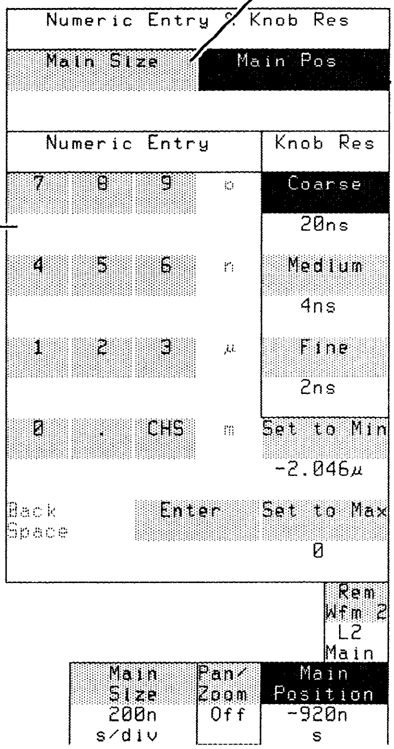
The Cursors major menu controls the cursors, which are markers that you position on your waveform to make measurements. Use the **Cursors** icon to display the Cursors major menu.
See page 71.

The Utility 1 and Utility 2 major menus control general DSA parameters including display colors, GPIB and RS-232-C settings, and the internal clock.
See pages 24 and 26.

Knobs, Knob Menu, and Keypad Menu

If you touch the wrong knob label by accident, the top two selectors let you choose the other knob parameter for Keypad Menu manipulation.

You can use the Keypad Menu to enter a numeric value for your parameter instead of turning the knob until the parameter is set. Touch number selectors as if you were typing the number, and end your entry by touching the **Enter** selector. **CHS** changes the sign of your number; **Back Space** lets you correct errors. The **p** (pico), **n** (nano), μ (micro), and **m** (milli) selectors let you scale your number.



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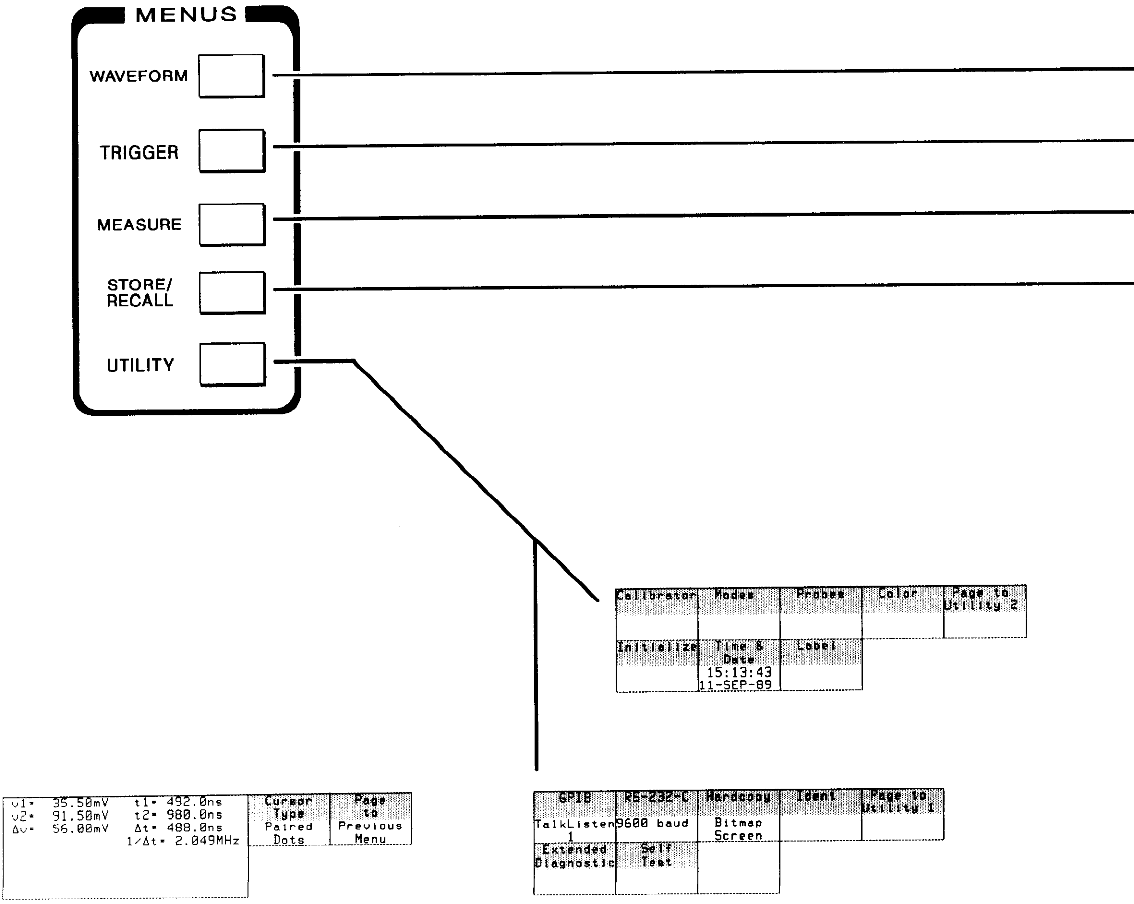
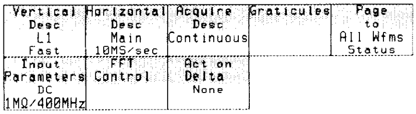


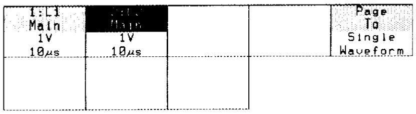
The Cursors major menu controls the cursors, which are markers that you position on your waveform to make measurements. Use the **Cursors** icon to display the Cursors major menu.
See page 71.

The Utility 1 and Utility 2 major menus control general DSA parameters including display colors, GPIB and RS-232-C settings, and the internal clock.
See pages 24 and 26.

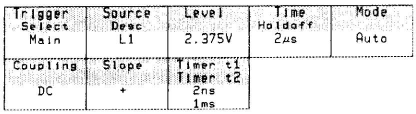
Major Menu Buttons



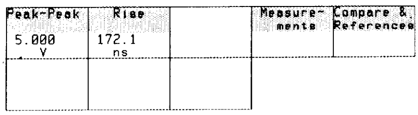
The Waveform major menu controls waveform definition, acquisition, and the plug-in units. See page 14.



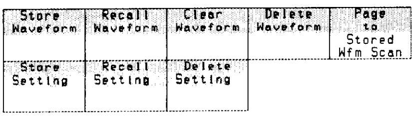
An alternate form of the Waveform major menu, the All Wfms Status menu, can be displayed using the **Page to** selector in the Waveform major menu. Press the Waveform major menu button to alternate between this menu and the Waveform major menu. See page 14.



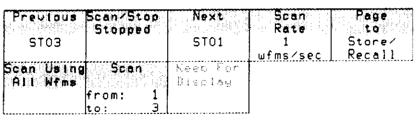
The Trigger major menu controls triggering. See page 16.



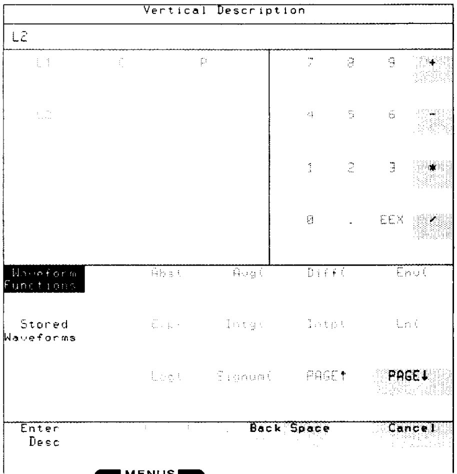
The Measure major menu controls the automatic measurement system. See page 18.



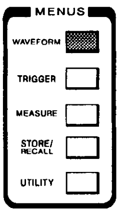
The Store/Recall major menu controls storage and recall of waveform data and DSA settings. See page 20.

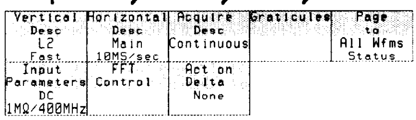


The Stored Wfm Scan major menu allows you to visually “scan” through a set of stored waveforms. See page 22.

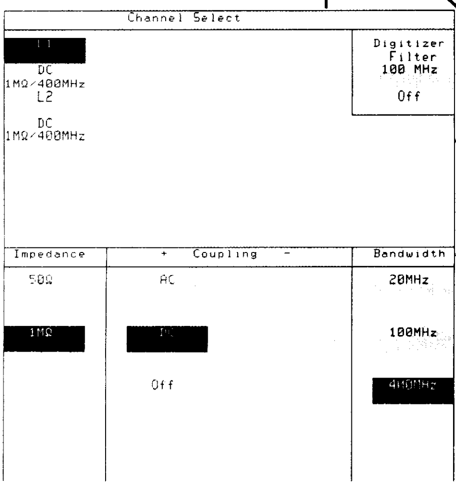


This pop-up menu lets you modify the waveform description of the selected waveform. See page 219.

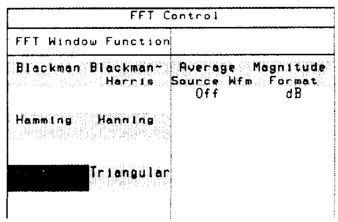




The **Page to** selector displays the alternate All Wfms Status major menu. This displays the status of all waveforms on the display. See page 226.

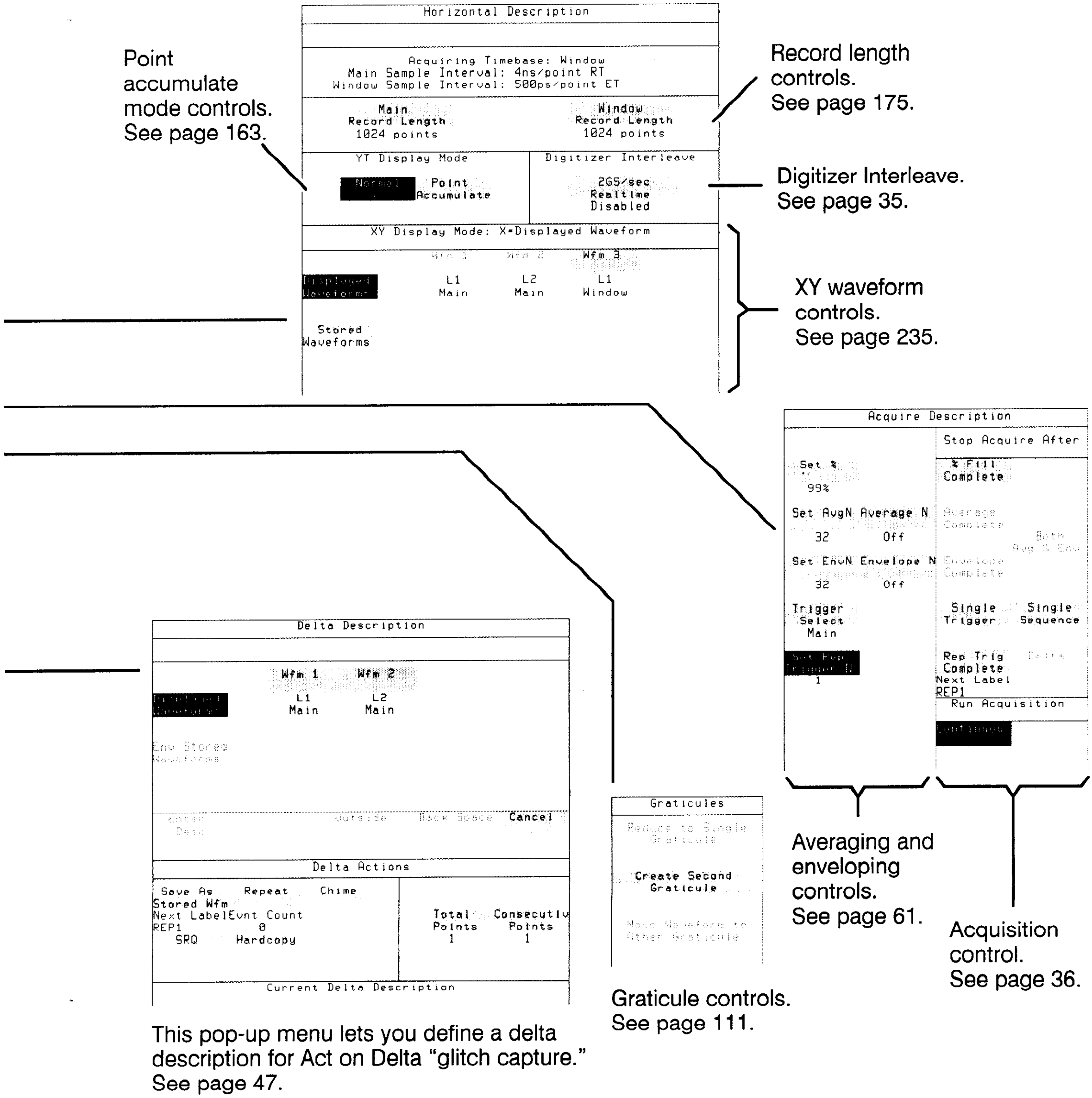


This pop-up menu lets you set the impedance, coupling, and bandwidth limits of plug-in amplifier input channels. See page 156.



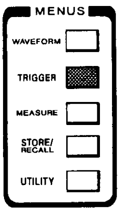
This pop-up menu lets you control Fast Fourier Transform parameters. See page 87.

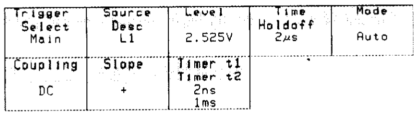
Waveform Major Menu



Select the Main or Window Trigger using this selector. See page 200.

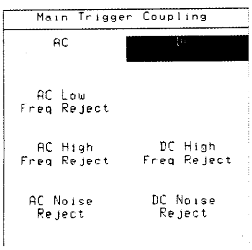
Touch these selectors to assign the knobs to control the trigger level and holdoff. See page 203.





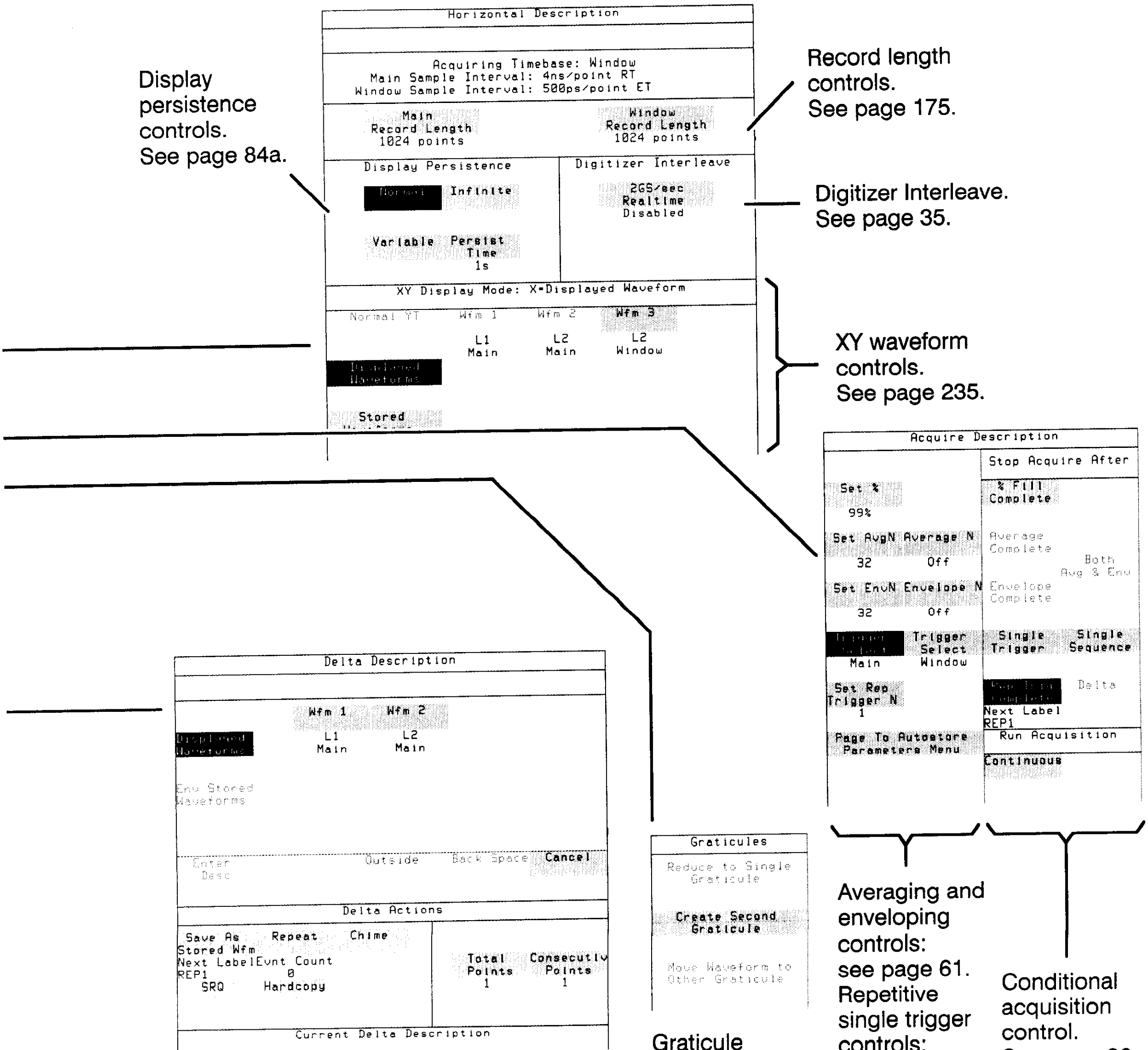
Touch this selector to assign the knobs to control timing for extended triggering. See page 207.

Touch this selector to change the trigger slope. See page 203.



Select the coupling for the trigger signal using this pop-up menu. See page 202.

Waveform Major Menu



Display persistence controls. See page 84a.

Record length controls. See page 175.

Digitizer Interleave. See page 35.

XY waveform controls. See page 235.

This pop-up menu lets you define a delta description for Act on Delta "glitch capture." See page 47.

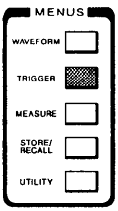
Graticule controls. See page 111.

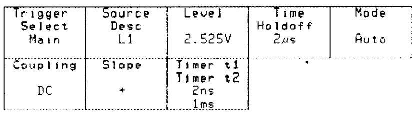
Averaging and enveloping controls: see page 61. Repetitive single trigger controls: see page 38.

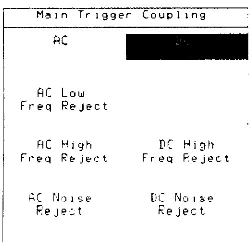
Conditional acquisition control. See page 36.

Select the Main or Window Trigger using this selector. See page 200.

Touch these selectors to assign the knobs to control the trigger level and holdoff. See page 203.







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Touch this selector to change the trigger slope. See page 203.

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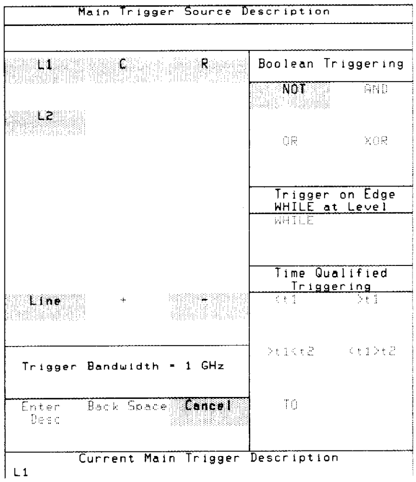
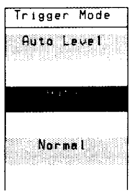
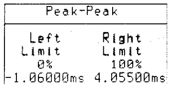
Trigger Major Menu



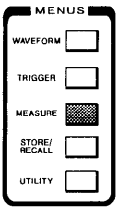
Define the trigger source for the selected trigger using this pop-up menu. See page 200.

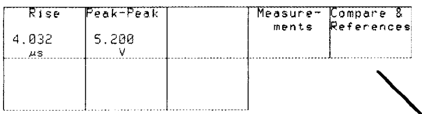


Select the trigger mode using this pop-up menu. See page 206.



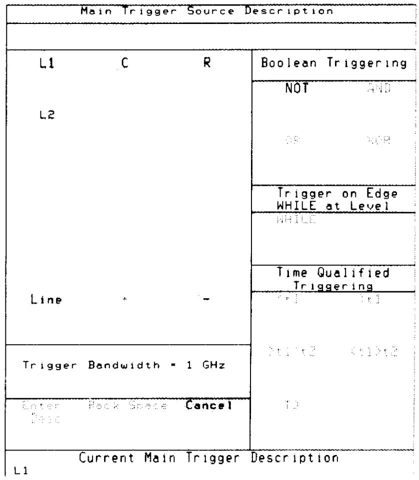
Touch a measurement readout to display a pop-up menu that lets you control the way the measurement is taken. See page 149.



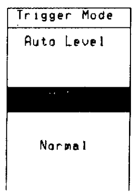


These six selectors are reserved for readouts of the measurements that you select. This sample menu shows that two measurements are selected. See page 139.

Trigger Major Menu



Define the trigger source for the selected trigger using this pop-up menu. See page 200.



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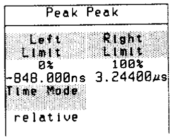

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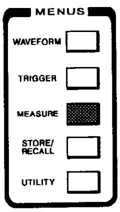
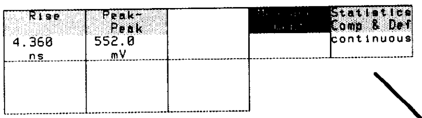
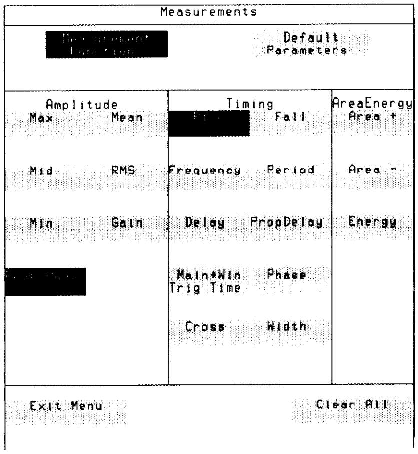


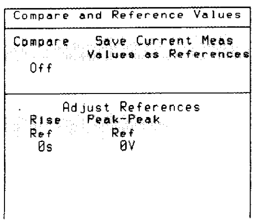


These six selectors are reserved for readouts of the measurements that you select. This sample menu shows that two measurements are selected. See page 139.

Measure Major Menu

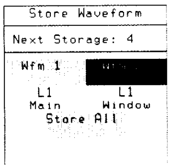


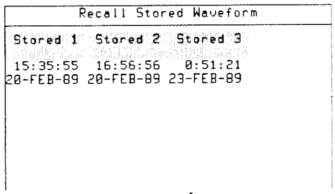
Use this pop-up menu to specify which measurements you want to take. As you select measurements, the readouts appear immediately in the unused selectors of the major menu. See page 142.

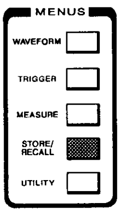


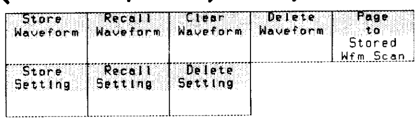
Use this pop-up menu to make your measurement relative to a reference value. See page 147.

These pop-up menus let you store and recall displayed waveforms. See page 189.

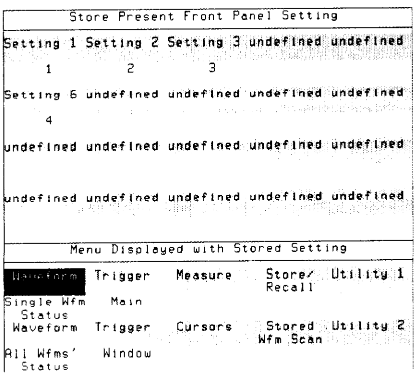






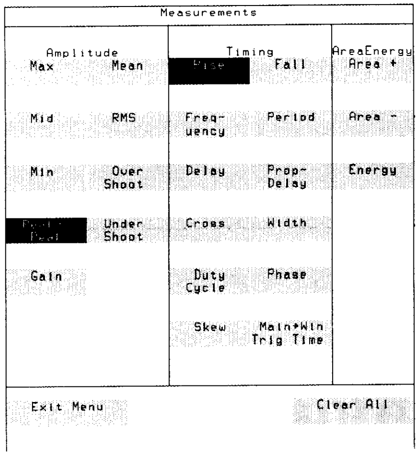


Use the **Page to** selector or the **STORE/RECALL** button to display the Stored Waveform Scan major menu.
See page 22.

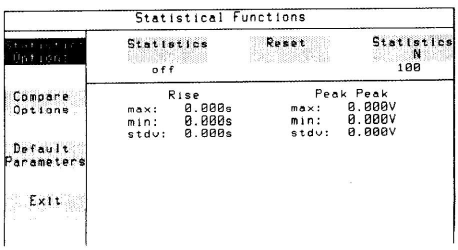


This pop-up menu lets you store a DSA setting. See page 183.

Measure Major Menu

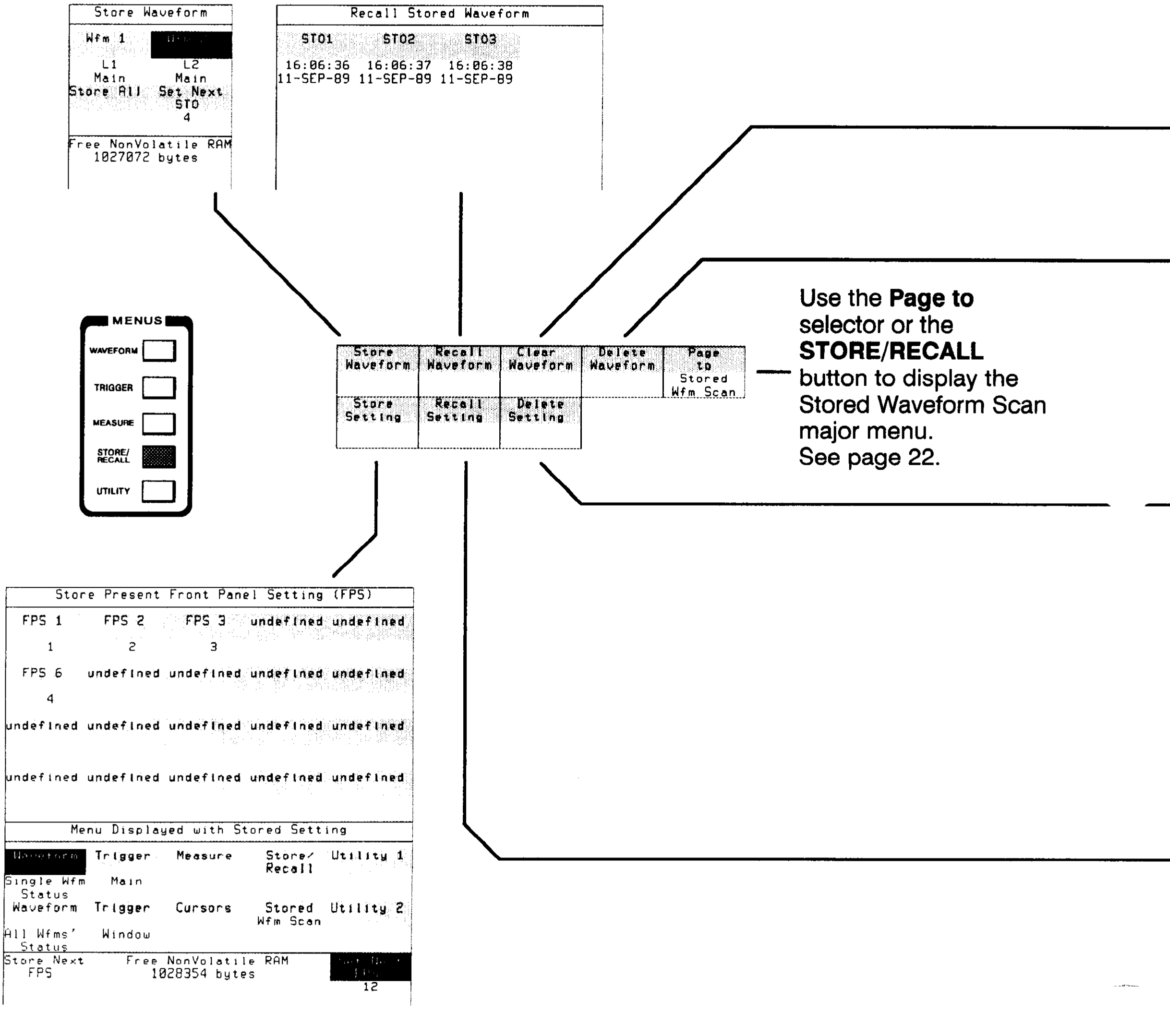


Use this pop-up menu to specify which measurements you want to take. As you select measurements, the readouts appear immediately in the unused selectors of the major menu. See page 142.



Use this pop-up menu to view measurement statistics or make your measurement relative to a reference value. See page 147.

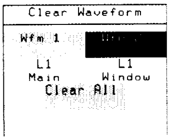
These pop-up menus let you store and recall displayed waveforms. See page 189.



Use the **Page to** selector or the **STORE/RECALL** button to display the Stored Waveform Scan major menu.
See page 22.

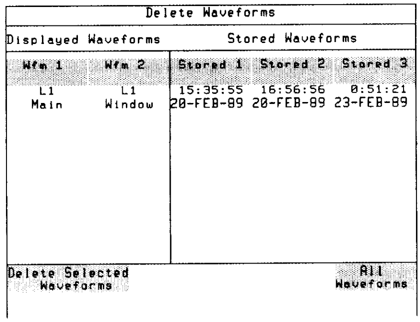
This pop-up menu lets you store a DSA setting. See page 183.

Store/Recall Major Menu

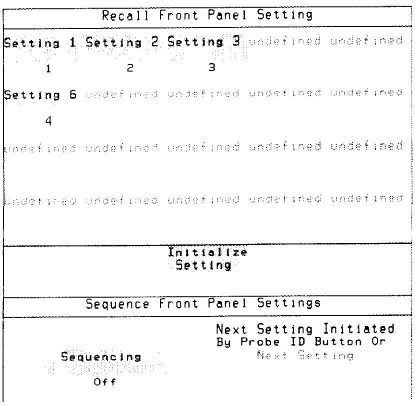


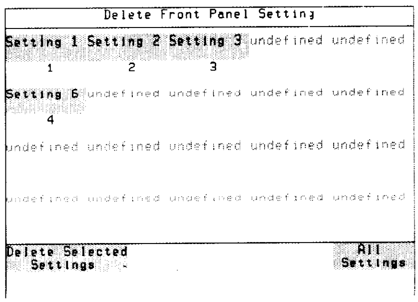
Clear displayed waveforms using this pop-up menu.
See page 41.

Delete displayed or stored waveforms using this pop-up menu.
See page 189.



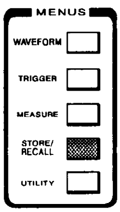
These pop-up menus let you recall or delete settings.
See page 183.

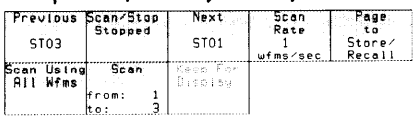




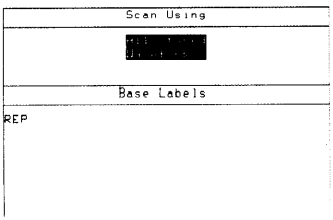
Use this selector to start or stop scanning through a sequence of stored waveforms. See page 193.

Use this selector to display the previous stored waveform in a sequence. See page 193.





Use the **Page to** selector or the **STORE/RECALL** button to display the Store/Recall major menu. See page 20.

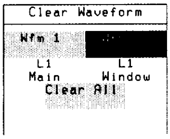


This pop-up menu lets you select a sequence of waveforms to scan on the display. See page 194.

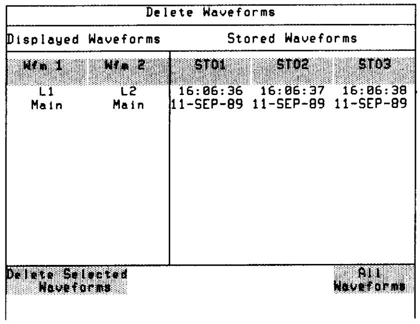
Touch this selector to assign the knobs to control the limits of the sequence of stored waveforms to scan. See page 193.

Store/Recall Major Menu

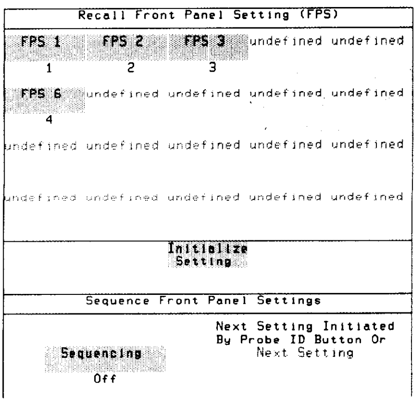
Clear displayed waveforms using this pop-up menu.
See page 41.

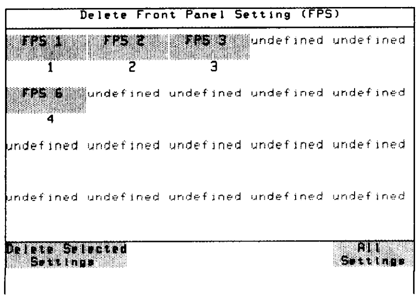


Delete displayed or stored waveforms using this pop-up menu.
See page 189.



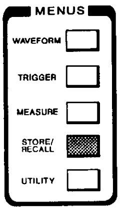
These pop-up menus let you recall or delete settings.
See page 183.

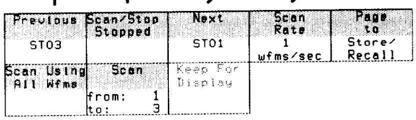




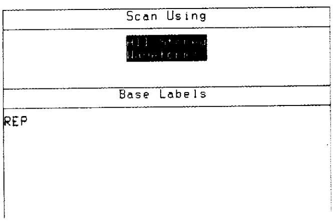
Use this selector to start or stop scanning through a sequence of stored waveforms. See page 193.

Use this selector to display the previous stored waveform in a sequence. See page 193.





Use the **Page to** selector or the **STORE/RECALL** button to display the Store/Recall major menu. See page 20.



This pop-up menu lets you select a sequence of waveforms to scan on the display. See page 194.

Touch this selector to assign the knobs to control the limits of the sequence of stored waveforms to scan. See page 193.

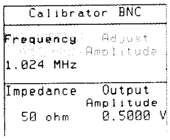
Stored Waveform Scan Major Menu

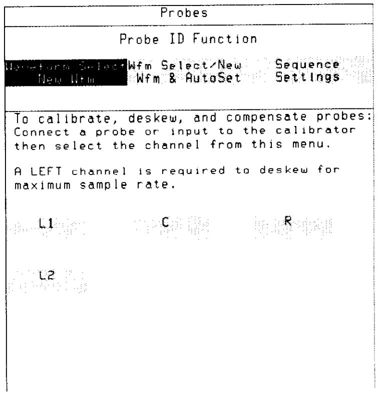
Use this selector to display the next stored waveform in a sequence. See page 193.

Touch this selector to assign the knobs to control the rate at which stored waveforms are displayed and replaced in scanning. See page 194.

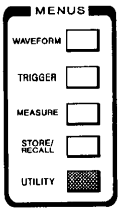
Touch this selector to create a new waveform that displays the current stored waveform in the scanning sequence. See page 193.

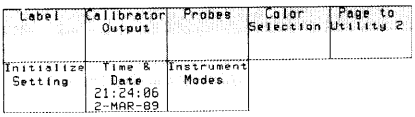
Use this pop-up menu to control the calibrator output. See page 65.





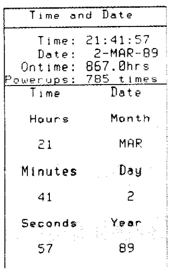
Use this pop-up menu to calibrate probes and to set the function of the probe ID button. See page 169.





Use the **Page to** selector or the **UTILITY** button to display the Utility 2 major menu. See page 26.

Use this selector to initialize the DSA to a known state. See page 131.



Use this pop-up menu to set the DSA clock. See page 197.

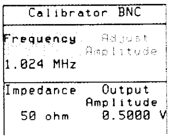
Stored Waveform Scan Major Menu

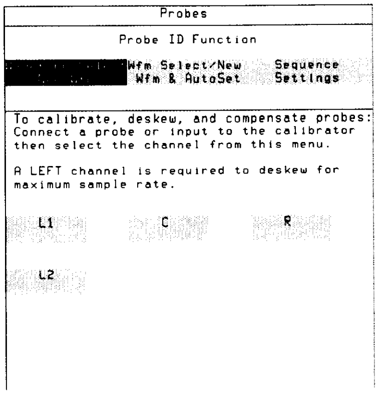
Use this selector to display the next stored waveform in a sequence. See page 193.

Touch this selector to assign the knobs to control the rate at which stored waveforms are displayed and replaced in scanning. See page 194.

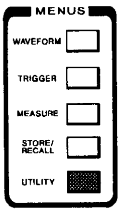
Touch this selector to create a new waveform that displays the current stored waveform in the scanning sequence. See page 193.

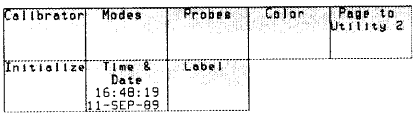
Use this pop-up menu to control the calibrator output.
See page 65.





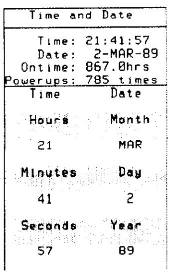
Use this pop-up menu to calibrate probes and to set the function of the probe ID button.
See page 169.





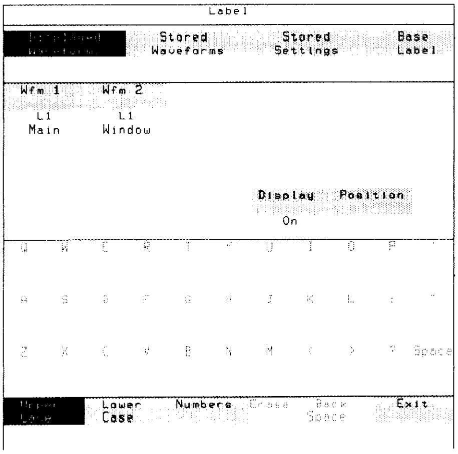
Use the **Page to** selector or the **UTILITY** button to display the Utility 2 major menu. See page 26.

Use this selector to initialize the DSA to a known state.
See page 131.



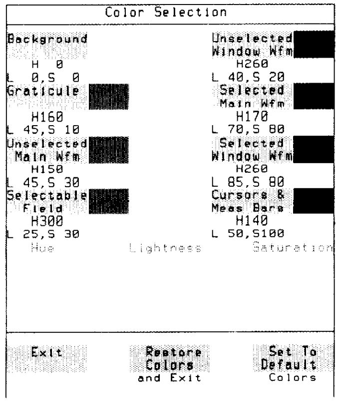
Use this pop-up menu to set the DSA clock.
See page 197.

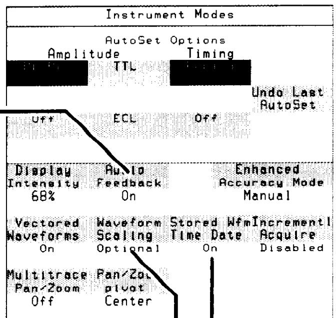
Utility 1 Major Menu



Use this pop-up menu to label a waveform or setting. See page 135.

Use this pop-up menu to adjust the display colors. See page 67.





Touch this selector to turn the audible beep on or off. See page 55.

Autoset controls are described on page 57.

Touch this selector to set the Enhanced Accuracy mode. See page 85.

Turn on or off vectored waveforms with this selector. See page 211.

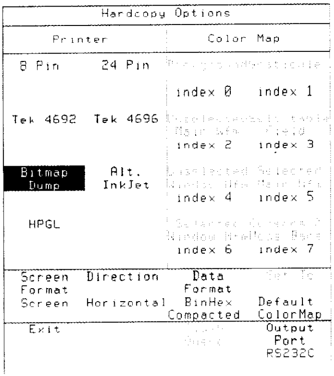
Touch this selector to enable or disable incremental acquisition. See page 40.

Pan/Zoom controls are described on page 127.

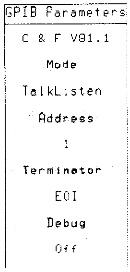
Touch this selector to turn on or off display of time and date with stored waveforms. See page 191.

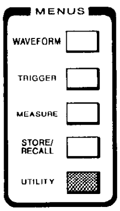
Control waveform scaling with this selector. See page 228.

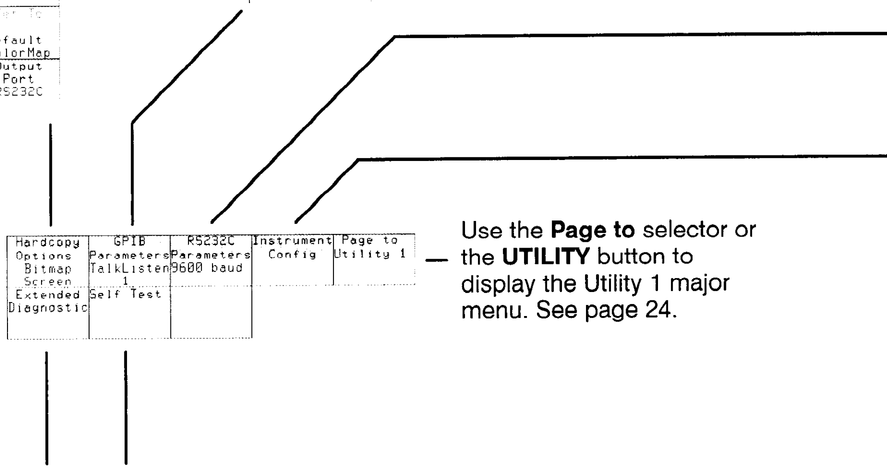
Hardcopy controls are described on page 115.



Use this pop-up menu to set GPIB parameters. See page 107.



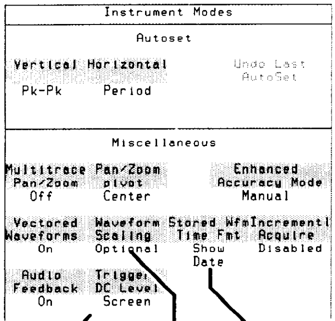




Use the **Page to** selector or the **UTILITY** button to display the Utility 1 major menu. See page 24.

Use the **Self Test** and **Extended Diagnostic** selectors to operate the diagnostic system and verify that the DSA is operating properly. See page 77.

Utility 1 Major Menu



Pan/Zoom controls are described on page 127.

Turn on or off vectored waveforms with this selector. See page 211.

Touch this selector to turn the audible beep on or off. See page 55.

Touch this selector to set the Trigger DC Level mode. See page 203.

Control waveform scaling with this selector. See page 228.

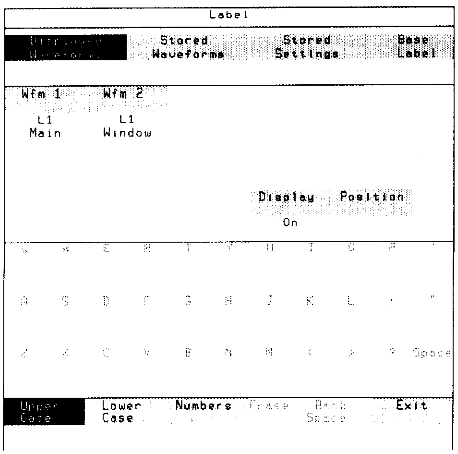
Autoset controls are described on page 57.

Touch this selector to set the Enhanced Accuracy mode. See page 85.

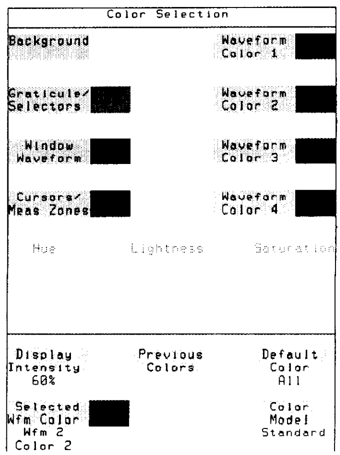
Touch this selector to enable or disable incremental acquisition. See page 40.

Touch this selector to change the format of the stored waveform timestamp. See page 191.

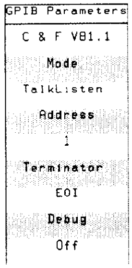
Use this pop-up menu to label a waveform or setting. See page 135.

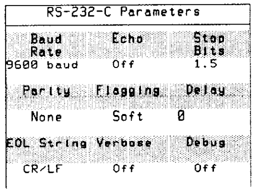


Use this pop-up menu to adjust the display colors. See page 67.

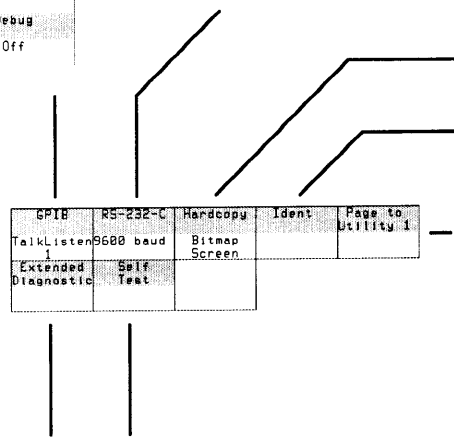


Use this pop-up menu to set GPIB parameters. See page 107.

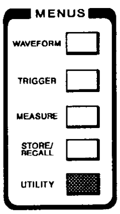




Use this pop-up menu to set RS-232-C parameters. See page 179.



Use the **Page to** selector or the **UTILITY** button to display the Utility 1 major menu. See page 24.



Use the **Self Test** and **Extended Diagnostic** selectors to operate the diagnostic system and verify that the DSA is operating properly. See page 77.

Utility 2 Major Menu

RS232C Parameters

Baud Rate	Echo	Stop Bits
9600 baud	On	2
Parity	**Flagging**	**Delay**
None	Soft	0
EOL String	**Verbose**	**Debug**
CR/LF	Off	Off

Use this pop-up menu to set RS-232-C parameters. See page 179.

Instrument Configuration

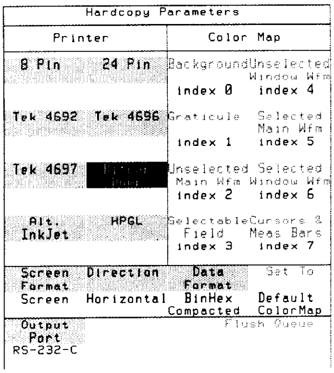
Instr	Section	ROM	ID#
DSA 602	Executive	F0.7	c03
DSA 602	Digitizer	F0.7	c03
DSA 602	Display	F0.7	c03
11A32	Left	F3.3	B010211
N/7K	Center		
N/7K	Right		

Installed Options

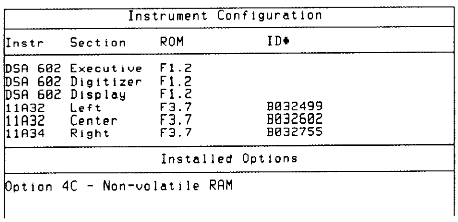
Option 4C - Non-volatile RAM

This pop-up menu shows DSA and plug-in unit identification, firmware version numbers, and installed options. See page 133.

Utility 2 Major Menu



Hardcopy controls are described on page 115.



This pop-up menu shows DSA and plug-in unit identification, firmware version numbers, and installed options. See page 133.

In Detail

In Detail

Acquisition

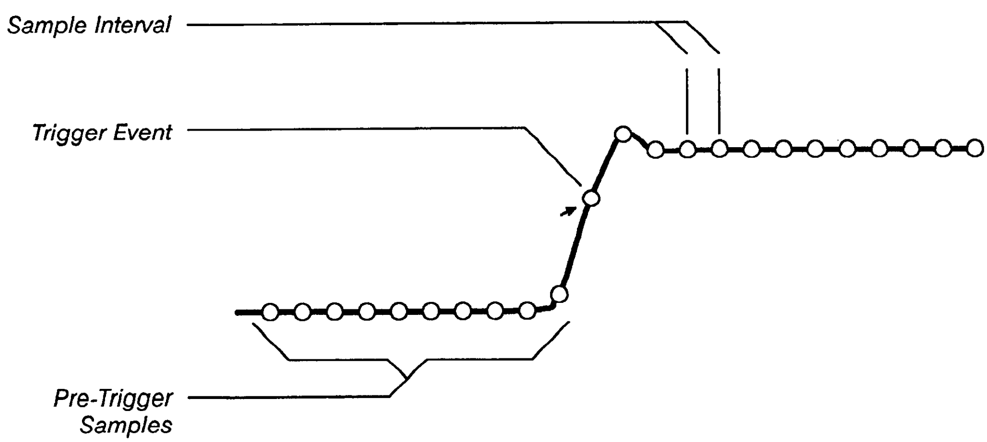
Acquisition is the process of collecting points of data from a signal and assembling them into a waveform record that is shown on the display. Once you create a waveform, the DSA continues to acquire the signal and you see a live waveform on the display.

How Waveforms are Acquired

The DSA collects samples from repetitions of a signal and determines the position of each sampled point with respect to the trigger event on that repetition. Samples may be taken both before and after the trigger event. This process continues until enough sampled points have been collected to assemble a complete waveform record.

Sampling in Real Time Mode

Real time sampling occurs only when the time between samples, or *sample interval*, is at least as great as the time required to take a sample. That is, the sample rate must be low enough that the DSA can acquire a complete waveform record based on a single trigger event.

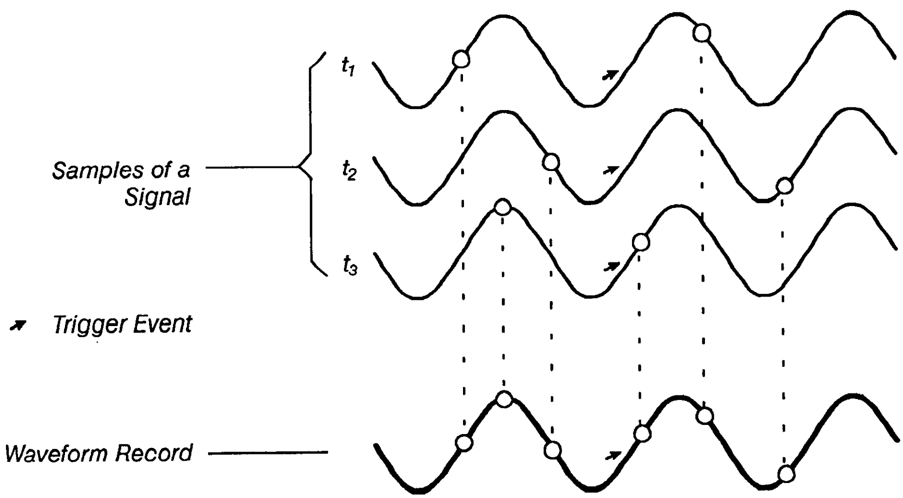


Real Time Acquisition of a Waveform

Non-repetitive events can be captured in real time sampling mode. The maximum sample rate at which real time acquisition will occur is 2 Gsample/s for the DSA 602 or 1 Gsample/s for the DSA 601.

Sampling in Equivalent Time Mode

When the DSA cannot acquire a complete waveform record in real time mode, samples from multiple repetitions of a signal will be assembled into a single waveform record. This is called *equivalent time sampling*. The DSA does not necessarily acquire the samples in sequential order, but determines the position of each sample in the final waveform record based on the time between the sample and its trigger event.



Equivalent Time Acquisition of a Waveform

Achieving Real Time Acquisition

For some applications you will want to insure that acquisition occurs in real time mode. For example, non-repetitive signals can be captured only in real time mode.

You can tell whether the DSA is acquiring signals in real time or equivalent time mode by observing the RT (Real Time) or ET (Equivalent Time) indicator that appears below the graticule. The acquisition mode is also reported in the **Horizontal Desc** pop-up menu, shown on the next page. To view this pop-up menu, select **Horizontal Desc** in the Waveform major menu.

Acquisition will occur in real time mode if the time between samples is at least as great as the time the DSA takes to sample and digitize a waveform record point. Therefore, real time acquisition can be achieved by increasing the sample interval.

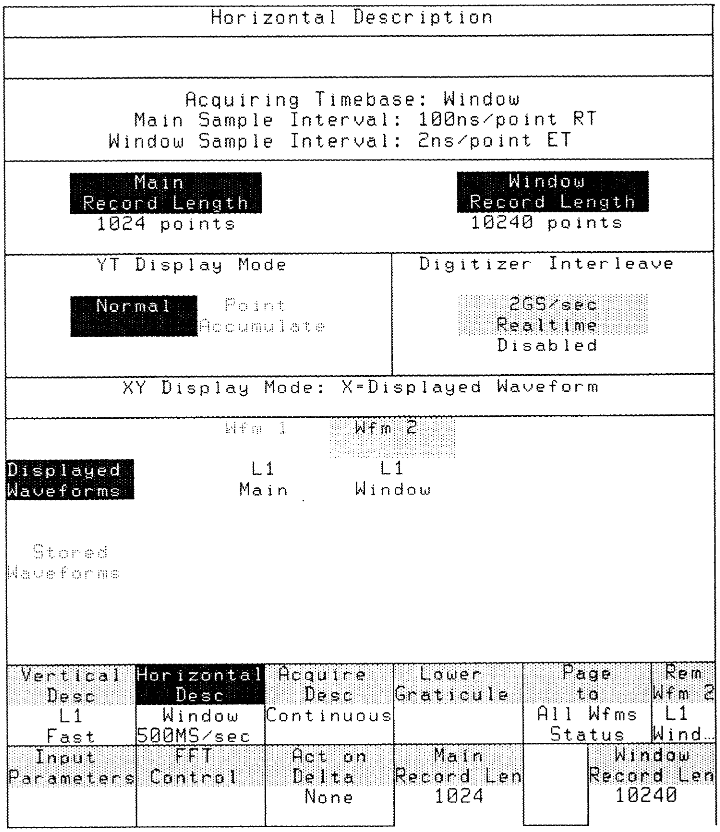
Increasing the Sample Interval

The sample interval is equal to the time period that the waveform record displays divided by the number of points in the waveform record. For example, if you display a waveform at 20 ns per division, a little more than 200 ns of time is displayed. (There are a few points outside the 10-division graticule on either side.) If the waveform has 2048 points, the sample interval is 204.8 ns divided by 2048 points, or 100 ps/point. The current sample interval is reported in the **Horizontal Desc** pop-up menu.

You can increase the sample interval by increasing the *horizontal size*, the time period the waveform record displays. To set the horizontal size, select the horizontal icon (↔) and use the left knob to adjust the size.

Setting the record length is described in more detail on page 175.

You can also increase the sample interval by decreasing the *record length*, the number of points in a waveform record. To change the record length, select **Main Record Length** or **Window Record Length** in the **Horizontal Desc** pop-up menu and use the knobs to adjust the record length.



The **Horizontal Desc** *Pop-Up Menu*

Increasing the Sample Rate

The sample rate is the inverse of the sample interval. When the DSA operates in equivalent time mode, the sample rate is an *equivalent* sample rate. The equivalent sample rate reflects the timing resolution of equivalent time acquisition.

The sample rate is always displayed in the status area of the **Horizontal Desc** selector in the Waveform major menu. To determine whether sampling is occurring in equivalent time or in real time, you can observe the ET or RT indicator below the graticule, or you can observe the "ET" or "RT" notation following the sample interval readout in the **Horizontal Desc** pop-up menu.

When the DSA operates in single shot (single trigger) mode, the RT notation in the **Horizontal Desc** pop-up menu may be followed by the notation "< 100%," meaning that the waveform sampled in real time mode will be an incomplete record.

Achieving the Maximum Real Time Sample Rate

You can use the Digitizer Interleave function, which is available from the **Horizontal Desc** pop-up menu, to increase the real time sample rate when a single channel is being acquired. Select **2GS/sec Realtime** (**1 GS/sec Realtime** for the DSA 601) under **Digitizer Interleave** in the **Horizontal Desc** pop-up menu to enable or disable this function. The DSA 601 has two digitizers which individually allow sample rates of up to 500 million samples per second (500 Msample/s). When Digitizer Interleave is enabled, the two digitizers of the DSA 601 can alternately sample a single channel to provide sample rates of up to 1 gigasample per second (1 Gsample/s). The DSA 602 has four digitizers, providing a maximum sample rate of up to 2 Gsample/s when Digitizer Interleave is enabled.

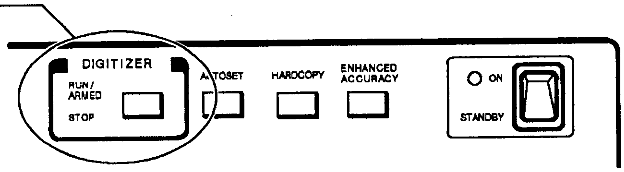
Enhanced Accuracy is discussed on page 85. Probe Calibration is discussed on page 173.

When you enable the Digitizer Interleave function, you will need to run Enhanced Accuracy calibration and Probe Calibration. Even if you are not using a probe, the Probe Calibration procedure is necessary to ensure optimum performance. If you are using a subminiature probe, you will need to use the subminiature probe tip to BNC adapter provided with the DSA in order to calibrate the system for the maximum sample rate.

Controlling Acquisition

You can freeze the waveforms on the display at any time by pressing the **DIGITIZER** button. This button is found above the plug-in compartment, near the column of major menu buttons. This technique lets you stop live waveforms to examine them more closely.

The **DIGITIZER** *Button*



Next to the **DIGITIZER** button are **RUN/ARMED** and **STOP** lights. One or the other of these lights is always on, telling you whether acquisition is occurring.

The **Acquire Desc** pop-up menu in the Waveform major menu also controls acquisition. Use the selectors in the **Stop Acquire After** section of this pop-up menu to specify that acquisition stop on various conditions. The status area below the **Acquire Desc** selector shows the current acquisition status, for example **Stopped**, **Trig Armed**, or **Continuous**.

% Fill Complete

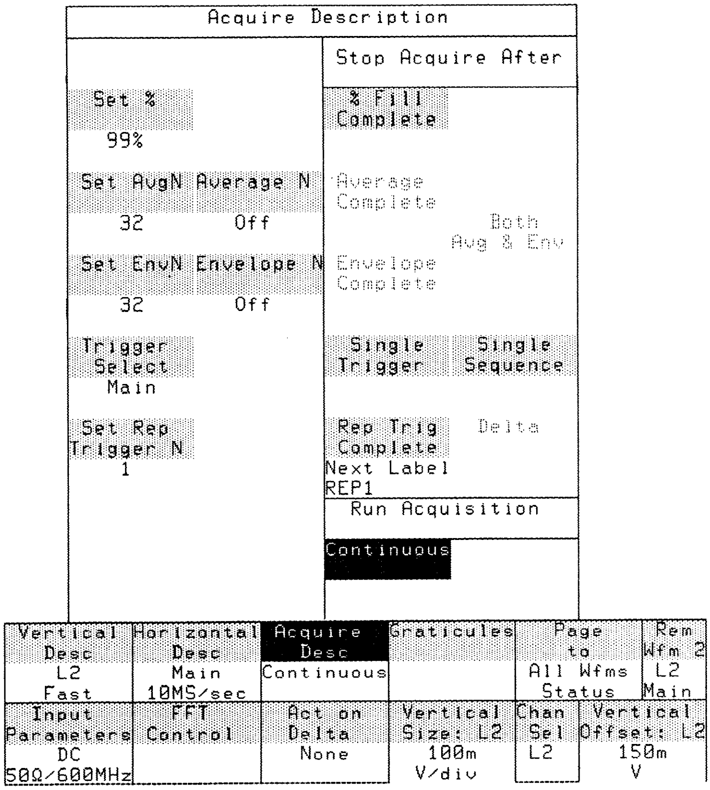
Select **% Fill Complete** to have equivalent time acquisition stop when the percentage of a complete record specified by the % Fill parameter has been reached for each waveform record.

Select **Set %** to set the % Fill parameter using the knobs or keypad menus.

Average or Envelope Complete

If you use the averaging or enveloping features, you can select **Average Complete**, **Envelope Complete**, or **Both Avg & Env** to specify that acquisition stop after enough records have been acquired to provide a complete average and/or envelope.

For details on how to use the **Acquire Desc** pop-up menu to select averaging or enveloping, see Averaging and Enveloping on page 61.



The **Acquire Desc** *Pop-Up Menu*

Triggering Functions

Triggering is discussed in detail starting on page 199.

The Single Trigger, Single Sequence, and Repetitive Single Trigger acquisition modes stop acquisition after acquiring a waveform record or partial waveform record based on a single trigger event or after acquiring a series of such waveform records. Touch **Trigger Select** in the **Acquire Desc** pop-up menu to select **Main** or **Window** trigger for these functions.

Select **Single Trigger** to stop acquisition when a single Main trigger is detected and the time base duration has expired. In Real Time sampling mode, you can use single trigger to acquire a single triggered sweep of a non-repetitive signal. Pressing the **DIGITIZER** button will re-arm the trigger circuit for another Single Trigger acquisition. If the first Single Trigger acquisition did not sample all the active input channels, the next will begin with those channels.

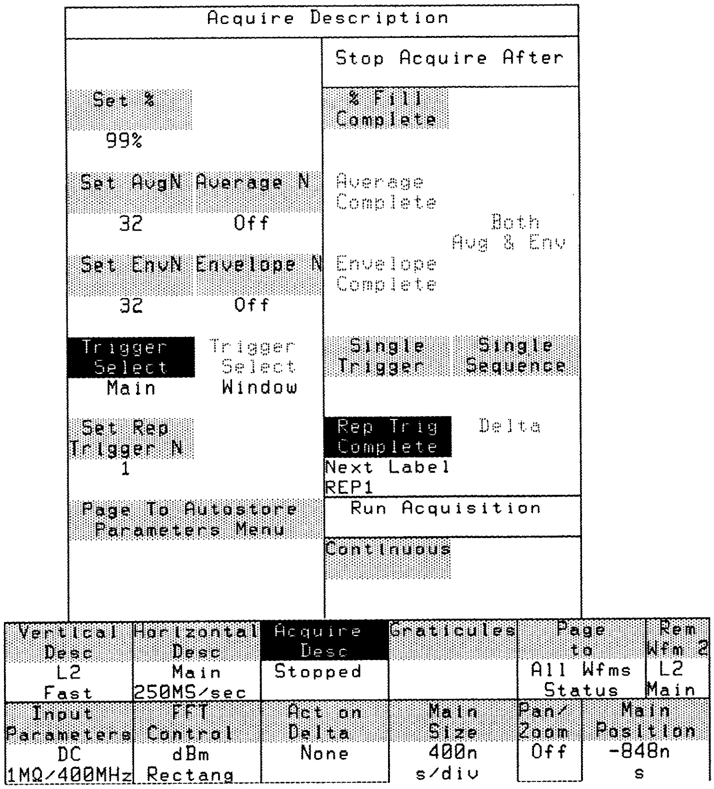
Select **Single Sequence** to have the DSA run a series of Single Trigger acquisitions, stopping when all waveform records are at least partially acquired. Press the **DIGITIZER** button to start another Single Sequence acquisition.

Selecting **Rep Trig Complete** enables Repetitive Single Trigger acquisition. The DSA will store a series of Single Trigger acquisitions of the selected waveform. You can set the number of acquisitions by selecting **Set Rep Trig N** and adjusting **Rep Trig N** using the knobs. Press the **DIGITIZER** button to begin Repetitive Single Trigger Acquisition.

See Labeling on page 135 for more information about labeled waveforms.

In Repetitive Single Trigger mode, each acquired waveform record is stored with a label consisting of a *base label* followed by a number. The numbers are assigned sequentially.

For details on how to use the **Acquire Desc** pop-up menu to select averaging or enveloping, see Averaging and Enveloping on page 61.



The **Acquire Desc** *Pop-Up Menu*

Triggering Functions

Triggering is discussed in detail starting on page 199.

The Single Trigger, Single Sequence, and Repetitive Single Trigger acquisition modes stop acquisition after acquiring a waveform record or partial waveform record based on a single trigger event or after acquiring a series of such waveform records. Touch a **Trigger Select** selector (Main or Window) in the **Acquire Desc** pop-up menu to select the Main or Window trigger for these functions. The Window trigger can be selected only when a separate Window trigger is defined.

Select Single Trigger—to stop acquisition when a single Main trigger is detected and the time base duration has expired. In Real Time sampling mode, you can use single trigger to acquire a single triggered sweep of a non-repetitive signal. Pressing the **DIGITIZER** button will re-arm the trigger circuit for another Single Trigger acquisition. If the first Single Trigger acquisition did not sample all the active input channels, the next will begin with those channels.

Select Single Sequence—to have the DSA run a series of Single Trigger acquisitions, stopping when all waveform records are at least partially acquired. Press the **DIGITIZER** button to start another Single Sequence acquisition.

Select Rep Trig Complete—to enable Repetitive Single Trigger acquisition. The DSA will store a series of Single Trigger acquisitions of the selected waveform. You can set the number of acquisitions by selecting **Set Rep Trigger N** and adjusting **Rep Trig N** using the knobs. Press the **DIGITIZER** button to begin Repetitive Single Trigger Acquisition. You may notice a brief delay as the DSA prepares to acquire and store waveforms.

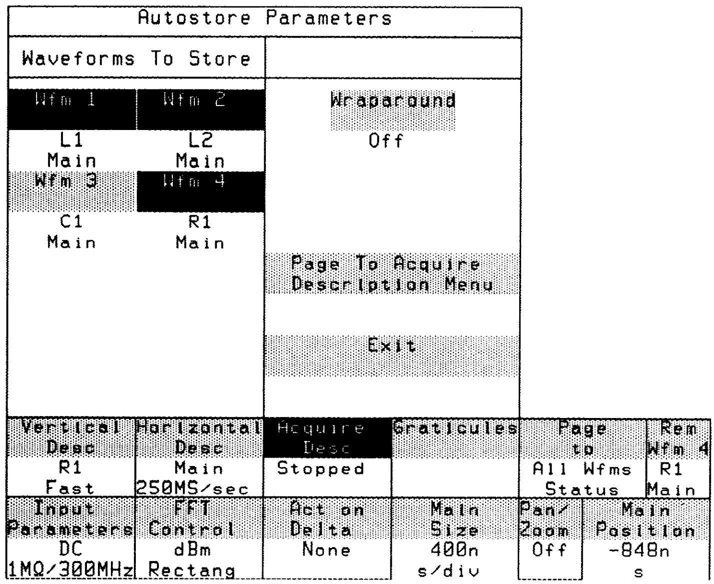
You can select **Rep Trig Complete** only when all active channels can be acquired concurrently. See Concurrent Acquisition on page 44 for a description of limitations on concurrent acquisition.

You can acquire multiple waveforms in Repetitive Single Trigger mode, provided the waveforms can be acquired concurrently. Select **Page to Autostore Parameters Menu** to display a pop-up menu that allows you to select multiple waveforms. Select the waveforms you want to acquire and save in repetitive single trigger mode by touching their selectors.

Revised 9/89

The **Wraparound** selector in the **Autostore Parameters** pop-up menu controls memory wrapping. When **Wraparound** is set to Off (the default), the number of acquisitions specified by **Set Rep Trigger N** are acquired and stored.

When **Wraparound** is set to On, all available waveform memory will be used for repetitive single trigger acquisitions. When waveform memory is filled, the oldest waveforms stored by repetitive single trigger will be replaced by new acquisitions. This is useful if you want to leave the DSA running for awhile and examine the most recent acquisitions.



The **Autostore Parameters** *Pop-Up Menu*

See Labeling on page 135 for more information about labeled waveforms.

In Repetitive Single Trigger mode, each acquired waveform record is stored with a label consisting of a *base label* followed by a number. The numbers are assigned sequentially.

Added 9/89

When you acquire multiple waveforms in repetitive single trigger mode, each stored waveform will be labeled with the base label, followed by the acquisition number, a colon, and the waveform number (1 through 8) of that waveform. For example, **REP10:2** identifies the tenth acquisition of waveform 2 in repetitive single trigger mode, using the base label "REP."

For fast repetitive single trigger acquisition, the DSA allocates stored waveform memory when you press the **DIGITIZER** button, before starting acquisition. If memory wraparound is off, enough memory to store N acquisitions (set by **Set Rep Trigger N** will be allocated. If memory wraparound is on, all available waveform memory will be allocated for repetitive single trigger.

Be aware of the following cautions when using repetitive single trigger:

- When you are using memory wraparound, any stored waveforms with labels matching the current base label will be deleted as soon as you initiate repetitive single trigger operation by pressing the **DIGITIZER** button.
- Because waveform memory is allocated before repetitive single trigger acquisition begins, you cannot reset the number of acquisitions while the DSA is acquiring waveforms in this mode. When memory wraparound is off, attempting to change **Rep Trig N** will stop acquisition.
- You should avoid performing other DSA operations while acquiring waveforms in repetitive single trigger mode, because you may slow down or interrupt repetitive single trigger operation. Any DSA operation can stop repetitive single trigger acquisition.
- Stored waveforms that have been allocated for repetitive single trigger acquisitions will have a time stamp of zero hours, minutes, and seconds and the date 00-JAN-00. (The time stamps are updated as acquisitions occur and are stored.) Although you cannot select these waveforms in the **Recall Waveform** pop-up menu, you can query them over the RS-232-C or GPIB interface, so you should be aware that stored waveforms with this time and date are not valid.

Act on Delta

See page 47 for more information about Act on Delta.

When you have defined a delta description comparing an actively acquired waveform to an enveloped waveform, you can select **Delta** to enable Act on Delta acquisition. Acquisition in this mode will not begin until you press the **DIGITIZER** button. Delta descriptions and Act on Delta acquisition are discussed in detail on page 47.

Returning to Continuous Acquisition

To resume normal, continuous acquisition after using a Stop Acquisition function, touch the **Continuous** selector under the heading **Run Acquisition**.

Incremental Acquisition

Incremental acquisition provides a regular display update for signal acquisition with a sample interval greater than or equal to 5 ms/point. The display of a very slow sweep is updated as soon as a part of the waveform record is acquired. Although the waveform record is filled from left to right, the display is free-running until a trigger occurs. That is, sample points are acquired and displayed, but there is no horizontal reference point. Hence, before a trigger occurs the horizontal scale end points do not relate to waveform features in any absolute way.

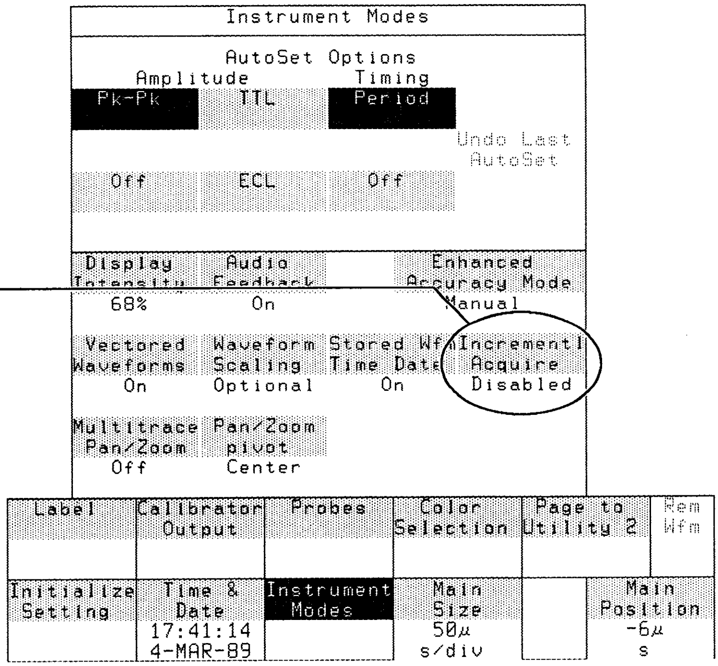
When multiple channels are active the DSA will obtain samples from one channel for a brief time and then switch or "chop" to the next channel. Each channel is briefly sampled on each sweep of the time base.

Enabling Incremental Acquire Mode

Touch the **Incrementl Acquire** selector in the **Instrument Modes** pop-up menu from the Utility 1 major menu to enable incremental acquisition mode. Incremental acquisition does not begin until the following conditions are met:

- The sample interval is greater that 5 ms/point.
- No window waveforms are displayed.
- No waveform functions are part of the vertical description of a displayed waveform.
- The triggering mode is set to **Normal**.
- The total sample points of all displayed waveform records does not exceed 32,256 points.

The **Incrementl Acquire** *Selector*



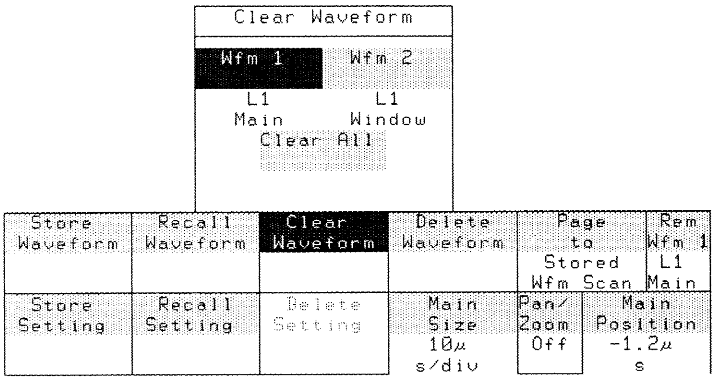
The **Instrument Modes** *Pop-Up Menu*

Clearing Waveforms

A waveform may be displayed but not acquiring new waveform data. This will happen when a waveform becomes untriggered in Normal trigger mode, or if you use the **DIGITIZER** button or a Stop Acquisition function to stop acquisition.

When the waveform is displayed but is not acquiring data, the waveform record from the last acquisition remains on the display. This is why waveforms appear frozen on the display when you stop acquisition.

You can clear waveform data from the display using the **Clear Waveform** pop-up menu in the Store/Recall major menu. To clear a waveform, touch the selector in the pop-up menu that represents the waveform you want to clear. Waveforms are identified both by waveform number (**Wfm 1** in the illustration below) and by waveform expression and time base (**L1** and **Main**).



The **Clear Waveform** *Pop-Up Menu*

The **Clear All** selector lets you clear all continuously acquired waveforms at once.

You cannot clear a waveform that displays only stored waveform data. For example, if you have a waveform that is defined to be **STO1 + STO2**, that waveform will not be listed in the **Clear Waveform** pop-up menu.

If you clear waveforms that are being acquired (live waveforms on the display), they will blink momentarily and then continue to be displayed as new waveform records are acquired.

Single-Shot Acquisition Tips

The DSA 601 and DSA 602 offer excellent capabilities for single-shot acquisition. Using the Single Trigger options described earlier in this section, you can capture non-repetitive events in real time at sample rates of up to 1 Gsample/s for the DSA 601 or 2 Gsample/s for the DSA 602. You can capture multiple signals concurrently at lower sample rates. To make the best use of these capabilities, you will need to be aware of factors that affect the real time sample rate of the DSA and you will need to know how to configure your DSA for concurrent acquisition.

Always run Enhanced Accuracy and probe calibration when you enable Digitizer Interleave. Probe calibration is necessary to align the DSA's digitizers, even if you are not using probes.

If you want the DSA to acquire signals at its maximum real time sample rate, enable Digitizer Interleave and set the Horizontal Size so that the maximum sample rate appears in the **Horizontal Desc** selector. Once you have acquired a waveform record, use Pan/Zoom to horizontally expand the waveform. Horizontal controls and Pan/Zoom are discussed in Horizontal Controls on page 125. The maximum sample rate is determined by the number of input channels acquired concurrently.

Main and Window Single-Shot Acquisition

You can use the DSA's windowing capabilities to acquire two simultaneous records of the same signal. Because the Main and Window time bases acquire signals at different sample rates, you can use a high sample rate to obtain a detailed record of an event on the Window time base while acquiring on the Main time base a less detailed record of a greater span of time surrounding the event. Windows are described on page 231.

For each channel, one waveform may be acquired on the Main time base and two Window waveforms (waveforms acquired on the Window time base) may be acquired in single-shot mode. The record length of the waveforms acquired can generally be up to 10240 points.

Observe the "ET"or "RT" readout in the **Horizontal Desc** pop-up menu when you set parameters for single-shot acquisition. If the qualification "< 100% Fill" appears after "RT," a complete waveform record cannot be acquired at the current sample rate and DSA configuration. A waveform will be acquired in real time mode, but some points in the waveform record will not be acquired.

Concurrent Acquisition

If you wish to acquire multiple channels concurrently, your choice of input channels can affect the sample rate. The DSA 601 can acquire two signals concurrently; the DSA 602 can acquire up to four signals concurrently. The waveform record samples of the signals will be concurrent to within ±100 ps.

The input channels that can be sampled simultaneously are limited to two channels from the left plug-in compartment and one channel each from the center and right plug-in compartments. For concurrent acquisition, connect your signal sources as follows.

- For four-channel concurrent acquisition, connect two signal sources to channels of the left plug-in amplifier. Connect one signal source to a channel of the center plug-in amplifier, and one to a channel of the right plug-in amplifier.

  Four-channel concurrent acquisition is available in the DSA 602 at up to 500 Msample/s and is not available in the DSA 601.

- For two-channel concurrent acquisition, connect two signal sources to channels of the left plug-in amplifier, or connect the two sources to channels of two plug-in amplifiers.

  Two-channel concurrent acquisition is available in the DSA 602 at up to 1 Gsample/s and in the DSA 601 at up to 500 Msample/s.

In any other configuration, the DSA will not acquire all of the input channels concurrently. Instead, the DSA will alternate between channels it cannot sample simultaneously, and some channels will be acquired on separate triggered sweeps of the time base.

For maximum single-shot timing accuracy, you can use the SCLOCKD command of the ASCII interface to disable dithering of the sample clock. See the *DSA 601 and DSA 602 Programmer Reference* or the *DSA 601 and DSA 602 Command Reference* for more information about this command. Alternatively, you can have a qualified service person connect an internal jumper to disable sample clock dithering. Either method results in greater single-shot accuracy at the expense of equivalent time performance.

High-Resolution Single-Shot Acquisition

The resolution of the DSA's digitizer is 8 bits. You can attain higher single-shot resolution by using the smoothing function.

Defining a smoothed waveform is explained in Waveform Definition and Management on page 219.

When you define a smoothed waveform, the DSA computes a running average of several adjacent points in the waveform. High-frequency information is attenuated in the resulting waveform record. The bandwidth of the smoothing operation is determined by the sample interval and by the number of points to be smoothed. The following table shows the maximum bandwidth available when you use smoothing to increase resolution.

Single-Shot Resolution and Bandwidth with Smoothing

Resolution (in bits)	Points to Smooth	Single-Shot Bandwidth (by Sample Rate)			
		2 GS/s	**1 GS/s**	**500 MS/s**	**100 MS/s**
8	none	1 GHz	500 MHz	250 MHz	50 MHz
9	3	295 MHz	147 MHz	74 MHz	15 MHz
10	5	177 MHz	86 MHz	44 MHz	9 MHz
11	9	98 MHz	49 MHz	25 MHz	5 MHz
12	17	52 MHz	26 MHz	13 MHz	3 MHz
13	33	37 MHz	13 MHz	7 MHz	1 MHz
14	65	14 MHz	7 MHz	3 MHz	680 kHz

Act on Delta

Act on Delta is an acquisition mode in which the DSA monitors a signal for anomalies, or "deltas." You can create an enveloped waveform that defines the acceptable limits of the signal and have the DSA perform one or more of the following actions when the signal travels outside the acceptable envelope:

- Save the waveform record in which the anomaly occurred
- Make a hardcopy of the waveform record
- Sound an audible alarm (chime)
- Send a signal to a GPIB or RS-232-C controller connected to the DSA.

Act on Delta acquisition stops when an anomaly is detected and can be set to restart automatically.

Test Waveform and Reference Waveform

In Act on Delta mode, the DSA compares the *test waveform*, the signal you are studying for anomalies, to a *reference waveform*. The reference waveform defines the acceptable limits of variation of the test waveform and must be an enveloped waveform.

The reference waveform may be a stored waveform or an actively acquired waveform, but in most cases you will probably want to use a stored waveform so that the reference limits do not change while the DSA is monitoring the test signal for variations outside the limits.

For more information on creating an enveloped wave-form, see Averaging and Enveloping on page 61.

A simple way to create a reference waveform is to envelope the test waveform. You might want to store a "clean" acquisition of the test waveform, add a small amount of noise to the stored waveform record, and envelope the result.

In order to compare the two waveforms, the record length of the reference waveform must be at least as great as the record length of the test waveform. The DSA considers only the points in the reference waveform record that correspond with points in the test waveform, so increasing the record length of the reference waveform does not affect the Act on Delta comparison.

Defining the Delta Event

A *delta event* occurs when points in the test waveform record are outside the bounds of the reference waveform. In addition to setting up the comparison between the test waveform and the reference waveform, you can specify an acceptable degree of variation of the test waveform from the reference waveform.

Defining the Delta Description

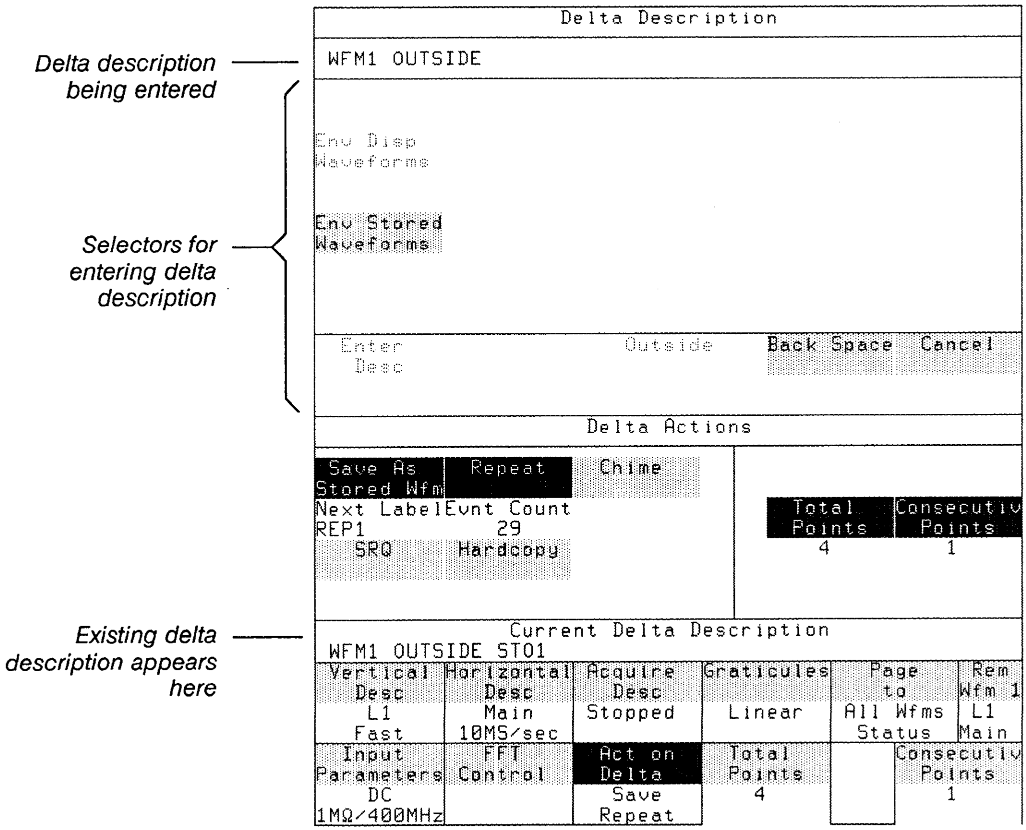
Once you have created a reference waveform, use the **Act on Delta** pop-up menu in the Waveform major menu to define a *delta description*, a definition of the comparison you want the DSA to make. A delta description is always of the form **Wfm1 OUTSIDE Wfm2. Wfm1**, the test waveform, must be a displayed waveform with an actively acquired component and **Wfm2**, the reference waveform, must be an enveloped waveform.

To enter a delta description, touch the selectors in the **Delta Description** section of the **Act on Delta** pop-up menu. Only the selectors that are appropriate are selectable at any point as you enter an expression. Select the active waveform you want to study from the **Displayed Waveforms** shown in the upper section of the pop-up menu, select the operator **OUTSIDE**, and select an enveloped waveform. If you make an error as you enter the description, you can select **Back Space** to correct it.

The reference waveform may be an actively acquired waveform or a stored waveform; select **Env Disp Waveforms** or **Env Stored Waveforms** to display selectors for displayed or stored enveloped waveforms, respectively.

As you enter the delta description, it appears at the top of the **Act on Delta** pop-up menu. If a delta description already exists, it appears on the **Current Delta Description** line at the bottom of the pop-up menu. The new delta description is entered when you select **Enter Desc.** If you select **Cancel** or otherwise remove the **Act on Delta** pop-up menu without entering the description, the existing delta description is retained.

The current delta description will be erased when either the test waveform or the reference waveform in the description is removed, or if the waveform description of the reference waveform is changed so that it is not an enveloped waveform. Changing the description of the test waveform will not affect the delta description, as long as the test waveform has an acquired component and is not an XY waveform.



The **Act on Delta** *Pop-Up Menu*

Setting Acceptable Limits of Signal Variation

You can set the number of out-of-bounds waveform record points that constitute an acceptable degree of variation of the test waveform from the reference waveform. You can also define a maximum acceptable length of variation. For example, you might want to ignore "spikes" that take only a few waveform record points out of the limits defined by the reference waveform.

Select **Total Points** and **Consecutiv Points** in the **Act on Delta** pop-up menu to adjust these delta event parameters. These selectors set the left knob to control the total number of out-of-bounds waveform record points and the right knob to control the minimum number of consecutive out-of-bounds record points required for a delta event.

A delta event will occur only when both conditions are satisfied. For example, if you set **Total Points** to fifteen and **Consecutiv Points** to ten, a delta event will occur when there are at least fifteen out-of-bounds points in the test waveform record, at least ten of which occur consecutively.

Delta Actions

When the DSA detects a delta event, acquisition stops. In addition, the DSA can perform any of the functions described below. Selectors for these delta actions appear in the **Act on Delta** pop-up menu in the Waveform major menu. You can choose to have the DSA perform any combination of these functions. A summary of the currently selected delta actions appears in the **Act on Delta** selector in the Waveform major menu.

Repeat

Select **Repeat** to have the DSA automatically restart acquisition in Act on Delta mode after a delta event has caused acquisition to stop. Otherwise, you would restart acquisition by pressing the **DIGITIZER** button.

The **Evnt Count** in the **Repeat** selector lists the number of delta events that have occurred, and is reset to zero when you press the **DIGITIZER** button. This count also appears in the **Acquire Desc** selector when the digitizer is running.

Save As Stored Wfm

Stored waveforms are discussed in detail on page 189. For more information on base labels, see Labeling on page 135.

Select **Save As Stored Wfm** to have the DSA store the waveform record in which a delta event occurred. Each stored waveform is assigned a label consisting of the current base label (the default base label is **REP**) followed by a sequentially-assigned number. The label that will be assigned to the next waveform stored appears in the **Save as Stored Wfm** selector. This label is not updated while acquisition is occurring and is therefore only valid before you begin Act on Delta acquisition.

You can store a series of waveform records for later study by using **Repeat** and **Save As Stored Wfm** together. If the DSA runs out of memory for stored waveforms, it will display a single error message and continue Act on Delta acquisition without storing waveform records.

Chime

Select **Chime** to have the DSA produce a single "beep" when a delta event is detected.

SRQ

When **SRQ** is selected, the DSA will send a "Conditional acquire complete" message to the GPIB or RS-232-C controller when acquisition stops on a delta event.

You do not need to select **SRQ** unless you have also selected **Repeat**; the "Conditional acquire complete" message will be sent to the controller at the end of a single Act on Delta acquisition even if **SRQ** is not selected.

Hardcopy

Select **Hardcopy** to have the DSA create a hardcopy of the display when acquisition stops on a delta event. See Hardcopy on page 115 for more information about making hardcopies of the display.

Do not use the **Hardcopy** and **Repeat** delta actions together if you expect delta events to occur in rapid succession.

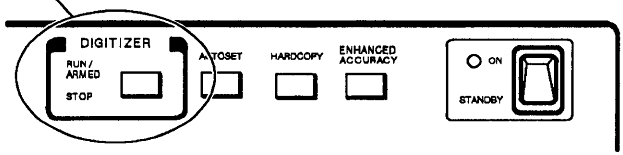
Do not use the **Hardcopy** delta action with **Repeat** if you expect the delta events to occur in rapid succession, because hardcopies will only be generated if there is space for them in the hardcopy queue when the delta event occurs. Instead, select **Save As Stored Wfm** and make hardcopies showing the stored waveform records later.

If you do select **Hardcopy** and **Repeat**, you may find that the display "freezes up" when delta events occur too frequently. You might need to press the **DIGITIZER** button to stop acquisition and then press the **HARDCOPY** button to abort the hardcopy being queued. If you press the **HARDCOPY** button without stopping acquisition, a new hardcopy might be started soon after you remove the current one.

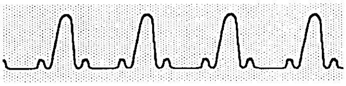
Initiating Act on Delta Acquisition

Once you have defined the delta event and set up the actions you want to occur on a delta event, you can start acquisition in Act on Delta mode by pressing the **DIGITIZER** button. Unless you have selected the **Repeat** delta action, you will need to press this button to restart acquisition after each delta event.

The **DIGITIZER** *Button*

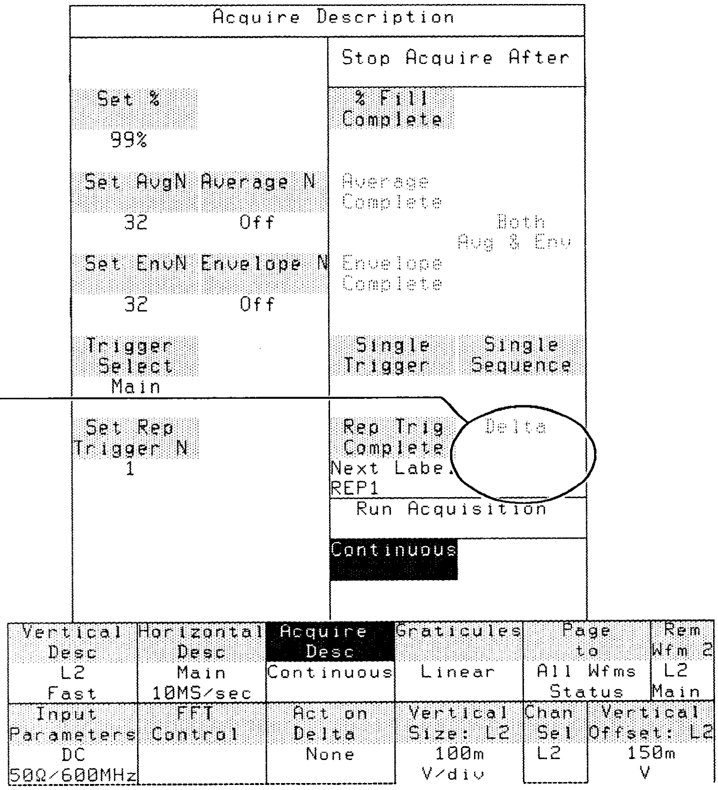


If a delta description already exists, you can also select **Delta** in the **Acquire Desc** pop-up menu in the Waveform major menu to enter Act on Delta acquisition. You must press the **DIGITIZER** button to start acquisition after you select **Delta.**This is an easy way to return to Act on Delta acquisition after doing intervening work in another acquisition mode.



See Acquisition on page 31 for information about the other acquisition modes you can select from the **Acquire Desc** pop-up menu.

The **Delta** *Selector*



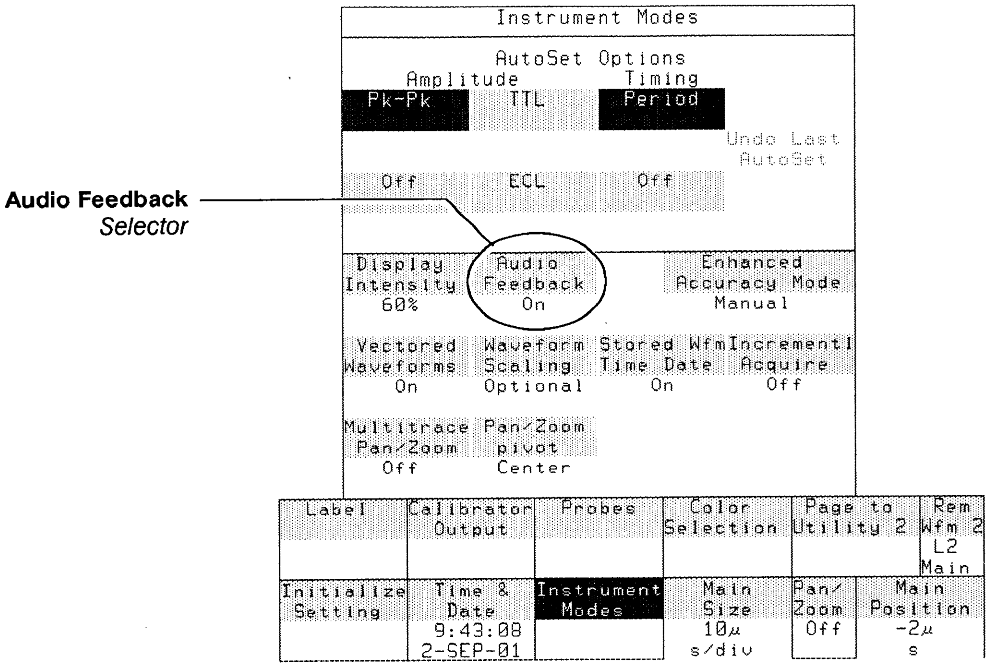
The **Acquire Desc** *Pop-Up Menu*

You cannot use Act on Delta acquisition with incremental acquisition or with XY waveforms.

Audio Feedback

When you select a function on the touch screen, you will hear a beep that means your selection has been noted and is being acted on. The beeper can be turned on or off.

To turn the audio feedback on or off use the **Instrument Modes** pop-up menu in the Utility 1 major menu. Touch the **Audio Feedback** selector in this pop-up menu to turn the beeper off or on.

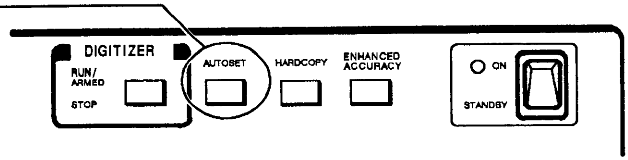


The **Instrument Modes** *Pop-Up Menu*

Autoset

Adjusting the DSA to display a stable waveform of usable horizontal and vertical size can be a time-consuming process. The DSA's Autoset feature can give you a stable, meaningful waveform display.

The **AUTOSET** *Button*



When you press the **AUTOSET** button you tell the DSA to examine the signal of the selected waveform and adjust the following controls for an optimum display:

- **Vertical** size and position
- **Horizontal** size and position
- **Trigger** level for main and window waveforms

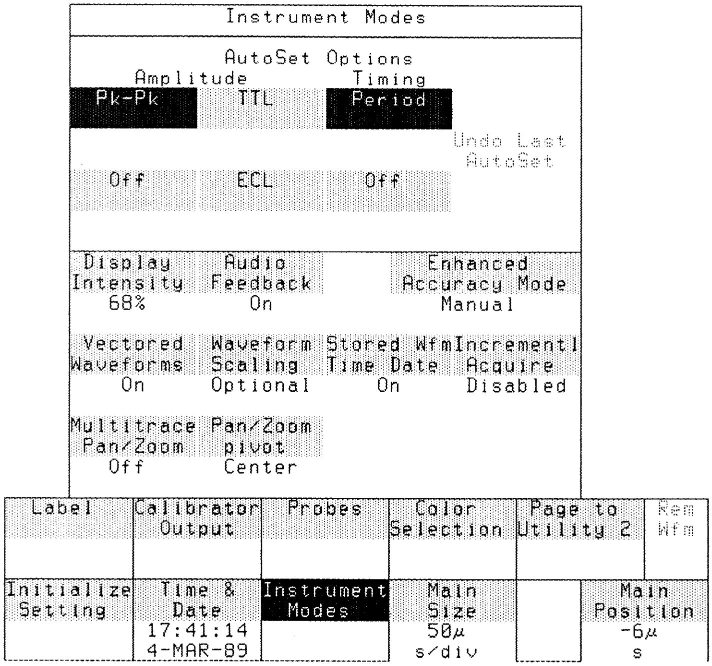
Autoset is also invoked when you press a Probe ID button if you have selected the Probe ID Function **Wfm Select/New Wfm & AutoSet** from the **Probes** pop-up menu of the Utility 1 major menu.

Undoing an Autoset

If you don't like the results of an Autoset, you can restore the status of the DSA by touching the **Undo Last AutoSet** selector in the **Instrument Modes** pop-up menu from the Utility 1 major menu. This pop-up menu is shown on the next page.

Autoset Options

The **Instrument Modes** pop-up menu lets you set several Autoset options so that you can tailor Autoset operation to your needs. In addition to the **Undo Last AutoSet** selector, the selectors in the **AutoSet Options** section of this pop-up menu let you specify independently the amplitude and timing Autoset characteristics of the DSA.

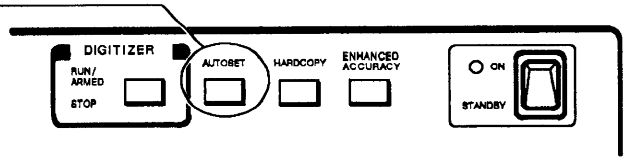


The **Instrument Modes** *Pop-Up Menu*

Autoset

Adjusting a DSA to display a stable waveform of usable size and amplitude can be a time-consuming process. The Autoset feature can give you a stable, meaningful waveform display.

The **AUTOSET** *Button*



The input channels must be calibrated for Autoset to work properly.

When you press the **AUTOSET** button, you tell the DSA to examine the selected waveform and adjust the following for optimal display:

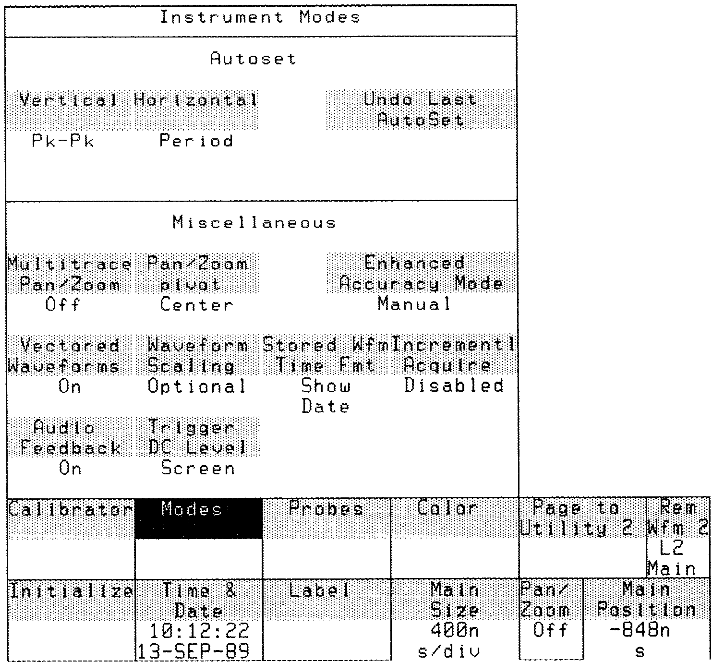
- **Vertical** gain and offset;for calculated waveforms, vertical size and position
- **Main** and **Window** horizontal size and position
- **Trigger** level and, if necessary, trigger source

If you press the **AUTOSET** button when no waveforms are defined, the DSA will search the input channels for a signal and display the first signal found. During the search, the plug-in amplifiers will be set to their most sensitive gain settings and to 0 V offset; they will be restored to their previous settings if no signal is found. Plug-in amplifier coupling is not changed, so a signal at an input channel that has coupling turned off will not be detected.

Autoset is also invoked when you press a Probe ID button if you have selected the Probe ID Function **Wfm Select/New Wfm & AutoSet** from the **Probes** pop-up menu of the Utility1 major menu.

Undoing an Autoset

If you don't like the results of an Autoset, you can restore the status of the DSA by touching the **Undo Last AutoSet** selector in the **Modes** pop-up menu of the Utility1 major menu.



The **Modes** *Pop-Up Menu*

Autoset Options

The **Modes** pop-up menu lets you set several Autoset parameters so that you can tailor the Autoset operation to your needs. In addition to the **Undo Last AutoSet** selector, the **Autoset** section of this pop-up menu has two selectors that let you specify independently the vertical and horizontal Autoset characteristics of the DSA.

Amplitude Autoset Options

You can select **Pk-Pk** (Peak-to-Peak) mode, **TTL** mode, **ECL** mode, or **Off** to determine the amplitude Autoset characteristics.

Peak-to-Peak mode – sets the vertical gain and offset so that the waveform will be four to nine divisions high and centered vertically on the graticule.

TTL and ECL modes – set the vertical gain and offset and trigger level to values appropriate to the TTL and ECL logic families.

Off – means that Autoset will not adjust vertical gain and offset.

Timing Autoset Options

You can select **Period** to have Autoset adjust the horizontal size and position so that at least three cycles of a repetitive signal appear on the graticule. If you select **Off**, Autoset will not affect horizontal size and position.

Vertical Autoset Options

The **Vertical** selector cycles among four values: Peak-to-Peak, TTL, ECL, and Off.

Peak-to-Peak mode – sets the vertical gain and offset so that the waveform will be four to nine divisions high and centered vertically on the graticule. Trigger level will also be set. The trigger source will be set to match the waveform source if the time base becomes untriggered.

TTL and ECL modes – set the vertical gain and offset and trigger level to values appropriate to the TTL and ECL logic families. Both set plug-in amplifier and trigger coupling to DC and set Main trigger mode to Auto and Window trigger mode to Normal.

Vertical Autoset may also be turned Off. If you turn Vertical Autoset off, Horizontal Autoset will not work properly unless the signal is triggered.

Horizontal Autoset Options

Horizontal Autoset will not function properly on signals with frequencies below 50 Hz.

The **Horizontal** selector cycles among four values: Period, Pulse, Edge, and Off. With any of the first three selected, Autoset will adjust the Main size and position. Main holdoff will be set to its minimum value of 2 μs if it is greater than 1 ms when Autoset is invoked. The trigger source will be set to match the signal source if the waveform becomes untriggered.

Period mode – adjusts the Main size and position so that at least three cycles of a repetitive signal appear on the graticule. Based on the trigger slope, either a rising edge or a falling edge is placed two divisions from the left of the graticule. The Window horizontal size is set to 1/10 of the main size, with Window1 and Window2 positions set to two and five divisions from the left of the Main graticule. Window holdoff will be set to its minimum if the delay between the Main and Window triggers is more than five times the Main size.

Pulse mode – sets the Main size so that approximately one pulse is displayed across six horizontal divisions of the screen. The trigger slope determines whether a rising or falling edge is placed two divisions from the left edge of the graticule.

Edge mode – sets the Main size to display the edge of a pulse across the entire graticule and sets Main position so that the edge is centered horizontally on the graticule. The trigger slope determines whether a rising or falling edge is displayed.

Horizontal Autoset may be turned off without affecting Vertical Autoset.

Special Cases

Autoset treats certain classes of waveforms differently. If you invoke Autoset with a stored waveform selected, the result will be a vertical scaling of the waveform (unless Vertical Autoset is turned off). If an active Horizontal Autoset mode is selected, Autoset will set the horizontal magnification (Zoom) to 1. Invoking Autoset on a high precision waveform will cause Pan/Zoom to be turned off.

Fast and high precision waveforms are explained in Waveform Scaling on page 228.

When the selected waveform is a multi-channel waveform, Vertical Autoset will be applied to each channel but Horizontal Autoset will be applied only to the first channel in the waveform description. The amplifier gains of the input channels will be matched only if the waveform is defined as a "fast," as opposed to "high precision," waveform.

When Autoset is performed on an XY waveform, the two components of the waveform are autoset individually. If one of the components of the XY waveform is a multi-channel "fast" waveform, both components will be treated as multi-channel waveforms and the amplifier gains for the channels involved will therefore be matched. Horizontal Autoset is executed only on the horizontal component of the XY waveform.

If the selected waveform is on a Window time base, invoking Autoset will cause the Main waveform to be autoset if the Main time base is not triggered. If the Main time base is triggered, Autoset will simply adjust the size and position of the window. If Vertical Autoset is in TTL or ECL mode, the vertical size and position of the window will also be set.

Averaging and Enveloping

The averaging and enveloping functions allow you to examine and manage noisy signals.

Averaging reduces the random noise of a displayed waveform and provides a cleaner display. The DSA presents a waveform that is an average of several accumulated waveform records. Each sample in a record is numerically averaged with the same sample in all the other records. The resulting waveform is displayed.

Enveloping shows the cumulative effect of noise and signal variation over a period of time. It is similar to averaging in that several waveform records are accumulated and a combined result is displayed. An enveloped waveform shows the maximum excursions of the individual waveform records. This often results in a "thicker" waveform that shows the limits of variation of the signal.

Defining an Averaged or Enveloped Waveform

There are two ways to establish an averaged or enveloped waveform.

- If you are establishing a new waveform you can use the **Avg(** or **Env(** waveform functions as you define your waveform. These can be selected from the **DefWfm** menu. For more information on this method, see Waveform Definition and Management on page 219.
- The easiest method is to establish the waveform without averaging or enveloping. Then, after you have the waveform adjusted, you can invoke averaging or enveloping.

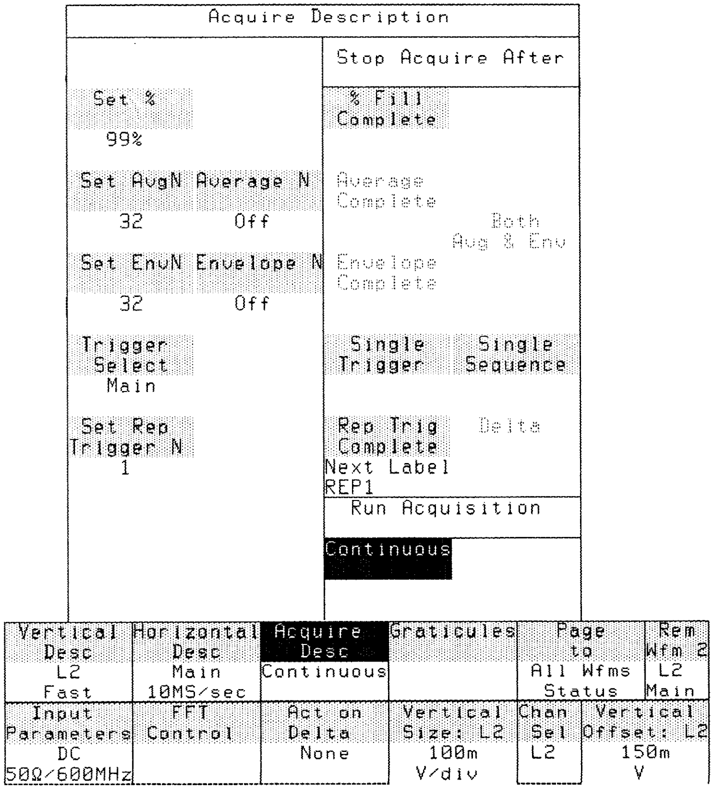
The following procedure describes averaging and enveloping using the second method described above.

If you aren't sure how to define a waveform, see Waveform Definition and Management on page 219.

☐ Step 1: Create the waveform you want using any method.

☐ Step 2: If the waveform isn't selected, touch the waveform to select it.

☐ Step 3: To average the waveform, press the **WAVEFORM** button, touch the **Acquire Desc** selector in the major menu, and then touch the **Average N** selector in the pop-up menu. To envelope the waveform, press the **Envelope N** selector in the pop-up menu.



The **Acquire Desc** *Pop-Up Menu*

The **Vertical Desc** selector status shows that the average or envelope function is now part of the waveform expression.

Record Count

Several complete waveform records are combined to form an averaged or enveloped waveform. You can set the number of records that the DSA accumulates and combines.

Use the **Set AvgN** and **Set EnvN** selectors in the **Acquire Desc** pop-up menu to assign the knobs to set the number of records. The left knob sets the number of records to accumulate for an average, and the right knob does the same for enveloping.

Each knob click changes the current value by a multiple of two in the coarse setting or in increments of one when the front panel button is set to **FINE**. You can use the numeric keypad to enter specific values.

Limiting Acquisition

You can have the DSA stop acquiring waveform data when a complete average or envelope is accumulated. When the DSA stops acquiring data the waveform will appear to be frozen on the display. The selectors in the **Stop Acquire After** section of the **Acquire Desc** pop-up menu let you specify **Average Complete**, **Envelope Complete**, or **Both Avg & Env**. (Both Average and Envelope functions must be used in waveform definitions for the **Both Avg & Env** function to be selectable.) When you want to resume normal continuous acquisition, touch the **Continuous** selector.

Side Effects of Averaging and Enveloping

Averaging improves the accuracy of some measurements because it reduces the effects of random noise. However, some measurements can be affected adversely by averaging or enveloping. For example, if the signal has horizontal jitter, a rise time measurement taken from the averaged waveform will be slower than the actual rise time. Be cautious when taking measurements of averaged or enveloped waveforms.

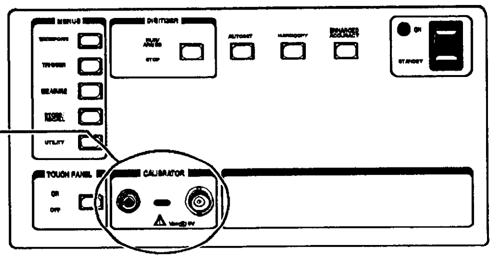
Terminating Averaging or Enveloping

To turn averaging or enveloping off, touch the **Average N** or **Envelope N** selector in the **Acquire Desc** pop-up menu.

Calibrator

The calibrator provides an accurate voltage/signal source for basic gain and timing applications and provides an accurate signal source for probe calibration. For information on probe calibration, see page 169.

CALIBRATOR
Output Connectors



The Calibrator is not available when Enhanced Accuracy, probe calibration, or diagnostics are in progress.

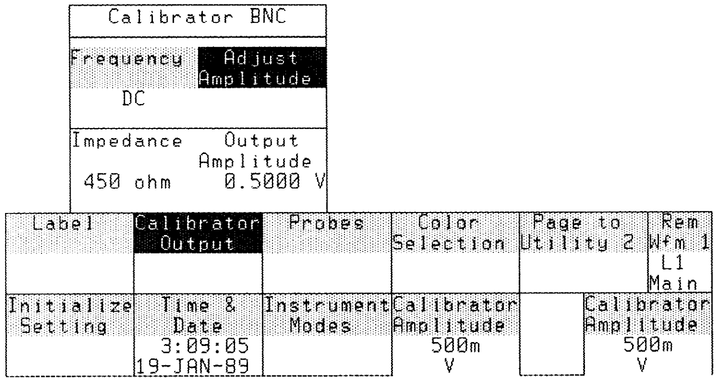
You can select the frequency and output voltage of the calibrator output. To set or determine the parameters of the Calibrator Output, select **Calibrator Output** from the Utility 1 major menu. Then, from the **Calibrator Output** pop-up menu successively touch the **Frequency** selector and note these selections:

- **1.024 MHz** sets the calibrator output to a 1.024 MHz, 500 mV pk-pk square wave signal. The baseline voltage is 0 V and the series output impedance is 50 Ω.

- **DC** sets the calibrator output to a DC level from −10 V to +10 V. The series output impedance is 450 Ω.

  When **DC** is selected, the **Adjust Level** selector can be used to assign both control knobs to **Calibrator Output**. The knob resolution may be set to 250 mV (Coarse), 5.0 mV (Medium), or 0.1 mV (Fine). Coarse and Fine resolution can be selected with the **FINE** button on the front panel. Medium resolution can be set from the **Numeric Entry & Knob Res** pop-up menu.

- **1.000 KHz** sets the calibrator output to a 1 kHz, 5 V pk-pk square-wave signal. The baseline voltage is 0 V and the series output impedance is 450 Ω.



The **Calibrator Output** *Pop-Up Menu*

The baseline voltage and series output impedance of the calibrator are listed in the **Calibrator Output** pop-up menu below the **Frequency** and **Adjust Amplitude** selectors.

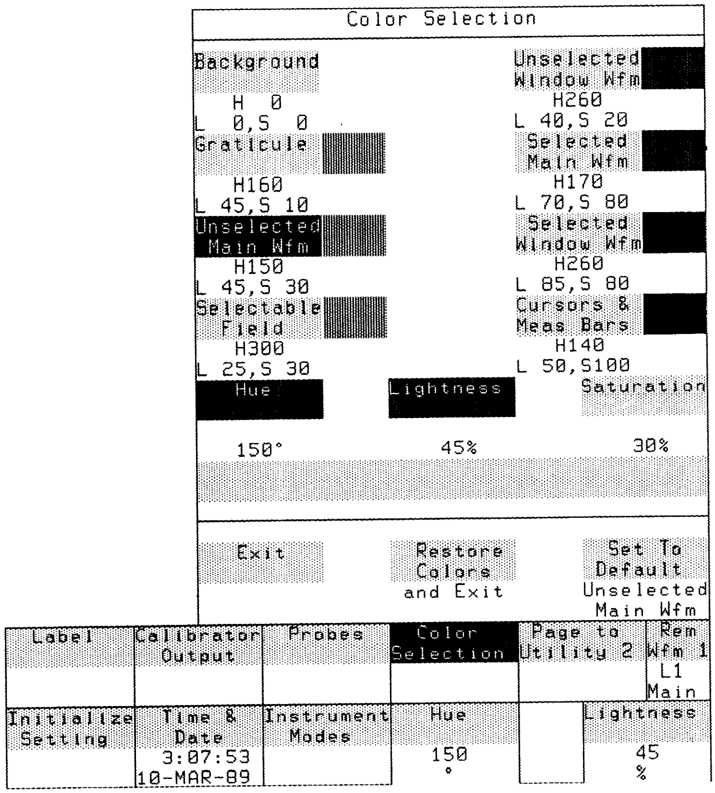
Color Display

The color display provides a convenient means to identify display items. Each class of items on the screen is displayed in a specific color. You can distinguish the selected waveform from unselected waveforms, for example, by its color. Default colors are assigned to the display parameters at the factory. You can modify these colors to suit your preferences. The display parameters are as follows.

- **Background** is the display background. The default color is black.
- **Graticule** is the grid on the display. The default color is gray.
- **Unselected Main Waveform** refers to the Main waveform(s) not currently selected. The default color is brown.
- **Selectable Field** is the background of menu selectors and icons that can be selected. The default color is dark blue.
- **Unselected Window Waveform** refers to the Window waveform(s) not currently selected. The default color is medium blue.
- **Selected Main Waveform** is the main waveform that is currently selected. This parameter also includes the background for icons and menu labels that are currently selected. The default color is yellow.
- **Selected Window Waveform** is the window waveform that is currently selected. The default color is bright blue.
- **Cursors & Meas Bars** are the cursors, waveform annotation lines and bars, display messages, and the touch box. The default color is red.

Color Selection

You can set the display colors using the **Color Selection** pop-up menu in the Utility 1 major menu.



The **Color Selection** *Pop-Up Menu*

There is a selector for each display parameter in the upper section of the **Color Selection** pop-up menu. Next to each selector is a square that is the color of that display parameter.

Color Display

The color display provides a convenient means to identify display items. Specific colors are assigned to the items on the display. The background, graticule and selectors, and cursors and measurement annotations are displayed in distinct colors for easy identification.

The DSA provides two separate color models. In the standard color model, there are up to four colors for waveforms and an additional color for window waveforms. When a window waveform is defined, it is displayed in the window waveform color. When you select a waveform, its color brightens.

In the second color model (called the "original" color model, there is a color for the selected waveform and a different color for unselected waveforms. Similarly, two separate colors distinguish the selected window waveform and the unselected window waveforms.

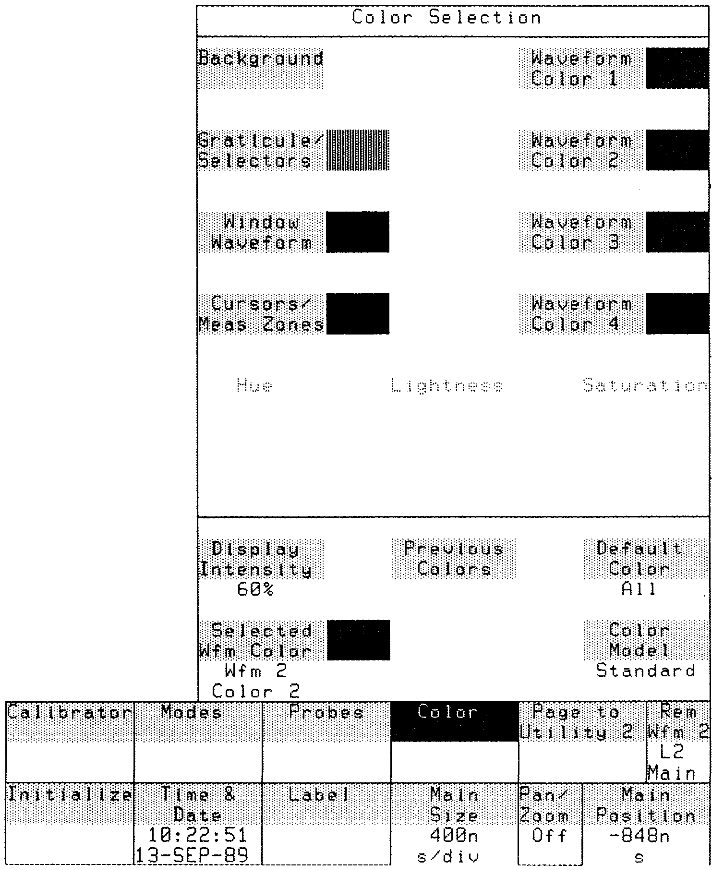
Color Selection

You can modify the display colors to suit your preferences using the **Color** pop-up menu in the Utility1 major menu, shown on the next page. You can change the colors displayed and the overall intensity of the display. You can also choose the default or original color model using this pop-up menu.

The upper section of the **Color** pop-up menu has a selector for each display color. Next to each selector is a box the color of that display parameter, and beneath the selector is a readout of the hue, lightness, and saturation values of that color.

- **Hue** is the characteristic associated with a color name, such as red. It is expressed in degrees on a range of 0° to 360°.
- **Lightness** is the intensity of the color, or the amount of light it transmits. Lightness is expressed from 0% (black) to 100% (white).
- **Saturation** is the vividness of the color, or the extent that it differs from gray. Saturation is expressed from 0% (maximum white content) to 100% (fully saturated).

To change the color of a display parameter, select the parameter in the **Color** pop-up menu. The knobs are automatically assigned to control **Lightness** and **Saturation**; select **Hue** if you want to adjust the hue of the color. Adjust the color using the control knobs.



The **Color** *Pop-Up Menu*

Colors are specified in terms of *hue*, *lightness*, and *saturation.* Touching the **Hue**, **Lightness**, or **Saturation** selector will assign the knobs to control these characteristics.

- **Hue** is the characteristic associated with a color name, such as red. It is expressed in degrees on a range of 0° to 360°.
- **Lightness** is the intensity of the color, or the amount of light it transmits. Lightness is expressed from 0% (black) to 100% (white).
- **Saturation** is the vividness of the color, or the extent that it differs from gray. Saturation is expressed from 0% (maximum white content) to 100% (fully saturated).

The hue, lightness, and saturation values for each display parameter appear beneath the parameter selector.

To change the color of a display parameter, select the parameter in the **Color Selection** pop-up menu. The knobs are automatically assigned to **Hue** and **Lightness**; select **Saturation** if you want to adjust the saturation of the color. A bar the color of the display parameter will appear below the **Hue**, **Lightness**, and **Saturation** selectors. Adjust the color using the control knobs. The color bar and the color of the square next to the display parameter selector will change as you adjust hue, lightness, or saturation.

When you have the display colors set the way you want them, touch the **Exit** selector to leave the menu and apply the color selection to the display.

Restoring Colors

Two selectors in the **Color Selection** pop-up menu let you restore colors to their default settings or to the colors previously defined:

- **Restore Colors and Exit** erases the **Color Selection** pop-up menu and restores all eight colors to the settings they had when you entered the **Color Selection** menu.

- **Set to Default** sets the selected color parameter to the factory default color.

  When no display parameters are selected, the **Colors** label is displayed below the **Set to Default** selector, and touching **Set to Default** will set all eight display parameters to the factory default colors.

Restoring Colors

Two selectors in the **Color** pop-up menu let you restore colors to their default settings or to the colors previously defined.

- **Previous Colors** restores all eight display parameters to the colors they had when you entered the **Color** pop-up menu.
- **Default Color** sets the selected display parameter to the factory default color.

  When no display parameters are selected, the **All** label is displayed below the **Default Color** selector, and touching **Default Color** will set all eight display parameters to the factory default colors.

Setting the Display Intensity

You can adjust the overall intensity, or brightness, of the display. Touch the **Display Intensity** selector in the **Color** pop-up menu to assign the knobs to control the intensity of the display. Overall intensity can be from 0% to 100%.

Selecting the Color Model

Touch the **Color Model** selector to change the color model. The status area of this selector shows which model is currently selected, **Standard** or **Original.**When you touch this selector, the screen clears and is re-drawn based on the other color model. The illustration on the previous page shows the **Color** menu with the **Standard**color parameters.

The Standard Color Model

In the standard color model, the selected waveform is *brightened.*

In the standard color model, four waveform colors are assigned to waveforms in order as they are created. When you select a waveform, its color brightens. You can reassign the color of the selected waveform to any of the four waveform colors using the **Selected Wfm Color** selector at the bottom of the **Color** pop-up menu.

The status area below the **Selected Wfm Color** shows the waveform number of the selected waveform and the number of the color assigned to that waveform, for example **Wfm 1 Color 1**. The box next to the selector displays the color of the waveform.

Revised 9/89

Touch the **Selected Waveform Color** selector to change the color assignment of the selected waveform. As you touch the **Selected Waveform Color** selector, it cycles through the four waveform colors available. If the selected waveform is a window waveform, only one color, the **Window Waveform** color, is available.

The Original Color Model

In the original color model, the selected waveform is displayed in a different color from other waveforms.

In the original color model, the selected waveform on the main time base is displayed in the **Selected Main Waveform** color, and all other waveforms on that time base are shown in the **Unselected Main Waveform** color. The selected waveform on the window time base is displayed in the **Selected Window Waveform** color, and other waveforms on that time base are displayed in the **Unselected Window Waveform** color.

Selecting Cursor Types

At the top of the **Cursor Type** pop-up menu, you can select from four cursor types. If you select **Vertical Bars**, **Horizontal Bars**, or **Paired Dots**, the DSA removes the pop-up menu and shows the selected cursors. The knobs control the cursor positions.

If you select **Split Dots**, the pop-up menu stays on the display and the lower half of the pop-up menu becomes active. The lower menu shows a selector for each displayed waveform (for example **Wfm 1**, **Wfm 2**). The selector for the selected waveform is highlighted.

At this point, both split-dot cursors are assigned to the selected (highlighted) waveform. To assign the second (right-most) cursor to a different waveform, touch the selector for that waveform. This action removes the pop-up menu and moves the second cursor to the selected waveform.

Additional Cursor Facts

- Cursors appear on the selected waveform. If another waveform is selected the cursors move to it.
- Split Dot cursors cannot be used on XY waveforms. Other cursor types operate normally on XY waveforms.
- The horizontal cursor readout includes the inverse of the delta ($1/\Delta t$), which can be used to show frequency. The cursor readout also shows the absolute values of the cursor locations and the distance between them.
- A dot cursor is displayed as a vertical bar if it is placed on a waveform where waveform data cannot be displayed. This is because without waveform data, there is no known vertical position for the dot.
- If a dot cursor is positioned on a waveform record point that is off the edge of the screen, an arrow appears at the screen edge pointing toward the off-screen cursor.

Cursor Examples

Measuring Waveform Amplitude

The following procedure shows how to use cursors to measure waveform amplitude.

- ☐ Step 1: Acquire and display a waveform you want to measure. Make sure all of the waveform is within the graticule area, but make the waveform as tall as possible.

- ☐ Step 2: Select the waveform you want to measure.

- ☐ Step 3: Touch **Cursors**, **Cursor Type**, and **Horizontal Bars**.

- ☐ Step 4: Use the knobs to move the cursor positions to the top and bottom of the waveform. Use the **FINE** buttons adjacent to the knobs to increase the resolution of the knobs. This lets you position the cursors more precisely. The Δv readout at the display bottom indicates the waveform amplitude.

Cursors

Cursors provide a way to measure the difference between two waveform locations that you specify. Cursors are markers that you position using the knobs. Once the cursors are positioned, readouts in the Cursors major menu show the absolute locations of the two cursors, and the difference (Δ) between them.

- **Vertical Bar** cursors are a pair of vertical bars. The positions of the cursors and the horizontal distance between them are shown in horizontal axis units.

- **Horizontal Bar** cursors are a pair of horizontal bars. The positions of the cursors and the vertical distance between them are shown in vertical axis units.

- **Paired Dot** cursors are a pair of small, diamond-shaped dots resting on the waveform. As you move a dot cursor using the knob, it follows the waveform to the left or right. The cursor readout shows both the vertical and horizontal positions, in the respective axis units.

Consider using the automated measurement system to take measurements instead of using cursors.

- **Split Dot** cursors appear similar to paired dots, except the dots may be on different waveforms. The readout indicates both the vertical and horizontal measurements, in the respective axis units.

You can use cursors to take several measurements. However, the automated measurement system is easier, faster, and more accurate. You can take many common measurements using the Measure major menu. See Measurements on page 139 for more information.

Cursor Operation

Establish all waveform displays *before* turning on the cursors.

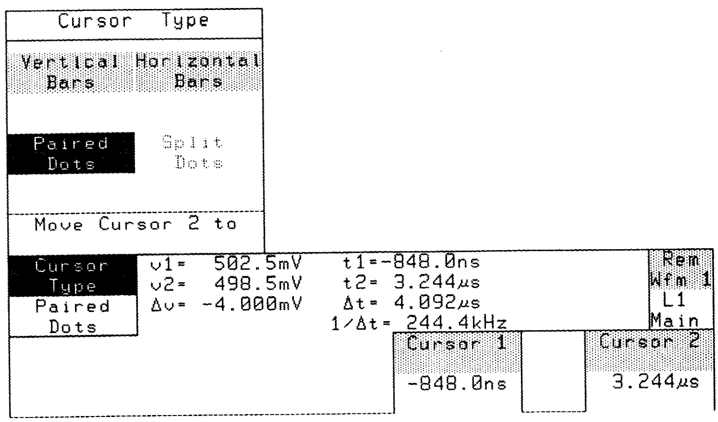
Before you use cursors, display the waveform(s) you want to measure. The waveform should be selected (highlighted). For split-dot cursors, either waveform may be selected.

To invoke the Cursor major menu, touch the **Cursors** icon, located above the graticule with the selected waveform. This icon operates like one of the menu buttons at the right of the screen: it has its own major menu. When the Cursor menu is displayed, none of the lights of the major menu buttons are lighted.

When you touch the **Cursors** icon, the DSA displays the cursors and their readouts. Whenever you touch the **Cursors** icon, the knobs are assigned to adjust cursor positions.

The **Cursors** icon functions like a major menu button.

The Cursors major menu has one selector, the **Cursor Type** selector. The rest of the major menu area shows the data readouts associated with the displayed cursors.



The Cursors Major Menu and **Cursor Type** *Pop-Up Menu*

Measuring Time Between Points On Different Waveforms

The following procedure shows how to use cursors to measure time between points on different waveforms.

☐ Step 1: Create a display of the two waveforms you want to measure. Make sure that the point you want to measure on each waveform is visible on the display. For the most accurate results, use the shortest time per division that shows the points to be measured.

☐ Step 2: Leave either of these waveforms as the selected waveform, and note the number of the other waveform.

☐ Step 3: Touch **Cursors, Cursor Type,** and **Split Dots.**

☐ Step 4: Touch the waveform selector of the other waveform that you want to place a cursor on. If you've forgotten its number, the waveform description appears in each selector.

☐ Step 5: The cursors are now placed, one on each waveform. Use the knobs to move the cursors to the two locations between which you want to measure time difference. Then read the time difference (Δt) at the bottom of the display.

Diagnostics

The DSA features a diagnostic system that performs comprehensive tests. This assures you that the DSA is operating correctly. A set of tests is performed automatically whenever the DSA is powered on. You can execute these and additional diagnostic tests at any time.

There are three categories of tests:

The DSA executes the power-on and self-test diagnostics whenever you turn the power on.

- Power-on Diagnostics are extremely basic functional tests. These ensure that the various microprocessors are running and communicating with each other. The power-on diagnostics take about 5 seconds to execute and are run only at power-on.

- Self-test Diagnostics are a subset of the extended diagnostics and are executed as a group at power-on. You can also execute this group at any time. This group of tests takes about 15 seconds to execute.

- Extended Diagnostics are a complete set of tests which you can execute either individually or as a group at any time. A separate menu system controls the extended diagnostics. Any time the self-test diagnostics encounter a failure, the extended diagnostics menu remains on the screen so that you are notified of the failure.

Do not touch the touch screen or press the front panel buttons during any diagnostic tests. Spurious failures may result.

The extended diagnostics menu is primarily intended as an aid for those servicing the DSA. This manual introduces the menu but does not discuss the extended diagnostics completely. For complete information, see the *DSA 601 and DSA 602 Service Reference*.

Power-on Diagnostics

Power-on diagnostics execute whenever you turn the power on. The power-on diagnostics test the most fundamental operations of the microprocessors and the communication paths between microprocessors.

Power-on diagnostics take about 5 seconds to execute. During this time the front panel lights will blink and the display will show the following message. (If the display is not yet warmed up, you may not be able to see the message.)

Diagnostics in Progress

Comm Test in Progress

You will also hear clicking as the plug-in amplifiers perform their power-on diagnostics.

If the power-on diagnostics are completed successfully, the self-test diagnostics are executed immediately and you will see the message **Self Test in Progress** on the display.

If the power-on diagnostics fail, one or both of the following indications will notify you.

- The DSA freezes and a message appears on the display. For example:

Dsy Kernel Failure
RAM Data Bit

- The DSA freezes, with some of the front panel lights turned on, and emits two high-low beeps.

Self-test Diagnostics

The self-test diagnostics execute automatically after the power-on diagnostics are completed successfully.

The self-test diagnostics can also be initiated by touching the **Self Test** selector in the Utility 2 major menu.

The self-test diagnostics take 15 seconds to execute. During this time you will see the message **Self Test in Progress** on the display. You will also see the front panel lights blink on and off, and you will see several test patterns on the display.

If the self-test diagnostics are completed successfully, the DSA will return to the state it was in before the self-test diagnostics ran. In the case where the self-test diagnostics were executed after power-on, the DSA will return to the state it was in when last powered off.

If the self-test diagnostics fail, the extended diagnostic menu is displayed and the failure is noted on the display. You can exit the extended diagnostic system and try to use the DSA, but until the failure is repaired you should not rely on any measurements taken. Call your service person to repair the cause of any failures.

Extended Diagnostics

You can enter the extended diagnostic system by touching the **Extended Diagnostic** selector in the Utility 2 major menu. When self-test diagnostics fail, the extended diagnostic system is entered automatically.

The extended diagnostic system is an independent subsystem of the DSA. While in this system, the front panel buttons will not operate and the Extended Diagnostics menu covers the entire display.

To leave the extended diagnostic system and return to normal DSA operation, touch the **(E) Exit** selector in the Extended Diagnostics menu. The DSA will return to the state it was in before the extended diagnostics were entered. In the case where extended diagnostics were entered after power-on, the DSA will return to the state it was in when last powered off.

The top portion of the Extended Diagnostics menu shows three columns with the status of the diagnostic tests. The first four blocks are shown below; there are a total of fifteen subsystem test blocks.

BLOCK	INDEX	FAULTS
a) Exec Control	****	
b) Front Panel	****	
c) Internal I/O	****	
d) External I/O	****	

If the extended diagnostic system has been entered because of a test failure, the asterisks in the **INDEX** column will be replaced with a failure index. The three columns of this display have the following meanings:

- BLOCK lists the names of the subsystem tests.

If the DSA does not pass the extended diagnostic tests, do not rely on any measurements taken. Call your service person for repair.

- INDEX shows the test status for each subsystem. Four asterisks (****) indicate the subsystem tests have yet to be executed. Four dashes (----) indicate the test requires some setup. If a blank appears in this column, the test requires interaction. The word **pass** indicates all tests in this subsystem have executed successfully. If **????** appears in this column, the tests of that particular subsystem are not appropriate for the DSA as it is configured. Any other number or letter sequence indicates a diagnostic failure.
- FAULTS shows the number of tests in the subsystem that fail.

Running all of the extended diagnostic tests takes about a minute. You may execute all the tests from the Extended Diagnostics menu by touching the **(x) All** selector to set the all parameter **On**, and then touching the **(r) Run** selector.

While the diagnostic tests are running, the **(r) Run** selector becomes a **(q) Quit** selector. You can touch this selector to stop execution of diagnostic tests.

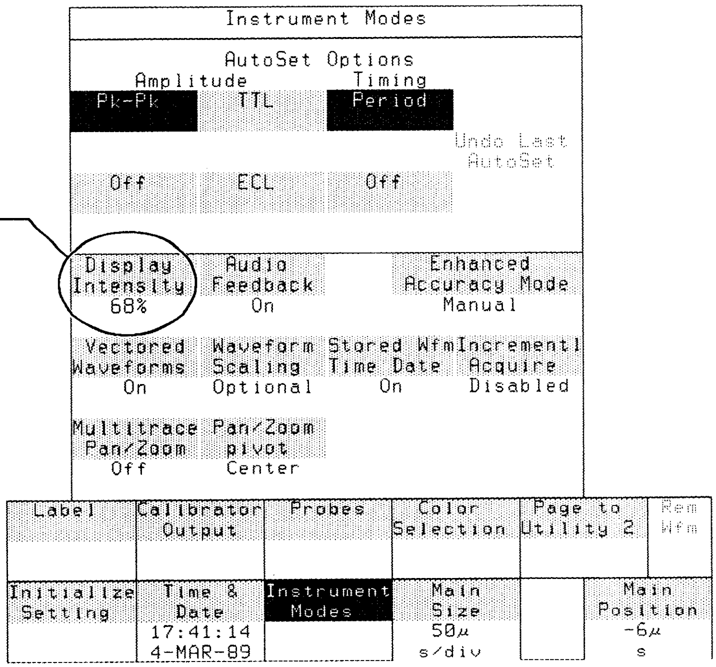
When the extended diagnostic tests are complete, the **(r) Run** selector is displayed again, and the test status appears in the **INDEX** and **FAULT** columns.

When you are done with the extended diagnostic tests, touch the **(E) Exit** selector.

Display Intensity

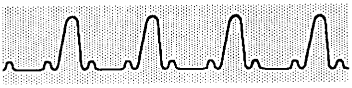
To change the brightness of the display, use the **Instrument Modes** pop-up menu from the Utility 1 major menu. Adjusting the display intensity affects all colors equally. Touch the **Display Intensity** selector in this pop-up menu. This assigns the knobs to control the intensity of the display. You can then use either knob to adjust the intensity.

The **Display Intensity** *Selector*



The **Instrument Modes** *Pop-Up Menu*

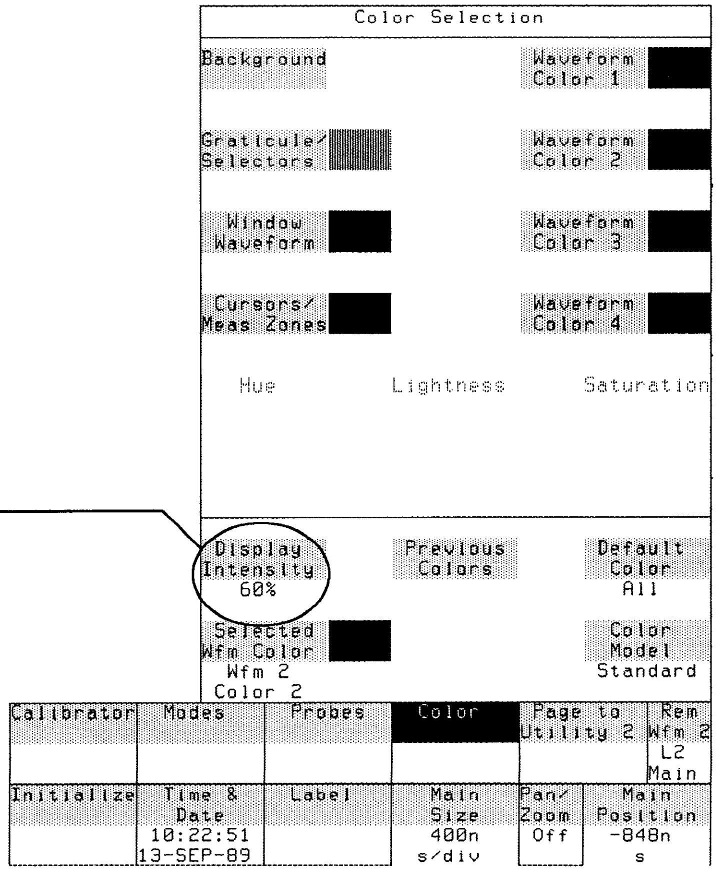
Display Intensity



Display Intensity

To adjust the display intensity, select **Display Intensity** in the **Color** pop-up menu of the Utility 1 major menu. This assigns the knobs to control the intensity of the display. You can then use either knob to adjust the intensity. Adjusting the display intensity affects all colors equally.

The **Display Intensity** *Selector*



The **Color** *Pop-Up Menu*

Display Persistence

Normally, a waveform appears "live" on the display because each acquired waveform record replaces the waveform record currently on the display. This is "normal" display persistence.

You can also display a waveform in a mode that shows a history of the waveform. If you select variable persistence, individual samples that compose each waveform record are added to the display as individual dots, and remain on the display for a length of time you specify while new samples are taken and displayed.

Infinite persistence is similar to variable persistence, but displayed waveform samples are not cleared from the display unless you explicitly clear or remove the waveform.

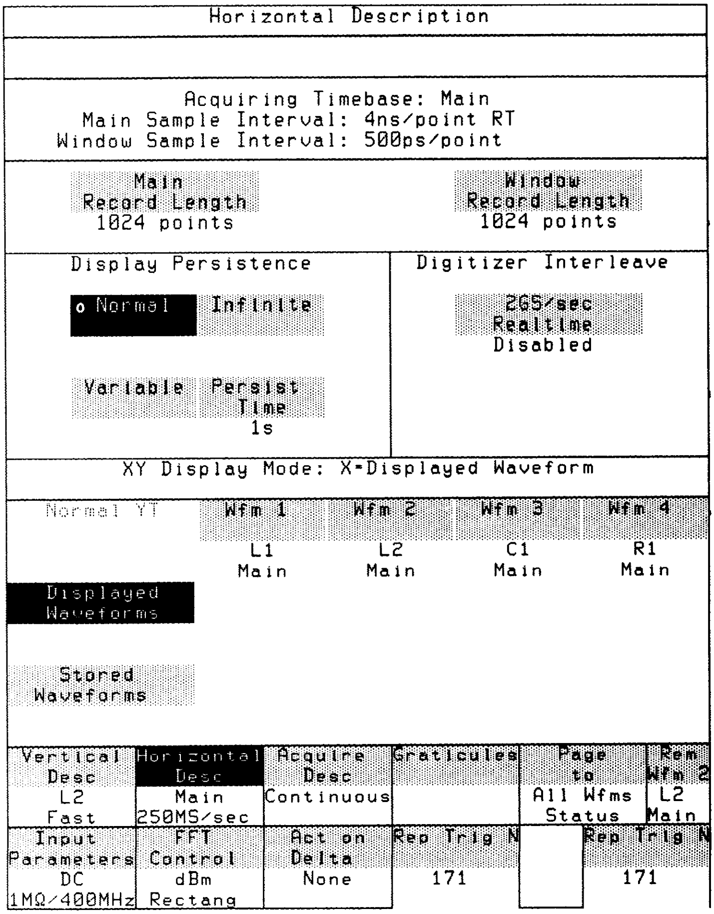
Use the **Horizontal Desc** pop-up menu in the Waveform major menu to change the display persistence of the selected waveform. This menu is shown on the next page. **Normal** selects normal display persistence, **Infinite** selects infinite persistence, and **Variable** selects variable persistence. To set the length of time that waveform points remain on the display in variable persistence mode, select **Persist Time** and adjust the time using the knobs or keypad pop-up menu.

The following restrictions apply to waveforms in variable or infinite persistence modes:

- You cannot perform automated measurements on waveforms displayed in variable or infinite persistence modes.
- Variable or infinite persistence is available only with record lengths up to 2048 points.
- You cannot use both variable and infinite persistence on the same graticule. If you select either **Variable** or **Infinite** persistence for one waveform, any other waveforms on the graticule that are not in normal mode will change to the selected persistence mode.
- All waveforms displayed in variable or infinite persistence mode on the same graticule will be displayed in the same color. Their color will match the color of the most recently selected waveform displayed in variable or infinite persistence mode.

- XY waveforms are always displayed with either variable or infinite persistence.

Display Persistence Controls



The **Horizontal Desc** *Pop-Up Menu*

Enhanced Accuracy

Use Enhanced Accuracy only after a 20-minute warm-up period.

Enhanced Accuracy is an automatic self-calibration that achieves the highest accuracy level (better than 1% vertical accuracy) for the DSA. Enhanced Accuracy calibrates the vertical system from the channel inputs of the plug-in units through the digitizer.

To compensate for differences in propagation delay and achieve best system accuracy, probes and cables should also be calibrated. See Probe Calibration on page 173.

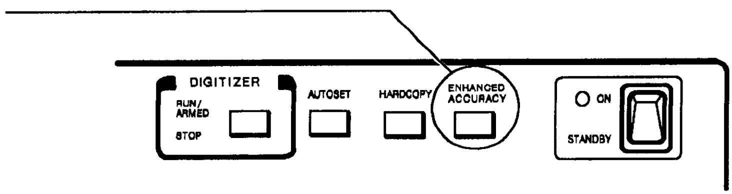
Changes of internal DSA temperature greater than ±5°C or configuration changes such as installing new plug-in units or probes will require Enhanced Accuracy calibration. If you choose not to run Enhanced Accuracy calibrations, the DSA will return to normal accuracy, which is typically 3% vertical accuracy or better.

When Enhanced Accuracy is in effect, the Enhanced Accuracy symbol (EA) appears to the left of the graticule. This symbol also appears when the selected waveform is a stored waveform that was acquired with the system in the Enhanced Accuracy state.

Running Enhanced Accuracy

Enhanced accuracy calibration can be initiated either manually or automatically. To manually run Enhanced Accuracy calibration, press the **ENHANCED ACCURACY** button twice during normal operation. The second push confirms that you wish to start calibration. A message on the display will prompt you to run Enhanced Accuracy whenever the system reverts to normal accuracy.

The **ENHANCED ACCURACY** *Button*



Do not turn the power off while Enhanced Accuracy calibration is in progress.

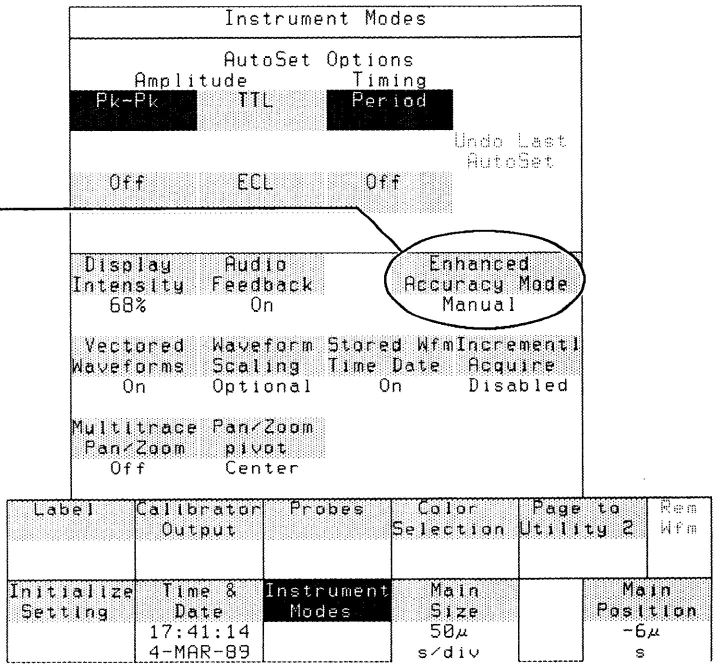
In automatic Enhanced Accuracy mode, a message on the display tells you that Enhanced Accuracy calibration is needed and is starting.

Enhanced Accuracy calibration takes several minutes to execute. You should not turn off the DSA or change any settings until the calibration is complete.

Setting the Enhanced Accuracy Mode

To set the Enhanced Accuracy mode to **Manual** or **Automatic,** touch the **Enhanced Accuracy Mode** selector in the **Instrument Modes** pop-up menu in the Utility 1 major menu.

The **Enhanced Accuracy Mode** *Selector*



The **Instrument Modes** *Pop-Up Menu*

Fast Fourier Transforms

You can use the Fast Fourier Transform (FFT) capability of the DSA to obtain a frequency domain display of a waveform. You can display both the magnitude and the phase of the frequency components of the signal. The FFT magnitude may be displayed with a linear or decibel vertical scale.

You can perform Fast Fourier Transforms on single-channel acquired waveforms and on stored waveforms. The record length of the waveform must be a power of two, up to a maximum of 16384 points.

The DSA offers a choice of six FFT windowing functions which modify the time domain data to minimize "leakage" of energy across frequency components.

Signal source averaging is available to improve the quality of the FFT display by reducing the effects of random noise.

You can use the cursors to take magnitude and phase measurements on frequency domain waveforms.

Defining an FFT Waveform

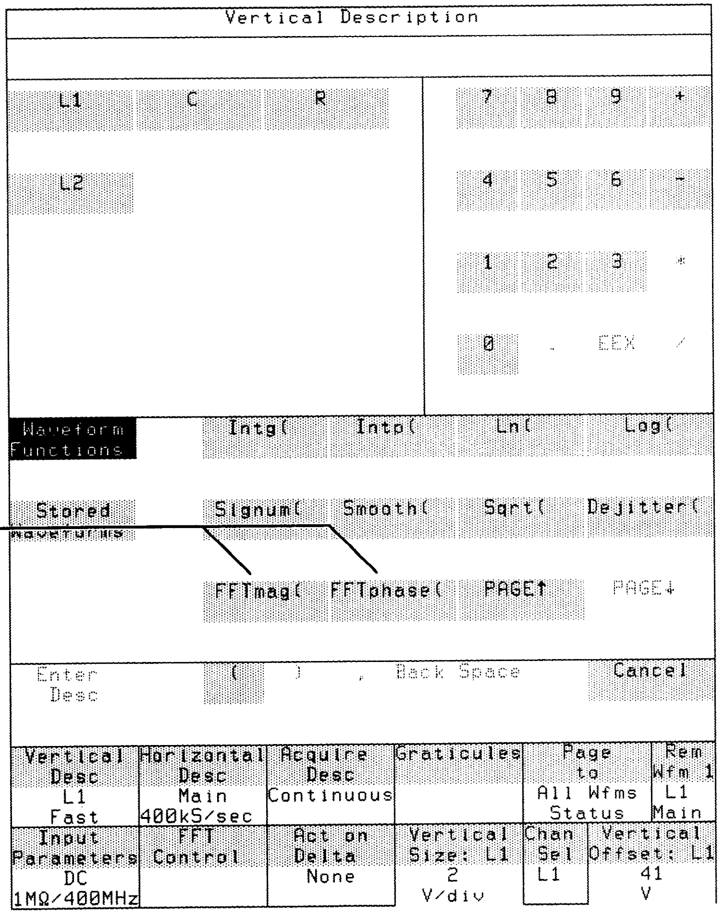
You can define an FFT display of a waveform using the **DefWfm** pop-up menu or you can use the **FFTmag** and **FFTpha** icons.

Defining an FFT Display Using the DefWfm Pop-up Menu

Using the **DefWfm** icon to define a waveform is explained on page 220.

You can define a waveform that displays the FFT magnitude or FFT phase using the **DefWfm** pop-up menu, which is displayed when you select the **DefWfm** icon. The **FFTmag(** and **FFTphase(** selectors in the **Waveform Functions** can be used to define a display of the magnitude or the phase of the frequency spectrum of a waveform. The part of the waveform description that is within the **FFTmag(** or **FFTphase(** function must be either a single input channel or a stored waveform.

FFTmag *and* **FFTphase** *Selectors*



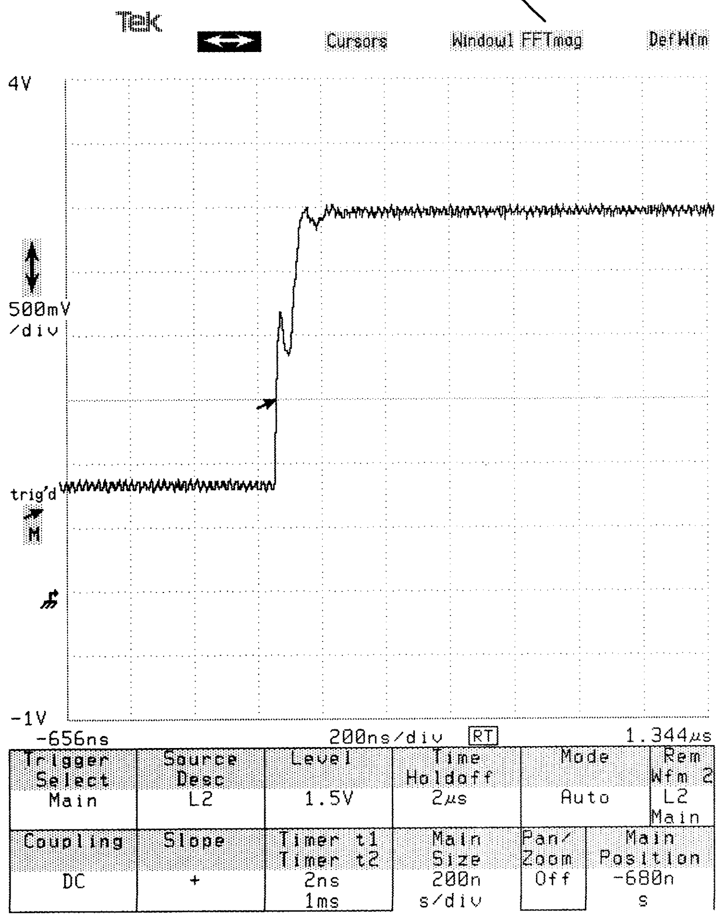
The **DefWfm** *Pop-Up Menu*

Defining an FFT Display Using the FFTmag and FFTpha Icons

You can display the magnitude of the frequency spectrum of a displayed waveform by selecting the waveform and touching the **FFTmag** icon. The DSA will create a second graticule to display the FFT magnitude of the waveform. If the display already shows two graticules, the FFT magnitude will be displayed on the lower graticule.

Once you have created a display of the magnitude of the frequency spectrum, the **FFTpha** icon appears above the lower graticule. Touch this icon to display the phase of the frequency components of the waveform. The FFT phase waveform will appear on the lower graticule.

The **FFTmag** *Icon*



Location of the **FFTmag** *Icon on the Display*

Amplitude Resolution

Amplitude resolution is influenced by the windowing function used and by the vertical adjustment of the time domain waveform. For maximum amplitude resolution, the time domain waveform should be adjusted so that it is centered vertically on the graticule and is as tall as possible without going beyond the graticule, above or below. Setting vertical size and position of waveforms is explained on page 215.

Frequency Range and Resolution

The range and resolution of the frequency spectrum displayed by the DSA are determined by the sample rate and record length of the time domain waveform.

A waveform record of N points in the time domain corresponds to a record of the same number of points in the frequency domain. However, for any real signal, the frequency domain data will be symmetrical about DC, so only the positive part of the spectrum is displayed. Of the displayed points of the FFT waveform, the N/2 even-numbered points are the *frequency lines* computed by the FFT; the N/2 odd-numbered points are added by interpolation.

The maximum frequency that can be determined by a Fast Fourier Transform is the *Nyquist frequency*, which is equal to one-half the effective sample rate. In fact, the maximum frequency displayed by the DSA, F_{max}, is slightly lower than the Nyquist frequency; it is equal to the Nyquist frequency minus the *frequency interval,* δF, the interval between frequency lines. The *frequency range* displayed is from DC (0 Hz) to F_{max}.

The frequency interval, δF, is equal to the Nyquist frequency (the maximum possible recognizable frequency) divided by the number of frequency lines in the FFT display (half the record length of the time domain waveform). Since the Nyquist frequency is half the sample rate, this works out to the sample rate divided by the record length.

$$\delta F = \frac{sample\ rate}{record\ length}$$

$$F_{max} = \frac{sample\ rate}{2} - \delta F$$

Equations for Frequency Interval and Frequency Range

For more information on setting horizontal size see page 125. Setting record length is discussed on page 175.

The sample rate is displayed in the status field of the **Horizontal Desc** selector in the Waveform major menu. The record length appears in the **Horizontal Desc** pop-up menu. You can change the frequency interval and frequency range by changing the record length and horizontal size of the time domain waveform. Both record length and horizontal size affect the sample rate.

If the record length increases without a change in the sample rate, frequency resolution improves (δF decreases). When possible, the DSA will automatically modify the sample rate to maintain the current horizontal size when you change the record length. When the sample rate increases, F_{max} and δF both increase, giving the FFT waveform a broader frequency range with less frequency resolution.

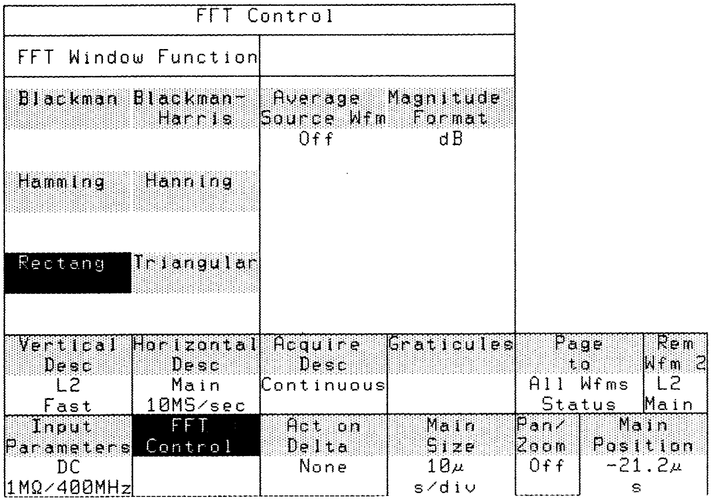
Aliasing

Aliasing occurs when the input signal includes components at frequencies higher than the Nyquist frequency. These frequency components appear in the FFT waveform display as peaks at lower frequencies. The higher-frequency components are reflected around the Nyquist frequency. For example, a frequency component 5 MHz above the Nyquist frequency will appear as a peak 5 MHz below the Nyquist frequency in the FFT waveform display.

You can eliminate aliasing by setting the sample rate to be at least twice the highest frequency in the input signal, or higher than twice the analog bandwidth of the DSA (1 GHz). Increasing the record length or decreasing the horizontal size will increase the sample rate.

The best way to avoid aliasing is to apply a filter to the signal to cut out high-frequency components. The plug-in amplifier bandwidth limits and the 100 MHz antialiasing digitizer filter of the DSA provide a limited filtering capability. See Plug-in Units on page 155 for more information on the digitizer filter and on setting plug-in amplifier bandwidth limits.

You can apply averaging to the source signal to reduce random noise and prevent aliasing of high-frequency noise in repetitive waveforms. Select **Average Source Wfm** in the **FFT Control** pop-up menu from the Waveform major menu to have the source waveform averaged prior to FFT computation. The time domain waveform, if it is displayed, is not affected by this averaging.



The **FFT Control** *Pop-Up Menu*

FFT Magnitude Format

You can change the vertical scaling of the FFT magnitude display by touching the **Magnitude Format** selector in the **FFT Control** pop-up menu. The format is either linear or in decibels (dB). When **Magnitude Format** is set to **dB**, the display is in dB relative to a 0.316 V peak sine wave (0 dBm).

If you want to display the FFT magnitude of a waveform in dB relative to a specific reference, you can subtract your reference value from the FFT magnitude of the waveform when you enter the FFT waveform description. For example, enter **FFTmag(L1) - 10** to display the FFT magnitude of the signal at channel one of the left plug-in unit relative to a 10 dB reference.

FFT Windowing Functions

The Fast Fourier Transform operates on the time-domain waveform record acquired by the DSA. The FFT algorithm assumes that the signal is composed of an infinite repetition of this waveform record.

Since the time domain waveform record rarely matches an actual periodicity in the signal, the frequency spectrum displayed will reflect extra frequencies due to discontinuities at the time-domain waveform record edges. These additional frequencies are known as *leakage error*.

The effect of discontinuities at the ends of the time domain waveform record can be limited by choosing an FFT windowing function that tapers near the waveform record ends. The DSA provides a rectangular FFT window, which does not taper the time domain data, and five tapering FFT windows of different shapes.

Each time domain FFT windowing function corresponds to a filter in the frequency domain. Each frequency domain filter has a high central lobe, or passband. The width of this lobe determines how well adjacent frequency components can be resolved. The height of the side lobes surrounding the central lobe determines how much leakage can occur. Leakage is the spreading of energy from one frequency component across the displayed frequency spectrum; low amplitude frequency components can be entirely masked by leakage.

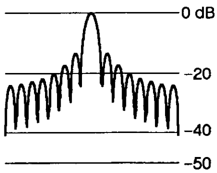
Select an FFT windowing function from the **FFT Window Selection** section of the **FFT Control** pop-up menu. The selected FFT windowing function applies to all FFT waveform displays. The shapes of the FFT windowing functions and their effects on a signal composed of two sine waves are shown in the following discussion; equations for the FFT windowing functions are provided in Appendix D: Algorithms.

The Rectangular Window

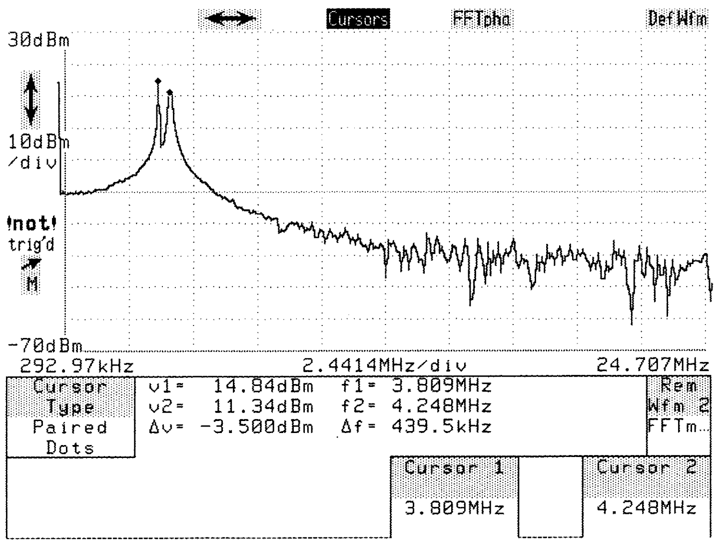
The rectangular window does not taper the time domain data. In the frequency domain, the filter shape is sin(x)/x. This is the best window to use when you want to examine the frequency spectrum of a non-repetitive signal. The rectangular window should also be used when you want to measure frequency components near DC.

Touch **Rectang** in the **FFT Control** pop-up menu to select this windowing function.

Time Window



Frequency Filter

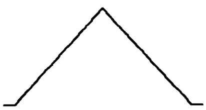


FFT Magnitude Displayed Using Rectangular Window

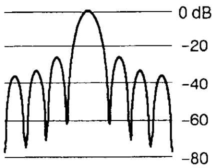
The Triangular Window

The triangular (or Bartlett) window is the convolution of two rectangles half the width of the window, so the frequency spectrum of the triangular window is the product of the rectangular window's spectrum with itself.

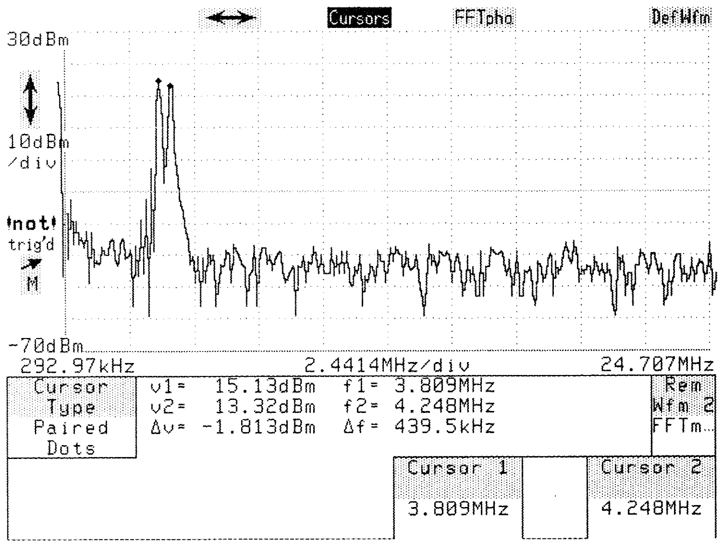
Touch **Triangular** in the **FFT Control** pop-up menu to select this windowing function.



Time Window



Frequency Filter



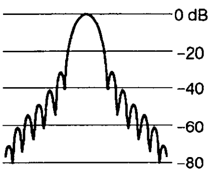
FFT Magnitude Displayed Using Triangular Window

The Hanning Window

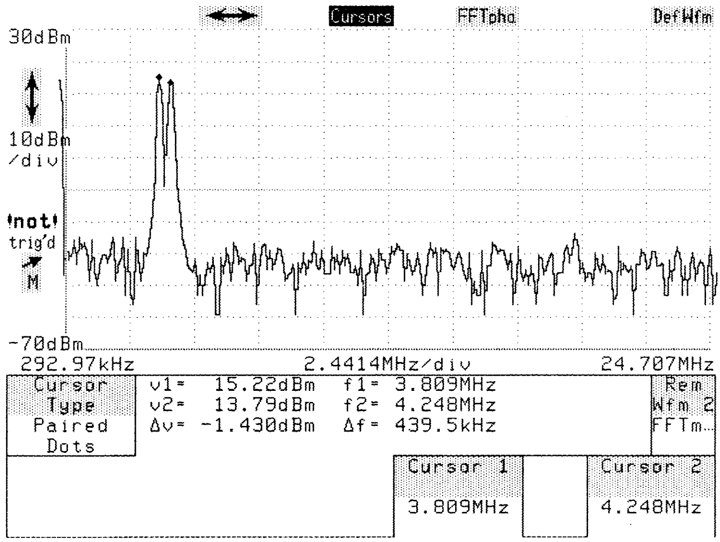
The Hanning (or Hann, or cosine) window is derived from a cosine. This window provides reasonably good amplitude accuracy and leakage rejection.

Touch **Hanning** in the **FFT Control** pop-up menu to select this windowing function.

Time Window



Frequency Filter



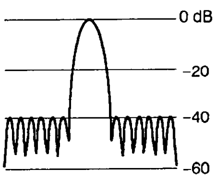
FFT Magnitude Displayed Using Hanning Window

The Hamming Window

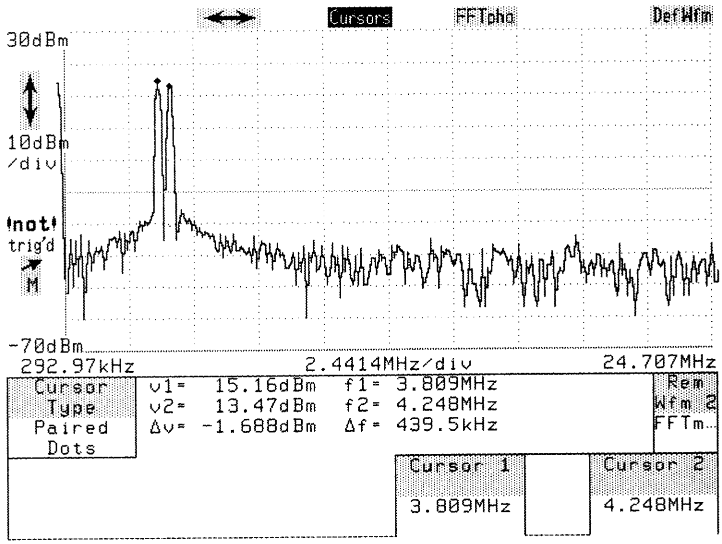
The Hamming window is similar to the Hanning window, but is optimized to lower the first side lobe, which is why the separation between the two spikes in the illustration below is greater than in the illustration on the previous page. This window is especially useful for resolution of frequencies that are very close together.

Touch **Hamming** in the **FFT Control** pop-up menu to select the Hamming window.

Time Window



Frequency Filter



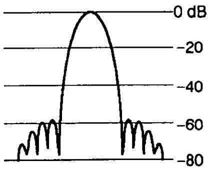
FFT Magnitude Displayed Using Hamming Window

The Blackman Window

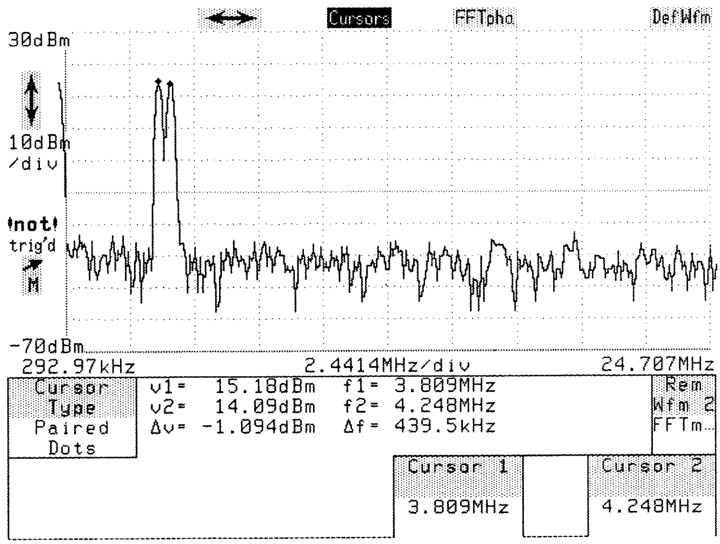
The Blackman window reduces leakage better than the Hamming window because of the lower side lobes in the frequency domain, but the resolution of nearby frequencies is diminished.

Touch **Blackman** in the **FFT Control** pop-up menu to select this windowing function.

Time Window



Frequency Filter



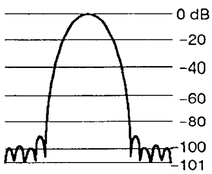
FFT Magnitude Displayed Using Blackman Window

The Blackman-Harris Window

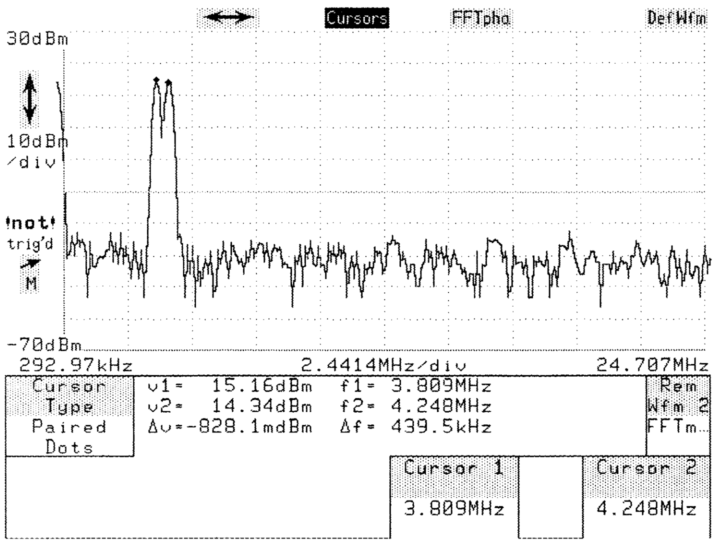
The Blackman-Harris window has the widest pass band (lowest frequency resolution) and lowest side lobes (best elimination of leakage) of the six window functions. This window is especially good for viewing a broad spectrum.

Touch **Blackman-Harris** in the **FFT Control** pop-up menu to select this windowing function.

Time Window



Frequency Filter



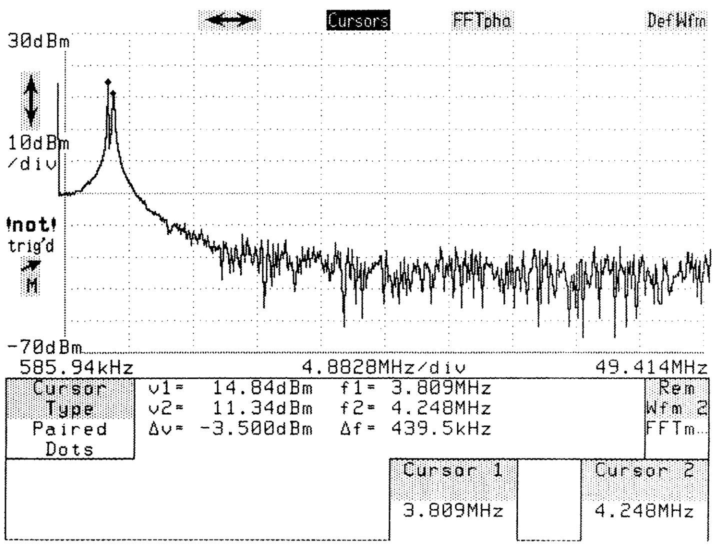
FFT Magnitude Displayed Using Blackman-Harris Window

Making Measurements

You can use the cursors to make measurements of an FFT waveform display. Select the FFT waveform and touch the **Cursors** icon to display the Cursors major menu. See Cursors on page 71 for more information on using cursors.

When making measurements on an FFT waveform, recall that the odd-numbered points in the waveform record are derived by interpolation. The even-numbered record points are the frequency lines; peaks in the FFT magnitude always occur on the even-numbered points. You can see the peaks more clearly by using Pan/Zoom to horizontally magnify the FFT waveform as described on the next page.

When you first display cursors on an FFT waveform, paired dots cursors are automatically selected, with one dot cursor placed at DC and the other at F_{max}. You can use the paired dots cursors to make relative measurements of the peaks of an FFT waveform.



Paired Dots Cursors on an FFT Magnitude Display

The DC value displayed with the FFT magnitude is twice the actual DC amplitude. This value does not include any vertical offset of the plug-in amplifiers. When making measurements near DC, use the rectangular window function.

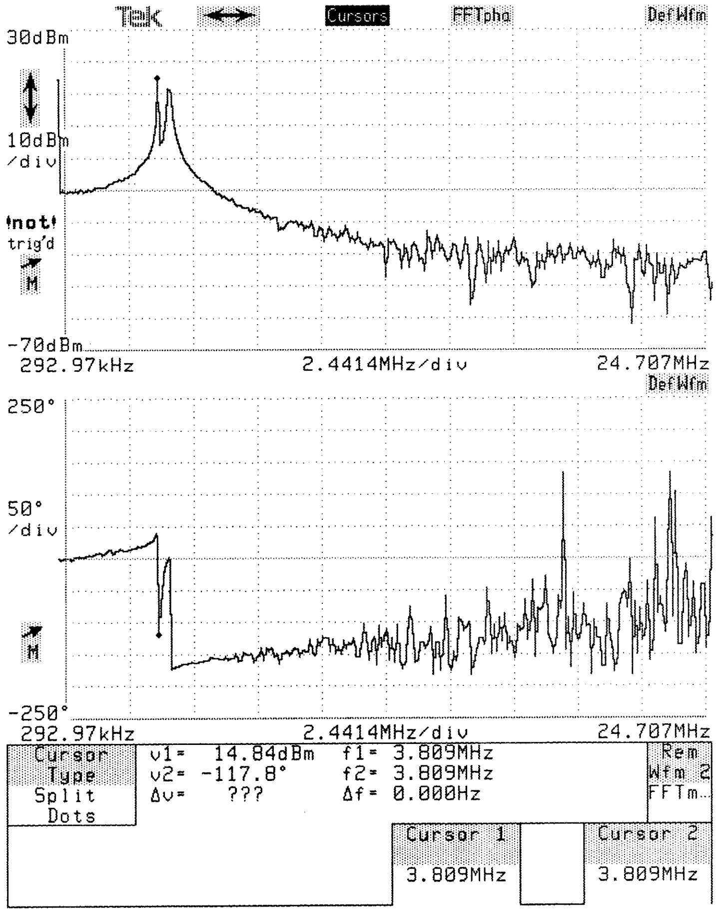
Split dots cursors can be used to make phase measurements. With both the magnitude and the phase of waveform in the frequency domain displayed, you can place one cursor on the FFT magnitude display and the other on the FFT phase display. By adjusting the cursors horizontally so that the Δf readout is 0.000 Hz, you can easily match the phase readout to the corresponding peak in frequency magnitude.

Changing Vertical and Horizontal Size

You can change the vertical and horizontal size and position of the FFT waveform display by selecting the vertical and horizontal icons and using the knobs to adjust size and position.

When you touch the vertical icon (↕), the knobs are assigned to control **Vertical Mag: Wfm** and **Vertical Pos: Wfm**, the vertical magnitude and position of the waveform. As with other calculated waveforms, the vertical controls of the FFT waveform affect only the appearance of the waveform. See Vertical Controls on page 215.

When you touch the horizontal icon (↔), the knobs are assigned to control **Horizontal Magnify** (zoom) and **Horizontal Pos Gr** (pan). Pan/Zoom is always on for an FFT waveform. Changing the horizontal magnification and position of an FFT waveform using Pan/Zoom changes the appearance of the waveform, but does not increase the horizontal (frequency) resolution. For more details about Pan/Zoom, including changing the pivot point and using multitrace Pan/Zoom, see page 127.



Using Split Dots Cursors to Measure FFT Phase

GPIB Parameters

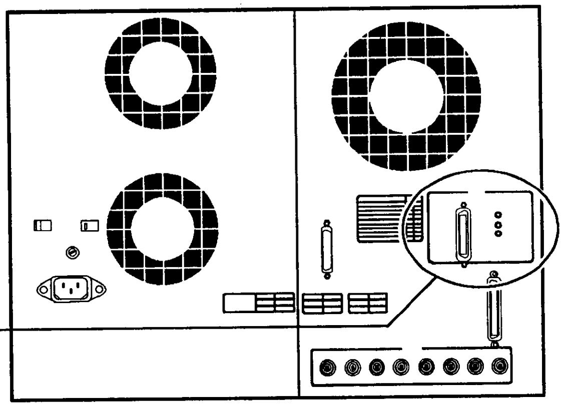
The DSA can be controlled by a remote computer through one of two interfaces. These interfaces are industry standards IEEE STD 488 and RS-232-C. IEEE STD 488 is also known as the General Purpose Interface Bus or GPIB.

This manual does not discuss the details of connecting a remote computer to the DSA or the syntax and capabilities of remote commands. That information is found in the *DSA 601 and DSA 602 Programmer Reference* and the *DSA 601 and DSA 602 Command Reference.*

GPIB Connection

The cable from your GPIB controller (computer) is connected to the **IEEE STD 488 PORT** connector on the DSA rear panel. Three red lights show the status of specific GPIB signal lines:

- **SRQ** (Service Request) is lighted whenever any device on the bus activates the Service Request line. This indicates to the controller that some device has requested service. You cannot tell which device on the bus has asserted SRQ.
- **NRFD** (Not Ready For Data) is lighted whenever any listener device on the bus is not yet ready for the next data byte. You cannot tell which device on the bus is not ready.
- **NDAC** (Not Data Accepted) is lighted whenever a data byte is on the bus but has not yet been captured by all listener devices.

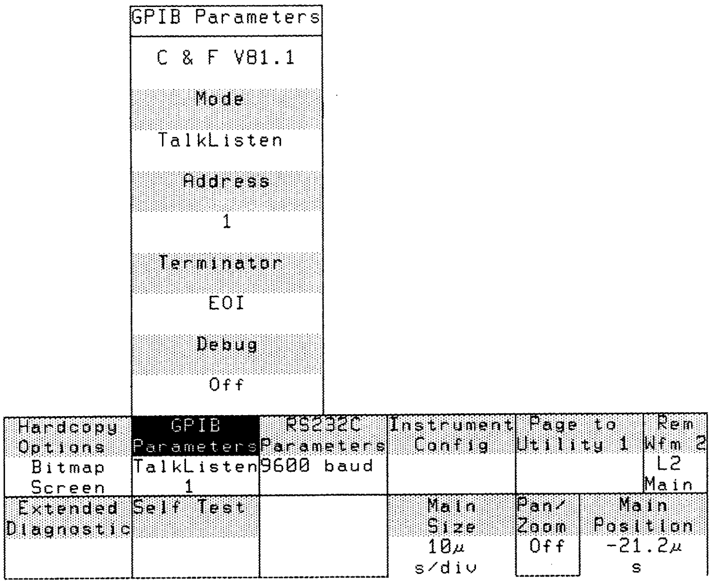


GPIB Rear Panel Connector and Lights

Setting GPIB Parameters

Communication between the devices on a GPIB can occur only if all bus devices are configured in a compatible manner. For example, each device on the bus must have a unique identifying address.

Use the **GPIB Parameters** pop-up menu in the Utility 2 major menu to set these GPIB parameters directly before you attempt to communicate with other devices on the bus.



The **GPIB Parameters** *Pop-Up Menu*

GPIB Parameters are not changed when you initialize the DSA.

The **Mode** selector in the **GPIB Parameters** pop-up menu lets you set the mode to **Talk/Listen**, **Talk Only**, or **Off Bus**. Off bus effectively disconnects the DSA from the bus. The DSA must be in talk/listen mode to communicate with the GPIB controller. Talk Only may be used to generate display hardcopies on a GPIB printer or plotter.

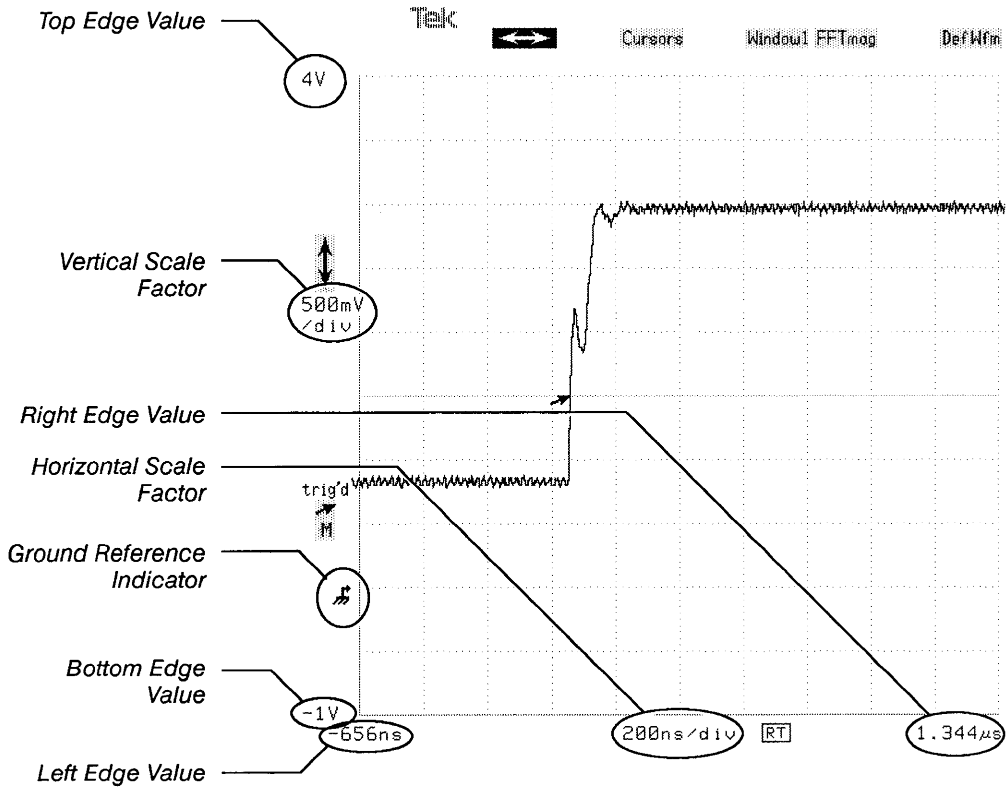
Touching the **Address** selector assigns the knobs to control the GPIB address of the DSA. The GPIB address can be from 0 to 30. No other device on the bus can use the number that you assign to the DSA.

The **Terminator** selector lets you choose between **EOI** and **EOI/LF** message terminators. With either message terminator, the DSA will assert EOI (the GPIB End Or Identify) at the end of each output message, and will recognize EOI as a message terminator. With the **Terminator** selector set to **EOI/LF**, the DSA will also recognize a Line Feed (LF) character as an input message terminator, and will end each output message with a Carriage Return followed by a simultaneous Line Feed and assert EOI. Set the **Terminator** selector to **EOI** to have the DSA recognize only EOI as an input message terminator.

The **Debug** selector lets you turn the debugging feature **On** or **Off**. When you turn Debug On, the DSA displays each command from the GPIB controller as it is executed. The messages appear at the top of the display. Debug Off is the normal mode of operation. Set Debug On if you need to watch the result of each DSA command of a controlling program running in the GPIB controller. When debug mode is on it slows the GPIB interface throughput significantly.

Graticules

The grid on the display where waveforms appear is called a graticule. The graticule axis labels show you the horizontal and vertical scale factors of the selected waveform, usually expressed in time per division and voltage per division.



Graticule with Waveform

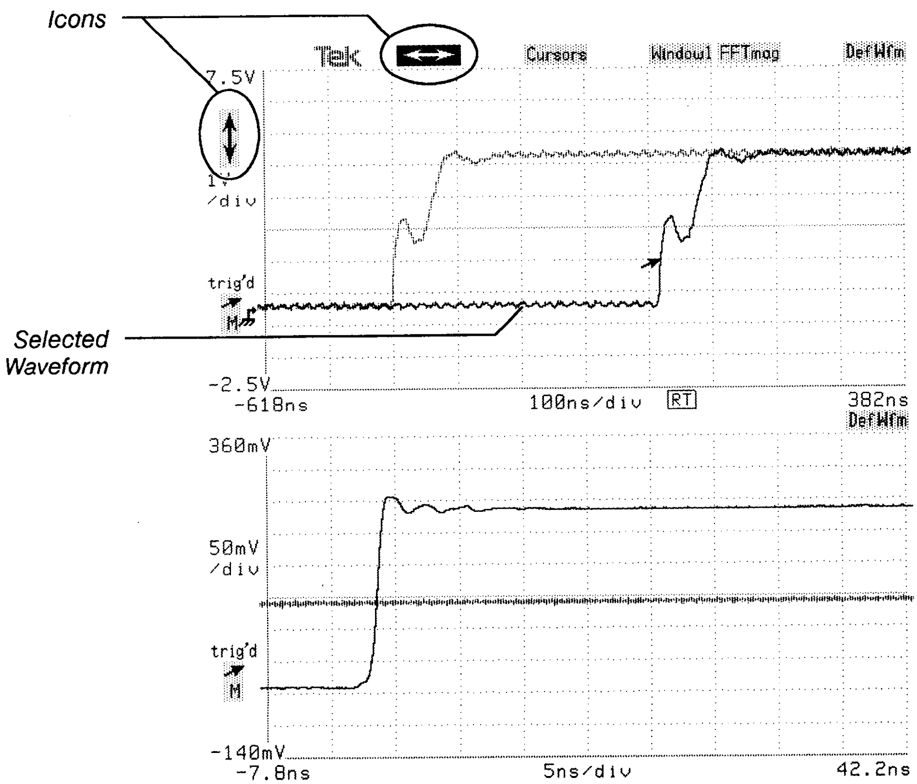
Waveforms extend outside the graticule area slightly. The axis labels represent the graticule edge, not the waveform edge.

If a graticule shows two or more waveforms, one is the selected waveform. The other waveforms may not share the same axis labels. The selected waveform is displayed in the color specified for a selected waveform.

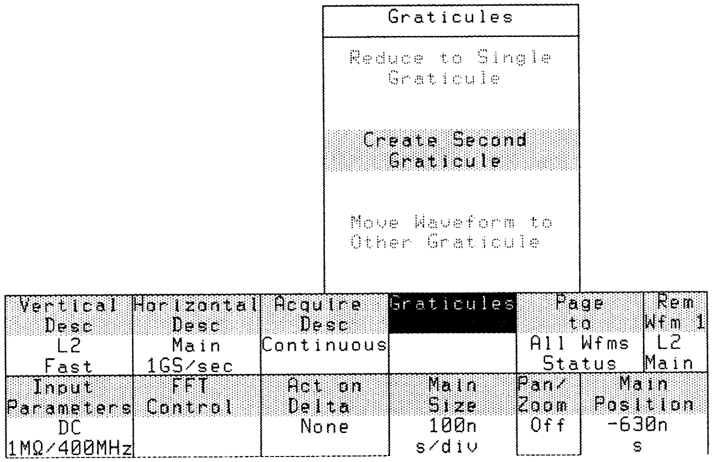
For more information about choosing display colors, see Color Display on page 67.

You can display two different graticules, each half the height of a single-graticule display. You can choose the colors for the selected waveforms on the Main and Window time bases. In addition, the graticule with the selected waveform has the vertical (↕) and horizontal (↔) icons.

As with a single-graticule display, the menu selectors affect the selected waveform.



Dual Graticules with Multiple Waveforms



The **Graticules** *Pop-Up Menu*

You can make any waveform the selected waveform by touching it. If you select the wrong one because the waveforms are close together, touch again until the desired waveform is selected. Other methods of selecting waveforms are discussed in Waveform Definition and Management on page 219.

You can control the number of graticules and the placement of waveforms on the graticules using the **Graticules** pop-up menu in the Waveform major menu. When dual graticules are displayed, the **Graticules** selector is renamed **Upper Graticule** or **Lower Graticule**, depending on which graticule has the icons and the selected waveform.

Managing Graticules and Waveforms

When only one graticule is displayed, you can create a dual-graticule display using the **Graticules** pop-up menu from the Waveform major menu. Touch the **Create Second Graticule** selector in this pop-up menu. The selected waveform and all waveforms from window time bases will be placed on the lower graticule. The upper graticule will show all other waveforms.

When two graticules are displayed, you can move the selected waveform from one graticule to the other. Touch the **Move Waveform to Other Graticule** selector to move the waveform. After the waveform is moved, it remains the selected waveform. The horizontal icon (↔) and vertical icon (↕) move to the new graticule.

When two graticules are displayed, you can combine the waveforms from both graticules into a single-graticule display. Touch the **Reduce to Single Graticule** selector to combine the waveforms onto one large graticule. The waveform that was selected before the operation remains the selected waveform on the new single graticule.

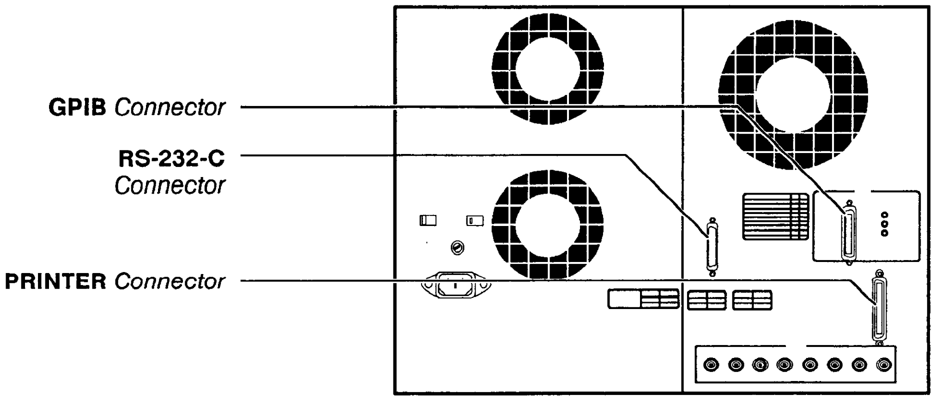
If you remove all the waveforms from the lower graticule of a dual-graticule display, the display automatically reverts to a single graticule.

Hardcopy

A variety of printers and plotters are supported for producing a paper copy of the display. This section will cover how to configure your system for most printers. Also, refer to your printer manual for the proper printer settings.

Installing the Printer

Connect the printer to the DSA. Depending on the printer, you will want to use the **PRINTER** connector, the **GPIB** connector, or the **RS-232-C** connector.



Rear Panel Connectors

- **PRINTER** is the appropriate connector for Centronics-compatible printers. This is the standard interface for the DSA, and no special configuration of the DSA is required.

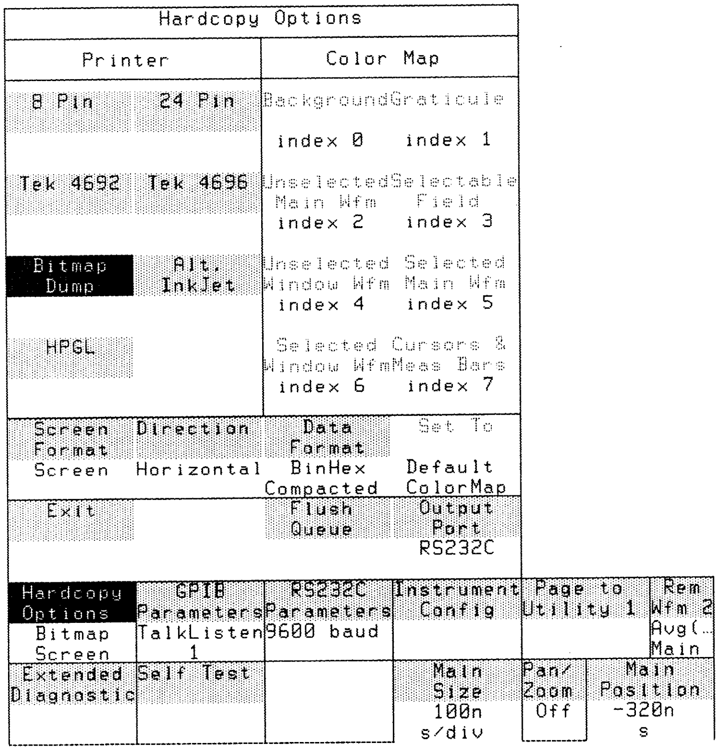
- **GPIB** is the General Purpose Interface Bus parallel interface connector. Use a standard cable fifteen meters or less in length. If you are not using a controller to initiate the hardcopy, set the GPIB Mode parameter of the DSA to Talk Only and set the printer to Listen Only or Listen Always mode (address 31). Setting GPIB parameters is explained on page 109.

- **RS-232-C** is a serial interface connector. Use a standard, straight-wired cable with male connectors on both ends. Hard flagging is used, so all lines must be connected. Do not use a null modem cable. (The DB-25 to Centronics cable provided with many personal computers *cannot* be used to connect a printer to the DSA, although it appears to match the RS-232-C connector.) The DSA acts as a DCE (Digital Communications Equipment) device. Connecting the DSA to a computer also requires a straight-wired cable, but soft flagging may be used.

  The DSA's RS-232-C parameters baud rate, parity, and number of stop bits, should be set to match those of the printer or computer. When you connect a printer to the RS-232-C connector, you may also need to set the RS-232-C flagging to **Hard**. Setting RS-232-C parameters is explained on page 180.

Hardcopy Options

Set the printing properties of the DSA using the **Hardcopy Options** pop-up menu in the Utility 2 major menu. This menu includes selectors for seven types of printers and for specific options available with some printers.



The **Hardcopy Options** *Pop-Up Menu*

Printer Selections

Printer selection and the associated parameters are not affected by initialization. The factory default settings appear in Appendix E.

The selectors in the Printer section of the **Hardcopy Options** pop-up menu determine the printing configuration of the DSA. The settings of the other hardcopy parameters will vary according to the printer that is selected. When you change one of these parameters, you are setting its default value for the selected printer type. These settings are not changed when you initialize the DSA.

- **8 Pin** supports several eight-pin dot-matrix printers, including the Tektronix 4644, Epson FX80 and Epson EX800. The IBM Proprinter and Epson RX80 may also be used, but only the **HiRes** screen format provides useful output. All the supported printers typically use the **PRINTER** connector.

  Set the configuration switches on your printer as recommended in its manual except set No Auto Line Feed, No Perf Skip, and Inbuf On.

- **24 Pin** supports the Extended Epson command set for 24-pin dot-matrix printers, including the Epson LQ500, Epson LQ1000, Nec P6, and Nec P7. These printers typically use the **PRINTER** connector.

  Set the configuration switches on your printer as recommended in its manual except set No Auto Line Feed, No Auto-Carriage Return, No Perf Skip, and Inbuf On.

- **Tek 4692** supports the Tektronix 4692 color graphics copier. The Tek 4693D may also be used when set to 4692 emulation, Full Color, Maximized by Interpolation, and Portrait Mode. These printers typically use the **PRINTER** connector.

- **Tek 4696** supports the Tektronix 4696 and 4695 color inkjet plotters. These printers typically use the **PRINTER** connector.

- **Bitmap Dump** provides the ability to acquire the screen data for external processing. For example, you can use this option to send the display data to a computer. The format of this information is determined by the **Data Format** selector. (Data format is discussed on page 121.) You will typically want to use the **GPIB** or **RS-232-C** connector for this type of transfer.

- **Alt Inkjet** supports the HP ThinkJet and HP LaserJet printers. The ThinkJet should be used in HP graphics mode, not Epson emulation mode. For the HP ThinkJet, either **Draft** or **HiRes** screen mode may be used, but **HiRes** mode will be very slow. Only **Draft** screen mode will produce usable output with the HP LaserJet. Either the **PRINTER** connector or the **GPIB** connector may be used.

- **HPGL** supports the HP-GL color plotter command set. An HPGL hardcopy will show graticules, axis labels and all waveforms. Supported printers include the Tek HC100, HP-7475, and HP-7550. These printers can be connected to the **PRINTER** connector. The HP-7474 and HP-7550 may be connected to the **GPIB** or **RS-232-C** connector.

Color Map

The selections in the **Color Map** section of the menu become available whenever a color printer or plotter is selected. A color selector is available for each display item. To change a color, simply select the item in the menu and then use the control knobs or keypad pop-up menu to adjust the setting. To restore the color map to its factory default settings, touch the **Set to Default Color Map** selector.

The color selections are expressed in terms appropriate to the selected printer. When **Tek 4692** is selected, the colors are expressed as hexidecimal RGB values. For the **Tek 4696** selection, twelve color name selections are available. **HPGL** supports pen numbers 0 to 8.

Specifically for the **Tek 4692** printer, selecting **Set to Screen Color Map** sets the color map to match the display color scheme.

Screen Format

The **Screen Format** selector provides several qualities of hardcopy output. Different format selections are available for different printer types.

- **HiRes** produces an enhanced contrast display on printers with limited gray-scale capability. Selected items, including windows, are highlighted for easy identification. For plotters, **HiRes** produces a hardcopy of the entire screen in which every waveform record point is plotted.
- **Draft** produces hardcopies faster than **HiRes** mode but sacrifices some gray-scale capability. For plotters, **Draft** reproduces the screen without the major menu area, and plots only the minimum and maximum points of each waveform record at each horizontal screen location.
- **Reduced** produces low-resolution hardcopies a quarter of the size of **Draft** hardcopies. Advantages are quicker printing and use of less memory.
- **Screen** produces an exact color replica of the screen without reformatting to enhance features. Available for color printers and plotters only. For plotters, **Screen** prints the entire screen, but plots only the minimum and maximum points of each waveform record at each horizontal screen location.
- **Dithered** reduces saturation and increases contrast by dithering icons and selector backgrounds. May be used with **Tek 4696**, **Tek 4692**, and **Bitmap Dump**.

Direction

The **Direction** selector controls whether information is sent to a printer as horizontal rows or as vertical columns. For most printers, this has the effect of rotating the image by 90°. Some printers will produce an image more quickly in one direction than in the other. When **Direction** is set to **Horizontal**, screen information is sent to the printer by horizontal rows starting at the top left corner of the display. When it is set to **Vertical**, the information is sent by vertical columns starting at the bottom left corner of the display.

Data Format

When **Bitmap Dump** is selected, the screen data is transferred as an ASCII title block followed by a pixel data block. The format of the pixel data is determined by the **Data Format** setting. Touch this selector to cycle through the four available formats.

- **Binary** mode bytes of pixel data are sent as a stream of binary values without delimiters.
- **Binary Compacted** mode pixel data are compressed before being sent. See the discussion of compression, below.
- **BinHex** mode converts every four bits into a hexidecimal character. Each line is terminated by a new-line character.
- **BinHex Compacted** mode pixel data are compressed and then converted into BinHex characters.

Title Block—consists of three character strings terminated by new-line characters. The first line contains includes the instrument name and the time and date. The second and third lines give the number of pixels per display line and the number of display lines, respectively. In **Binary** mode the title block is terminated by a NULL character.

Pixel Data Compression – significantly reduces the size of the pixel data block. Without compression, each data byte contains a single three-bit pixel. With compression, two pixels are stored in the six low-order bits of the data byte, and the two high-order bits are a repetition encoding with the following meaning:

Repetition Encodings

Bit 7	Bit 6	Meaning
0	1	Pattern repeats once
1	0	Pattern repeats twice
1	1	Pattern repeats three times
0	0	Following byte(s) contain repetition count

If the second byte of the pixel block has a value in the range 4–255, it is the pattern repetition count. If the value is 1–3 decimal, it is the high order bits of a 10-bit repetition count, and the third byte of the pixel block contains the eight lower-order bits.

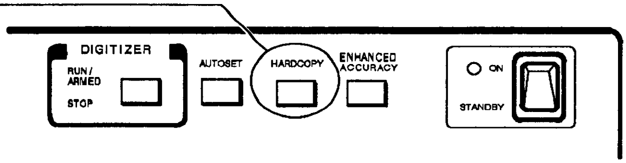
Output Port

The **Output Port** selector allows you to choose **GPIB**, **RS232C**, or **Centronics** (the **PRINTER** connector). The selection must match the rear panel connection.

Making a Hardcopy

Once you have installed a printer and configured the DSA properly, you can make a hardcopy of the screen by pressing the **HARDCOPY** button on the front panel.

The **HARDCOPY** *Button*



Any displayed messages are removed before the hardcopy process begins. When you press the **HARDCOPY** button, the display freezes for a short time. The shades of intensity on the display may be altered. The printer starts printing immediately.

The length of time that the display is frozen depends on the hardcopy mode, complexity of the display, and memory available for hardcopies. During this pause the DSA formats and buffers the print commands.

After the pause, the DSA returns to normal operation and continues to print the hardcopy. When the display becomes active again, you may operate the DSA without affecting the hardcopy being printed.

You can also initiate a new hardcopy at this point. The DSA will automatically queue multiple screen displays for hardcopy output. The number of hardcopies that can be queued is subject to the amount of available memory.

Do not turn off the DSA or perform diagnostics until the hardcopy is complete.

When the hardcopy is printed, a message is displayed. The hardcopy is not complete until this message appears. You should not turn off the DSA, perform self-test diagnostics, or use the Extended Diagnostics menu until the hardcopy is complete. Any of these actions will terminate the hardcopy.

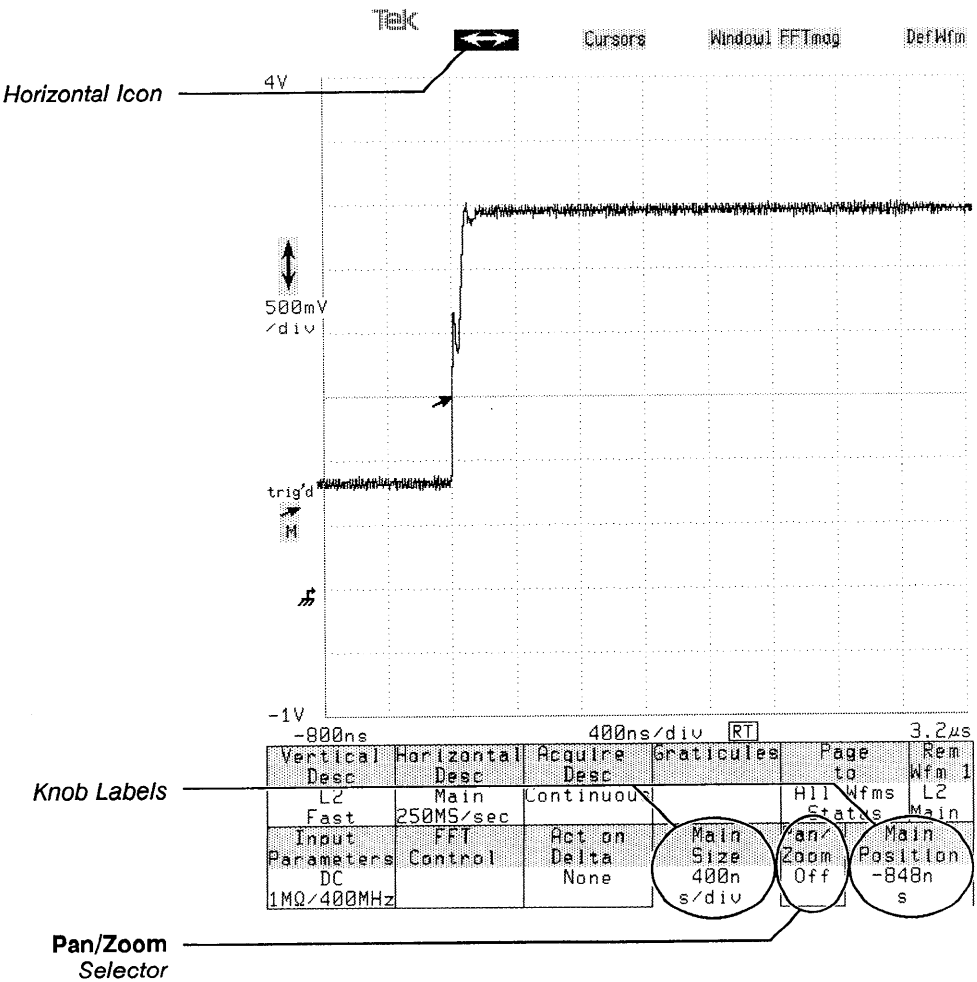
Terminating A Hardcopy In Progress

You can terminate a hardcopy by selecting **Flush Queue**, in the **Hardcopy Options** pop-up menu. A message will appear stating that the hardcopy has been cancelled. If this message does not appear, the printer may no longer be communicating with the DSA. The **Flush Queue** selector becomes a **Clear Interface** selector until a message is received from the printer. Select **Clear Interface** to abort any hardcopies that have not already been sent to the printer.

You can also terminate the hardcopy while the screen is still frozen by pressing the **HARDCOPY** button a second time.

Horizontal Controls

The horizontal controls let you set the horizontal size and placement of your waveforms. Touch the horizontal icon (↔) to access these controls.



Horizontal Controls

Setting Horizontal Size and Position

Touch a knob label to display the Keypad pop-up menu. This lets you set horizontal size and position numerically, or quickly set them to maximum or minimum limits. It also lets you set the knob resolution.

You can change the horizontal scale factor, or *size*, of a waveform. You can also move the waveform left or right to see different portions of the waveform. This is called adjusting the horizontal position. To do either of these, touch the horizontal (↔) icon. This assigns the knobs to adjust the horizontal size (left knob) and position (right knob) of the selected waveform.

The axis label for the left edge of the graticule is slightly different from the horizontal position of a waveform. This is because waveforms extend slightly beyond the edges of the graticule. The illustration on the previous page shows that the main position (the knob label) is –848 ns, and the left edge of the graticule is -800 ns.

Interactions With Other Waveforms

The knob labels tell you whether the selected waveform is from the Main time base or a Window time base.

All waveforms from the Main time base share the same size and position. If you change the size or position of one main waveform, you will change the size or position of all of main waveforms.

All waveforms from Window time bases have the same horizontal size. If you change the horizontal size of one window waveform, you will change the horizontal size of all window waveforms. Each window waveform can, however, have a unique horizontal position.

Pan/Zoom

Pan/Zoom allows you to magnify any portion of the selected waveform to examine it more closely. You can magnify (zoom) the selected waveform to the point where each digitized sample appears on the display, and you can move the magnified waveform left and right (pan) to examine any part of the waveform.

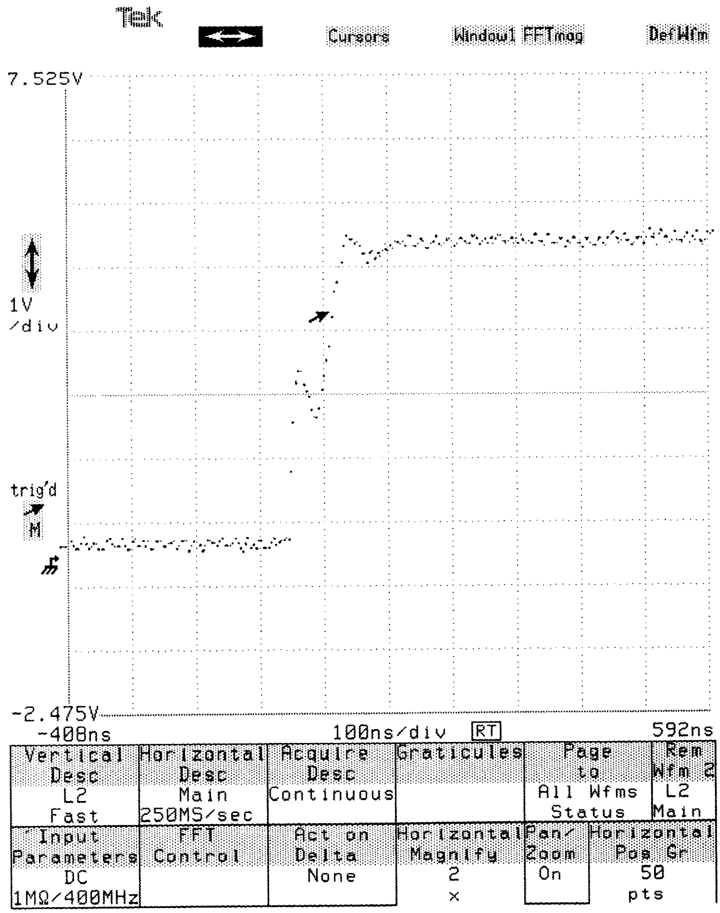
Pan/Zoom does not change the way waveform data are sampled and recorded; it only changes the way the waveform data are displayed.

The maximum magnification is determined by the waveform record length, which is described on page 175. You can magnify a waveform until one point is shown for each horizontal division on the graticule. There are 10 horizontal divisions, so you can magnify a 512-point waveform up to 50 times. The greater the record length of a waveform, the greater the maximum available magnification will be.

Whenever the horizontal icon (↔) is highlighted, the **Pan/Zoom** selector appears between the knob labels. Normally, Pan/Zoom is **Off** and the knobs are assigned to horizontal size and position. When you touch the **Pan/Zoom** selector to set it **On**, the knobs are assigned to **Horizontal Magnify** (Zoom) and **Horizontal Pos Gr** (Pan). The waveform on the next page is the same waveform shown on page 125, but magnified 8 times horizontally.

Use the left knob, **Horizontal Magnify**, to specify how much magnification you want on the selected waveform. Use the right knob, **Horizontal Pos Gr**, to position onto the display the segment of the waveform that you want to view. The knob label status area shows how many waveform data points are not shown because they are off the left end of the screen. When you set **Horizontal Pos Gr** to zero, you display the left-most portion of the waveform.

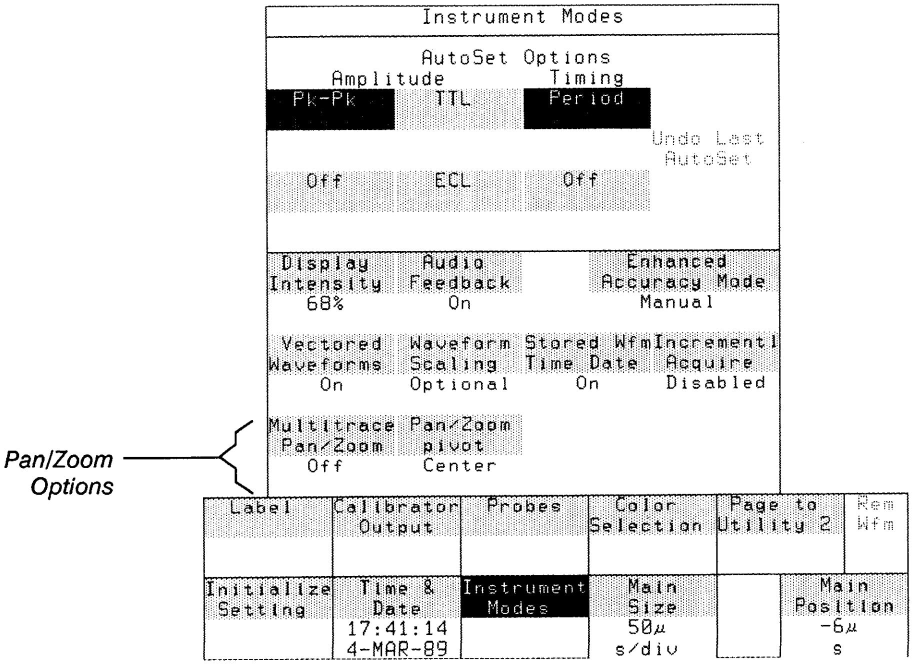
You can use horizontal magnification to see the exact data points of a waveform record. Turn off waveform vectoring and set the magnification so that no more than 512 record points are shown on the graticule. Waveform vectoring is discussed in the Vectored Waveforms section on page 211.



Horizontal Magnification with Pan/Zoom

Pan/Zoom Pivot

When you change the horizontal magnification with Pan/Zoom, the displayed waveform is expanded or contracted around a reference point, which remains fixed on the graticule. By entering the **Instrument Modes** pop-up menu of the Utility 1 major menu and touching the **Pan/Zoom pivot** selector, you can define this reference point to be the **Left**, **Center**, or **Right** of the graticule. Changing the pivot point will not affect the horizontal magnification or position of waveforms already on the display.



The **Instrument Modes** *Pop-Up Menu*

Multitrace Pan/Zoom

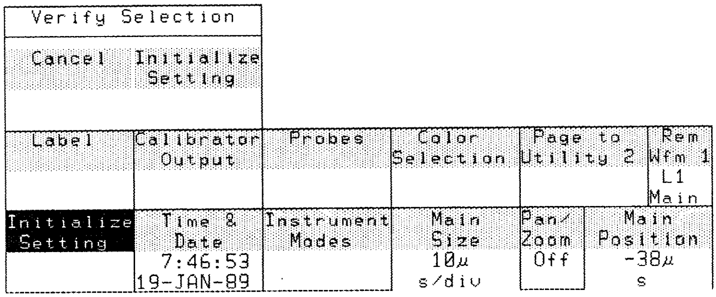
Pan/Zoom can be used to position and magnify multiple waveforms. Select **Multitrace Pan/Zoom**, in the **Instrument Modes** pop-up menu of the Utility 1 major menu. When you set Pan/Zoom to **On**, you will simultaneously set the horizontal magnification and graphical position of all waveforms that are on the same graticule and have the same record length as the selected waveform.

Turning off Multitrace Pan/Zoom does not change the horizontal magnification and position of displayed waveforms.

Initialization

Whenever you begin a new task, you should initialize the DSA so that all settings are at "factory default." That way you do not get unexpected results from settings that remain from the last use of the DSA.

To initialize the system settings to their defaults, touch the **Initialize Setting** selector in the Utility 1 major menu and select **Initialize Setting** in the displayed pop-up menu to verify the selection.



The **Initialize Setting** *Verify Pop-Up Menu*

An alternate initialization method is to select **Initialize Setting** in the **Recall Setting** pop-up menu in the Store/Recall major menu.

The following settings are *not* affected when you initialize:

- Stored settings and stored waveforms
- Hardcopy printer default settings
- Display intensity and display color settings
- The GPIB parameters Address, Debug, Mode, and Terminator
- The RS-232-C parameters Baud Rate, Debug, Echo, Verbose, Stop Bits, Parity, Flagging, Delay, and EOL String
- Time and date

Initializing and Erasing Nonvolatile RAM

You can erase all information stored in nonvolatile RAM by holding down the **WAVEFORM** and **TRIGGER** major menu buttons when you turn on the DSA. Release the buttons when the lights next to the major menu buttons stop flickering. When the power-on sequence is complete, the message "Teksecure Erase Memory Status: erased; Instrument ID, on-time, and number of power-ups retained" will appear on the display.

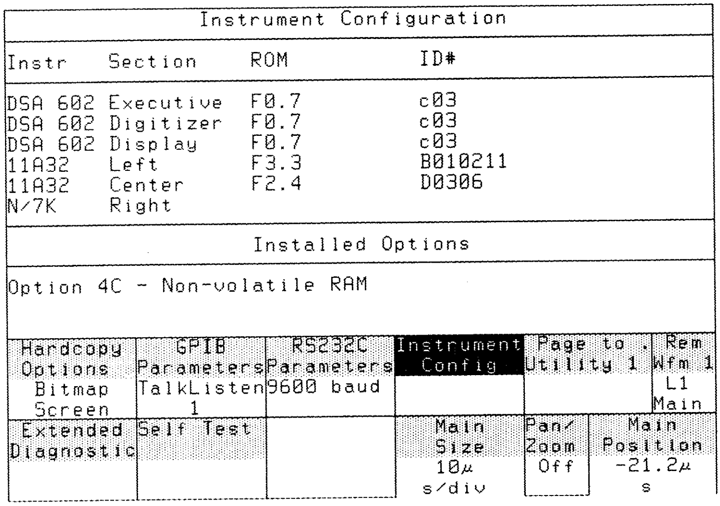
When nonvolatile RAM is erased in this manner, the DSA writes over all nonvolatile RAM locations where settings can be stored with the hexidecimal value FFFF and writes the hexidecimal value ABCD over all locations where waveforms can be stored. Any Enhanced Accuracy calibration of the DSA is lost.

The following information is *not* lost when nonvolatile RAM is erased:

- Serial number of the DSA
- Accumulated time the DSA has been on
- Number of times the DSA has been turned on
- Factory calibration constants, which are established at the factory and cannot be changed by the user or by the DSA
- Time and Date

Instrument Configuration

You can determine the configuration of your system by looking at the **Instrument Config** pop-up menu in the Utility 2 major menu.



The **Instrument Config** *Pop-Up Menu*

The upper section of the **Instrument Config** pop-up menu lists the internal processors of the DSA and the contents of its plug-in compartments, and displays the version number of the firmware (programming) and the serial number for each component. A notation of N/7K means that the plug-in compartment is empty or contains a 7000-Series plug-in unit.

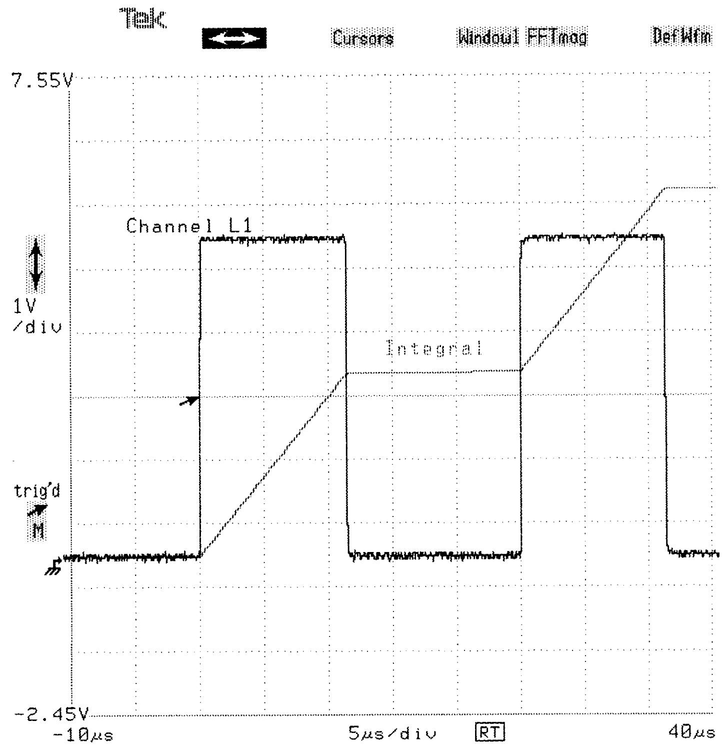
The lower section of the **Instrument Config** pop-up menu lists any installed options along with a brief description.

You will need the information from this menu when discussing the DSA with your local Tektronix representative.

Labeling

You can label active waveforms, stored waveforms, and stored settings for easier identification. You can also change the *base label*. The base label is assigned automatically to stored waveforms acquired in the repetitive single trigger mode or in the Act on Delta mode.

A label is a string of up to ten letters, numbers, or spaces that appears in the selector for a waveform or a stored setting. Labels for active waveforms may also be displayed on the screen with the waveform.



Labels Displayed with Active Waveforms

Creating Labels

You can create and edit labels by using the **Label** pop-up menu, which appears on the next page. Select **Label** in the Utility 1 major menu to display this pop-up menu. The uppermost section of this menu contains selectors for **Active Waveforms**, **Stored Waveforms**, **Stored Settings**, and **Base Label**. Beneath these selectors, the selectors for individual active waveforms, stored waveforms, or stored settings appear. If there are more stored waveforms or stored settings than can be displayed at once, use the **Page↑** and **Page↓** selectors to scroll through the menu.

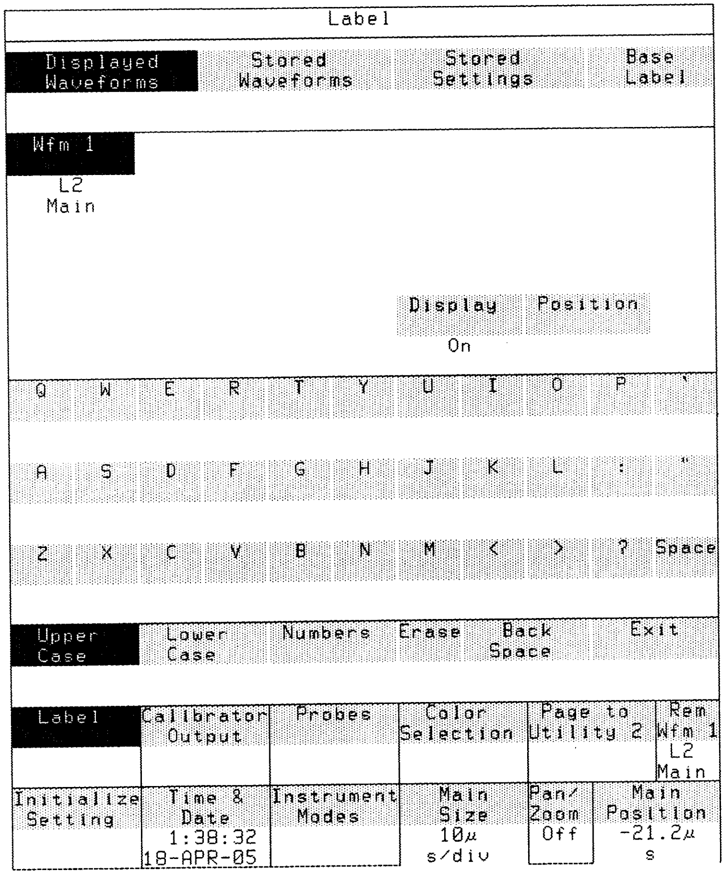
To create or change a label, select the item you want to label from the **Label** pop-up menu. For example, select **Stored Waveforms**, then select the stored waveform you want to label. You can then type the label by touching the character selectors in the lower half of the menu. The selectors beneath the characters allow you to choose **Upper Case** letters, **Lower Case** letters, or **Numbers**, which include some punctuation and symbols. You can mix uppercase letters, lowercase letters, and numbers within a label. As you type, the label appears in the selector, just below the waveform or setting number.

Use the **Backspace** selector to correct errors as you type a label. Touch the **Erase** selector to completely erase the selected label. Use the **Exit** selector to leave the pop-up menu. When you leave the pop-up menu, new labels are entered automatically. If you want to enter a label without leaving the **Label** menu, touch the selector for the labeled item in the menu. Once a label is entered, it appears in every selector for the labeled item.

You cannot enter the same label for two items of the same type.

You cannot use the same label for two items of the same type. If you attempt to enter a duplicate label, the error message "Duplicate label - label not changed" will appear on the display and the previous label will be restored.

When you store a labeled waveform, or create an active waveform that displays a single stored waveform, the label will be copied to the new waveform unless this would duplicate a label on another waveform in the same class.



The **Label** *Pop-Up Menu*

Changing the waveform description of an active waveform will not change the label of the waveform, except when the new waveform description consists of a single stored waveform. The label of the stored waveform would then replace the active waveform's label.

Changing the Base Label

The current base label is the one that is used whenever acquisition occurs in repetitive single-trigger mode or in Act on Delta mode. As each waveform record is acquired, it is stored and labeled with a sequential number appended to the base label. For example, a series of waveform records might be labeled "REP1," "REP2," "REP3," etc. The default base label is "REP," for "repetition."

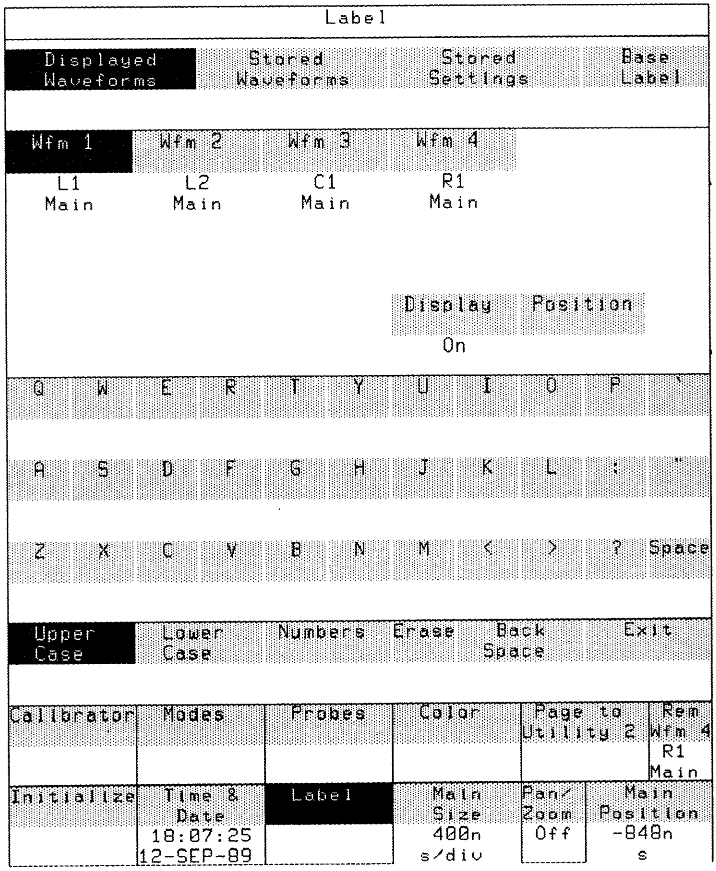
Repetitive Single Trigger mode is discussed on page 38. Act on Delta is discussed on page 47.

You can change the base label just as you would change any other label. Select **Base Label** in the **Label** pop-up menu. Erase the existing base label and enter a label of your choice. The base label is limited to seven characters, so that numbers of up to three digits may be appended to the label. Digits may not be entered as part of the base label.

Displaying Labels with Active Waveforms

Labels of active waveforms may be displayed on the screen with the waveforms. When **Active Waveforms** is selected, **Display** and **Position** selectors appear beneath the waveform selectors in the **Label** pop-up menu. Turning on **Display** will cause the labels to appear with the displayed waveforms. Labels will appear in the selectors for active waveforms whether **Display** is turned on or off.

Labels that are displayed on the screen move with the waveforms. You can position each label relative to its waveform. Select **Position** to assign the knobs to set the vertical (left knob) and horizontal (right knob) position of the label. The label position is relative to a specific point on the waveform. By changing the horizontal position of the label, you are changing the point the label will follow. By changing the vertical label position, you can specify the vertical offset of the label from the point. If the waveform record point is out of the range of the graticule, the label will remain at the top or bottom of the graticule.



The **Label** *Pop-Up Menu*

Changing the waveform description of an active waveform will not change the label of the waveform, except when the new waveform description consists of a single stored waveform. The label of the stored waveform would then replace the active waveform's label.

Changing the Base Label

The current base label is the one that is used whenever acquisition occurs in repetitive single trigger mode or in Act on Delta mode. As each waveform record is acquired, it is stored and labeled with a sequential number appended to the base label. For example, a series of waveform records might be labeled "REP1," "REP2," "REP3," etc. The default base label is "REP," for "repetition."

When multiple waveforms are acquired in repetitive single trigger mode, a colon and the waveform number of the acquired waveform are appended to the label. For example, if waveform 1 and waveform 3 are acquired in this mode, the first acquisition would produce waveforms labeled "REP1:1" and "REP1:3."

Repetitive Single Trigger mode is discussed on page 38. Act on Delta is discussed on page 47.

You can change the base label just as you would change any other label. Select **Base Label** in the **Label** pop-up menu. Erase the existing base label and enter a label of your choice. The base label is limited to five characters, so that a numbers of up to three digits, a colon, and the waveform number may be appended to the label. Digits may not be entered as part of the base label.

Displaying Labels with Active Waveforms

Labels of active waveforms may be displayed on the screen with the waveforms. When **Active Waveforms** is selected, **Display** and **Position** selectors appear beneath the waveform selectors in the **Label** pop-up menu. Turning on **Display** will cause the labels to appear with the displayed waveforms. Labels will appear in the selectors for active waveforms whether **Display** is turned on or off.

Labels that are displayed on the screen move with the waveforms. You can position each label relative to its waveform. Select **Position** to assign the knobs to set the vertical (left knob) and horizontal (right knob) position of the label. The label position is relative to a specific point on the waveform. By changing the horizontal position of the label, you are changing the point the label will follow. By changing the vertical label position, you can specify the vertical offset of the label from the point. If the waveform record point is out of the range of the graticule, the label will remain at the top or bottom of the graticule.

Measurements

Measurements are numeric readouts of properties of a waveform such as rise time, fall time and frequency. Measurements are updated continuously so that as the signal changes the numeric readouts change also. You can select up to six measurements for each waveform. The readouts of the measurements of the selected waveform appear in the Measure major menu. The measurements are listed in the table below.

Measurements

	Selector	Measures
Amplitude Measurements	**Gain**	The ratio of the peak-to-peak amplitude of the selected waveform to the peak-to-peak amplitude of a reference waveform.
	Max	Maximum amplitude, the most positive peak voltage.
	Mean	The average vertical amplitude (arithmetic mean).
	Mid	Middle amplitude, halfway between maximum and minimum amplitude.
	Min	Minimum amplitude, the most negative peak voltage.
	Peak-Peak	The voltage difference between maximum and minimum amplitude.
	RMS	True Root Mean Square voltage.
Area and Energy Measurements	**Area+**	The area under the curve of a waveform bounded at the bottom by a reference level.
	Area-	The difference between the area under the curve above a reference level, and the area under the curve below that reference level.
	Energy	The energy represented under the curve of a waveform. This integral of the squared voltages can be divided by the resistance of the circuit to yield a power value.

Measurements (Cont.)

Timing Measurements

Selector	Measures
Cross	The time from the trigger point to a specified level crossing with the specified slope.
Delay	The time between the first mesial crossing and the last mesial crossing.
Fall	The transition time of a falling pulse edge.
Frequency	The reciprocal of the period.
Main→Win Trig Time	The time between the Main and Window trigger points. This measurement allows much greater precision than other timing measurements, and is discussed in more detail later in this section.
Period	The time taken for one complete signal cycle.
Phase	The phase angle derived from the time difference between edges on two waveforms.
PropDelay	The time between mesial crossings of two different waveforms.
Rise	The transition time of a rising pulse edge.
Width	The pulse duration measured from one mesial crossing to the next mesial crossing of opposite slope.

Measurements

Measurements are numeric readouts of properties of a waveform. Measurements are updated continuously so that as the signal changes the numeric readouts also change. You can select up to six measurements at a time. The measurement readouts for the selected waveform appear in the Measure major menu. The measurements are listed in the following table.

Measurements

	Selector	Measures
Amplitude Measurements	**Max**	Maximum amplitude, the most positive peak voltage.
	Min	Minimum amplitude, the most negative peak voltage.
	Mid	Middle amplitude, halfway between maximum amplitude and minimum amplitude.
	Mean	Arithmetic mean voltage.
	RMS	True Root Mean Square voltage.
	Peak-Peak	The voltage difference between maximum amplitude and minimum amplitude.
	Gain	The ratio of the peak-to-peak amplitude of the reference waveform† to the peak-to-peak amplitude of the selected waveform. For example, the gain of a waveform compared to itself is 1 (no units).
	Over Shoot	The difference between the maximum amplitude and the topline value, expressed as a percentage of the difference between the topline and baseline values.
	Under Shoot	The difference between the baseline value and the minimum amplitude, expressed as a percentage of the difference between the topline and baseline values.
Area and Energy Measurements	**Area+**	The area under the curve of a waveform.
	Area–	The difference between the area under the curve above a reference level and the area under the curve below that reference level.
	Energy	The energy represented under the curve of a waveform. This integral of the squared voltages can be divided by the resistance of the circuit to yield power measurements.

Timing Measurements

Measurements (Cont.)

Selector	Measures
Rise	The transition time of a rising pulse edge.
Fall	The transition time of a falling pulse edge.
Period	The time taken for one complete signal cycle.
Frequency	The reciprocal of the period.
Width	The time the signal takes to go from one voltage level crossing to the next crossing of opposite slope.
Cross	The time from the trigger point to a specified level crossing.
Delay	The time between the first and last mesial crossings of a waveform within the measurement zone.
PropDelay	The time from the first mesial crossing of the selected waveform to the first mesial crossing of the delayed waveform† within the measurement zone.
Skew	The time from the first mesial crossing of the reference waveform† to the first mesial crossing of the selected waveform within their respective measurement zones.
Duty Cycle	The percentage of a period that a waveform spends above the mesial.
Phase	The phase angle from the reference waveform† to the selected waveform.
Main→Win Trig Time	The time from the Main trigger point to the Window trigger point. This measurement allows much greater precision than other timing measurements, and is discussed in more detail later in this section.

† The delayed waveform is set separately for each waveform, and is used only for the PropDelay measurement. The reference waveform is the same for all selected waveforms; it does not change when you select a new waveform.

Setting up a Waveform for Measurements

Measurements are taken from waveform record points. The waveform on which measurements are based must be adjusted so all areas that are needed to take the measurements are visible on the display. No part of the waveform should extend above or below the graticule display area. If a measurement requires a full cycle, as in frequency or period measurements, adjust the horizontal size to show at least two complete cycles of the signal. If a measurement requires a rising or falling edge, as in rise or cross measurements, adjust the horizontal size and position to show the complete rising or falling edge.

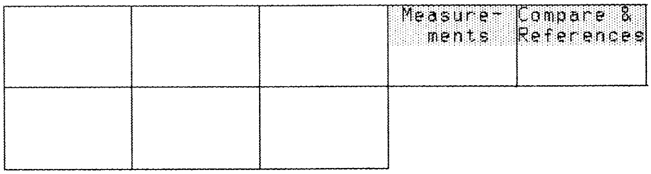
The %Fill parameter is discussed in Acquisition on page 36.

For best accuracy, the %Fill parameter should be set to 100. Otherwise the waveform record may include null points, which will affect the accuracy of the measurements.

Having an improperly adjusted waveform for a measurement may result in a qualified measurement readout. For example, measurements may be qualified by greater than or equal to (≥), less than or equal to (≤), or a question mark (**?**). An **error** readout may also result.

Establishing Measurements

Once the waveform display is established, press the **MEASURE** button to display the Measure major menu. Initially, this menu is mostly blank. The six empty selectors are reserved as places for measurement readouts that appear when you select measurements.



Measure Major Menu

Touch the **Measurements** selector to display a pop-up menu showing the measurement selectors. Touch the individual measurement selectors to take measurements of your waveform. As you select each measurement, the result of the measurement is immediately displayed in one of the selector areas of the Measure major menu.

The illustration on the next page shows the **Measurements** pop-up menu with two measurements, RMS and Frequency, selected. The numeric readouts for these two measurements are in the major menu area.

Setting up a Waveform for Measurements

Measurements are taken from waveform record points. The waveform on which measurements are based must be adjusted so all areas that are needed to take the measurements are visible on the display. No part of the waveform should extend above or below the graticule display area. If a measurement requires a full cycle, as in frequency or period measurements, adjust the horizontal size to show at least two complete cycles of the signal. If a measurement requires a rising or falling edge, as in rise or cross measurements, adjust the horizontal size and position to show the complete rising or falling edge.

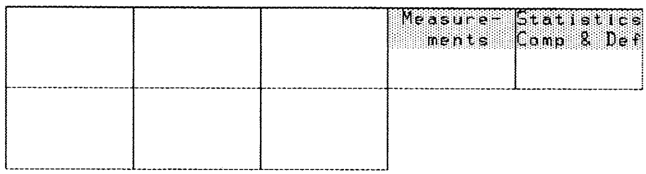
The %Fill parameter is discussed in Acquisition on page 36.

For best accuracy, the %Fill parameter should be set to 100. Otherwise the waveform record may include null points, which will affect the accuracy of the measurements.

Having an improperly adjusted waveform for a measurement may result in a qualified measurement readout. For example, measurements may be qualified by greater than or equal to ($\geq$), less than or equal to ($\leq$), or a question mark (**?**). An **error** readout may also result.

Establishing Measurements

Once the waveform display is established, press the **MEASURE** button to display the Measure major menu. Initially, this menu is mostly blank. The six empty selectors are reserved as places for measurement readouts that appear when you select measurements.



Measure Major Menu

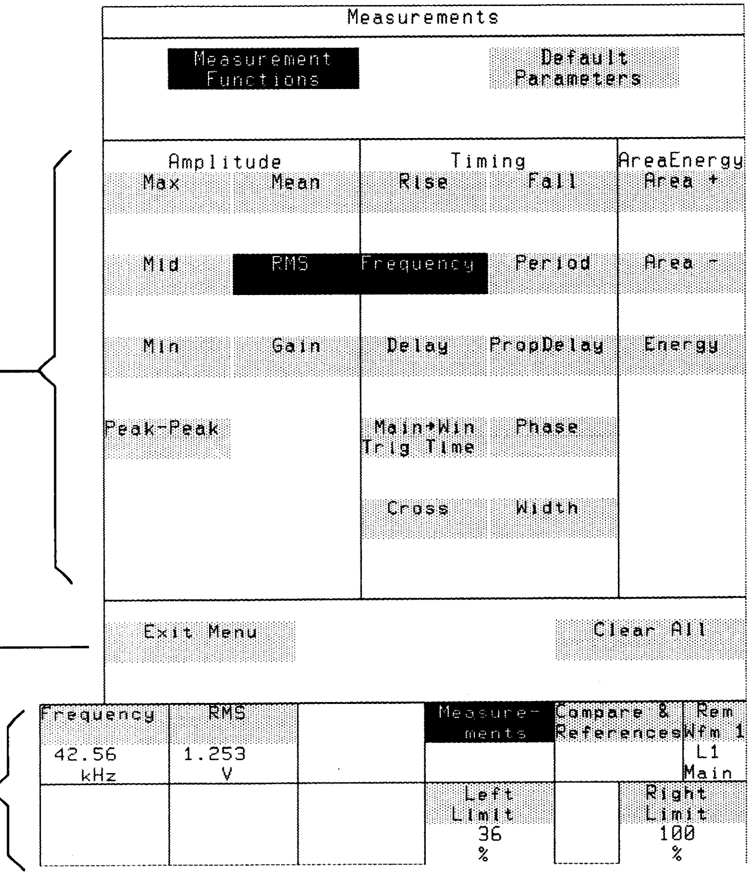
Touch the **Measurements** selector to display a pop-up menu showing the measurement selectors. Touch the individual measurement selectors to take measurements of your waveform. As you select each measurement, the result of the measurement is immediately displayed in one of the selector areas of the Measure major menu.

The illustration on the next page shows the **Measurements** pop-up menu with two measurements, RMS and Frequency, selected. The numeric readouts for these two measurements are in the major menu area.

Select measurements here

Remove the pop-up menu here

View the readouts here



Measurements *Pop-Up Menu with RMS and Frequency Selected*

When the measurements you want are selected, you can remove the pop-up menu by touching the **Exit Menu** selector in the pop-up menu. This lets you see the waveform as the measurements are taken. You can adjust the selected waveform with the vertical, horizontal, and trigger icons while measurements are in progress. Some measurement results will be affected, particularly timing measurements that use the trigger point.

Measurements are taken on the selected waveform. The same measurements are taken for any waveform selected until you change the set of active measurements using the **Measurements** pop-up menu.

The Main→Window Trigger Time Measurement

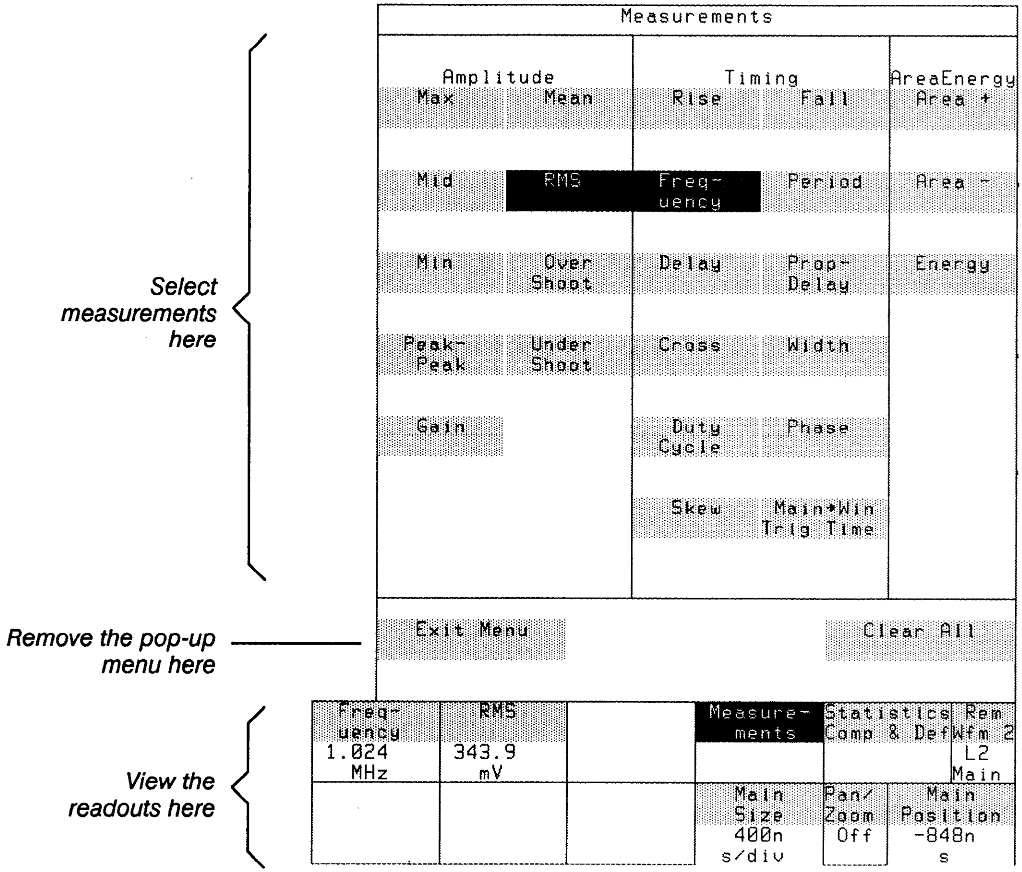
Unlike the other timing measurements, which are taken from digitized waveform samples, the Main→Window Trigger Time measurement is taken directly from the signals passing through the trigger circuits. You can use this feature to obtain very precise time interval measurements, similar to the "Time A→B mode" on a counter/timer.

You do not need to acquire a window waveform in order to use the **Main→Win Trig Time** measurement.

To use the Main→Window Trigger Time measurement, select **Main→Win Trig Time** in the **Measurements** pop-up menu. Since you can set the trigger source, slope, level, and holdoff separately for the Main and Window time bases, you can define the Main and Window trigger events so that the time between them represents the time between edges on two different waveforms or on the same waveform, and you can be very specific about the events that define the beginning and end of the time interval.

For more information about triggering, see page 199.

First, define a separate trigger for the Window time base: touch the **Trigger Select** selector in the **Trigger** major menu until **Window** is selected, then select **Window Holdoff: By Time** or **Window Holdoff: By Events** in the **Source Desc** pop-up menu. Window triggering is described fully in the Window Triggering section on page 204. Use the **Source Desc** pop-up menu to define the trigger signal for the selected trigger (the one listed in the **Trigger Select** selector).



Measurements *Pop-Up Menu with* **Frequency** *and* **RMS** *Selected*

When the measurements you want are selected, you can remove the pop-up menu by touching either the **Exit Menu** selector in the pop-up menu or the **Measurements** selector in the major menu area. This lets you see the waveform as the measurements are taken.

The Main→Window Trigger Time Measurement

Unlike the other timing measurements, which are taken from digitized waveform samples, the Main→Window Trigger Time measurement is taken directly from the signals passing through the trigger circuits. You can use this feature to obtain very precise time interval measurements, similar to the "Time A→B mode" on a counter/timer.

You do not need to acquire a window waveform in order to use the **Main→Win Trig Time** measurement.

To use the Main→Window Trigger Time measurement, select **Main→Win Trig Time** in the **Measurements** pop-up menu. Since you can set the trigger source, slope, level, and holdoff separately for the Main and Window time bases, you can define the Main and Window trigger events so that the time between them represents the time between edges on two different waveforms or on the same waveform, and you can be very specific about the events that define the beginning and end of the time interval.

For more information about triggering, see page 199.

First, define a separate trigger for the Window time base: touch the **Trigger Select** selector in the **Trigger** major menu until **Window** is selected, then select **Window Holdoff: By Time** or **Window Holdoff: By Events** in the **Source Desc** pop-up menu. Window triggering is described fully in the Window Triggering section on page 204. Use the **Source Desc** pop-up menu to define the trigger signal for the selected trigger (the one listed in the **Trigger Select** selector).

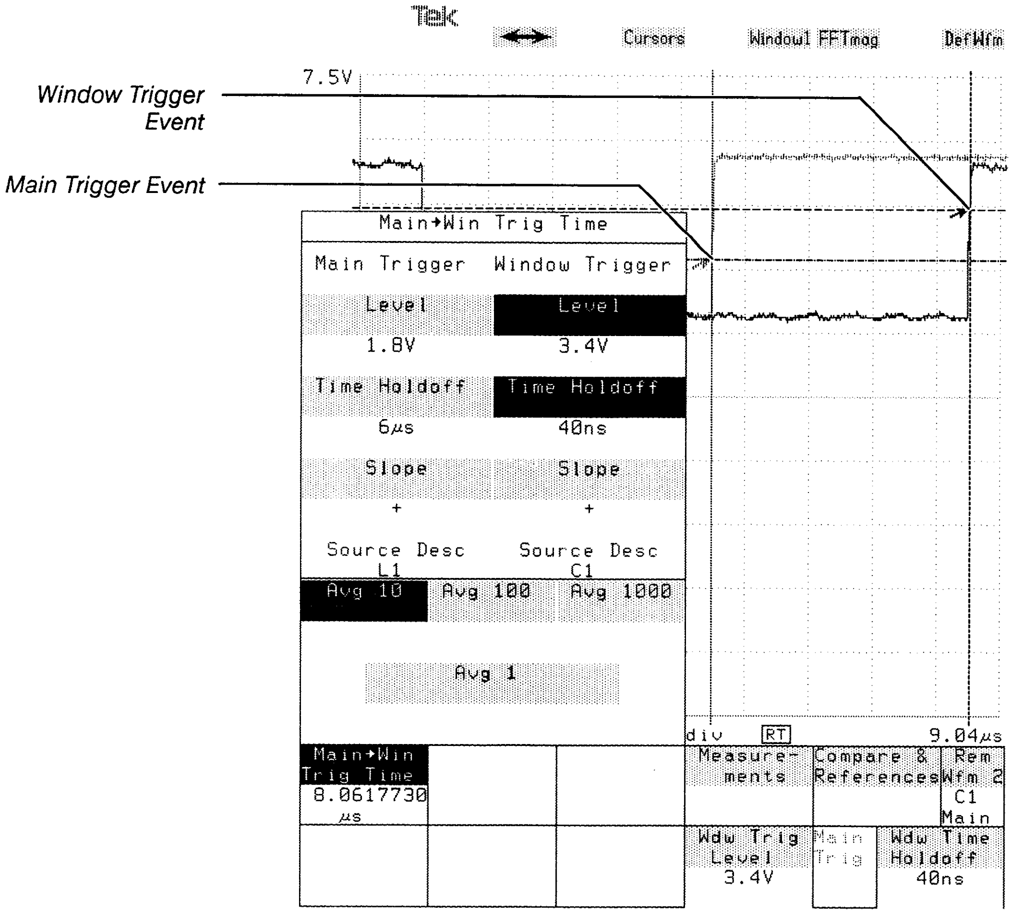
Selectors for trigger **Level**, **Holdoff**, and **Slope** for both the Main and Window triggers appear in the **Main→Win Trig Time** pop-up menu, which appears on the next page. Touch the **Main→Win Trig Time** selector to view this pop-up menu. The horizontal lines that appear on the display show the trigger levels. The vertical bars show the location of the trigger events in time and the trigger indicators (↗) show the location of the trigger events on the trigger signals.

Selectors for trigger **Level**, **Holdoff**, and **Slope** for both the Main and Window triggers appear in the **Main→Win Trig Time** pop-up menu. Touch the **Main→Win Trig Time** selector to view this pop-up menu, which appears on the next page. The horizontal lines that appear on the display show the trigger levels. The vertical bars show the location of the trigger events in time and the trigger indicators (➚) show the locations of the trigger events on the trigger signals.

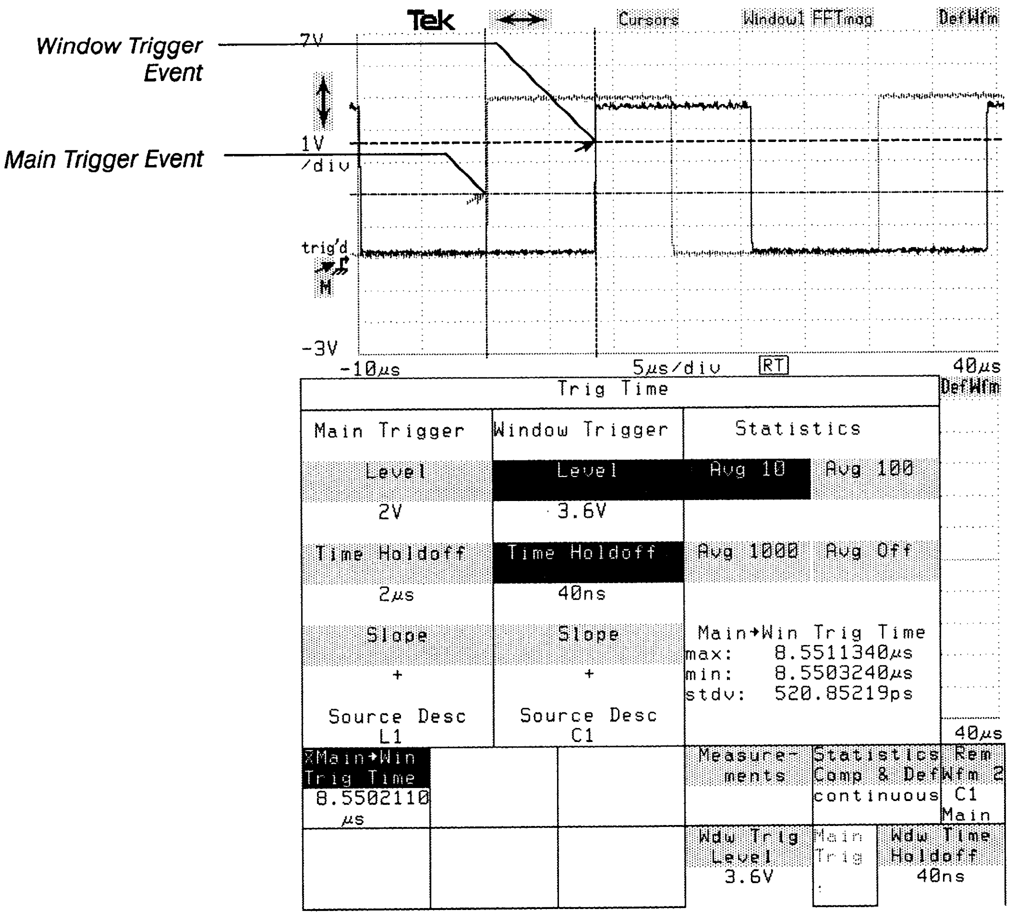
Main→Window Trigger Time Averaging

You can increase the precision of the **Main→Win Trig Time** measurement by taking an average of 10, 100, or 1000 instances of the measurement. Select **Avg 10**, **Avg 100**, or **Avg 1000** in the **Main→Win Trig Time** pop-up menu to display an average of the **Main→Win Trig Time** measurement. The averaged value will appear in the status field of the **Main→Win Trig Time** selector.

To terminate averaging of the **Main→Win Trig Time** measurement, select **Avg 1** in the **Main→Win Trig Time** pop-up menu.



The **Main→Win Trig Time** *Pop-Up Menu*



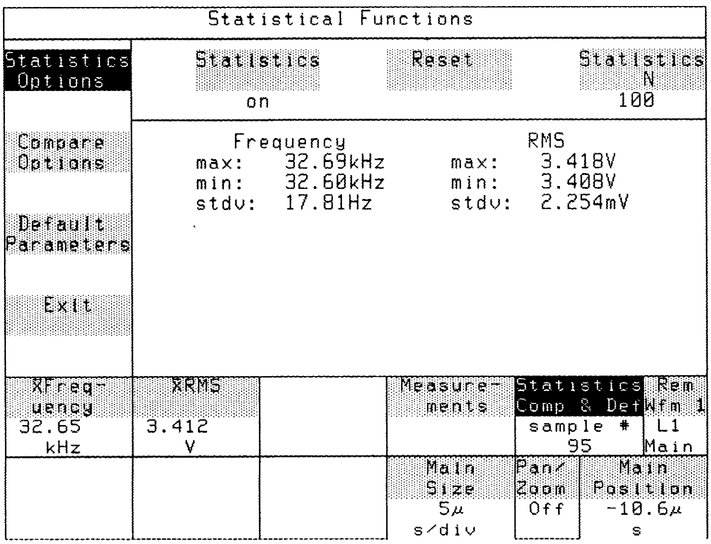
The **Main→Win Trig Time** *Pop-Up Menu*

Deleting Measurements

To delete a measurement, touch the **Measurements** selector in the Measure major menu. In the pop-up menu, touch the selectors for the measurements you want to remove. As you touch the measurement selectors, they will turn off highlighting and the measurement readouts will be removed from the major menu area. **Clear All** deletes all measurements. When you are finished removing measurements, touch the **Exit Menu** selector to remove the pop-up menu.

Measurement Statistics

The DSA can collect mean, standard deviation, maximum, and minimum values for all active measurements. To control these statistical functions, select **Statistics Comp & Def** (Statistics, Compare, and Default Parameters) in the Measure major menu. The **Statistics Comp & Def** pop-up menu is displayed with **Statistics Options** selected.



Statistics Options *in the* **Statistics Comp & Def** *Pop-Up Menu*

Deleting Measurements

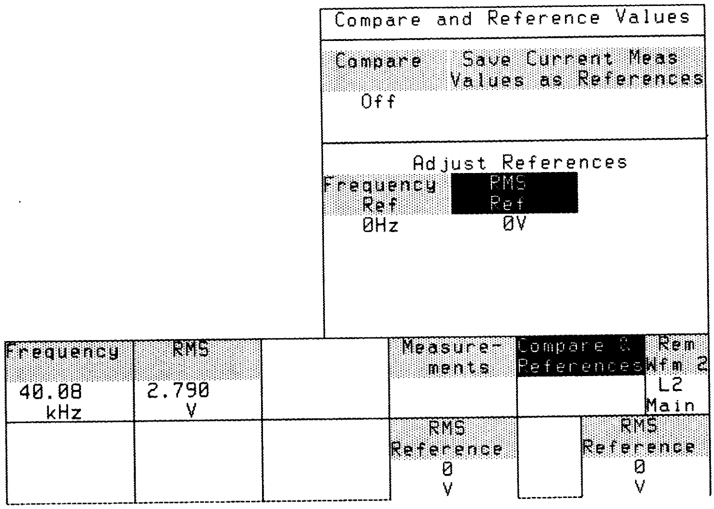
To delete a measurement, touch the **Measurements** selector in the Measure major menu. In the pop-up menu, touch the selectors for the measurements you want to remove. As you touch the measurement selectors, their readouts will be removed from the major menu area. **Clear All** deletes all measurements. When you are finished removing measurements, touch the **Exit Menu** selector to remove the pop-up menu.

Comparing Measurements to References

You can establish reference values for your measurements and have the DSA display the measurement readouts as the amount of variance from the reference value. For example, if you want to see how much a waveform varies from 0.5 V rms, establish a reference value of 0.5 V rms. Then turn the compare mode on and the DSA displays the difference between the reference value of 0.5 V rms and the rms value of the waveform being measured.

Alternatively, you can save the current measurement readouts as the reference values for those measurements. If you then turn on the compare feature, you can observe how much the signal deviates from those references as you tune the circuit under test.

To turn the compare mode on or off, touch the **Compare** selector in the **Compare & References** pop-up menu located in the Measure major menu.



Compare & References *Pop-Up Menu*

When **Compare** is **on**, the measurement readouts show a delta (Δ) in the active measurement selectors to remind you that difference values are being displayed. For example, the **RMS** measurement readout in the major menu area becomes the Δ**RMS** readout when compare mode is turned on.

The compare feature affects all measurements on all waveforms. When you turn on compare mode, all measurement readouts show Δ comparison values, even if you select a different waveform.

Setting Reference Values

You set the reference values to the current measurement values by touching the **Save Current Meas Values as References** selector. When you touch this selector, all the reference values for the measurements established on the selected waveform are copied from the current measurement readouts.

Whenever the **Statistics Comp & Def** pop-up menu is displayed, selecting **Statistics Options** will display the statistical functions page of the pop-up menu.

Touch the **Statistics** selector to turn statistical computation on or off. When statistics are on, the mean values of the measurements appear in the measurement selectors in the major menu. The symbol $\bar{x}$, for mean, precedes the name of each measurement. The standard deviation, maximum, and minimum values of each measurement appear in the lower portion of the **Statistics Comp & Def** pop-up menu.

When statistics are on, the number of samples that have been used to determine the statistical values appears in the **Statistics Comp & Def** selector in the major menu. You can set the number of samples to be used for statistics by selecting **Statistics N** in the statistical functions page of the **Statistics Comp & Def** pop-up menu and then setting the value by using the control knobs.

To restart statistics, select **Reset** in the statistical functions page of the **Statistics Comp & Def** pop-up menu. Statistics will also be reset whenever the value of **Statistics N** is changed, when measurement parameters are changed, and when measurements are turned on or off.

If the DSA encounters an error or an otherwise qualified measurement while computing statistics, the qualified sample will be discarded and a question mark (**?**) will precede the displayed statistics.

Main→Window Trigger Time Statistics

Statistics for the **Main→Win Trig Time** measurement do not appear in the **Statistics Comp & Def** pop-up menu. Instead, the **Main→Win Trig Time** statistics are controlled from the **Main→Win Trig Time** pop-up menu. To view statistics for this measurement, select **Main→Win Trig Time** in the measurement readout area and select **Avg 10**, **Avg 100**, or **Avg 1000** in the **Statistics** section of the pop-up menu to set the number of samples to take to determine the statistical values.

The mean **Main→Win Trig Time** value appears in the status area of the **Main→Win Trig Time** selector, and the maximum, minimum, and standard deviation values appear in the **Statistics** section of the **Main→Win Trig Time** pop-up menu. Select **Avg Off** to terminate statistics for this measurement. Always select **Avg Off** for a Main→Window Trigger time measurement in single trigger mode.

Comparing Measurements to References

You can establish reference values for your measurements and have the DSA display the measurement readouts as the amount of variance from the reference value. For example, if you want to see how much a waveform varies from 0.5 V rms, you establish a reference value of 0.5 V rms. Then you turn on compare mode and the DSA displays the difference between the reference value of 0.5 V rms and the rms value of the waveform being measured.

You can also save the current measurement readouts as the reference values for those measurements. If you then turn on the compare feature, you can observe how much the signal deviates from those references as you tune the circuit under test.

When the compare mode is on and measurement readouts show difference values, the measurement readouts show a delta (Δ) in the selector label to remind you that difference values are being displayed. For example, the **RMS** measurement readout in the major menu area becomes the **ΔRMS** readout when compare mode is turned on.

The compare feature affects all measurements on all waveforms. When you turn on compare mode, all measurement readouts show Δ comparison values, even if you select a different waveform.

Compare mode is turned on or off using the compare options page of the **Statistics Comp & Def** pop-up menu. Select **Compare Options** in the **Statistics Comp & Def** menu to display this page.

You set the reference values to the current measurement values by touching the **Save Current Meas Values as References** selector. When you touch this selector, all the reference values for measurements established on the selected waveform are copied from the current measurement readouts.

When compare mode is off, you can use the knobs or keypad menu to set the reference values. A selector appears in the **Adjust References** section of the **Compare & References** pop-up menu for each measurement currently established on the selected waveform. Each of these has the word **Ref** after the measurement name, for example, the **RMS Ref** selector. Touch the reference selector for the measurement reference you want to adjust, and use either knob to adjust the value. Touch either knob label to display the keypad pop-up menu and enter a numeric reference value.

Changing Measurement Parameters

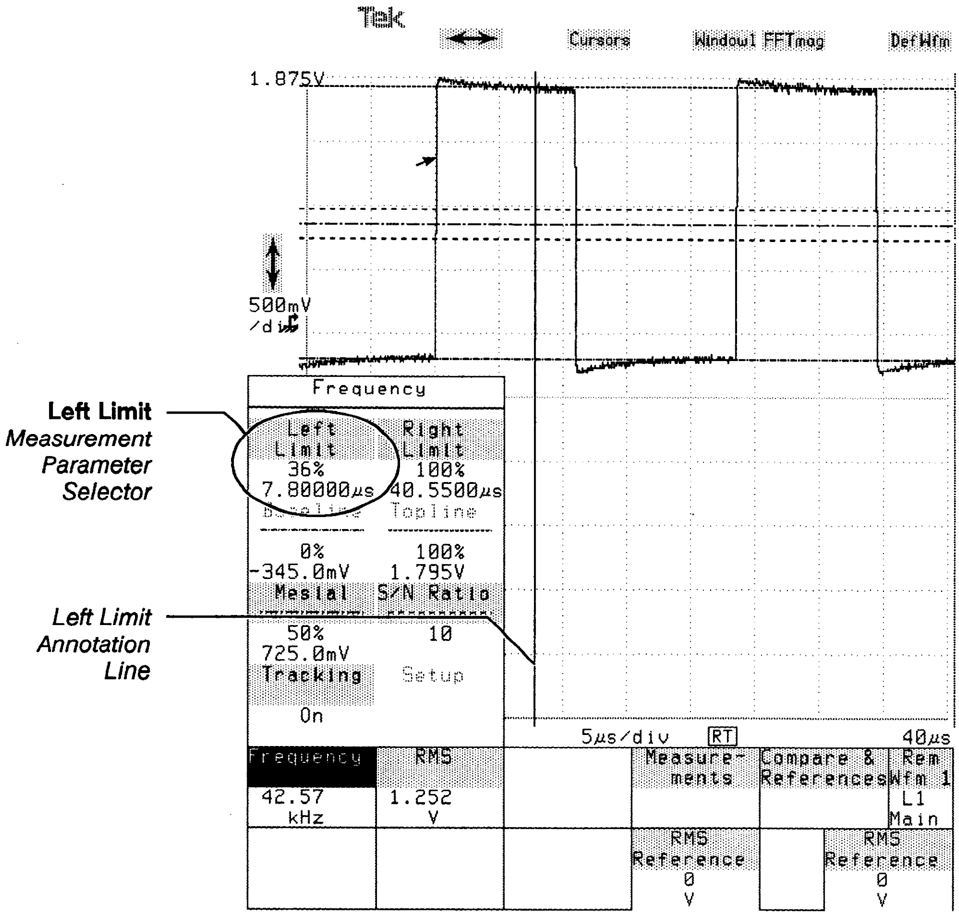
Once you have established a measurement, you can find out more information about the measurement by displaying the individual measurement pop-up menu. You can use this menu to adjust the measurement parameters.

Touch a measurement readout selector in the major menu area to display the pop-up menu for the individual measurement. When you touch a measurement selector, red *annotation lines* overlay the currently selected waveform. These lines show the value of the *measurement parameters* that pertain to that particular waveform. These measurement parameters are shared by all measurements taken on that waveform. So, changing a parameter, such as mesial, for one measurement will affect all measurements on that waveform that use mesial.

In addition to the annotation lines, the portion of the waveform the DSA uses to determine the measurement value is highlighted in red.

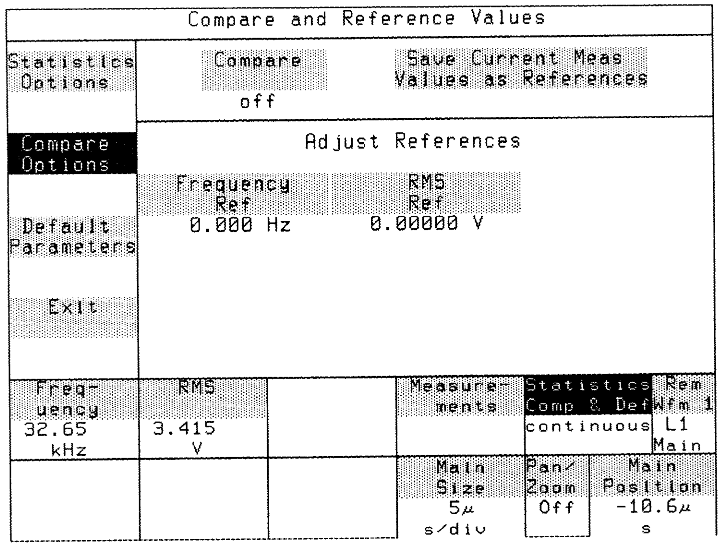
The illustration on the next page shows a typical pop-up menu for a measurement, along with the annotation lines and the highlighted portion of the waveform.

Many selectors in the measurement pop-up menu set the knobs to adjust the measurement parameters. As you turn the knob, the annotation lines move to reflect the new value of the measurement parameter. For example, in the **Frequency** pop-up menu, the **Left Limit, Right Limit, Mesial,** and **S/N Ratio** selectors set the knobs to control those measurement parameters.



A Typical Individual Measurement Pop-Up Menu

The dotted line style of the annotation lines is repeated in the measurement parameter selectors in the pop-up menu.



Compare Options *in the* **Statistics Comp & Def** *Pop-Up Menu*

When compare mode is off, you can use the knobs to set the reference values. A selector appears in the **Adjust References** section of the **Statistics Comp & Def** pop-up menu for each measurement currently established on the selected waveform. Each of these has the word **Ref** after the measurement name, for example, the **RMS Ref** selector. Touch the reference selector for the measurement reference you want to adjust, and both knobs are set to adjust that reference value. To set the numeric reference value, turn either knob or touch either knob label to display the keypad pop-up menu.

Changing Measurement Parameters

Once you have established a measurement on a waveform, you can find out more information about the measurement and you can control the way the DSA takes the measurement by changing the measurement parameters.

Touch the measurement readout selector in the major menu area to see the additional information. This displays a pop-up menu for the individual measurement. It also displays *annotation lines* that overlay the selected waveform displayed on the graticule. These lines show the value of the *measurement parameters* that pertain to that particular measurement.

In addition to the annotation lines, the portion of the waveform the DSA uses to determine the measurement value is highlighted.

The illustration on the next page shows a typical pop-up menu for an individual measurement, along with the annotation lines and the highlighted portion of the waveform.

Many of the selectors in the measurement pop-up menu set the knobs to adjust the measurement parameters. As you turn the knob, the annotation lines move to reflect the new value of the measurement parameter. In the Frequency pop-up menu, the **Left Limit**, **Right Limit**, **Mesial**, and **S/N Ratio** selectors set the knobs to control those measurement parameters.

When you remove the measurement pop-up menu by touching its selector in the major menu area, the annotation lines remain on the display. The knob settings also remain, so you can set the knobs in the pop-up menu, remove the pop-up menu from the display, and adjust the measurement parameter with the annotation lines on the waveform. Your view of the waveform is not impeded by the measurement pop-up menu.

The annotation lines will remain on the display until you leave the Measure major menu.

In the illustration on the next page, the Left Limit measurement parameter is set to 36%. The left limit vertical line is positioned 36% of the way across the graticule, and the DSA measures the frequency from the first complete cycle to the right of the left limit. The highlighted portion of the waveform shows the area being measured.

When you remove the measurement pop-up menu by touching its selector in the major menu area, the annotation lines remain on the display. The knob settings remain also, so you can adjust the measurement parameter with the annotation lines on the waveform. Your view of the waveform is not impeded by the measurement pop-up menu. To remove the annotation lines, touch an icon, such as the vertical icon (↕), that re-assigns the knobs. The annotation lines are also removed when you replace the Measure major menu with another major menu.

In the preceding illustration, the **Left Limit** measurement parameter is set to 36%. The left limit vertical line is positioned 36% of the way across the graticule and the DSA measures the frequency from the first complete cycle to the right of the left limit. The highlighted portion of the waveform shows the area (one period) being measured.

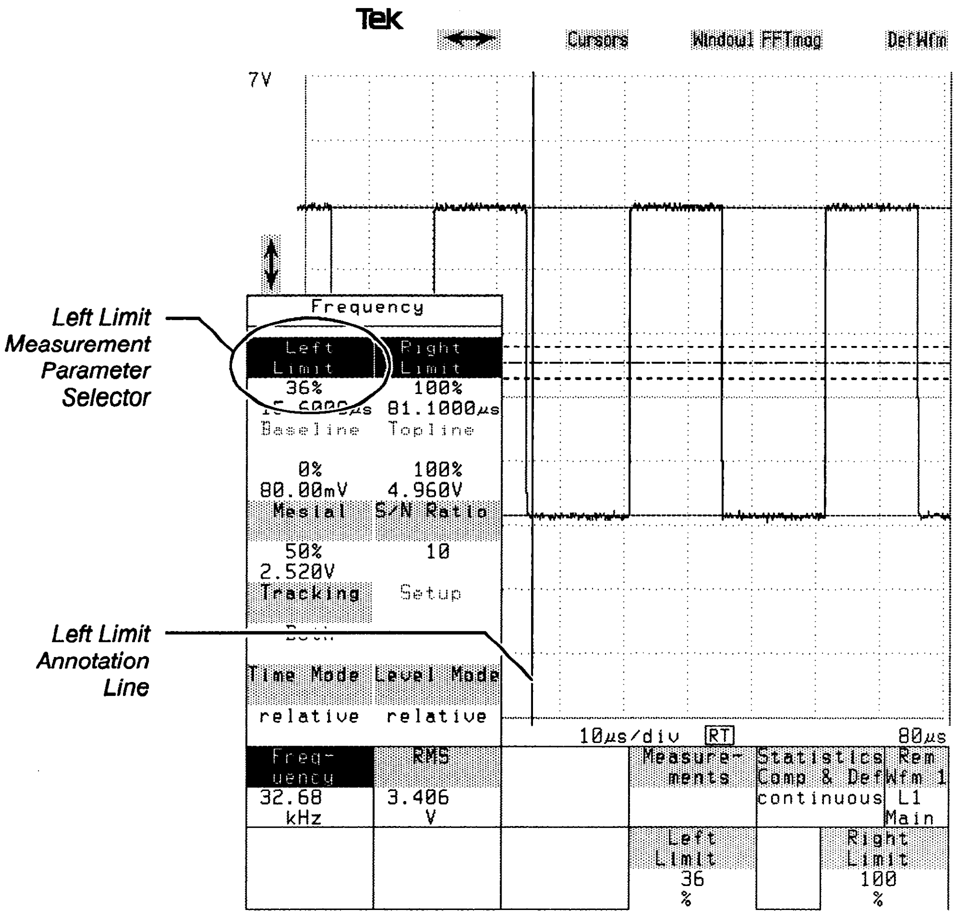
The following table shows the measurement parameters. No measurement uses all these parameters; only the ones that apply to a particular measurement appear in the individual measurement pop-up menu.

Measurement Parameters

Name	Definition
Baseline	The baseline value is the 0% level on which proximal, mesial, and distal levels are based. When tracking is on, the DSA repeatedly determines the baseline and you cannot adjust it. When tracking is off, you can set baseline or you can have the DSA set it once by touching the **Setup** selector in the individual measurement pop-up menu.
Data Interval	Determines whether the measurement will be taken from one period of the waveform or from the entire measurement zone.
Distal	The distal (most distant from the origin) voltage level. Rise and fall times are measured between the proximal and distal voltage levels, which are typically 10% and 90% of the baseline to topline values.

Measurement Parameters (Cont.)

Name	Definition
Left Limit	The beginning of the waveform measurement zone (0% is the first waveform record point).
Mesial	The middle voltage level, expressed as a percentage of the baseline to topline distance.
Proximal	The proximal (closest to the origin) voltage level. Rise and fall times are measured between the proximal and distal voltage levels, which are typically 10% and 90% of the baseline to topline voltage.
Reference Level	The transition crossing voltage level.
Reference Waveform	The waveform to which the selected waveform is compared for measurements that compare two waveforms.
Right Limit	The end of the waveform measurement zone.
S/N Ratio	The amplitude of a noise rejection band centered on the mesial level. Transitions through the mesial level are qualified by S/N ratio by the requirement that the signal enter the noise rejection band and leave the band at the opposite limit with the same slope. S/N ratio may be set to any value from 1 to 99. The reciprocal of the number is the fraction of the peak-to-peak signal value that the noise rejection band extends above and below the mesial line. For a 1 V peak-to-peak signal, S/N ratio of 20 creates a noise rejection band 0.05 V above and below the mesial level.
Slope	The direction the waveform must pass through a reference level.
Topline	The 100% level on which proximal, mesial, and distal levels are based. When tracking is on, the DSA repeatedly determines the topline and you cannot adjust it. When tracking is off, you can set topline or you can have the DSA set it once by touching the **Setup** selector.
Tracking	With tracking on, the topline and baseline are repeatedly determined by the DSA. Turning tracking off allows you to set topline and baseline.



A Typical Individual Measurement Pop-Up Menu

The following table shows the measurement parameters. No pop-up menu for an individual measurement uses all these parameters; only the ones that apply to that particular measurement are shown in the pop-up menu.

Changing a measurement parameter in one measurement changes it in all measurements of the selected waveform that use that parameter, but does not change the parameter for other waveforms.

Measurement Parameters

Name	Definition
Baseline	The baseline value is the 0% level on which proximal, mesial, and distal levels are based. When tracking mode is set to **Both** or **Baseline**, the DSA repeatedly determines the baseline and you cannot adjust it. When tracking mode is set to **Topline** or **Off**, you can set baseline, or you can have the DSA set it once by touching the **Setup** selector in an individual measurement pop-up menu.
Data Interval	Determines whether the measurement will be taken from one cycle of the waveform within the measurement zone, or from the entire measurement zone. (You can change the measurement zone by changing the Left Limit and Right Limit parameters.)
Distal	The distal (most distant from the origin) voltage level. Rise and fall times are measured between the proximal and distal voltage levels, which are typically 10% and 90% of the baseline to topline voltages.
Left Limit	The beginning of the waveform measurement zone.
Level Mode	Determines how the proximal, distal, mesial, and reference levels are set. In *absolute* level mode, you set these parameters as absolute values. In *relative* level mode, you set them in terms of percentages of the baseline to topline distance. In *top delta* and *base delta* modes, you set the parameters as offsets to be added to the topline and baseline, respectively.
Mesial	The middle voltage level.

Changing Default Parameters

Whenever you define a new waveform, the measurement parameters for that waveform are initialized from a set of default parameters. The DSA has one set of default parameters. You can set the default parameters to the values you want. This does not change the measurement parameters of any existing waveforms, but will set the initialized state of all new waveforms that you define.

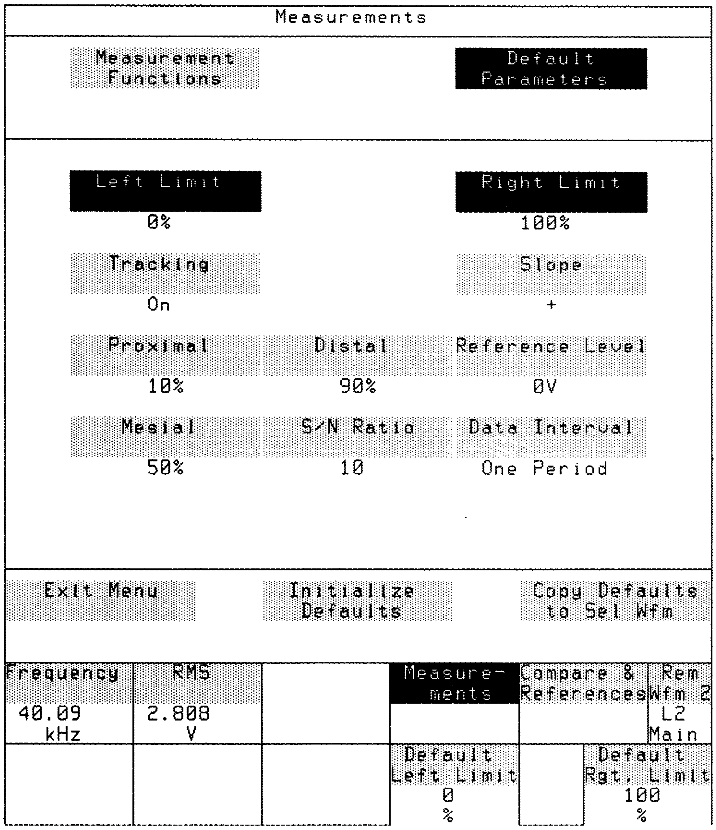
You might want to change the default parameters if you are about to create several waveforms that will all need the same measurement parameters. Setting the default parameters before creating the waveforms is quicker than changing the individual measurement parameters of each waveform.

You access the default parameters through the **Measurements** pop-up menu in the Measure major menu. When this pop-up menu is first displayed, it shows a list of measurements, and the **Measurement Functions** selector is highlighted. If you touch the **Default Parameters** selector, the menu changes to show the measurement default parameters.

To change a default parameter, touch the selector that names the default you want to set. A knob will be assigned to set the value of that default parameter.

Once the defaults are set the way you want them, you can change all the measurement parameters of the selected waveform to the default settings by touching the **Copy Defaults to Sel Wfm** selector. This selector changes all the measurement parameters of the selected waveform only; other waveforms are not affected.

To restore the default parameters to their initialized state, select **Initialize Defaults**.



Measurements *Pop-Up Menu with Measurement Defaults*

Measurement Parameters (Cont.)

Name	Definition
Proximal	The proximal (closest to origin) voltage level. Rise and fall times are measured between the proximal and distal voltage levels, which are typically 10% and 90% of the baseline to topline voltages.
Reference Level	The transition-crossing voltage level.
Right Limit	The end of the waveform measurement zone.
S/N Ratio	The amplitude of a noise rejection band centered on the mesial level. Transitions through the mesial level are qualified by S/N ratio by the requirement that the signal enter the noise rejection band and leave the noise rejection band at the opposite limit with the same slope and with no intermediate values outside the noise rejection band. S/N ratio may be set to any value from 1 to 99. The reciprocal of the number is the fraction of the peak-to-peak signal value that the noise rejection band extends above and below the mesial line. For a 1 V peak-to-peak signal, S/N ratio of 20 creates a noise rejection band 0.05 V above and 0.05 V below the mesial level.
Reference Waveform	The waveform to which the selected waveform is compared for the Gain, Phase, and Skew measurements. There is one reference waveform for all waveforms; it does not change when you select a different waveform.
Delayed Waveform	The waveform compared to the selected waveform for the PropDelay measurement. The delayed waveform is set separately for each waveform.
Slope	The direction the waveform must pass through a reference level.

Measurement Parameters (Cont.)

Name	Definition
Time Mode	Determines whether the left limit and right limit are set as absolute values or as percentages of the record length. In *absolute* time mode, these boundaries are set to absolute values. In *relative* mode, the boundaries are set as percentages of the record length, and the corresponding absolute values of the limits are displayed along with the percentages in the individual measurement pop-up menu.
Topline	The 100% level on which proximal, mesial, and distal levels are based. When tracking is set to **Both** or **Topline**, the DSA repeatedly determines the topline for itself and you cannot adjust it. When tracking is set to **Baseline** or **Off**, you can set the topline or you can have the DSA set it once by touching the **Setup** selector.
Tracking	Determines how the topline and baseline are set. When tracking is set to **Both**, the topline and baseline are repeatedly determined by the DSA. When tracking is set to **Topline**, the DSA determines the topline value and you can set the baseline. Similarly, setting tracking to **Baseline** causes the DSA to set the baseline but allows you to set the topline. When tracking is **Off**, you set both topline and baseline.

Changing Default Parameters

Whenever you define a new waveform, the measurement parameters for that waveform are set to their initial values by copying them from a set of default parameters. The DSA has one set of default parameters. You can set the default parameters to the values you want. This does not change the measurement parameters of any existing waveforms, but it will determine the initial value of the measurement parameters for all new waveforms that you define.

You might want to change the default parameters if you are about to create a number of waveforms and take measurements from them, and know that they will all need the same measurement parameters. Setting the default parameters before creating the waveforms is quicker than changing the measurement parameters of each waveform individually.

To change the default parameters, select **Default Parameters** in the **Statistics Comp & Def** pop-up menu. The Default Parameters page of the menu will be displayed, showing a selector for each measurement parameter. This pop-up menu appears on the next page.

Touch the selector that names the default you want to set. **Time Mode**, **Level Mode**, **Tracking**, **Slope**, and **Data Interval** cycle through the appropriate values. The other selectors set the knobs to adjust the measurement parameters. To reset the defaults to the values they have when the DSA is initialized, select **Initialize Defaults**.

When you have set the defaults the way you want them, you can change all the measurement parameters of the selected waveform to the default settings by touching the **Copy Defaults to Sel Wfm** selector.

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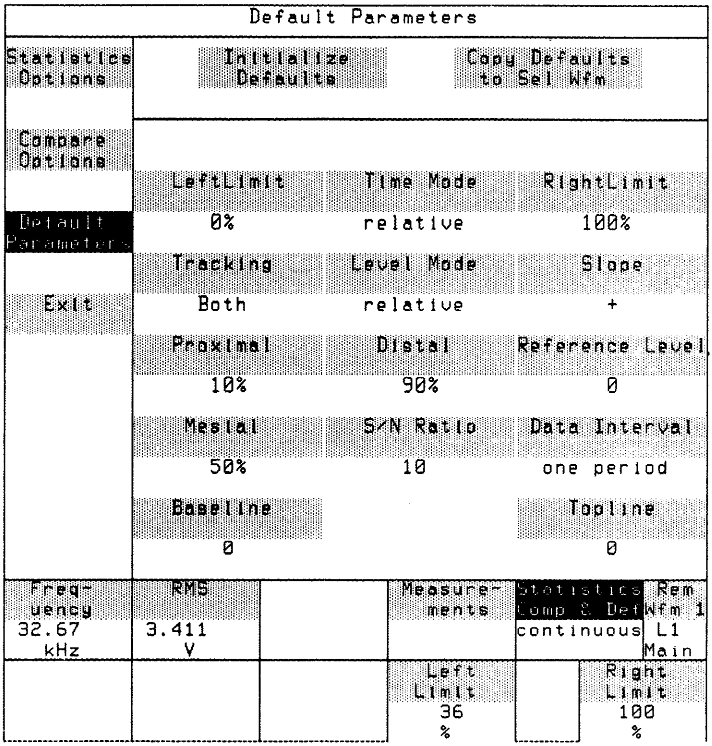


Default Parameters *in the* **Statistics Comp & Def** *Pop-Up Menu*

Plug-in Units

The DSA has compartments for up to three plug-in units. Several types of plug-in units are available. This section includes general information about plug-in units. For information about a specific plug-in unit, refer to the manual for that unit.

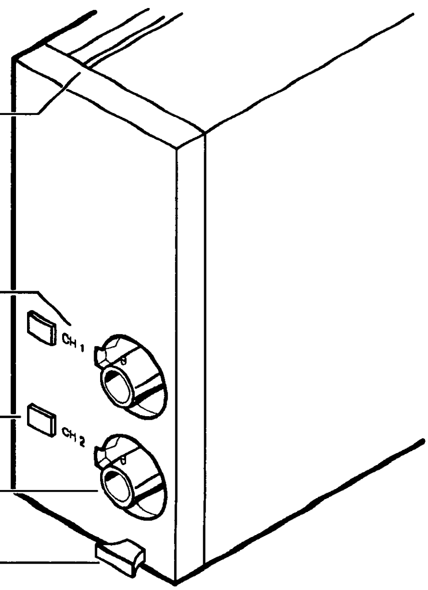
Installing and Removing a Plug-in Unit

CAUTION

Never install or remove a plug-in unit when the DSA power is on. Set the **ON/STANDBY** switch to **STANDBY** first.

Before installing a plug-in unit, set the DSA **ON/STANDBY** switch to **STANDBY**. Align the grooves in the top and bottom of the unit with the guides at the top and bottom of the plug-in compartment. Push the plug-in unit until its front panel is flush with the front panel of the DSA.

To remove a plug-in unit, set the **ON/STANDBY** switch to **STAND-BY**, then pull the release latch to disengage the unit and pull the plug-in unit straight out of the compartment.



A Plug-in Amplifier

Plug-in settings are initialized when you install a new type of plug-in unit in the compartment. If you replace one plug-in unit with another of the same type, the existing settings are retained.

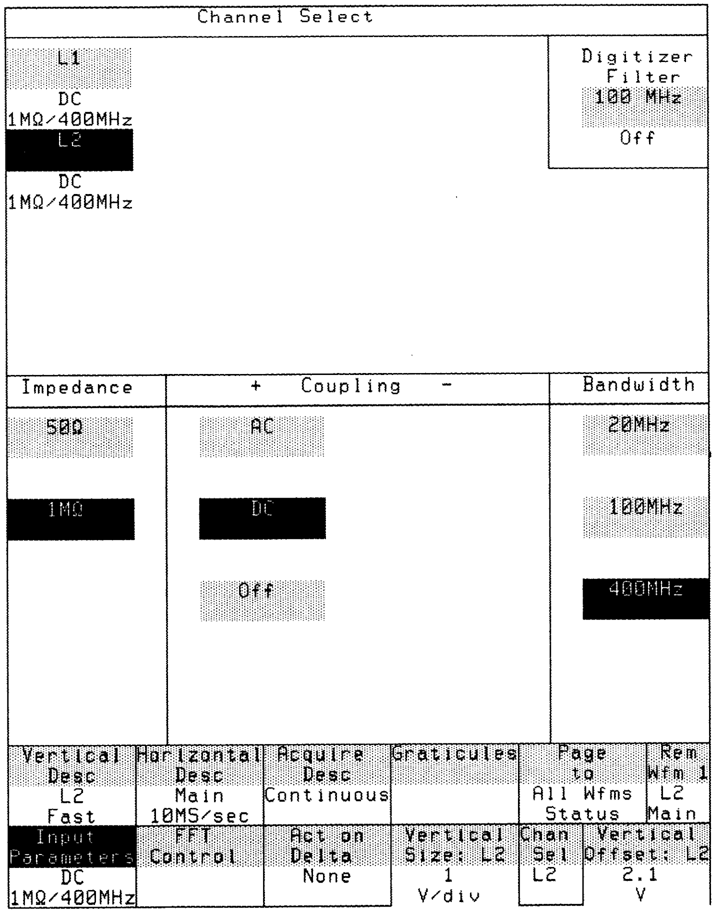
Display On/Off

A plug-in unit has a signal connector and an associated button and indicator light for each input channel. Buttons are labeled **CH#**, where **#** is the channel number. Pressing the button turns display of the input channel on or off. The yellow light next to the button will light whenever that channel is displayed.

Display of an input channel may also be turned on or off from the DSA. For example, the display of an input channel of a plug-in amplifier is turned on when you define a waveform expression that includes that channel, and is turned off when all waveforms displaying the channel are removed from the display.

Setting Input Parameters

The operation of a plug-in unit is controlled by the DSA. Some of the input channel controls are determined by selections made in the **Input Parameters** pop-up menu. Select **Input Parameters** in the Waveform major menu to display this pop-up menu.



The **Input Parameters** *Pop-Up Menu*

Input parameters are specified individually for each channel. To set the input parameters for a channel, select the channel from the **Channel Select** section of the **Input Parameters** pop-up menu, then use the other selections in the menu to set the parameters.

Channel Impedance

The **Impedance** section of the **Input Parameters** pop-up menu shows the input impedance values available for the selected channel. The available values are dependent on the type of plug-in unit. Touch a selector in this section of the pop-up menu to select the input impedance.

When you use a probe, the impedance of the plug-in unit should match the impedance of the probe. Active "intelligent" probes will eliminate inappropriate impedance options. Probes are discussed on page 169.

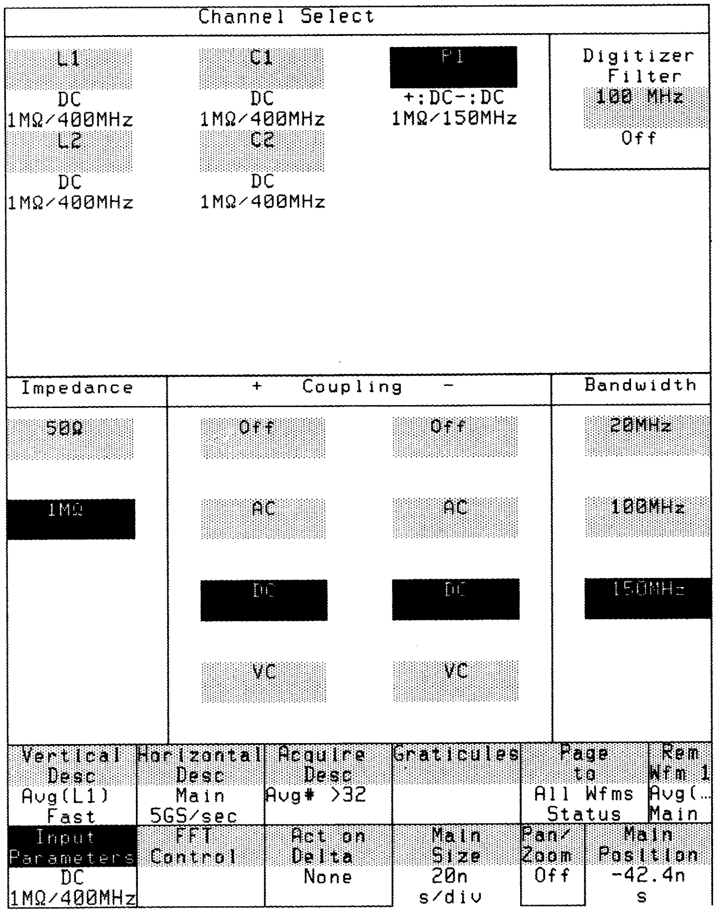
Channel Coupling

You can set the coupling of the selected input channel by making a selection from the **Coupling** section of the **Input Parameters** pop-up menu. The coupling options are different for single-ended and differential plug-in units. For a single-ended channel, three coupling options are available.

AC coupling blocks the DC component of the signal and allows only the AC component of the signal to be displayed. **DC** coupling passes the whole signal to be displayed on the screen. **Off** disconnects the selected channel and presents an infinite impedance at the input.

If you select a channel of a differential plug-in unit, impedance may be selected for the "+" channel and the "–" channel, and an additional impedance option is available. **VC**, or voltage comparator, coupling generates a DC offset voltage, which you can set using the control knobs, at the specified channel for comparison to the input signal at the other differential channel. The signal connector will be disabled for the **VC** coupled channel.

The use of an active intelligent probe will eliminate the **AC** coupling option.



The **Input Parameters** *Menu with a Differential Channel Selected*

Channel Bandwidth Limit

You can set the bandwidth limit of the selected channel to reduce the amplitude of unwanted noise or interference at frequencies above the frequency of interest. The bandwidth limits available depend on the type of plug-in unit you are using. Touch one of the selectors in the **Bandwidth** section of the **Input Parameters** pop-up menu to set the bandwidth limit.

Digitizer Filter

A 100 MHz digitizer filter is available and may be turned on or off by touching the **100 MHz** selector in the **Digitizer Filter** section of the **Input Parameters** pop-up menu. This filter reduces the effects of noise and signals above 100 MHz.

You can get better filtering by using both the digitizer filter and a channel bandwidth limit. The resultant bandwidth will be less than 100 MHz. The DSA will automatically calculate the bandwidth and will display its value in the **Input Parameters** selector.

Vertical Offset and Sensitivity

The vertical offset and sensitivity of a plug-in amplifier are controlled by the vertical settings of the DSA. See Vertical Controls on page 215 for information on setting vertical size (sensitivity) and position (offset).

DC Circuit Loading

For several plug-in amplifiers, the input impedance for DC coupling is 50 Ω. This low impedance requires some caution.

When input coupling is set to 50 Ω, a 50 Ω termination resistance is connected directly from the input connector to ground. Take care that the circuit connected to the input will not be damaged by the 50 Ω load.

CAUTION

Use caution when working with voltages in excess of 25 volts.

Switching coupling to DC when more than 25 V is present at the input will exceed the peak input voltage specification for some plug-in amplifiers, and thus may damage the input relay. A damaged relay could cause an error in calibration. Refer to the specifications for your plug-in amplifier.

Two ways of unintentionally invoking DC coupling are:

- Pressing the **AUTOSET** button, because the Autoset process starts by searching for a DC voltage
- Recalling a stored setting that specifies DC coupling

Some plug-in amplifiers will automatically disconnect the 50 Ω termination and display a message on the DSA when the input voltage substantially exceeds 5 V rms. Refer to the manual for your plug-in amplifier.

Overdriving

Overdriving occurs whenever a plug-in amplifier is driven out of its linear range. For many of the plug-in amplifiers, this linear range is ±15 divisions. The *overdrive recovery* of a plug-in amplifier is the time it takes the amplifier to settle to within a stated fraction of the equilibrium value after an input step. Overdriving can be used as a tool for certain measurements with plug-in amplifiers that have fast overdrive recovery.

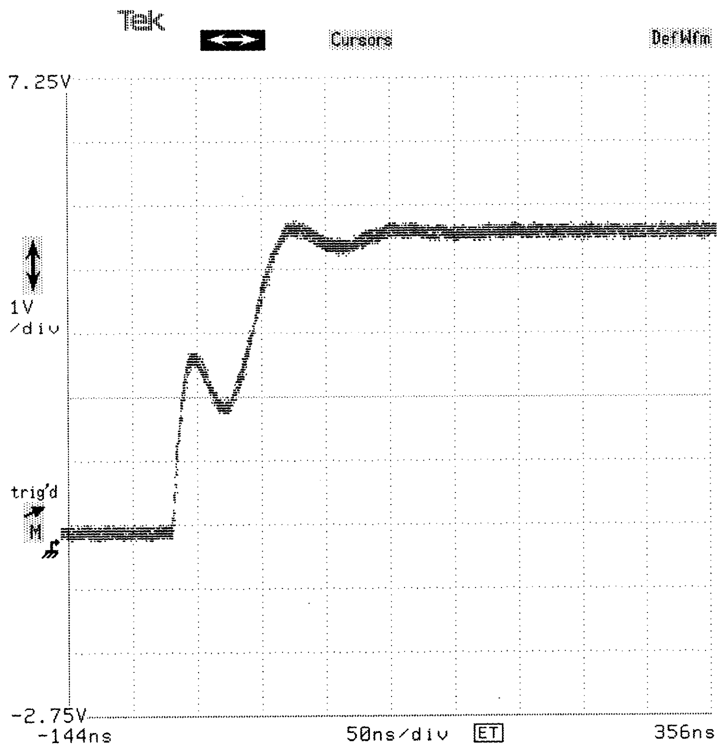
For example, suppose a signal changes from +1.7 V to +0.8 V in 1 ns. A plug-in amplifier could be used to determine if the signal stabilized immediately at +0.8 V or if it had some small aberration after the transition. By setting the amplifier offset (vertical offset) to +0.8 V and the sensitivity (vertical size) to 1 mV/division, aberrations of just 0.1% of the original transition will be 2.5 divisions in amplitude.

Refer to the specifications for your plug-in unit to determine whether its overdrive recovery is fast enough for your application.

Point Accumulate Mode

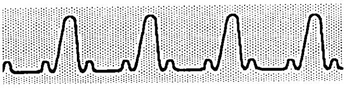
You can display a waveform in a mode that shows a history of the waveform. In point accumulate mode, individual samples that compose each waveform record are added to the display as individual dots, and remain on the display indefinitely while new samples are taken and displayed.

Point accumulate mode is limited. It cannot be used with measurements or with record lengths longer than 2048 points. Only one waveform on a graticule can be a point accumulate waveform.



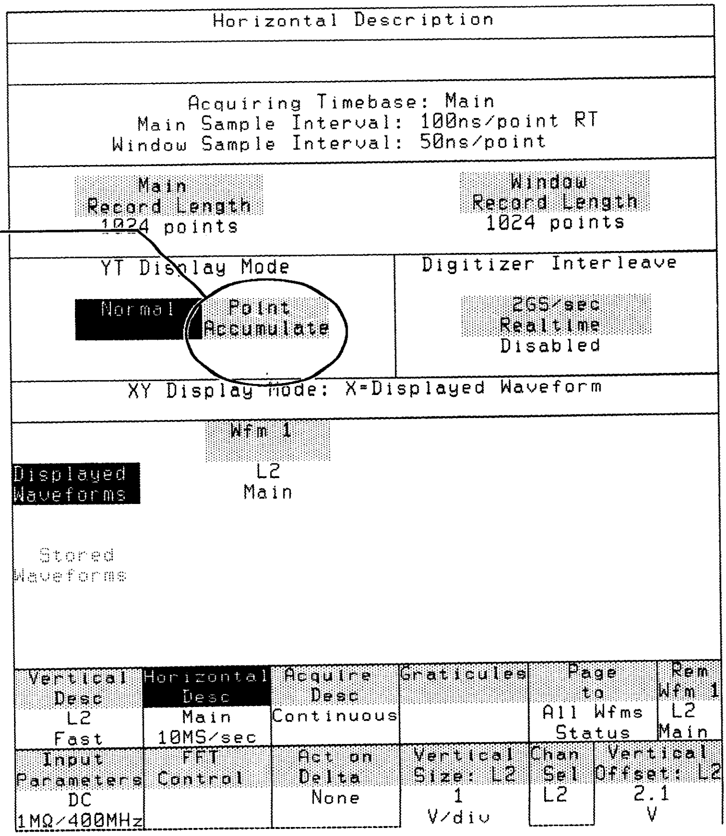
A Point Accumulate Waveform

A point accumulate mode waveform appears different from an enveloped waveform, because you see the individual waveform record samples. For a complete discussion of enveloped waveforms, see Averaging and Enveloping on page 61.



You use the **Horizontal Desc** pop-up menu in the Waveform major menu to turn Point Accumulate mode on or off. Select **Point Accumulate** to turn Point Accumulate mode on and select **Normal** to turn it off.

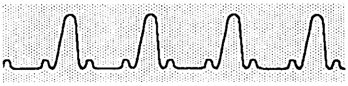
Point Accumulate
Selector



The **Horizontal Desc** *Pop-Up Menu*

Point Accumulate Mode

The point accumulate feature of firmware versions 1.1 and below has been replaced by infinite display persistence. Refer to Display Persistence, on page 84a, for information about this feature.



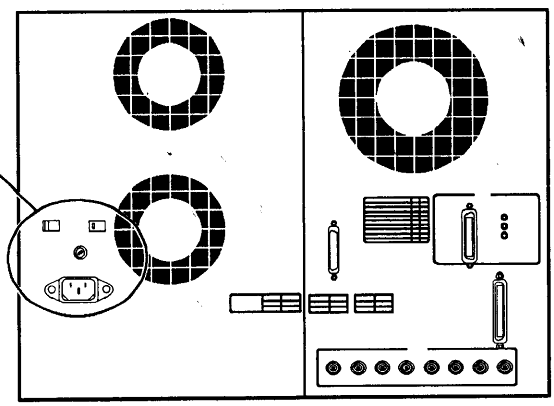
Power-On

Installation

Before you first power on your DSA, you should be certain that it is correctly installed. The installation sequence involves the following controls, connectors and switches on the rear panel:

- **POWER** Connector
- **FUSE**
- **LINE VOLTAGE SELECTOR** switch
- **PRINCIPAL POWER SWITCH**

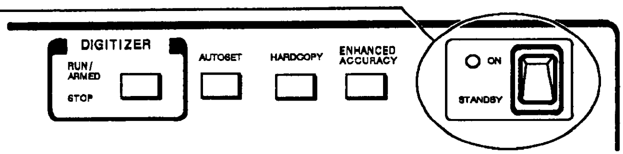
Power Area



Power Connector, Fuse, and Switches

In addition, you will need to know the location of the **ON/STANDBY** switch on the front panel.

The **ON/STANDBY** *Switch*



The following steps describe the installation procedure.

☐ Step 1: Set the **PRINCIPAL POWER SWITCH** to **OFF**.

☐ Step 2: Set the front panel **ON/STANDBY** switch to **STANDBY**.

☐ Step 3: Set the **LINE VOLTAGE SELECTOR** to the proper range for your power system.

☐ Step 4: Check the **FUSE** to be sure it is of the proper type and rating, as printed on the rear panel.

CAUTION

Never install or remove a plug-in unit with the DSA power on.

☐ Step 5: Install one or more plug-in amplifiers in the front panel compartments.

To install a plug-in unit, align the grooves in the top and bottom of the plug-in unit with the guides at the top and bottom of the plug-in compartment. Push the plug-in unit until its front panel is flush with the front panel of the DSA. Plug-in units are described onpage155.

☐ Step 6: Connect the power cord from the **POWER** connector to your power system.

☐ Step 7: Set the **PRINCIPAL POWER SWITCH** to **ON**.

The **PRINCIPAL POWER SWITCH** controls all AC power to the DSA. The **ON/STANDBY** switch controls power to most of the DSA's circuits, but continues to supply power to certain circuits even when set to **STANDBY**.

☐ Step 8: To operate the DSA, set the front panel **ON/STANDBY** switch to **ON**.

Once the DSA is installed, use the **ON/STANDBY** switch as the power switch.

Power-On Sequence

Each time you power on the DSA, it performs a sequence of internal checks and then restores the settings that were established when it was last powered off. The sequence is:

Complete descriptions of the diagnostics are on page 77.

1. The power-on diagnostics are performed, and take about 5 seconds to execute. If these diagnostics fail, the DSA will freeze and you will not be able to operate it.

2. The self-test diagnostics are performed, and take about 15 seconds to execute. If these diagnostics fail, the extended diagnostic system is entered, and the Extended Diagnostic menu is displayed.

3. The system restores all the settings and waveforms that it can. If the configuration of plug-in units has not changed since the last power-down, then the DSA will completely restore to the state it was in when powered down.

   Waveforms that have been stored with the Store Waveform functions are saved *only* if the DSA is equipped with Option 4C, Nonvolatile RAM.

   DSAs that are equipped with Option 3C, Acquisition Memory External Power Input, can save information in the acquisition memory in the event of a power failure. This feature is especially useful for Single Trigger and Single Sequence applications.

Warm-Up Period

It takes about 20 minutes for the DSA to warm up after power-on. Enhanced Accuracy is available after the DSA warms up and achieves thermal stability. Enhanced Accuracy is described on page 85.

Probes and Cables

You can connect a signal source to the DSA with a probe or with a coaxial cable with a BNC connector. Connect a cable by pushing the BNC connector onto the input channel connector of a plug-in amplifier and turning the connector to secure it. Use an attenuator with the cable when the signal voltage may exceed the capabilities of your plug-in amplifier. In general, it is best to use the shortest cable possible to avoid signal distortion.

When you use a probe, the impedance of the input channel must match the impedance of the probe connected to it. See Channel Impedance on page 158.

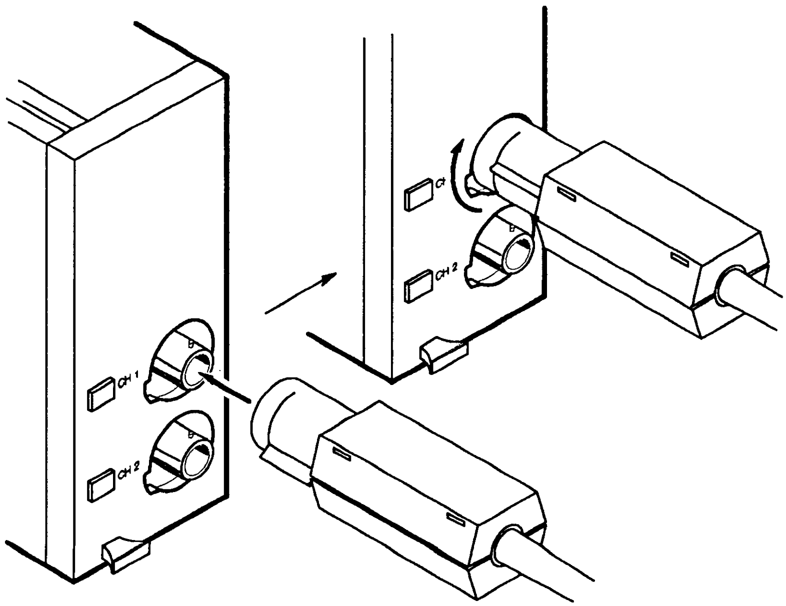
For many applications a probe is preferable to a cable connection. Common probe features include small, easily portable signal connectors and attenuation. Special-purpose probes are available for some applications, such as differential probes used for comparison of two signals.

This section concerns properties and functions common to most probes used with 11000-Series plug-in amplifiers. Refer to the documentation for the probe you are using for specific information.

Installing a Probe

The Tektronix product catalog lists TekProbe probes that are recommended for use with 11000-Series plug-in amplifiers and DSAs. These probes have a special connector and are connected both to the input channel and to an interface that provides communication between the probe and the plug-in amplifier. The active probes draw their power from the plug-in amplifier.

To install a probe, place the probe connector over the input connector of the plug-in amplifier. The probe connector must be oriented so that the tab points to the lower left. The prongs around the outer rim of the probe connector will be flush with the interface connector of the plug-in amplifier. Twist the circular plastic casing clockwise to secure the connection.



Connecting a Probe to the Input Channel

Probe ID Functions

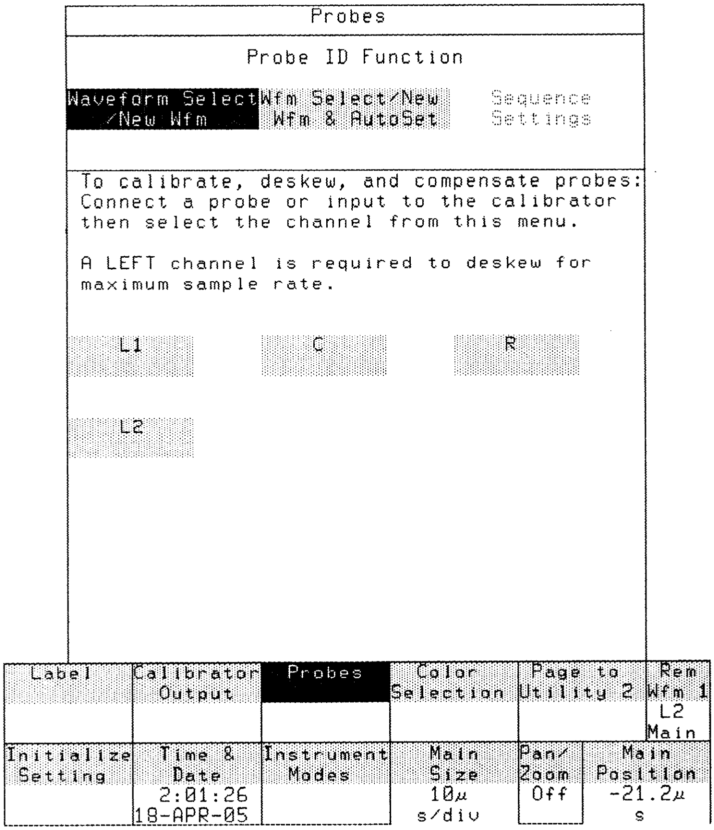
TekProbe intelligent probes can communicate with the DSA through the plug-in amplifier interface connection. In addition, each probe is equipped with a **Probe ID** button which, when pressed, initiates some action by the DSA.

You can use the **Probe ID** button on a probe to signal the DSA to perform one of three functions. In the **Probes** pop-up menu in the Utility 1 major menu three selectors determine the action that is initiated when a **Probe ID** button is pressed.

- **Waveform Select/New Wfm** sets the DSA so that pressing the Probe ID button will select a waveform displaying the channel the probe is connected to. If no such waveform exists, the DSA will create a new waveform displaying only that channel.

- **Wfm Select/New Wfm & Autoset** sets the DSA so that pressing the Probe ID button selects a waveform displaying the channel, or defines a new waveform displaying the channel and invokes autoset on the new waveform.

- **Sequence Settings** sets the DSA so that pressing the Probe ID button selects the next setting in the sequence. See Sequencing Through Stored Settings, on page 188, for an explanation of sequencing.



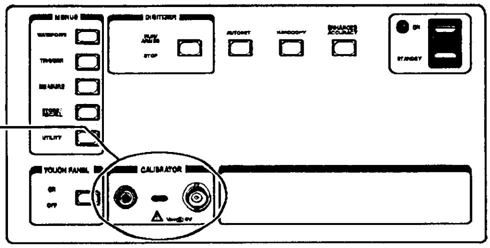
The **Probes** *Pop-Up Menu*

Probe Calibration

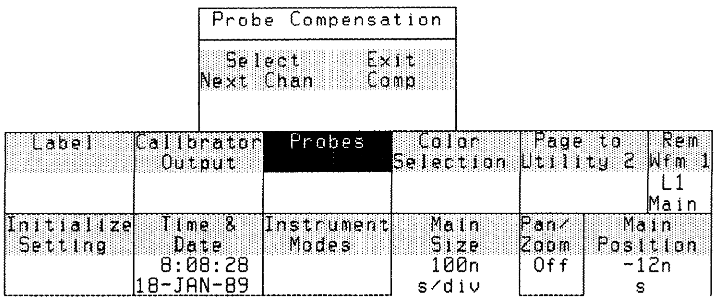
The **Probes** pop-up menu is also used to calibrate, deskew, and compensate probes. The following procedure may be used to calibrate, deskew, and compensate probes when you are using a standard single-ended plug-in amplifier:

☐ Step 1: Connect the probe or other input lead to the **CALIBRATOR** signal and ground connections.

CALIBRATOR
Connector



☐ Step 2: Select the channel of the probe or input lead from the **Probes** pop-up menu. The channel will be vertically calibrated and then deskewed against an internal reference signal. When this process is complete, a message will appear prompting you to compensate the probe, and the **Probe Compensation** menu will replace the **Probes** menu.



The **Probe Compensation** *Menu*

☐ Step 3: Adjust the compensation control on the probe so that the top of the square wave is flat.

☐ Step 4: If you wish to calibrate another channel, touch the **Select Next Chan** selector to return to the **Probes** pop-up menu. Otherwise, select **Exit Comp** to finish compensation.

The two probes used with a differential plug-in unit should be of the same type.

A different procedure is recommended to calibrate, deskew, and compensate probes when you are using a differential amplifier or differential comparator plug-in unit. This procedure will improve common mode rejection when you are using probes designed for use with a differential plug-in unit.

☐ Step 1: Connect one probe to the − input of the differential amplifier or comparator. There must be no probe connected to the + input.

☐ Step 2: Calibrate, deskew, and compensate the probe as described above, but do not exit the **Probe Compensation** menu.

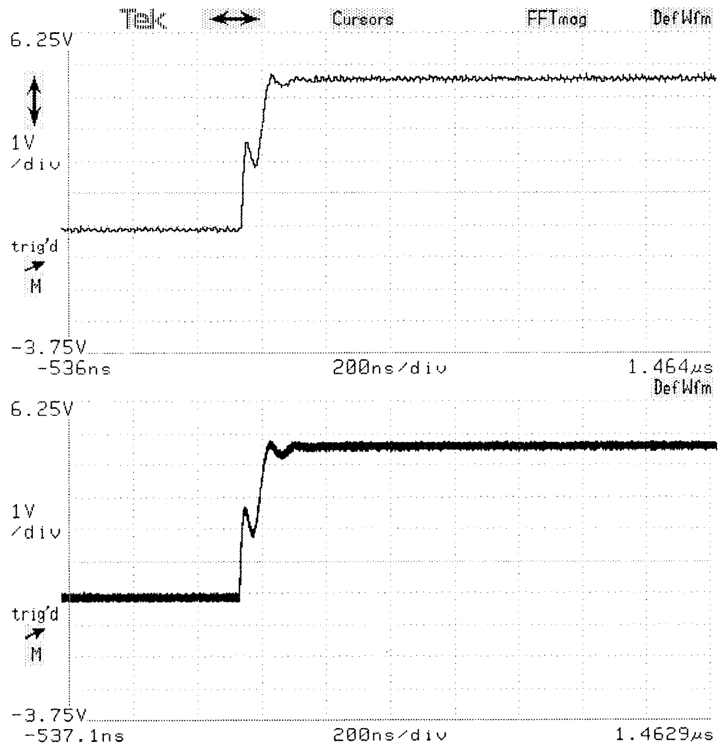
☐ Step 3: Connect the other probe to the + input of the differential plug-in unit. Connect the probe to the **CALIBRATOR** signal and ground connections. Do not disconnect the other probe from the **CALIBRATOR**. The waveform on the screen will become a straight line which may have a small spike where the step was displayed. The segments of the waveform before and after this point may be vertically displaced from each other.

☐ Step 4: Compensate the probe by eliminating the spike in the displayed waveform. If the probes have a DC attenuation adjustment, you should use it to eliminate any vertical displacement of the two waveform segments.

☐ Step 5: Select **Exit Comp** in the **Probe Compensation** menu, and disconnect the probes from the **CALIBRATOR**.

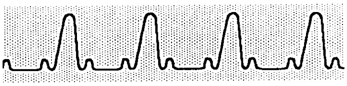
Record Length

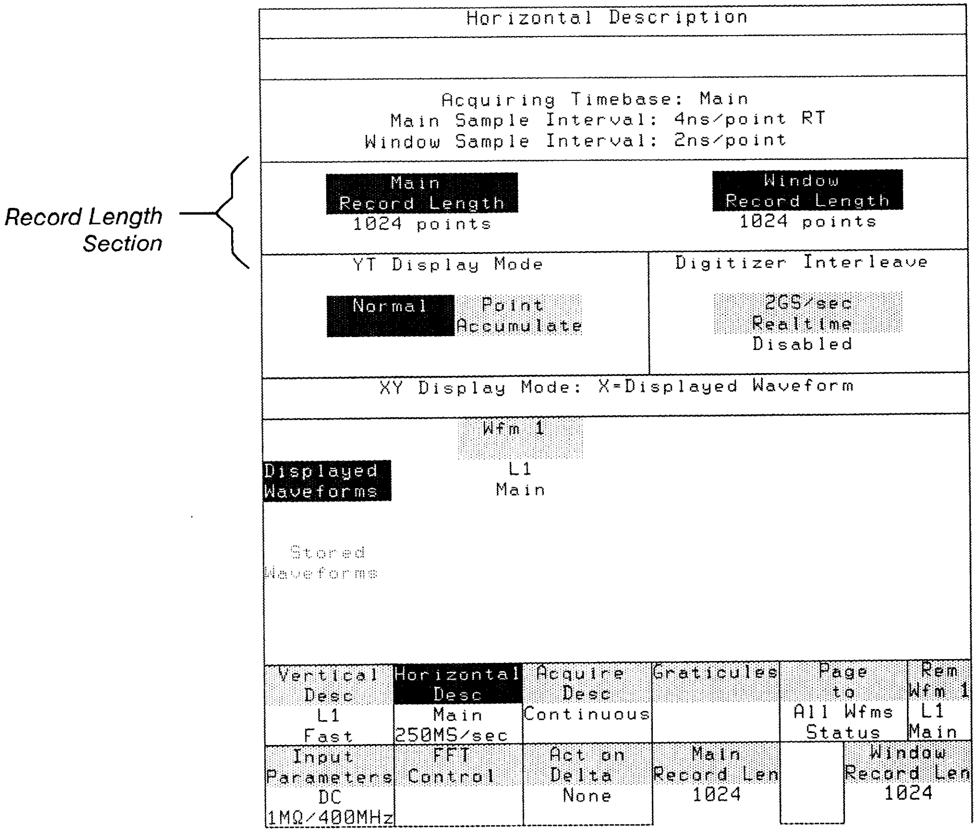
The number of samples that form a waveform is called the record length. You can select record lengths of 512, 1024, 2048, 4096, 5120, 8192, 10240, 16384, 20464, and 32768 points (samples).



Waveforms with Record Lengths of 512 (top) and 20464 (bottom)

You control the record length by using the **Horizontal Desc** pop-up menu in the Waveform major menu. The **Main Record Length** and **Window Record Length** selectors assign the knobs to set the record lengths. The **Horizontal Desc** pop-up menu shows the sample intervals for the current settings.





The **Horizontal Desc** *Pop-Up Menu*

All waveforms on the main time base have the same record length. Window waveforms similarly share identical record length.

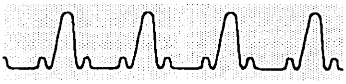
Point accumulate mode can only be used with waveforms having record lengths of 512, 1024, or 2048 points.

The 4096-, 8192-, 16384-, and 32768-point record lengths do not cover the entire horizontal length of the graticule. Each of these record lengths has the same sample interval as the next-larger record length. They are provided for use with Fast Fourier Transforms, which can only be performed on record lengths that are a power of two. The Fast Fourier Transform of the DSA operates on any waveform with a record length that is a power of two *except* 32768 points.

The record length selected also limits the horizontal size range (time/division) as follows:

Horizontal Size by Record Length

Record Length	Horizontal Size (Time/Division)
512 points	200 ps/div
1024 points	200 ps/div
2048 points	200 ps/div
4096 points	500 ps/div
5120 points	500 ps/div
8192 points	1 ns/div
10240 points	1 ns/div
16384 points	2 ns/div
20464 points	2 ns/div
32768 points	5 ns/div



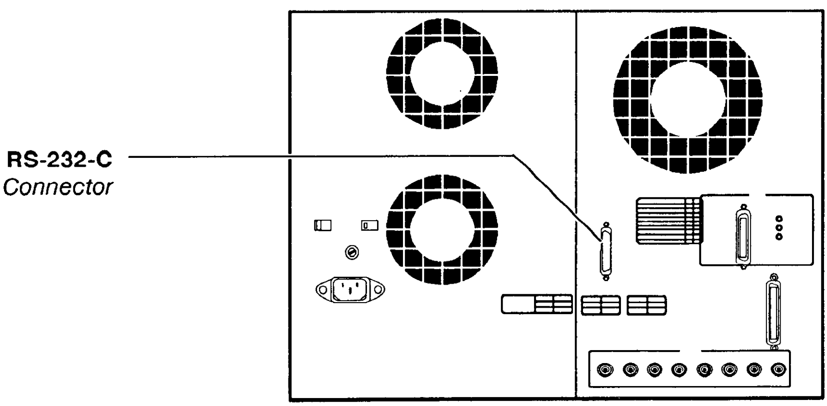
RS-232-C Parameters

The DSA can be controlled by a remote computer through one of two interfaces. These interfaces are industry standards IEEE STD 488 and RS-232-C.

This manual does not discuss the details of connecting a remote computer to the DSA or the syntax and capabilities of remote commands. That information is found in the *DSA 601 and DSA 602 Programmer Reference* and the *DSA 601 and DSA 602 Command Reference*.

RS-232-C Connection

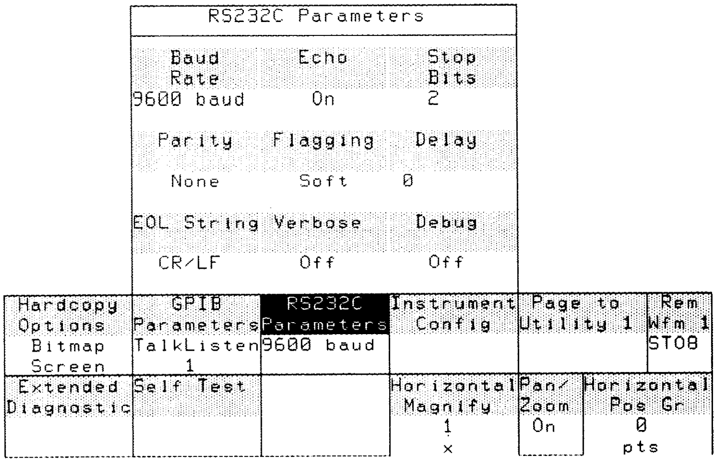
Connect the cable from your computer to the **RS-232-C** connector on the DSA rear panel. The DSA is configured as data communications equipment (DCE), and the computer must be configured as data terminal equipment (DTE).



Location of the **RS-232-C** *Connector on the Rear Panel*

Setting RS-232-C Parameters

Communication between the DSA and the attached computer can occur only if the two are configured in a compatible manner.



The **RS232C Parameters** *Pop-Up Menu*

Use the **RS232C Parameters** pop-up menu in the Utility 2 major menu to set the RS-232-C parameters directly, before you attempt to communicate with the attached computer. The following list describes each selector on the RS-232-C pop-up menu:

The RS-232-C parameters are not changed when you initialize the DSA.

- **Baud Rate** assigns the knobs to adjust baud rate and delay. You can set the baud rate to 110, 150, 300, 600, 1200, 2400, 2400, 4800, 9600, or 19200. You should set the baud rate to match the computer or terminal you are using.

- **Echo** lets you set Echo to **On** or **Off**. If you observe two identical characters transmitted when you expect only one, Echo is On when it shouldn't be. If you see no character transmitted when one was expected, Echo might be set to Off inappropriately.

- **Stop Bits** lets you select among **1**, **1.5**, or **2** stop bits. Touch the selector repeatedly until the appropriate number is shown in the selector. You should set the number of stop bits to match the computer you are using.
- **Parity** lets you select among **Even** parity, **Odd** parity, or **None**. Touch the selector repeatedly until the appropriate setting is displayed in the selector. Parity is an error detection scheme. You should set parity to match that of the computer you are using.
- **Flagging** lets you select among **Hard** flagging, **Soft** flagging, or **None**. Touch the selector repeatedly until the appropriate setting is displayed in the selector. Flagging is used by the DSA or the computer to signal that its input buffer is full, and that the other device should stop transmitting until further notice. You should set the type of flagging to match the computer you are using.
- **Delay** assigns the knobs to set the baud rate and delay. Delay is the minimum time that the DSA will wait before responding to a command sent from the computer. The delay setting can be 0 to 60 seconds.
- **EOL String** lets you select the end-of-line query terminator to one of the following: **LF** (Line Feed), **CR** (Carriage Return), **CR/LF**, or **LF/CR**. Touch the selector repeatedly until the appropriate setting is displayed in the selector.

- **Verbose** lets you set Verbose **On** or **Off**. When Verbose is On, the DSA posts to the computer a message stating the success or failure of each command sent to the DSA. When Verbose is Off, the computer can specifically query the DSA about the success or failure of each command.

- **Debug** lets you set Debug **On** or **Off**. When Debug is On, the DSA displays each command from the computer as it is executed. The messages appear at the top of the display. Debug Off is the normal mode of operation. Set Debug On if you need to watch the result of each DSA command of a program that is running in the computer. When Debug mode is on it slows performance significantly.

Stored Settings

When you initialize the DSA, you recall a stored setting that was established at the factory. You can save your own settings for quick recall.

If you establish a test setup, you might want to store the setting and go to another task. After the settings have been changed because of the intervening work, you could recall the test setting that you saved.

You can also use sequencing to recall saved settings in a specific order. This is useful if your work requires several DSA setups for standardized tests.

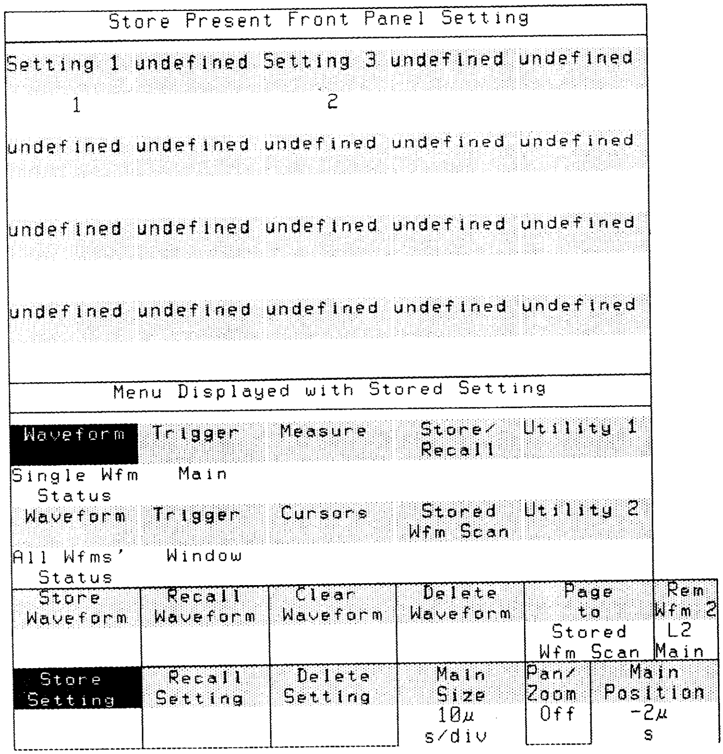
Stored settings are saved when you power off the DSA. They will be available when you power on.

The following controls are not saved with stored settings, and are not changed when settings are recalled:

- Stored waveforms
- GPIB and RS-232-C parameters
- Sequence settings mode

Storing Settings

Use the **Store Setting** pop-up menu in the Store/Recall major menu to store a setting. After you set the DSA, touch the **Store Setting** selector to display the pop-up menu.



The **Store Setting** *Pop-Up Menu*

You can choose the major menu that will display when the stored setting is recalled. Touch the selector for the desired major menu in the section of the pop-up menu titled **Menu Displayed with Stored Setting.** Each major menu is listed.

Stored Settings

When you initialize the DSA, you recall a stored setting that was established at the factory. You can save your own settings for quick recall.

If you establish a test setup, you might want to store the setting and go to another task. After the settings have been changed because of the intervening work, you could recall the test setting that you saved.

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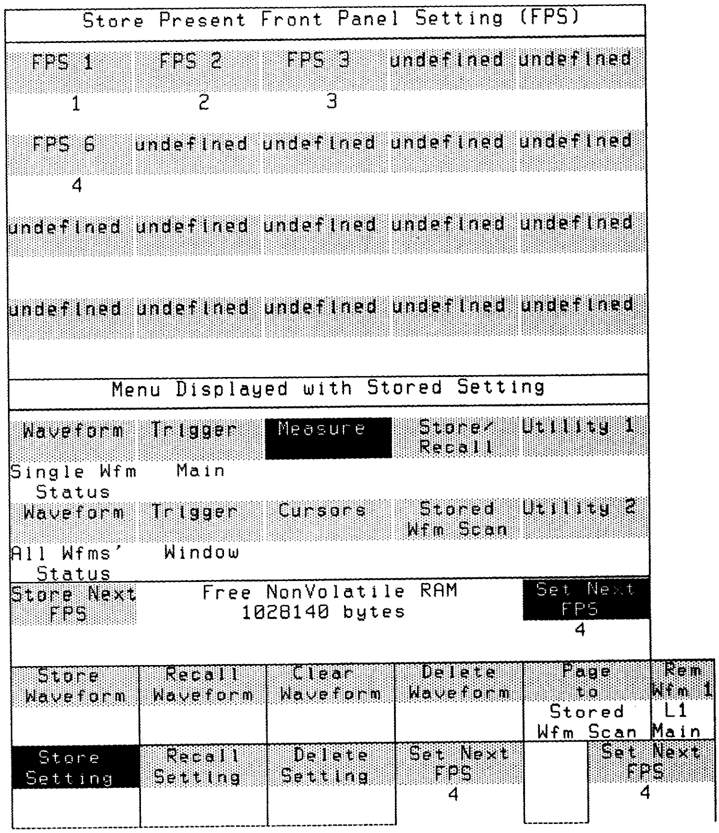
The following controls are not saved with stored settings, and are not changed when settings are recalled:

- Stored waveforms
- GPIB and RS-232-C parameters
- Sequence settings mode

Storing Settings

Use the **Store Setting** pop-up menu in the Store/Recall major menu to store a setting. After you set the DSA, touch the **Store Setting** selector to display the pop-up menu.



The **Store Setting** *Pop-Up Menu*

You can choose the major menu that will display when the stored setting is recalled. Touch the selector for the desired major menu in the section of the pop-up menu titled **Menu Displayed with Stored Setting**. Each major menu is listed as an option.

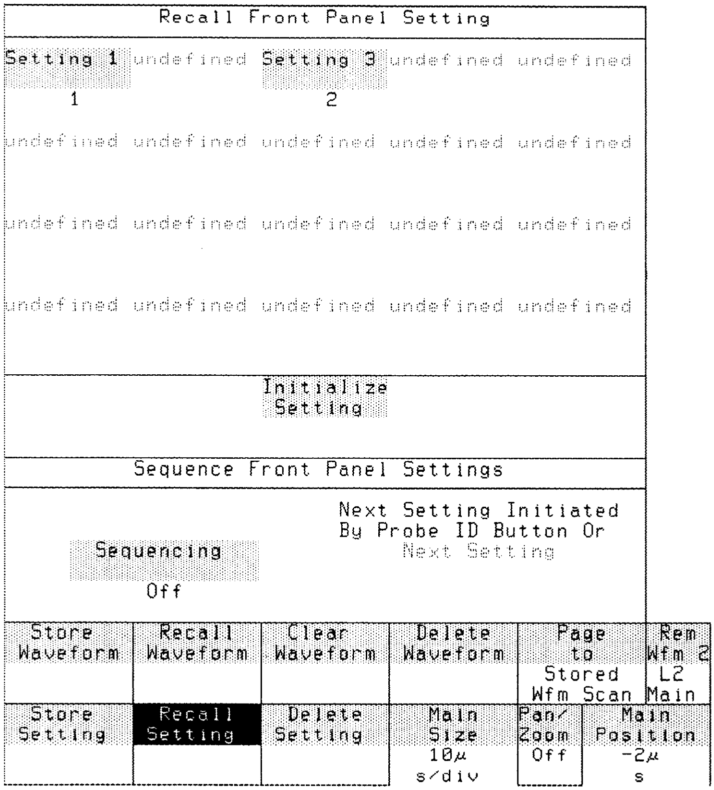
You can label stored settings. See Labeling on page 135.

After you choose the major menu you want recalled with the stored setting, touch one of the twenty selectors in the upper part of the **Store Setting** pop-up menu to store the setting in that storage area. This removes any setting previously stored there.

Although there are twenty stored setting locations, the number of settings you can store is limited by the amount of memory available. You will not be able to store more than seven settings unless your DSA is equipped with Option 4C, Nonvolatile RAM.

Recalling Stored Settings

You can recall a stored setting using the **Recall Setting** pop-up menu in the Store/Recall major menu. Touch the **Setting n** selector, where **n** is the number of the setting you want to recall.



The **Recall Setting** *Pop-Up Menu*

The **Recall Setting** pop-up menu also provides a way to initialize the DSA. Touch the **Initialize Setting** selector to reset the DSA in the same way as when you touch the **Initialize Setting** selector in the Utility 1 major menu. Initialization is described completely on page 131.

You can label stored settings. See Labeling on page 135.

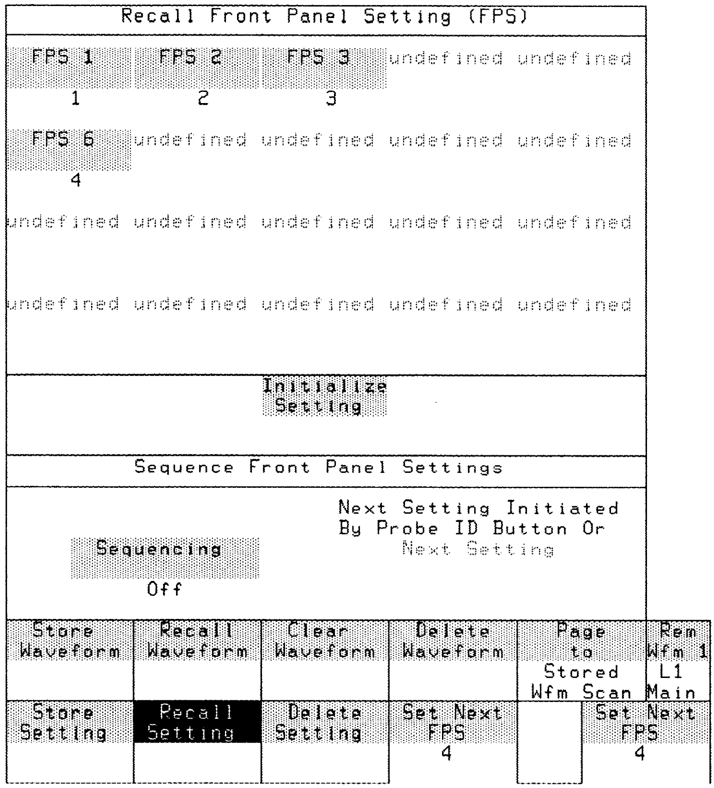
After you choose the major menu you want recalled with the stored setting, touch **Store Next FPS** to store the setting. The FPS (Front Panel Setting) number that will be assigned to the setting appears under the label **Set Next FPS**. If you want to specify a number other than the default, you can assign the knobs to set the number by touching **Set Next FPS**. You can choose any number from 1 to 20. If you choose a number that is already in use, the word "Exists!" appears under the **Store Next FPS** label. If you store the setting under that number, the previously stored setting will be deleted.

As a shortcut, you can store a setting by touching one of the twenty selectors in the upper part of the **Store Setting** pop-up menu. This removes any setting previously stored there. If no setting has been stored, the selector reads **undefined**.

Although there are twenty stored setting locations, the number of settings you can store is limited by the amount of memory available. You will not be able to store more than seven settings unless your DSA is equipped with Option 4C, Nonvolatile RAM.

Recalling Stored Settings

You can recall a stored setting using the **Recall Setting** pop-up menu in the Store/Recall major menu. Touch the **FPS n** selector, where **n** is the number of the setting you want to recall.

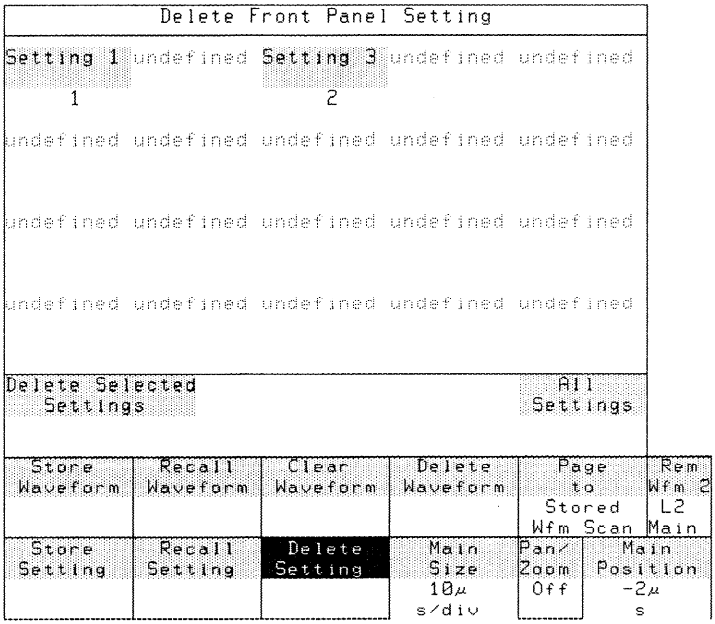


The **Recall Setting** *Pop-Up Menu*

The **Recall Setting** pop-up menu also provides a way to initialize the DSA. Touch the **Initialize Setting** selector to reset the DSA in the same way as when you touch the **Initialize Setting** selector in the Utility 1 major menu. Initialization is described completely on page 131.

Deleting Stored Settings

Use the **Delete Setting** pop-up menu in the Store/Recall major menu to delete a stored setting. Select the setting or settings to delete by touching the selectors in the top part of the pop-up menu. As you touch these selectors, they highlight to show that they will be deleted when you touch the **Delete Selected Settings** selector. Touch a highlighted selector a second time to remove it from the list of settings to be deleted. Touching the **All Settings** selector is a quick way to select all the stored settings.



The **Delete Setting** *Pop-Up Menu*

Sequencing Through Stored Settings

If you have several settings saved, you can cycle through the settings in order. This is useful if you have a series of test setups that you want to use repeatedly.

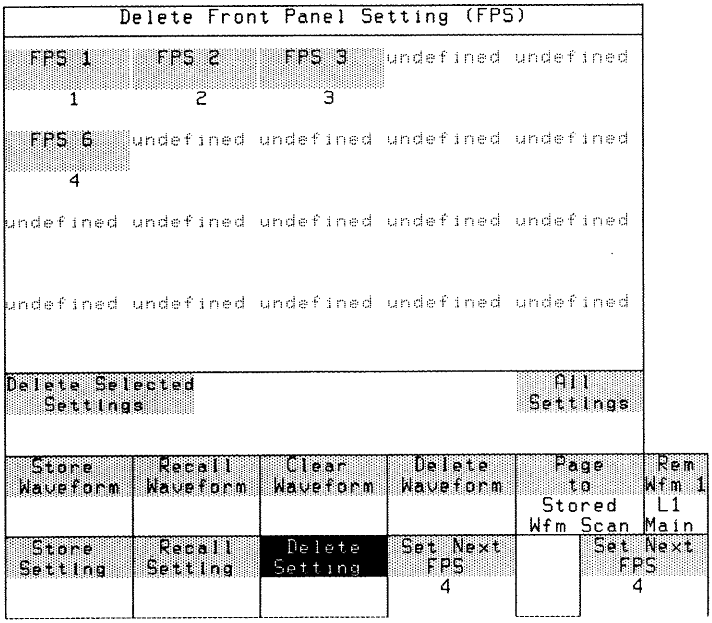
The sequencing order of stored settings is the same as the order in which they appear in the **Store Setting** pop-up menu. The sequence number of a setting appears in the selector for that setting in the **Store Setting** and **Recall Setting** pop-up menus.

The **Sequencing** selector in the **Sequence Front Panel Settings** section of the **Recall Setting** pop-up menu allows you to turn sequencing on or off. The field beneath the **Recall Setting** selector shows which setting is displayed. **2 of 1: 6** means the second stored setting is being displayed from a total of six stored settings.

When sequencing is on, you can recall the next setting by touching the **Next Setting** selector in the **Sequence Front Panel Settings** section of the pop-up menu or by pressing a probe ID button, when the probe ID function is set to **Sequence Setting**. Setting the probe ID function is explained on page 171.

Deleting Stored Settings

Use the **Delete Setting** pop-up menu in the Store/Recall major menu to delete a stored setting. Select the setting or settings to delete by touching the selectors in the top part of the pop-up menu. As you touch these selectors, they highlight to show that they will be deleted when you touch the **Delete Selected Settings** selector. Touch a highlighted selector a second time to remove it from the list of settings to be deleted. Touching the **All Settings** selector is a quick way to select all the stored settings.



The **Delete Setting** *Pop-Up Menu*

Sequencing Through Stored Settings

If you have several settings saved, you can cycle through the settings in order. This is useful if you have a series of test setups that you want to use repeatedly.

The sequencing order of stored settings is the same as the order in which they appear in the **Store Setting** pop-up menu. The sequence number of a setting appears in the selector for that setting in the **Store Setting** and **Recall Setting** pop-up menus.

The **Sequencing** selector in the **Sequence Front Panel Settings** section of the **Recall Setting** pop-up menu allows you to turn sequencing on or off. The field beneath the **Recall Setting** selector shows which setting is displayed. **2 of 1: 6** means the second stored setting is being displayed from a total of six stored settings.

When sequencing is on, you can recall the next setting by touching the **Next Setting** selector in the **Sequence Front Panel Settings** section of the pop-up menu or by pressing a probe ID button, when the probe ID function is set to **Sequence Setting**. Setting the probe ID function is explained on page 171.

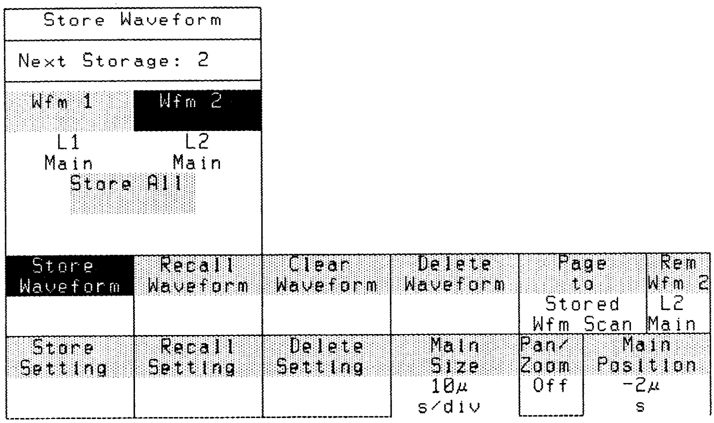
Stored Waveforms

A stored waveform is a record of a single acquisition cycle. You can think of it as a "snapshot" of a waveform.

Once you have stored a waveform, you can use it as an element of waveform expressions in other waveforms. For example, you could define a waveform to be **L1-STO3**. This waveform acquires data from plug-in channel L1 and subtracts from each sample the data recorded in stored waveform number 3.

Storing Waveforms

When you store a waveform, you take a copy of the waveform record of the selected waveform. Use the selectors in the **Store Waveform** pop-up menu of the Store/Recall major menu to store waveforms.



The **Store Waveform** *Pop-Up Menu*

Use the following steps to store a waveform:

- ☐ Step 1: Create a stable waveform on the display.
- ☐ Step 2: Press the **Store/Recall** major menu button, and touch the **Store Waveform** selector.
- ☐ Step 3: Observe the **Next Storage:** notation at the top of the pop-up menu. The waveform you store will be assigned this number.

You can label stored waveforms. See Labeling on page 135.

- ☐ Step 4: Touch the selector that represents the waveform you want to store. All displayed waveforms are listed.

You can also use the **Store All** selector to store all the displayed waveforms as separate stored waveforms. In this case, the **Next Storage:** notation tells you the first storage number that will be used.

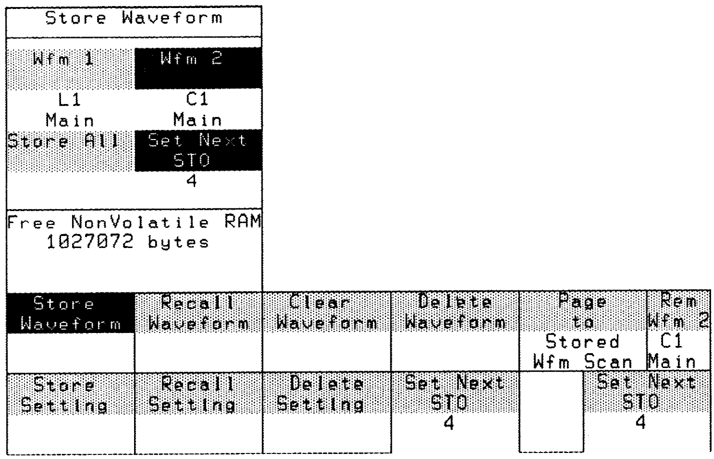
Stored Waveforms

A stored waveform is a record of a single acquisition cycle. You can think of it as a "snapshot" of a waveform.

Once you have stored a waveform, you can use it as an element of waveform expressions in other waveforms. For example, you could define a waveform to be **L1-STO3**. This waveform acquires data from plug-in channel L1 and subtracts from each sample the data recorded in stored waveform number 3.

Storing Waveforms

When you store a waveform, you take a copy of the waveform record of the selected waveform. Use the selectors in the **Store Waveform** pop-up menu of the Store/Recall major menu to store waveforms.



The **Store Waveform** *Pop-Up Menu*

Use the following steps to store a waveform:

☐ Step 1: Create a stable waveform on the display.

☐ Step 2: Press the **Store/Recall** major menu button, and touch the **Store Waveform** selector.

You can label stored waveforms. See Labeling on page 135.

☐ Step 3: The waveform will be stored under the number shown in the **Set Next STO** selector. If you want to change the number, touch this selector and use the knobs to change the number. You cannot store a waveform in a location where another waveform is already stored.

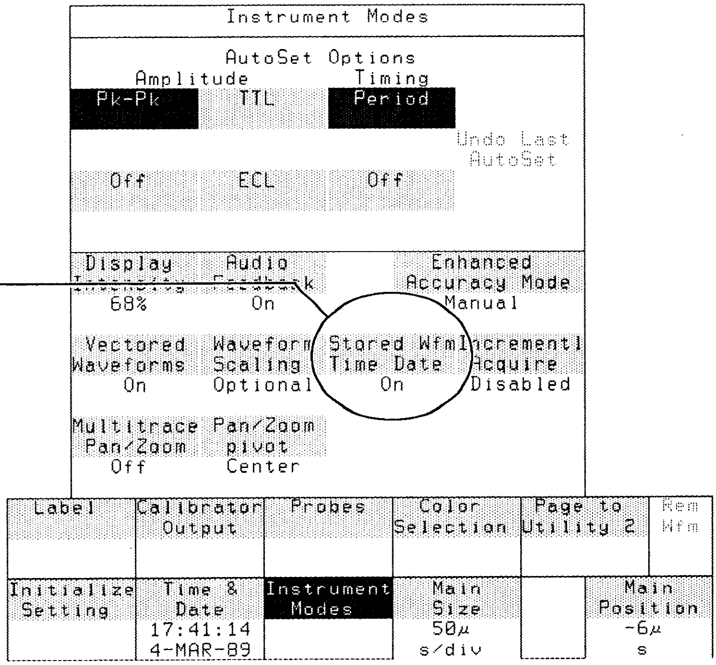
☐ Step 4: Touch the selector that represents the waveform you want to store. All displayed waveforms are listed.

You can also use the **Store All** selector to store all the displayed waveforms as separate stored waveforms. In this case, the **Set Next STO** number is the first storage number that will be used.

Displaying Time and Date with Stored Waveforms

You can display the time and date that a waveform was stored by selecting **Stored Wfm Time Date**, in the **Instrument Modes** pop-up menu of the Utility 1 major menu. The time and date for each stored waveform appears in the waveform selectors. Time and date can be displayed with stored waveforms regardless of whether **Stored Wfm Time Date** was on when the waveforms were stored.

The **Stored Wfm Time Date** *Selector*

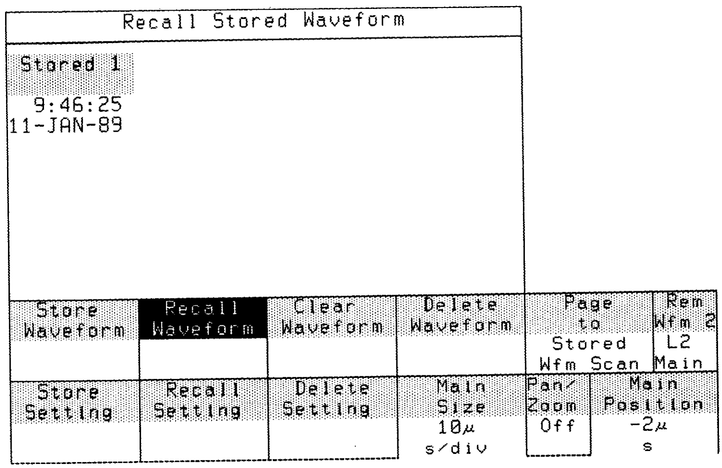


The **Instrument Modes** *Pop-Up Menu*

Recalling Stored Waveforms

Once a waveform is stored, you can use it in a waveform expression. To create a waveform that displays a stored waveform, touch the **DefWfm** icon, then in the pop-up menu touch the **Stored Waveforms** selector, the selector for the stored waveform you want to display, and the **Enter Desc** selector.

The **Recall Waveform** pop-up menu provides a simpler way to do the same thing. Press the **Store/Recall** major menu button and touch the **Recall Waveform** selector to display the pop-up menu. In the pop-up menu, touch the selector for the stored waveform you want to display.



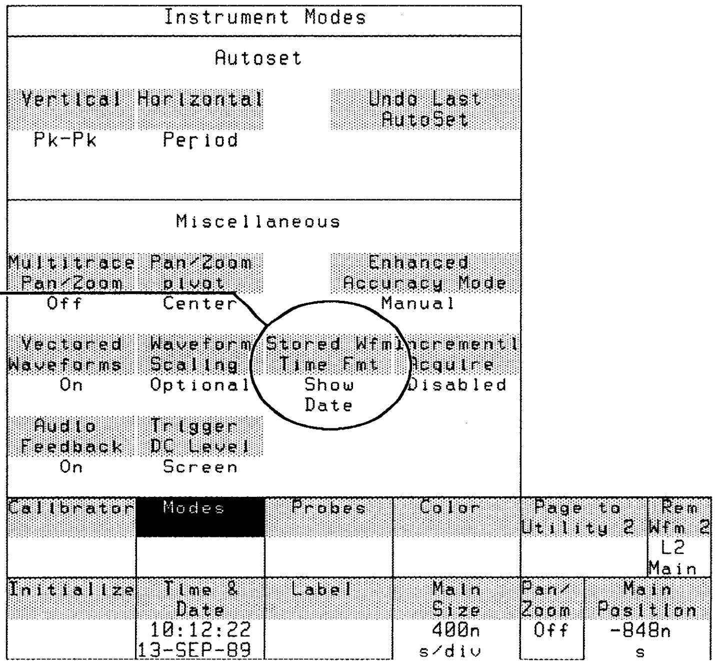
The **Recall Waveform** *Pop-Up Menu*

The Stored Waveform Time Stamp Format

A time stamp is displayed in the status field of each selector for a stored waveform. The first line of this time stamp shows the time, in hours, minutes, and seconds, that the waveform was stored. The second line can show either the date the waveform was stored, or hundredths of seconds. You may want to display hundredths of seconds, for example, when you have acquired waveforms in the Repetitive Single Trigger or Act on Delta mode.

Select **Stored Wfm Time Fmt**, in the **Modes** pop-up menu in the Utility 1 major menu, to change the format of the time stamp. This selector can be set to **Show Date** or **Show Hundredths.**

The **Stored Wfm Time Fmt** *Selector*

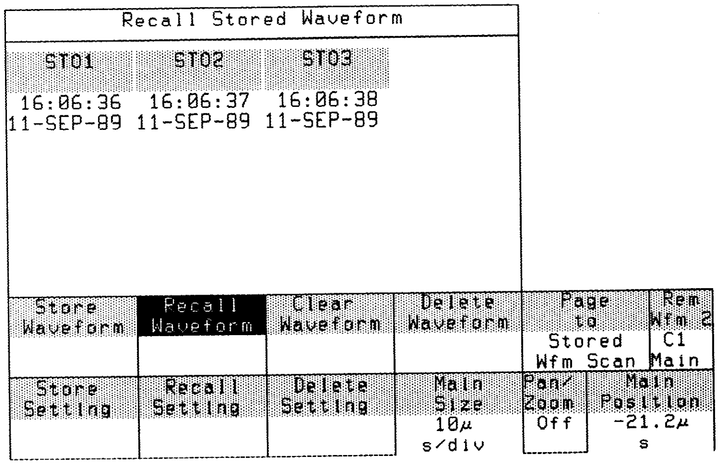


The **Modes** *Pop-Up Menu*

Recalling Stored Waveforms

Once a waveform is stored, you can use it in a waveform expression. To create a waveform that displays a stored waveform, touch the **DefWfm** icon, then in the pop-up menu touch the **Stored Waveforms** selector, the selector for the stored waveform you want to display, and the **Enter Desc** selector.

The **Recall Waveform** pop-up menu provides a simpler way to do the same thing. Press the **Store/Recall** major menu button and touch the **Recall Waveform** selector to display the pop-up menu. In the pop-up menu, touch the selector for the stored waveform you want to display.

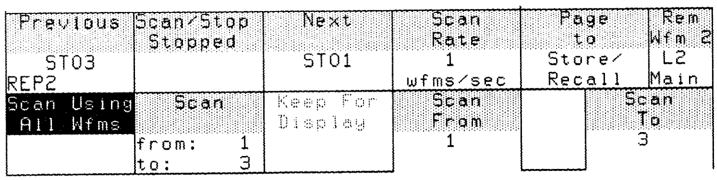


The **Recall Waveform** *Pop-Up Menu*

Scanning Stored Waveforms

You can visually scan through a set of stored waveforms. The DSA will display each stored waveform briefly and you can stop the scanning when you see a waveform of interest. You can scan through a specified set of stored waveforms, such as the waveforms stored using repetitive single trigger, to find the record of an event of interest. For more information on the repetitive single trigger capability, see page 38.

To scan through stored waveforms, select **Page to Stored Wfm Scan** in the **STORE/RECALL** major menu. This will display the **Stored Waveform Scan** major menu. The selectors in this menu allow you to select a set of stored waveforms for scanning, scan through them, stop and restart scanning, and keep a waveform for display.



The **Stored Waveform Scan** *Menu*

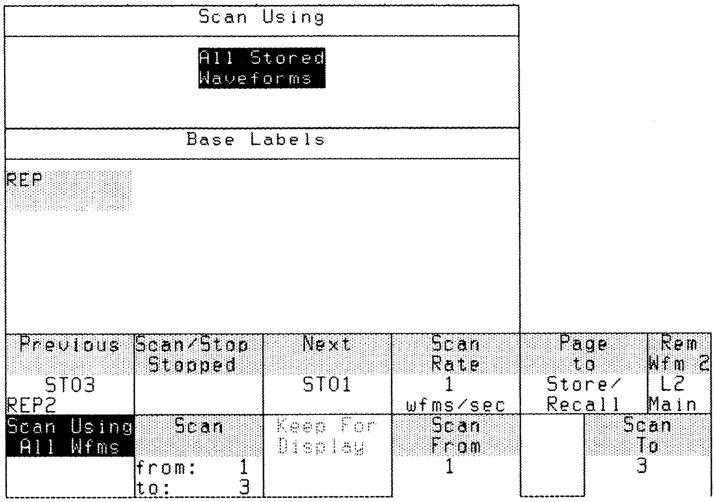
You will not be able to initiate scanning if there are already eight waveforms on the display.

Start and stop scanning by touching the **Scan/Stop** selector. The name of the waveform that is currently displayed appears in this selector. You can step through the sequence manually by touching the **Next** and **Previous** selectors. The **Scan/Stop** selector will not be selectable when there are already eight waveforms on the display, because one displayed waveform must be created for scanning.

When you identify a waveform you would like to examine in more detail, you should select **Keep for Display** to make a copy of it. This will create a displayed waveform with the same label as the stored waveform it displays. If eight waveforms are already displayed, **Keep for Display** will not be selectable.

For more information on base labels, see Labeling on page 135.

You can specify a set of stored waveforms that will be displayed in scanning. The **Scan Using** selector displays a pop-up menu that lets you limit the scan to waveforms with a particular base label. Select **All Stored Waveforms** in the upper section of this menu to include all waveforms in the scan. The lower section of the pop-up menu displays a selector for every existing base label. Touch one of these selectors to limit the scan to waveforms stored by the repetitive single trigger using that base label.



The **Scan Using** *Pop-up Menu*

You can also limit the range of stored waveforms displayed. The **Scan** selector shows the numbers of the first and last stored waveforms in the scanning range. Touch this selector to assign the knobs to control the limits of the scanning range. Coarse resolution will let you adjust the limits in increments of ten; fine resolution gives you increments of one.

You can set the rate at which scanned waveforms are displayed. Select **Scan Rate** to assign the knobs to adjust the rate. You can scan as fast as ten waveforms per second or as slowly as one waveform every ten seconds.

Deleting Stored Waveforms

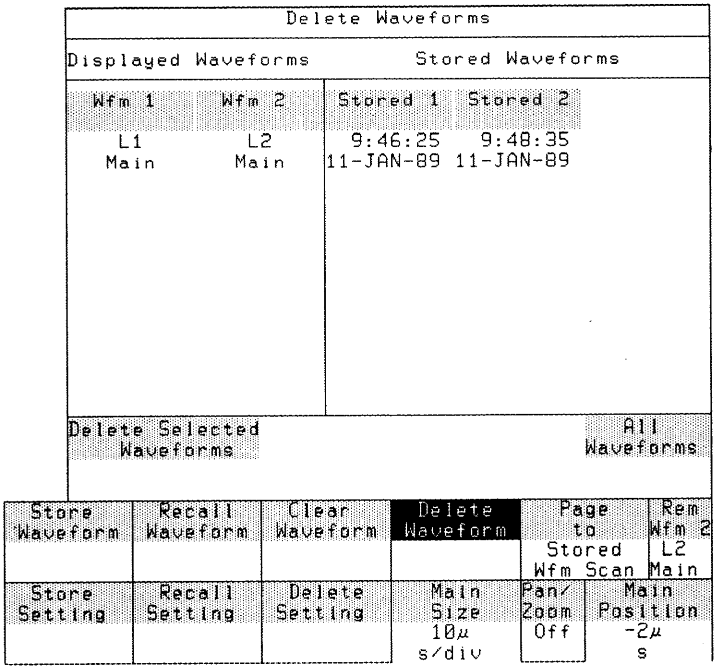
You can delete stored waveforms by using the **Delete Waveform** pop-up menu in the Store/Recall major menu. This pop-up menu is also used to delete displayed waveforms.

In the **Delete Waveform** pop-up menu, touch the selectors for the displayed and stored waveforms you want to delete. The waveforms are not deleted until you touch the **Delete Selected Waveforms** selector. You may select several waveforms to be deleted before touching the **Delete Selected Waveforms** selector. As you select waveforms to delete, their selectors highlight to tell you they will be deleted. If you touch a waveform selector by accident, touch it again to remove the highlighting.

When you select a stored waveform with a label that matches the current base label, all stored waveforms with labels that match that base label will be selected. You can use this method to delete a set of waveforms stored with the repetitive single trigger function.

If you want to delete all the displayed and stored waveforms, touch the **All Waveforms** selector, then touch the **Delete Selected Waveforms** selector.

You cannot delete a stored waveform if it is being used as part of a displayed waveform. In the illustration on the next page, stored waveform 1 is used in the waveform definition of displayed waveform 3. The selector for stored waveform 1 cannot be selected.

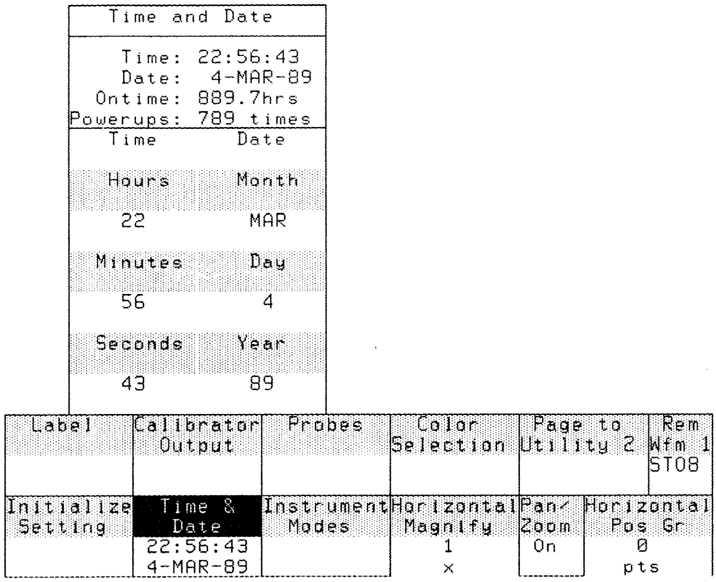


The **Delete Waveform** *Pop-Up Menu*

Time and Date

The DSA has an internal clock that keeps track of the time and date. You can set the clock using the **Time & Date** pop-up menu in the Utility 1 major menu.

This menu also shows you how many times the DSA has been powered on, and how many hours it has been on.



The **Time & Date** *Pop-Up Menu*

When you touch the **Year**, **Month**, **Day**, **Hour**, **Minute**, or **Second** selector, one of the knobs is assigned to set that clock parameter.

Triggering

A trigger is an electrical event on which acquisition is based. The trigger event occurs when the trigger *source*, the signal being monitored by the trigger circuits, passes through a specified voltage *level* in the specified direction (the trigger *slope*). This event becomes a reference point in time when waveform samples are combined into a waveform record. In the absence of a trigger event, the DSA cannot assemble a waveform record and the signal becomes *untriggered*.

The trigger status is shown to the left of the graticule. If the selected waveform is triggered, the status appears as **trig'd**. Otherwise, **!not! trig'd** appears. Depending on the trigger *mode*, acquisition may stop when the signal becomes untriggered, leaving the last triggered waveform record frozen on the display. When acquisition continues in the absence of an adequate trigger, acquired samples will be displayed but will not be positioned properly, producing an unstable waveform display.

You can set the trigger signal source to be a plug-in channel, a combination of plug-in channels, or the AC line. You can also set the trigger *coupling* to selectively pass part or all of the trigger signal to the trigger circuits. To improve trigger stability, you can adjust the trigger *holdoff*, the period after a trigger event during which triggers are ignored.

The DSA has a set of *extended trigger* options that allow you to define more specific conditions in which triggering can occur. These extended trigger capabilities include Boolean triggering, time-qualified triggering, and level-qualified triggering.

To find out more about window waveforms, see Windows on page 231.

Window waveforms are acquired on a separate time base which may be triggered either from the Main trigger or from a distinct Window trigger. The trigger icon to the left of each graticule shows which trigger applies to the selected waveform on that graticule. The Main trigger icon appears as an arrow over the letter M ($\overset{\uparrow}{\mathrm{M}}$), the Window trigger as an arrow over the letter W ($\overset{\uparrow}{\mathrm{W}}$).

Use the trigger icon ($\overset{\uparrow}{\mathrm{M}}$ or $\overset{\uparrow}{\mathrm{W}}$) to assign the knobs to set the trigger level and holdoff.

You can assign the knobs to set the trigger level and time holdoff of the selected waveform by touching the trigger icon ($\overset{\uparrow}{\mathrm{M}}$ or $\overset{\uparrow}{\mathrm{W}}$). Use the selectors in the Trigger major menu to access all other trigger controls.

Trigger Selection

Trigger Select selects the Main or Window trigger. Selections you make from the Trigger major menu affect the selected trigger. You can also select the trigger by touching the trigger icon (M or W).

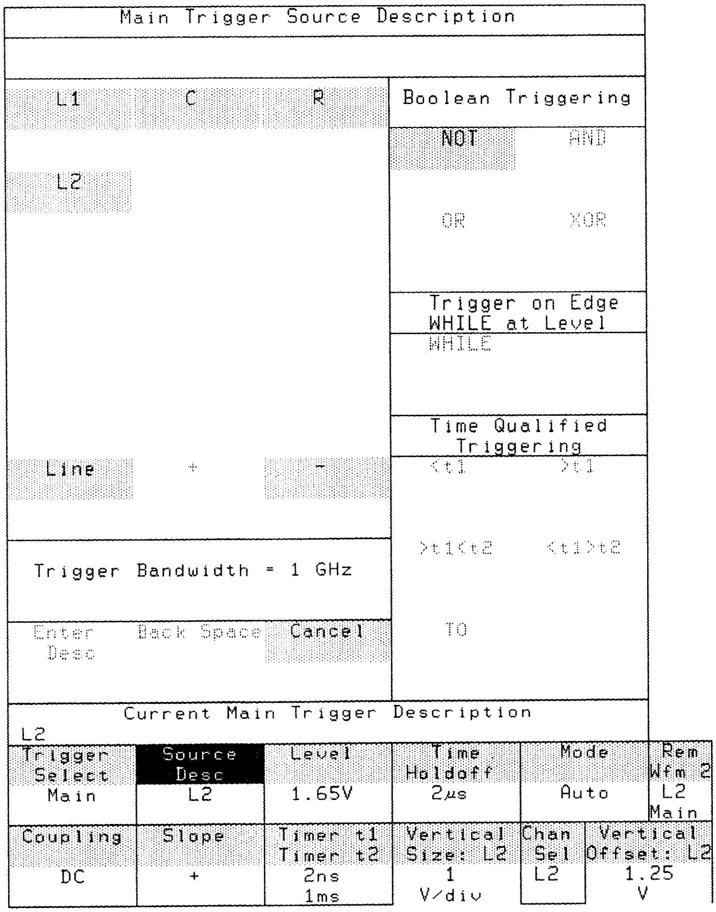
Source

The **Source Desc** selector displays a pop-up menu that allows you to define the trigger source. You can choose any plug-in channel, combine channels from the center and left plug-ins by adding and subtracting them, or select the AC line as the trigger source. As you type in the trigger source description, it appears at the top of the **Source Desc** pop-up menu. Use **Backspace** to correct errors as you type in the description. Press **Enter Desc** to enter the description and remove the pop-up menu. You can cancel your selection and remove the pop-up menu at any point by pressing **Cancel**.

The current trigger description is displayed in the bottom line of the **Source Desc** pop-up menu. The DSA trigger bandwidth is also reported in this pop-up menu. (The system trigger bandwidth also depends on the plug-in amplifier used and may be less than the DSA trigger bandwidth.)

You can also select extended triggering functions from the **Source Desc** pop-up menu. These functions appear under **Boolean Triggering**, **Trigger on Edge WHILE at Level**, and **Time Qualified Triggering** in the **Source Desc** pop-up menu. See Extended Triggering on page 207 for more information about these triggering functions.

When a single channel is being acquired from a plug-in amplifier in the left compartment at the maximum sampling rate (1 Gsample/s for the DSA 601 and 2 Gsample/s for the DSA 602), selecting a different channel from the same plug-in amplifier as the trigger source will cause acquisition to revert to equivalent time mode, although you can select a channel from a different plug-in amplifier without affecting the real-time acquisition of the channel. Similarly, if two channels from the left and right compartments are being acquired at half the maximum sampling rate, your choosing as the trigger source a channel from the left compartment other than the one already being acquired will force the DSA to revert to equivalent time acquisition.



The Trigger Major Menu and **Source Desc** *Pop-Up Menu*

Coupling

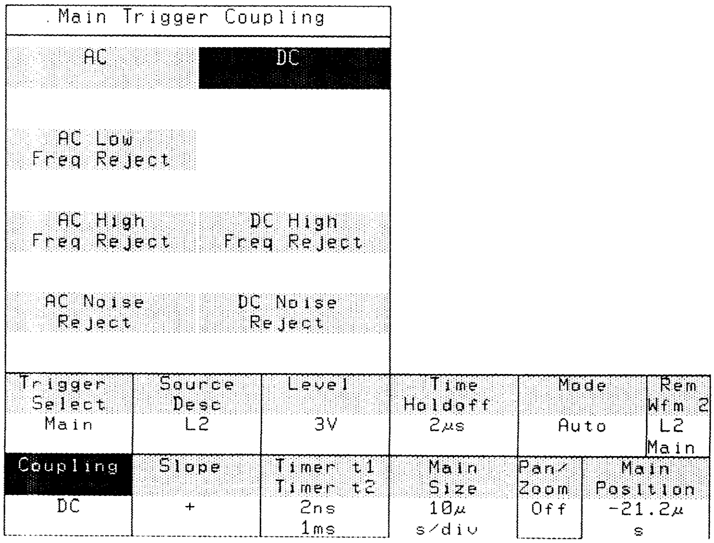
The **Coupling** selector displays a pop-up menu that allows you to specify one of several trigger coupling options.

None of the AC trigger coupling options are available when extended trigger functions are used.

AC coupling attenuates signals at frequencies below 60 Hz. **DC** coupling triggers acquisition when the DC level of the trigger signal reaches the specified trigger level.

AC Low Freq Reject rejects the DC component of the trigger signal and attenuates signals at frequencies below 80 kHz. **AC High Freq Reject** rejects the DC component of the trigger signal and attenuates high-frequency signals above 30 kHz. Select **DC High Freq Reject** to retain the DC component of the trigger signal and attenuate signals above 30 kHz.

AC Noise Reject rejects the DC component of the trigger signal and requires a greater peak-to-peak amplitude to produce a trigger event. **DC Noise Reject** also requires a greater peak-to-peak signal to produce a trigger event.



The **Coupling** *Pop-Up Menu*

Slope

The **Slope** selector selects between + (a rising slope trigger event) and - (a falling slope trigger event). The trigger slope must always be positive when extended trigger functions are used.

Level and Holdoff

The **Level** selector assigns the knobs to set the trigger level (and trigger holdoff). Touching this selector is the same as touching the trigger icon to the left of the graticule.

The **Time Holdoff** selector assigns the knobs to set the trigger holdoff (and trigger level). This is the same as touching the trigger icon. If you have a window time base defined with trigger holdoff by events, this selector will appear as **Events Holdoff** when the window trigger is selected.

The Main time base holdoff can be set to any value from 2 μs to 500 seconds. The range of the Window time base holdoff by time is from 35 ns to the end of the Main record duration, up to 1000 seconds. Window time base holdoff by events may be from one to one billion events.

When one of the waveforms on the display matches the trigger signal, the trigger indicator (➔) appears on the waveform to show the trigger level.

Window Triggering

You specify a separate trigger for the Window time base by choosing Window holdoff by time or events. The Window trigger will occur on the Window trigger signal only after a specified amount of time or number of events have elapsed since the Main trigger event. You can specify trigger holdoff on the Main time base by time only.

When **Window Trigger** is selected, the **Source Desc** pop-up menu allows you to select **Window Triggered From Main**, to have the window acquired on the Main time base, **Window Holdoff By Time** to select a Window time base with a trigger time holdoff, or **Window Holdoff By Events** to select a Window time base with trigger holdoff by events.

You can specify different trigger sources for the Window trigger and the Main trigger, but you cannot use different trigger sources from the same plug-in unit. For example, if the Main trigger source is channel **L1**, you can define the Window trigger source to be **L1**, or even **L1 + C1**, but not **L1 + L2**. If you want to change the source description for both the Main and the Window trigger to **L1 + L2**, you must first eliminate the separate Window trigger (by selecting **Window Triggered From Main**) so that the trigger sources will not conflict.

A status indicator appears between the knob labels in the Trigger major menu. This indicator tells you which trigger applies to the selected waveform (not which trigger is selected).

Slope

The **Slope** selector selects between + (a rising slope trigger event) and - (a falling slope trigger event). The trigger slope must always be positive when extended trigger functions are used.

Level and Holdoff

The **Level** selector assigns the knobs to set the trigger level (and trigger holdoff). Touching this selector is the same as touching the trigger icon to the left of the graticule.

The **Time Holdoff** selector assigns the knobs to set the trigger holdoff (and trigger level). This is the same as touching the trigger icon. If you have a window time base defined with trigger holdoff by events, this selector will appear as **Events Holdoff** when the window trigger is selected.

The Main time base holdoff can be set to any value from 2 μs to 500 seconds. The range of the Window time base holdoff by time is from 35 ns to the end of the Main record duration, up to 1000 seconds. Window time base holdoff by events may be from one to one billion events.

When one of the waveforms on the display matches the trigger signal, the trigger indicator (↗) appears on the waveform to show the trigger level.

Trigger DC Level

The trigger DC level may be set either as a fixed level on the display or as a fixed value in vertical axis units (usually volts). To change the way trigger DC level is set, select **Trigger DC Level** in the **Modes** pop-up menu in the Utility 1 major menu. This selector shows **Screen** or **Absolute** as status.

When **Trigger DC Level** is set to **Screen**, the trigger DC level is independent of the vertical offset (vertical position) of the trigger source. If you change the offset of the trigger source, the trigger level will remain at the same vertical level on the screen.

When **Trigger DC Level** is set to **Absolute**, the trigger DC level is an absolute voltage (or other vertical axis unit) level. If you change the vertical offset of the trigger source, the trigger level is also offset; it remains at the same level relative to the input signal.

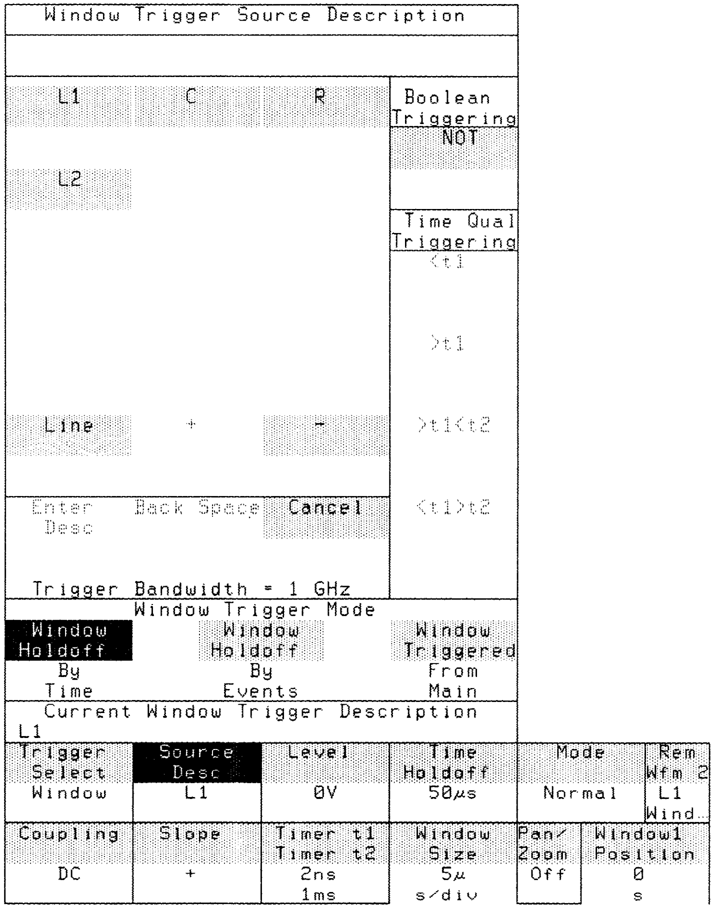
Window Triggering

You specify a separate trigger for the Window time base by choosing Window holdoff by time or events. The Window trigger will occur on the Window trigger signal only after a specified amount of time or number of events have elapsed since the Main trigger event. You can specify trigger holdoff on the Main time base by time only.

When **Window Trigger** is selected, the **Source Desc** pop-up menu allows you to select **Window Triggered From Main**, to have the window acquired on the Main time base, **Window Holdoff By Time** to select a Window time base with a trigger time holdoff, or **Window Holdoff By Events** to select a Window time base with trigger holdoff by events.

You can specify different trigger sources for the Window trigger and the Main trigger, but you cannot use different trigger sources from the same plug-in unit. For example, if the Main trigger source is channel **L1**, you can define the Window trigger source to be **L1**, or even **L1 + C1**, but not **L1 + L2**. If you want to change the source description for both the Main and the Window trigger to **L1 + L2**, you must first eliminate the separate Window trigger (by selecting **Window Triggered From Main**) so that the trigger sources will not conflict.

A status indicator appears between the knob labels in the Trigger major menu. This indicator tells you which trigger applies to the selected waveform (not which trigger is selected).



The **Source Desc** *Pop-Up Menu for the Window Trigger*

Trigger Mode

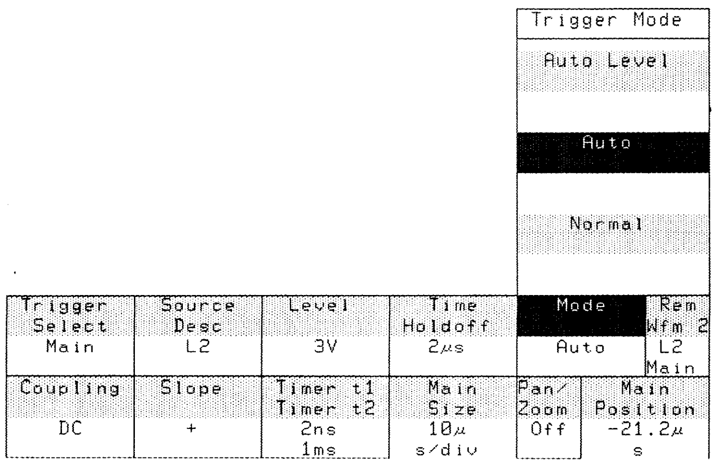
The **Mode** selector displays a pop-up menu which allows you to select **Auto Level**, **Auto**, or **Normal**.

In Auto Level mode, the DSA automatically sets the trigger level on a triggering signal. You can change the level within 20% to 80% of the peak-to-peak signal. In the absence of an adequate trigger signal, the DSA will acquire and display waveform samples without reference to a trigger event. Auto Level mode is not available when extended trigger functions are used.

Auto mode is available for the Main trigger only. This mode provides triggered signal acquisition when the trigger level is correctly set and an adequate trigger signal is present. When the trigger signal is inadequate or the level is inappropriate, acquired samples are displayed without reference to a trigger event.

Use Normal mode to acquire signals with repetition rates below 30 Hz.

Normal mode is similar to Auto mode, except that acquisition stops when the trigger signal is inadequate or the level setting is inappropriate. When acquisition is stopped, the previously acquired waveform record remains “frozen” on the display. This mode should be used to acquire signals with repetition rates below 30 Hz.



The **Mode** *Pop-Up Menu*

Extended Triggering

In addition to its basic triggering capabilities, the DSA provides Boolean triggering, time-qualified triggering, and level-qualified triggering.

These extended triggering options may be used separately or, with some exceptions, can be combined in the trigger source description. When any of these triggering options is used, the trigger bandwidth is limited to 500 MHz. Also, the trigger coupling must be set to DC, DC Noise Reject, or DC High Frequency Reject, the trigger slope must be positive, and the trigger mode must be Auto or Normal. If other trigger settings are selected, the DSA will automatically change the trigger settings when you enter an extended trigger expression.

Boolean Triggering

With Boolean triggering, a trigger event occurs whenever a Boolean function of up to two trigger sources changes from false to true. The Boolean value of a trigger source is true if the trigger source voltage is above a level you set for that source. You can use the Boolean logic operators NOT, AND, OR, and XOR to construct a Boolean trigger function. The Boolean trigger function must be false a minimum of 2 ns before the transition, and must remain true a minimum of 2 ns after the transition, in order to be recognized.

Use the **Source Desc** pop-up menu in the Trigger major menu to enter a Boolean trigger expression. Selectors for the operators **NOT**, **AND**, **OR**, and **XOR** appear under the heading **Boolean Triggering**.

The unary operator NOT may be applied to a trigger source to create a function that is true whenever the trigger source voltage is below the level you set for the source. You can use this operator along with the other Boolean operators or with the other extended triggering options. The NOT operator may be used for the Main or Window trigger.

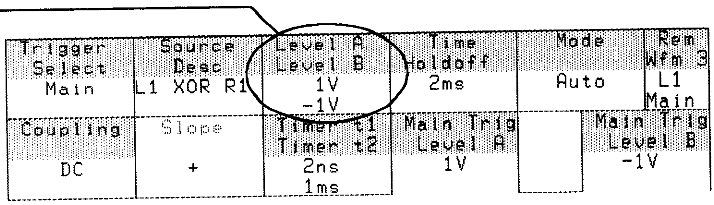
The binary operator AND combines two trigger source descriptions into a function that is true only when both of the components of the function are true.

The binary operator OR combines two trigger source descriptions to form a function that is true whenever either, or both, of the components is true.

The binary operator XOR (exclusive OR) may be used to create a function that is true when either of its components is true, but false when both are true or both are false.

When you define a Boolean trigger expression, you must set the level that distinguishes a "high" or "true" value from a "low" or "false" value. Touch the **Level** selector and use the left knob to adjust the level. If you have entered a binary Boolean trigger expression, the **Level** selector changes to show **Level A Level B**. When you touch this selector, the left knob is assigned to control the level (**Level A**) for the first source in the Boolean expression and the right knob controls the level (**Level B**) for the second source.

The **Level A Level B** *Selector*



The Trigger Major Menu with a Binary Boolean Trigger Expression

You cannot define a separate Window trigger when you are using binary Boolean triggering.

The binary operators AND, OR, and XOR are available only for the Main trigger. You cannot use a binary Boolean expression in conjunction with level-qualified or comparison time-qualified triggering. You cannot have a separate window trigger when you are using binary Boolean triggering; the Window time base will automatically be set to trigger on the Main trigger.

Extended Triggering

In addition to its basic triggering capabilities, the DSA provides Boolean triggering, time-qualified triggering, and level-qualified triggering.

These extended triggering options may be used separately or, with some exceptions, can be combined in the trigger source description. When any of these triggering options is used, the trigger bandwidth is limited to 500 MHz. Also, the trigger coupling must be set to DC, DC Noise Reject, or DC High Frequency Reject, the trigger slope must be positive, and the trigger mode must be Auto or Normal. If other trigger settings are selected, the DSA will automatically change the trigger settings when you enter an extended trigger expression.

Boolean Triggering

With Boolean triggering, a trigger event occurs whenever a Boolean function of up to two trigger sources changes from false to true. The Boolean value of a trigger source is true if the trigger source voltage is above a level you set for that source. You can use the Boolean logic operators NOT, AND, OR, and XOR to construct a Boolean trigger function. The Boolean trigger function must be false a minimum of 2 ns before the transition, and must remain true a minimum of 2 ns after the transition, in order to be recognized.

Use the **Source Desc** pop-up menu in the Trigger major menu to enter a Boolean trigger expression. Selectors for the operators **NOT**, **AND**, **OR**, and **XOR** appear under the heading **Boolean Triggering.**

The unary operator NOT may be applied to a trigger source to create a function that is true whenever the trigger source voltage is below the level you set for the source. You can use this operator along with the other Boolean operators or with the other extended triggering options. The NOT operator may be used for the Main or Window trigger.

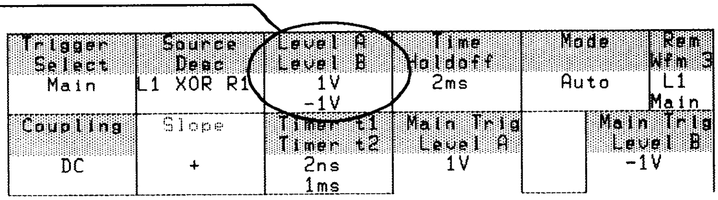
The binary operator AND combines two trigger source descriptions into a function that is true only when both of the components of the function are true.

The binary operator OR combines two trigger source descriptions to form a function that is true whenever either, or both, of the components is true.

The binary operator XOR (exclusive OR) may be used to create a function that is true when either of its components is true, but false when both are true or both are false.

When you define a Boolean trigger expression, you must set the level that distinguishes a "high" or "true" value from a "low" or "false" value. Touch the **Level** selector and use the left knob to adjust the level. If you have entered a binary Boolean trigger expression, the **Level** selector changes to show **Level A Level B**. When you touch this selector, the left knob is assigned to control the level (**Level A**) for the first source in the Boolean expression and the right knob controls the level (**Level B**) for the second source.

The **Level A Level B** *Selector*



The Trigger Major Menu with a Binary Boolean Trigger Expression

You cannot define a separate Window trigger when you are using binary Boolean triggering.

The binary operators AND, OR, and XOR are available only for the Main trigger. You cannot use a binary Boolean expression in conjunction with level-qualified or comparison time-qualified triggering. You cannot have a separate window trigger when you are using binary Boolean triggering; the Window time base will automatically be set to trigger on the Main trigger.

You can use the same trigger source on either side of a boolean trigger expression, for example **L1 AND NOT L1**. In this case, the settings for **Level A** and **Level B** determine the logic thresholds for the first and second use of the trigger source.

Time-Qualified Triggering

When you define a time-qualified trigger expression, a trigger will be generated when the state of one or two trigger sources meets the timing requirement you set. The length of time that a trigger source remains above the transition level is compared to the set time. When the timing restrictions are satisfied, a trigger event occurs. You can use time-qualified triggering and Boolean trigger functions together.

Use the **<t1** selector in the **Time Qualified Triggering** section of the **Source Desc** pop-up menu to specify that a trigger will occur when the trigger source has been above the transition level for a time period less than the specified limit, **t1**. Similarly, if you select **>t1**, a trigger will occur on the true-to-false transition of a trigger source pulse longer than the time limit **t1**. If the trigger source description does not include any binary Boolean operators, you can define a separate time interval for the Window trigger. An example of a time-qualified triggering expression is **NOT L1 <t1**, which specifies that triggering occurs after the trigger source has remained *below* the transition level for a time no longer than **t1**.

The **>t1<t2** and **<t1>t2** selectors are not available if a separate (Main or Window) trigger expression already uses one of the timers.

The **>t1<t2** and **<t1>t2** selectors let you specify a range of duration for the trigger source to exceed the transition level. The value of **t2** must always be greater than the value of **t1**. Select **>t1<t2** to have a trigger event occur after a pulse of the trigger source with duration between the values of **t1** and **t2**. Select **<t1>t2** to have a trigger event occur when the trigger source has been above the transition level for a time outside the boundaries defined by **t1** and **t2**; that is, a time less than **t1** or greater than **t2**. You can use these timing functions for either the Main trigger or the Window trigger, but not for both. If the trigger source description includes a binary Boolean expression, a separate Window trigger will not be available.

You can use the operator **TO** to create a comparison time-qualified triggering expression. The time between transitions on two trigger signals is then compared to the timing restrictions. Comparison timing may not be used with binary Boolean expressions, nor can it be used for the Window trigger expression. Use the **Level A Level B** selector in the Trigger major menu or the trigger icon ( ) to assign the knobs to set the transition levels for the two signals compared.

Select **Timer t1 Timer t2** in the Trigger major menu to set the knobs to control the values of **t1** and **t2**.

Level-Qualified Triggering

You can define a trigger expression in which trigger events on the trigger source signal are valid only when a second source is above or below a certain level.

To use level-qualified triggering, enter the trigger source on which the trigger event, or edge, will occur in the **Source Desc** pop-up menu, select **WHILE**, and enter the description of the source whose level will determine whether trigger events are recognized. Neither trigger source can include binary Boolean operators. You can use the unary operator NOT to indicate a negative-slope transition for the first source or, for the second source, to accept trigger events only when the source is *below* the level. Use the **Level A Level B** selector in the Trigger major menu or the trigger icon ( ) to assign the knobs to control the qualifying levels of the two trigger sources.

You cannot define a separate Window trigger when you are using Level-qualified triggering.

Level-qualified triggering is available for the Main trigger only; a separate Window trigger may not be defined. Level-qualified triggering and time-qualified triggering cannot be combined in a trigger source description.

Vectored Waveforms

Vectored waveforms is a display mode that enhances the appearance of displayed waveforms by eliminating any gaps or discontinuities.

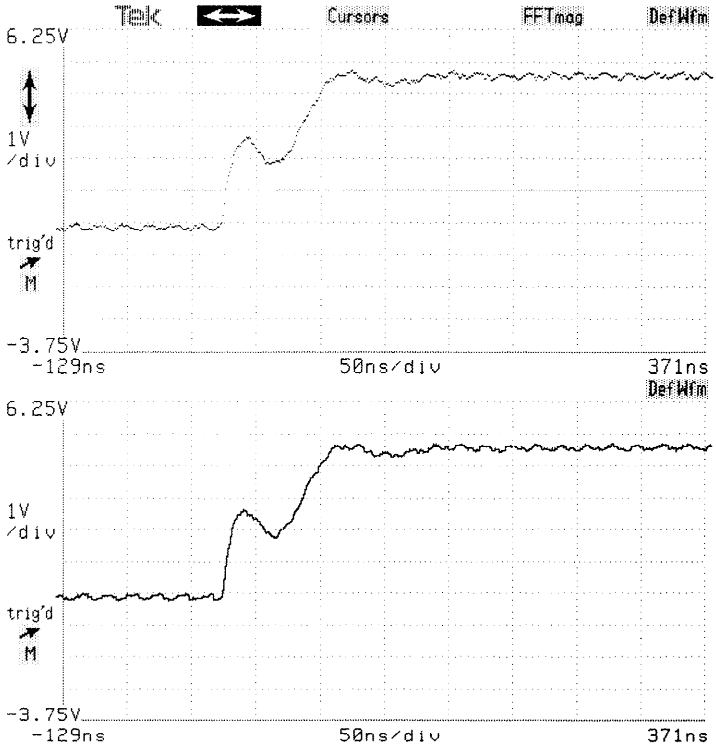
The waveform display area is 512 pixels (dots) wide. When a waveform with a record length of 512 samples is displayed, each sample has its own unique horizontal position on the display. When waveforms with record lengths longer than 512 samples are displayed, two or more samples must share the same horizontal location. For a waveform of 5120 samples, each horizontal place shows the results of ten samples.

When more than one sample share the same horizontal location, the resulting display is always a series of vertical lines, called columns, that extend from the top sample to the bottom sample.

The DSA normally extends the columns to "touch" adjacent columns, so that no gaps are shown in the waveform. You can turn this waveform vectoring off so that no intermediate data is assumed for display purposes.

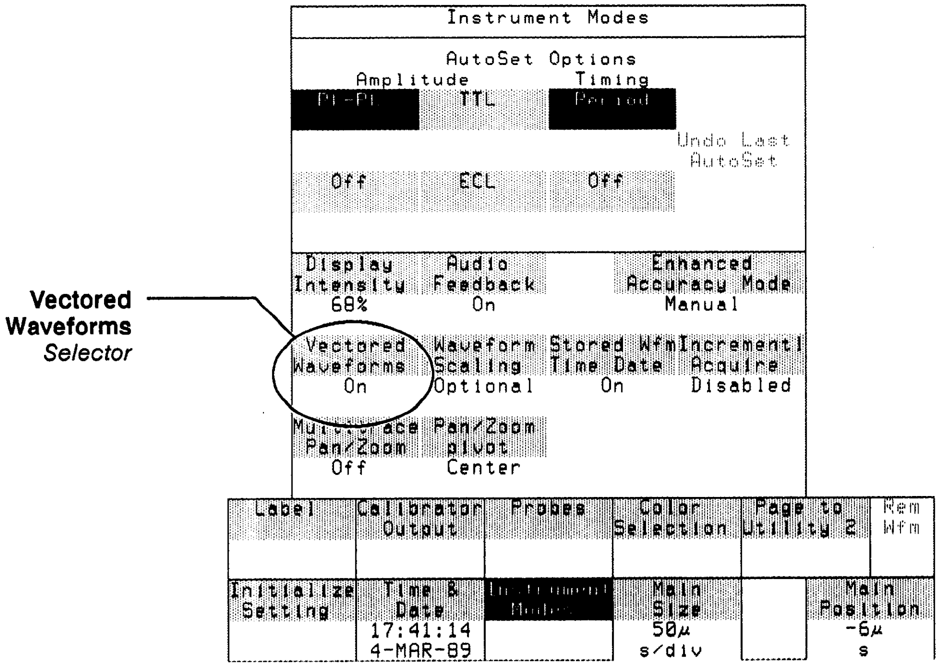
Waveform vectoring makes the greatest difference in the appearance of a waveform with 512 samples. As the record length of a waveform increases, the visual enhancement of waveform vectoring becomes less evident.

When you display a 512-sample waveform with waveform vectoring turned off, the individual samples of the waveform appear as dots.



Identical 512-Point Waveforms without Waveform Vectoring (top) and with Waveform Vectoring (bottom)

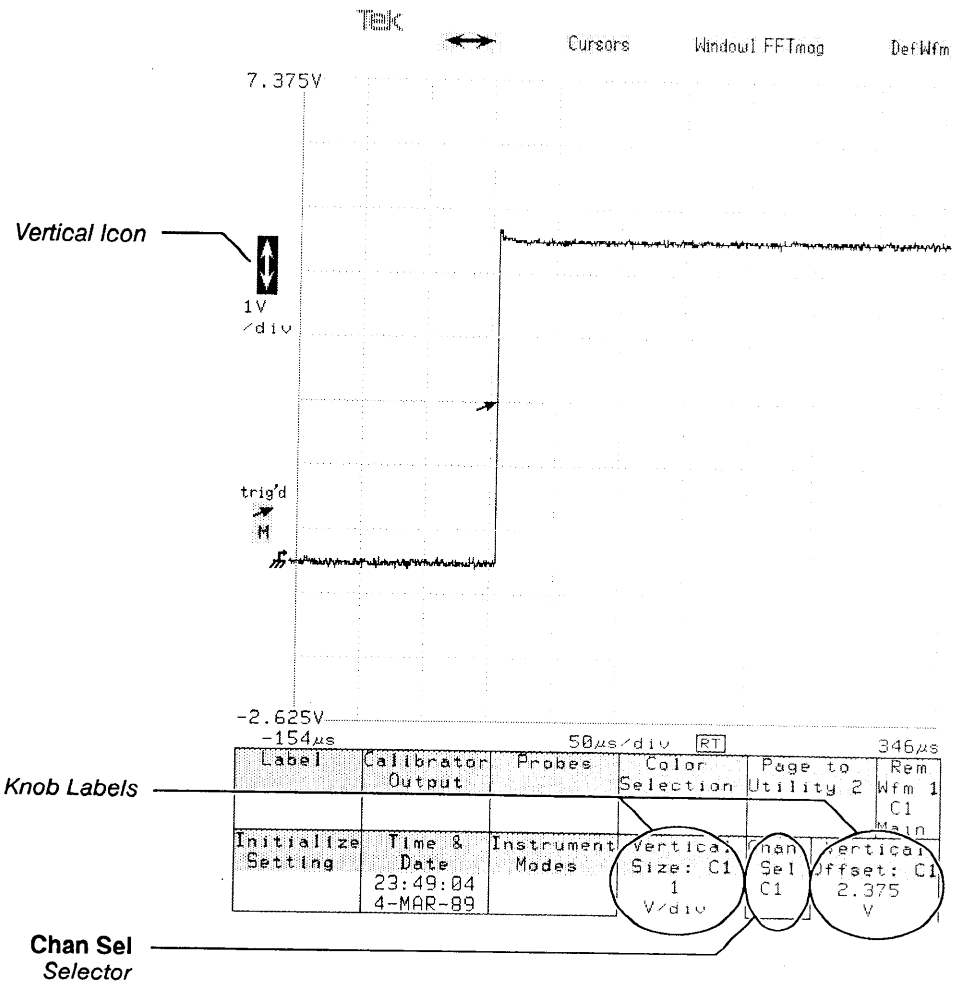
You turn waveform vectoring on or off using the **Instrument Modes** pop-up menu in the Utility 1 major menu. Touch the **Vectored Waveforms** selector to set it to **Off** or **On**.



The **Instrument Modes** *Pop-Up Menu*

Vertical Controls

The vertical controls let you set the vertical size and placement of your waveforms. Touch the vertical icon (↕) to access these controls.



Vertical Controls

Setting Vertical Size and Offset

You can change the vertical magnification, or *size*, of a waveform. You can also move the waveform up or down on the display. This is called adjusting the vertical *offset*. To do either, touch the vertical (↕) icon; this assigns the knobs to adjust the vertical size (left knob) and offset (right knob) of a channel of the selected waveform.

Touch a knob label to display the keypad pop-up menu. This lets you set vertical size and offset numerically, or set them to maximum or minimum limits.

If you want to change the size or offset of a different waveform, touch the desired waveform to select it. Then use the knobs to adjust vertical size and offset.

Adjusting Channels and Adjusting Waveforms

When you adjust the vertical size or offset of a waveform, you are adjusting the sensitivity or DC offset of one of the channels that is in the waveform expression. If the waveform you are adjusting has the waveform expression **L1 + L2**, for example, you can adjust the vertical size of only one channel at a time. This has the following side effects:

- Changing the channel size or offset for this waveform changes the channel size or offset for all the other waveforms that display that channel.
- If the waveform you are adjusting has more than one channel in its waveform expression, changing the vertical size of one channel does not change the size of the other channels. If the vertical scale factors of all the channels in a waveform do not match, the vertical size of the waveform is undefined.

  For example, in the case of the waveform **L1 + L2**, if L1 has a vertical size of 50 mV/div and L2 has a vertical size of 100 mV/div, the waveform will have undefined vertical units.

You can select the channel you want to adjust. Whenever the vertical icon (↕) is highlighted, the **Chan Sel** selector appears between the knob labels. This selector always shows the channel the knobs are set to adjust. You can touch this selector until it shows the channel you want to adjust, then use the knobs to adjust the channel.

Adjusting High Precision Waveforms

High precision waveforms use floating-point arithmetic in their calculation. When the selected waveform is a high precision waveform, you will see **High Prec** in the bottom line of the **Vertical Desc** selector in the Waveform major menu.

You can adjust the vertical magnification and position of high precision waveforms without adjusting a channel.

See Waveform Scaling on page 228 for a description of high precision waveforms.

When you adjust the vertical controls of a high precision waveform, the **Chan Sel** selector can be used to specify the individual channel to adjust, and to specify the **Calcd Wfm**, or calculated (high precision) waveform. When you specify that you want to adjust the calculated waveform, the knobs adjust the magnification and position of the waveform without changing the vertical size and position of other waveforms displaying that channel.

Trace Separation

When you adjust the vertical size and offset of a waveform on a Window time base, the **Chan Sel** selector can be used to specify the individual channel to adjust, and to specify **Trc Sep Md**, or trace separation mode. This vertical offset control lets you move a window waveform up or down, to visually separate it from other window waveforms or from the Main time base waveform.

Waveform Definition and Management

Waveforms are the visible representation on the display of the electrical signals, or combinations of signals, that the DSA acquires and digitizes. You can define and display up to eight waveforms simultaneously.

Defining New Waveforms

You define new waveforms on a window time base using the **Window1** and **Window2** icons, described on page 231.

You can define a new waveform by:

- Pressing the appropriate Channel button on a plug-in amplifier.
- Entering a waveform description.

A waveform description is a description of the signal sources and mathematical computation that determines the waveform display. An example of a simple waveform description is **L1**, which specifies that a waveform should show the signal source from channel 1 of the left plug-in amplifier.

An example of a more complex waveform description is **Log(L1 + L2)**, which specifies that the signals from channels 1 and 2 of the left plug-in amplifier are to be algebraically added, and the base 10 log of the sum is to be shown as the final waveform.

Defining Waveforms Using the Channel Button

A short-cut method of defining waveforms is available. When you want to define a waveform that represents a plug-in amplifier channel, you can press the channel button on the plug-in amplifier. There are two limitations to this method:

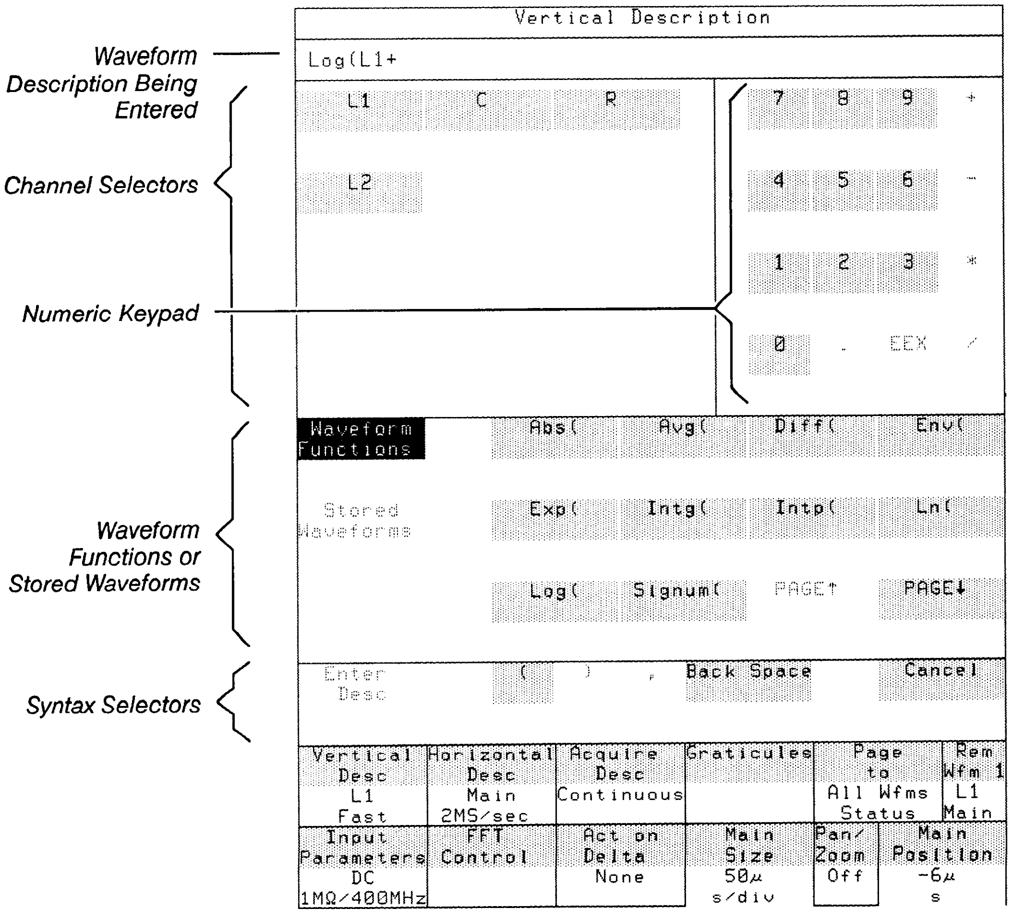
- The channel must not be displayed as part of any other waveform being displayed. If the yellow channel light is on, pressing the channel button removes all waveforms that include that channel as part of their waveform definition.
- The waveform description will consist only of this channel. You cannot use this method to enter complex waveform descriptions.

Defining Waveforms Using the DefWfm Icon

You enter waveform descriptions using the **DefWfm** icon. Touch the **DefWfm** icon above the top right corner of the graticule on which you want to define a new waveform. When you touch the icon, the **DefWfm** pop-up menu is displayed.

Use the selectors on the pop-up menu to "type" your waveform description. As you type, the waveform description you are building appears at the top of the pop-up menu. The **Back Space** selector lets you correct errors as you type. When your waveform description is complete, touch the **Enter Desc** selector to remove the pop-up menu and create the new waveform.

For example, to enter the description **Log(L1 + L2)**, touch the following selectors in sequence: **Log(**, **L1**, **+**, **L2**, **)**, **Enter Desc**.



The ***DefWfm*** *Pop-Up Menu*

The selectors in the **DefWfm** pop-up menu are grouped into the following categories:

- **Channel Selectors** let you specify a channel of a plug-in amplifier. Channel numbers of installed plug-in amplifiers only are displayed.

- **Numeric Keypad** lets you enter a numeric value, or one of the four arithmetic operators +, -, *, and /, as part of your waveform description.

You can include both waveform functions and stored waveforms in a single waveform description.

- **Waveform Functions** let you specify functions, which are listed on the next page. This area of the menu is shared with the stored waveforms selectors described below. If the **Waveform Functions** selector is highlighted, the waveform function selectors are shown. Touch the **Waveform Functions** selector to highlight it if the stored waveforms list is shown.

- **Stored Waveforms** list all the waveforms that have been stored. This area of the menu is shared with the waveform functions selectors described above. If the **Stored Waveforms** selector is highlighted, the stored waveforms selectors are shown. Touch the **Stored Waveforms** selector to highlight it if the waveform functions list is shown.

  You can combine Waveform Functions and Stored Waveforms in the same waveform description by using the **Waveform Functions** and **Stored Waveforms** selectors. The description **L1-(2*Smooth(STO1, 5))** is entered as **L1**, **-**, **(**, **2**, *****, **Smooth(**, **Stored Waveforms**, **STO1**, **,** , **5**, **)**, **)**, **Enter Desc**.

All waveform functions have an opening parenthesis. You must use a closing parenthesis to enclose the function arguments.

- **Syntax Selectors** let you specify the order of mathematical operations. Each opening parenthesis must be matched with a closing parenthesis. Use the comma (,) selector to separate arguments to functions, like **Smooth(**, that require more than one argument. Use **Back Space** to correct errors as you enter the waveform description. Always finish your waveform description by touching the **Enter Desc** selector.

Using Waveform Functions in Waveform Descriptions

Waveform functions operate on arguments which are usually input channels or waveform descriptions. The function is applied to each individual sample of the waveform. The waveform that is displayed results from the function's being applied to each sample.

Average and envelope can be applied to a waveform that is already defined and being displayed. See page 61.

Fast Fourier Transforms are described on page 87.

Waveform Functions

Function	Effect on Arguments
Abs (...)	The absolute value of the argument waveform.
Avg (...)	The average of several waveform record acquisitions of the argument. The number of records acquired is controlled by the knobs after touching the **Avg N** selector in the **Acquire Desc** pop-up menu.
Dejitter (...)	Compensates for the horizontal effects of noise to remove jitter from a repetitive signal. Dejitter can be applied only to a waveform consisting of a single input channel. A second argument, a number from 0 to 9, determines the noise tolerance; maximum dejitter is performed with a second argument of 0.
Diff (...)	The differential of the argument.
Env (...)	The limit of excursion of several waveform record acquisitions of the argument. The number of records acquired is controlled by the knobs after touching the **Env N** selector in the **Acquire Desc** pop-up menu.
Exp (...)	The natural antilog of the argument.
FFTmag(...)	Provides a Fast Fourier Transform magnitude display of a stored waveform or of a single-channel live waveform.
FFTphase (...)	Provides a Fast Fourier Transform phase display of a stored waveform or of a single-channel live waveform.
Intg (...)	The integral of the argument.

Waveform Functions (Cont.)

Stored waveforms are described on page 189.

Function	Effect on Arguments
Intp (...)	Interpolates the waveform record by replacing null points with the average value of the points on either side of the null point. You can apply the Interpolate function to any single active waveform or to any single stored waveform.
Ln (...)	The natural logarithm of the argument.
Log (...)	The base 10 logarithm of the argument.
Signum (...)	The sign of the argument. Returns 1 if the vertical data point is greater than zero, -1 if it is less than zero, and 0 if it is equal to 0.
Sqrt (...)	The square root of the argument.
Smooth (...)	A moving average of a stored waveform or single-channel live waveform. This function has two arguments, separated by a comma (,). The first argument is the waveform to be smoothed; the second is the number of samples in the moving average. If the second argument is 9, then 4 samples before each point and 4 samples after each point are averaged with the point value. If the second argument is an even number, one is subtracted from it to make it odd.

Waveform Numbers

When you define a new waveform, the DSA assigns it a waveform number. Waveform numbers range from 1 through 8. New waveforms are assigned the lowest available number. Once a number is assigned to a waveform, the number does not change.

Selecting Waveforms

When you define a new waveform, it is displayed in yellow. This indicates that it is the selected waveform. When multiple waveforms are displayed, one of the waveforms is the selected waveform.

The selectors, knobs, and buttons operate on the selected waveform. The graticule axis labels show the vertical and horizontal size and position of the selected waveform. Selectors that show waveform status, such as the **Vertical Desc** and **Horizontal Desc** selectors in the Waveform major menu, show the status of the selected waveform. When you use the horizontal (↔) and vertical (↕) icons to assign the knobs to horizontal or vertical size and position, the adjustments affect the selected waveform.

When you have more than one waveform on the display, you can select any waveform. You can select a waveform by touching it on the display or by using the All Wfms Status menu.

Selecting Waveforms by Touch

The fastest way to select a waveform is to touch it on the display. When you touch the graticule area of the display, a box is displayed that shows the boundaries of your touch. If a single waveform passes through the boxed area when you remove your finger, that waveform will become the selected waveform. The touch box disappears when you remove your finger from the display and select a waveform.

You can drag your finger across the display to change the position of the box before you lift your finger to select the waveform.

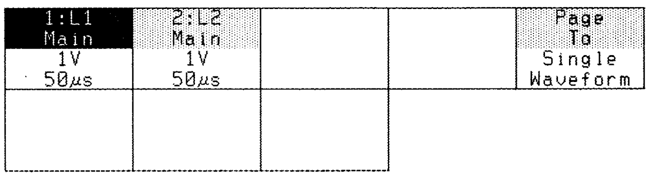
If several waveforms pass through the area indicated by the touch box, one becomes the selected waveform when you remove your finger from the display. Touching the same area repeatedly will select different waveforms. You can select waveforms by touching the same spot on the display repeatedly until the waveform you want is selected.

Selecting Waveforms Using the All Wfms Status Menu

You can see the status of all displayed waveforms at once using the All Wfms Status menu. You are shown the waveform number, the first part of the waveform description, the time base, and the vertical and horizontal size per division.

To view this information, touch the **Page to All Wfms Status** selector in the Waveform major menu or press the **WAVEFORM** button to page the Waveform major menu. The light beside the **WAVEFORM** button remains lighted.

This menu shows one selector for each displayed waveform. You can select any waveform by touching its selector. The selector for the selected waveform is always highlighted. Touch the **Page to Single Waveform** selector or press the **WAVEFORM** button to restore the regular Waveform major menu.



The All Wfms Status Menu

Modifying Waveforms

You can change the waveform description of the selected waveform. When you touch the **Vertical Desc** selector in the Waveform major menu, the **Vertical Desc** pop-up menu is displayed.

This menu is identical to the pop-up menu that is displayed when you touch the **DefWfm** icon. When you display the **Vertical Desc** pop-up menu, the waveform description of the selected waveform appears at the top of the pop-up menu. You can use the **Back Space** selector to alter the waveform, or you can extend the waveform description. When you touch the **Enter Desc** selector, the new waveform description is applied to the selected waveform.

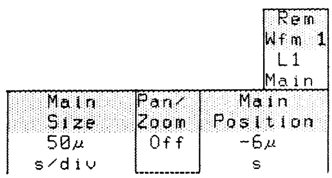
Removing Waveforms

You can remove waveforms from the display in two different ways: using the **Rem Wfm** selector in the knob menu or using the Channel button on the plug-in amplifier.

Removing Waveforms Using the Rem Wfm Selector

The **Rem Wfm** selector in the status area always shows the number, the waveform description, and the time base of the selected waveform. The status area is displayed at all times, so the **Rem Wfm** selector is available regardless of the major menu displayed.

When you touch the **Rem Wfm** selector, a small pop-up menu asks you to verify that you want to remove the waveform. This prevents accidental removal of waveforms.



The **Rem Wfm** *Selector in the Knob Menu*

Removing Waveforms Using the Channel Button

You can use the **CH** button on the plug-in amplifier to remove all waveforms displaying that channel as part of their waveform description.

When a channel on a plug-in amplifier is incorporated as part of a waveform, the yellow channel light on the plug-in amplifier is on. If you press the channel button when the light is on, *all* waveforms displaying that channel are removed.

Waveform Scaling

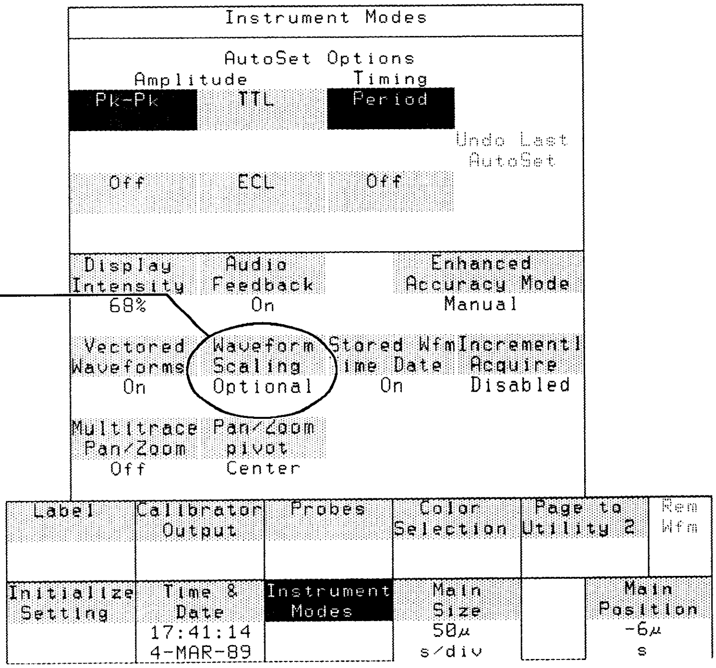
When you define a new waveform, it is defined as either a fast waveform or a high precision waveform. Fast waveforms are computed with integer arithmetic, and operate significantly faster than high precision waveforms. High precision waveforms use floating-point arithmetic to provide highest precision and accuracy.

Normally, the waveform is defined to be fast unless some part of the waveform description forces high precision. Floating-point functions such as **Diff(** and **Log(** will force the waveform to be defined as high precision.

You can force all waveforms to be defined as high precision waveforms by using the **Instrument Modes** pop-up menu in the Utility 1 major menu. In this pop-up menu, the **Waveform Scaling** selector can be set to **Optional** or **Forced**. When set to optional, new waveforms are defined as fast waveforms if they can be implemented as fast waveforms. When set to forced, new waveforms are defined as high precision waveforms.

Once a waveform is defined, its waveform scaling cannot be changed. The setting of the **Waveform Scaling** selector affects only the definition of new waveforms.

The **Waveform Scaling** *Selector*



The **Instrument Modes** *Pop-Up Menu*

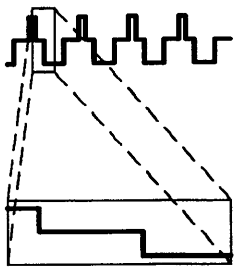
Windows

A window waveform is a waveform that represents a horizontally magnified portion of another waveform. A window waveform is acquired separately from the main waveform that it magnifies.

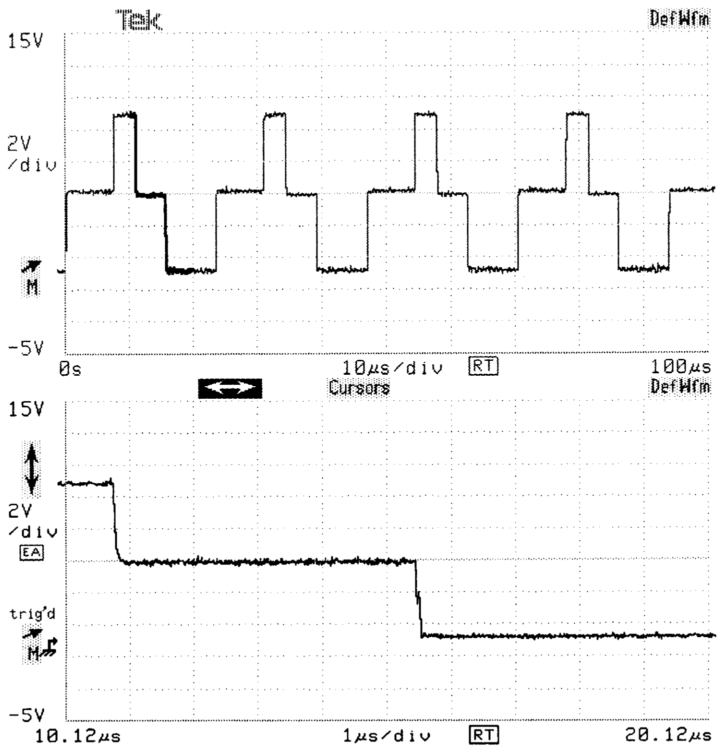
Creating a Window

You create a window by touching the **Window1** icon above the graticule. When you touch the **Window1** icon, the DSA creates a second graticule to show the window waveform. If a second graticule already exists, the window waveform will be displayed on the lower graticule.

Main



Window



A Window Waveform Display

When you create a window waveform, it becomes the selected waveform. The DSA shows this waveform in the selected window waveform color and highlights the windowed portion of the main waveform in this color.

Window Time Base and Trigger

The window waveform has the same waveform expression as the main waveform. The difference between the two is the time base that each uses; the main waveform uses the Main time base, while the window waveform uses a Window time base. The **Horizontal Desc** selector in the Waveform major menu always shows the time base of the selected waveform.

For more information on Triggering, see page 199.

The Window time base can be triggered from the Main trigger or by a separate Window trigger. To define a window trigger, set **Trigger Select** in the Trigger major menu to **Window**, then select either **Window Holdoff By Time** or **Window Holdoff By Events** from the lower section of the Window Trigger **Source Desc** pop-up menu. You can then set the Window trigger source, level, and holdoff just as you set the Main trigger. If you define a Window trigger, the Window trigger icon ( ) will appear to the left of the graticule when a window waveform is selected and a second trigger arrow may appear on the main waveform.

For more information on Record Length, see page 175.

You can set the record length for window waveforms by touching the **Window Record Length** selector in the **Horizontal Desc** pop-up menu. The knobs will be assigned to adjust the Main and Window record lengths.

The window waveform is independent of the main waveform. Once a window waveform is established, you can remove the main waveform or move the window waveform from graticule to graticule.

Creating a Second Window

You can create two window waveforms from each main waveform. After you create one window waveform, the **Window2** icon becomes available when the main waveform is selected. Touching this icon creates a second window waveform. Once a window waveform is created, touching the **Window1** or **Window2** icon simply selects that waveform. You cannot create a window waveform of a window waveform.

Changing Window Size and Position

All window waveforms are the same horizontal size. If you change horizontal size on one window waveform, you change horizontal size on all window waveforms.

You can change the size and position of a window waveform just as you do with any main waveform. Touch the horizontal icon (↔) to assign the knobs to horizontal size and position. Complete information about horizontal size and position is on page 125.

All main waveforms share the same time base, so all have the same horizontal size and position. Each window waveform has its own time base, so each can have a different horizontal position. However, all window time bases have the same horizontal size. When you touch the horizontal icon (↔), the knobs are assigned to **Window Size** and **Window1 Position** or **Window2 Position**. The window size must be less than the main horizontal size.

As you change the horizontal size or position of a window waveform, the highlighted portion of the main waveform changes size and position. This allows you to always see the portion of the main waveform that the window waveform magnifies.

Trace Separation

When you touch the vertical icon (↕), the **Chan Sel** selector will indicate **Trc Sep Md**, or trace separation mode. In trace separation mode, the knobs are labeled **Trace Separation** and move the selected waveform up or down without moving other waveforms that show the same channels as the selected waveform. The offset of the plug-in channel is not changed. This lets you visually separate the selected window waveform from other window or main waveforms that may overlap it.

When you have used trace separation mode to move a window waveform, the graticule labels and ground reference indicator ( ) always apply to the selected window waveform.

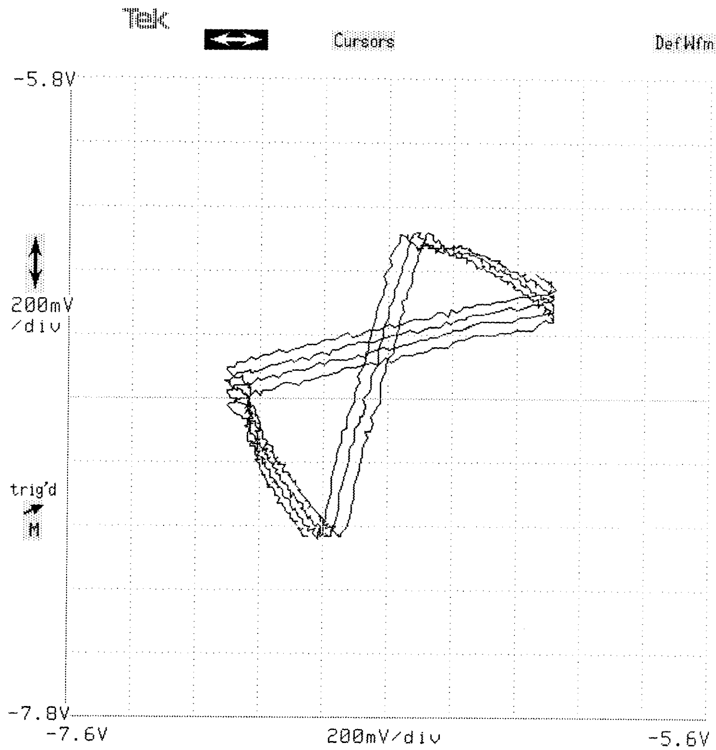
You can use the **Chan Sel** selector to select a channel, and then adjust the vertical size or offset just as you would with any main waveform. Touch the **Chan Sel** selector until it indicates the channel you want. Complete information about vertical size and offset is on page 215.

XY Waveforms

Most waveforms show a signal voltage (the vertical axis) as it varies over time (the horizontal axis). You can display a waveform that compares the amplitudes of two waveforms, independent of time. Such an XY waveform shows the signal voltage of one waveform on one axis against the signal voltage of the other waveform on the other axis.

You cannot take measurements of XY waveforms.

At most one actively acquired XY waveform or two stored XY waveforms may be displayed at one time.



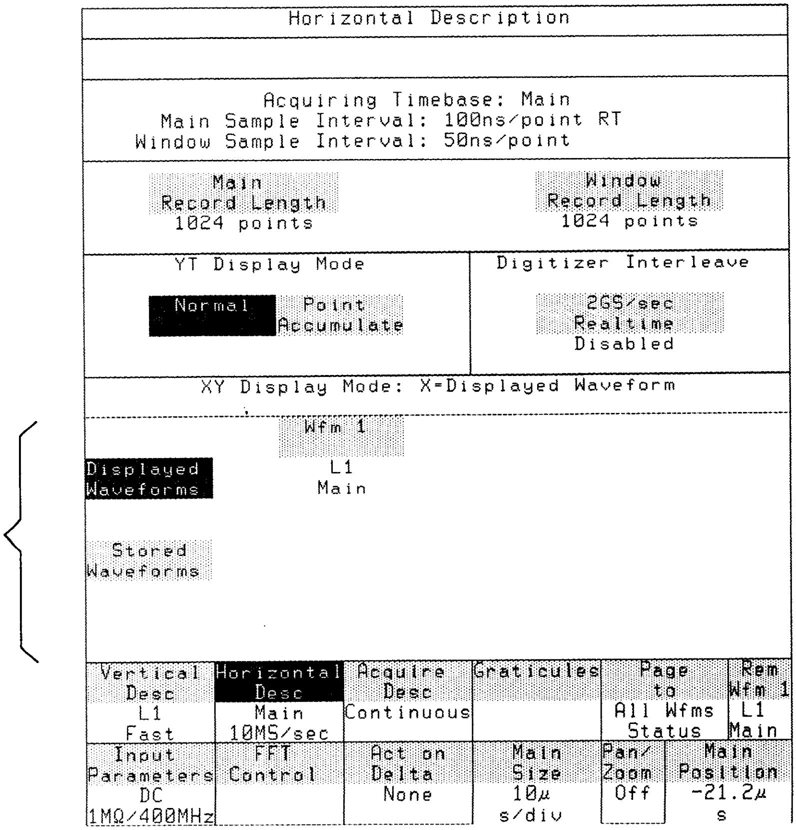
An XY Waveform

Fast and high-precision waveforms are described in Waveform Scaling on page 228.

You can create an XY waveform to compare the amplitudes of two high-precision waveforms, or of two fast waveforms, but you cannot combine a fast waveform with a high-precision waveform.

Creating an XY Waveform

You initiate and control an XY waveform using the **Horizontal Desc** pop-up menu in the Waveform major menu. The **XY Display Mode** section of this menu allows you to choose **Displayed Waveforms** or **Stored Waveforms**.



The **Horizontal Desc** *Pop-Up Menu*

The sequence to follow when creating an XY waveform is:

- [ ] Step 1: Define a waveform that shows the information you want on the X axis (the horizontal axis). This waveform may be a displayed waveform or a stored waveform.

- [ ] Step 2: Define and display a waveform with the information you want on the Y axis (the vertical axis).

- [ ] Step 3: Touch or otherwise select the waveform that displays the Y-axis information.

- [ ] Step 4: Press the **WAVEFORM** major menu button, and touch the **Horizontal Desc** selector to display the pop-up menu.

- [ ] Step 5: If the waveform that shows the information for the X axis is a displayed waveform, verify that **Displayed Waveforms** is selected in the **XY Display Mode** section of the pop-up menu. If the X-axis waveform is a stored waveform, **Stored Waveforms** should be selected.

- [ ] Step 6: Touch the selector in the **Horizontal Desc** pop-up menu that represents the waveform showing the X-axis information.

When you touch the X-axis waveform selector in the **Horizontal Desc** pop-up menu, the selected waveform is immediately converted into an XY waveform on the display. The waveform description of the X-axis waveform appears in the **Horizontal Desc** selector, and the waveform description of the Y-axis waveform appears in the **Vertical Desc** selector.

If the waveform defining the X-axis information is a displayed waveform, this process will leave two waveforms on the display: the XY waveform and the X-axis information waveform. Once the XY waveform is established, you can remove the waveform defining the X-axis information.

To restore an XY waveform to normal Yt (voltage versus time) mode, select the XY waveform and touch the **Normal** selector in the **Horizontal Desc** pop-up menu.

Adjusting Size and Position

You can adjust the vertical and horizontal size and position of an XY waveform.

Touch the vertical icon (↕) to adjust the vertical size and position of the XY waveform. The knobs will be assigned to adjust **Vertical Size** and **Vertical Offset** of a channel that is displayed as part of the vertical axis description of the XY waveform. If the vertical axis description includes more than one channel, you can select and adjust the channels separately by touching the **Chan Sel** selector. The selected channel appears in the **Chan Sel** selector and in the knob labels.

Touch the horizontal icon (↔) to assign the knobs to adjust the horizontal size and position of the XY waveform. Since voltage information is displayed along the horizontal axis, horizontal position is controlled by adjusting the vertical size and offset of the channel(s) of the X-axis waveform. The knob labels will display **Horizontal Pos: XY** and **Horizontal Size: XY** , and the channel controlled by the knobs will appear in the **Chan Sel** selector. If more than one channel is displayed along the X axis, use the **Chan Sel** selector to select each displayed channel.

When you adjust the horizontal or vertical size and position of an XY waveform that displays stored waveform information, the **Chan Sel** selector displays **Calcd Wfm**, and adjusting the size and position scales the waveform.

Appendix A: Accessories

Standard Accessories

The DSA 601 or DSA 602 instrument package includes the following standard accessories:

- *DSA 601 and DSA 602 Tutorial*, Tektronix part number 070-7249-00.
- *DSA 601 and DSA 602 User Reference* (this manual).
- *DSA 601 and DSA 602 Programmer Reference*, Tektronix part number 070-7251-00.
- *DSA 601 and DSA 602 Command Reference*, Tektronix part number 070-7252-00.
- *DSA 601 and DSA 602 Service Reference*, Tektronix part number 070-7254-00.
- Power Cord (North American 120 V), Tektronix part number 161-0066-00.

To obtain replacements, refer to a Tektronix products catalog or contact your local Tektronix field representative.

Optional Accessories

The following optional accessories have been selected from our catalog specifically for the DSA 601 and DSA 602 Digitizing Signal Analyzers. For detailed information and prices, see a Tektronix products catalog or contact your local Tektronix field representative.

- Option 1R Rack Mount, which converts the DSA for rack mounting.
- Option 2R Without Scopemobile, which deletes the Scopemobile cart and which is usually ordered with Option 1R.
- Option 1D Loop-through BNC's, which adds eight BNC's to the front and rear panels so that signals may be routed from the front panel to the rear panel (or rear to front).

- Option 3C Acquisition Memory External Power Input, which allows external battery power to back up the acquisition memory of the DSA. Option 3C adds an external power connector to the rear panel, adds an HSDMA board (signal processor), and removes waveform processor features (Fast Fourier Transforms, Act on Delta, and the Dejitter function). This option is appropriate for single-shot acquisition only.
- Option 4C Nonvolatile RAM, which adds nonvolatile memory for internal storage of 468,288 waveform points.
- Two-meter GPIB cable, Tektronix part number 012-0991-00.
- Ten-foot RS-232-C cable, Tektronix part number 012-0911-00.
- Ten-foot Centronics printer cable, Tektronix part number 012-0555-00.
- Tektronix 4692, 4693D, or 4696 Color Ink-jet printer, or Tektronix HC-100 pen plotter.
- Tektronix P6701 and P6702 optical to electrical converters.
- Tektronix P6408 word recognizer probe.

Power Cord Options

The following power cords are available for the DSA:

- Option A1 Universal European 220 V/6A, 50 Hz, Tektronix part number 161-0066-09.
- Option A2 United Kingdom 240 V/13A, 50 Hz, Tektronix part number 161-0066-10.
- Option A3 Australian, 240 V/10A, 50 Hz, Tektronix part number 161-0066-11.
- Option A4 North American 240 V/15A, 60 Hz, Tektronix part number 161-0066-12.
- Option A5 Switzerland 220 V/10A, 50 Hz, Tektronix part number 161-0154-00.

Appendix B: Specifications

The electrical characteristics apply to the following conditions:

- The DSA has had a 20-minute warm-up period.
- The DSA is operating in an environment that meets the limits described in Environmental Specifications in this section.

Vertical System Specifications

Characteristic	Specifications
Input sources	3 plug-in amplifiers, up to 12 channels
Bandwidth	Dependent on plug-in amplifier
Rise time	Dependent on plug-in amplifier
Amplifier gain accuracy	±1% of full-scale range, in Enhanced Accuracy state
Vertical resolution	8 bits Signal averaging of N acquisitions increases bit resolution by $\log_2(N)$ up to a limit of 14 bits
Input sensitivity	Dependent on plug-in amplifier
Vertical acquisition resolution	
Single graticule	25 points/div
Dual graticule	25 points/div
Vertical display resolution	
Single graticule	50 pixels/div
Dual graticule	25 pixels/div
Antialiasing Filter	
Bandwidth	100 MHz
Attenuation	-17 dB at 250 MHz, -25 dB at $\geq$ 500 MHz

Time Base Specifications

Characteristic	Specification
Internal reference clock	500 MHz surface acoustic wave resonator oscillator
Time Base Accuracy	+0.005%, -0.015%, from 0°C to 50°C
Sample rate	
DSA 601	1 Gigasample/s maximum (single channel, from Left plug-in compartment)
DSA 602	2 Gigasample/s maximum (single channel, from Left plug-in compartment)
Record Length	User selectable, 512, 1024, 2048, 4096, 5120, 8192, 10240, 16384, 20460, or 32768
Sweep rates	In general, a 1-2-5 sequence from 200 ps/div to 100 s/div
Record duration	2.04 ns to 1023.95 s

Input and Output Specifications

Characteristic	Specification
Touch panel	Infrared beam touchable array, 22 rows of 11 columns
Knobs	2 general-purpose knobs, set by user to desired function
Calibrator output: DC Levels	DC voltages suitable for calibrating the gain of 10X probes from the probe tip at $\leq$5 V/div
Calibrator output: Low-Frequency AC Square Wave	
Frequency	1.000 kHz $\pm$ 0.1%
Voltage	5.0 V $\pm$ 3% into 1 MΩ load, 500 mV $\pm$ 3% into a 50 Ω load. Positive polarity with baseline at 0 V.
Output Resistance	450 Ω $\pm$ 0.5%
Calibrator output: High Frequency AC Square Wave	
Frequency	1.024 MHz $\pm$ 0.1%

Trigger Specifications

Characteristic	Specification
Trigger source	Two independent trigger circuits can derive triggers from the Left, Center, and Right plug-in compartments
Trigger mode	
Auto	Free runs after 40 ms timeout (Main trigger only)
Auto Level	Automatically establishes a level for the trigger source; seeks new level after 40 ms timeout. Main free runs in absence of signal
Normal	Triggering occurs only after valid triggering event
Trigger level	Can be set independently for two trigger circuits. In Basic Trigger, Level determines the vertical position on the trigger signal where triggering can occur. In Extended Trigger, Level is the threshold that determines the state (high or low) of the trigger signal
Trigger level resolution	0.01 divisions
Trigger accuracy	0.2 divisions

Trigger Specifications (Cont.)

Characteristic	Specification
Trigger sensitivity	
DC coupled	0.4 divisions from DC to 50 MHz, increasing to 1 division at maximum trigger bandwidth
DC Noise-Reject Coupled	1.2 divisions from DC to 50 MHz, increasing to 3 divisions at maximum trigger bandwidth
DC High-Freq. Reject Coupled	0.5 divisions from DC to 30 kHz
AC coupled	0.4 divisions from 60 Hz to 50 MHz, increasing to 1 division at maximum trigger bandwidth
AC Noise-Reject Coupled	1.2 divisions from 60 Hz to 50 MHz, increasing to 1 division at maximum trigger bandwidth
AC High-Freq. Reject Coupled	1.2 divisions from 60 Hz to 50 MHz, increasing to 3 divisions at maximum trigger bandwidth
AC Low-Freq. Reject Coupled	0.5 divisions from 80 kHz to 50 MHz, increasing to 1 division at maximum trigger bandwidth
Main holdoff	Minimum 2 μs holdoff
Window holdoff	Minimum 35 ns holdoff
Boolean trigger	
Minimum TRUE time	The Boolean trigger function must remain TRUE a minimum of 2 ns in order to be recognized
Minimum FALSE time	2 ns prior to being recognized

Trigger Specifications (Cont.)

Characteristic	Specification
Time Qualified trigger, single timer	
Time Interval Range	2 ns to 1.048 ms
Time Interval Resolution	2 ns increments
Time Interval Accuracy	Within 2% of reading ± 2 ns
Time Qualified trigger, trigger time bracket defined (>t1<t2 or <t1>t2)	
Time Interval Range	Lower bound range: 2 ns to 1.048 ms. Upper bound range: lower bound + (2 ns to 1.048 ms)
Time Interval Resolution	2 ns (upper or lower bound)
Time Interval Accuracy	Lower bound within 2% of reading ± 3 ns. Upper bound within 2% of reading ± 4 ns
Edge Qualified trigger	
Set-up time, ENABLE to EDGE	The enabling trigger source must be stable (either high or low) at least 2 ns before the transition of the edge trigger source
Hold time, EDGE to ENABLE	The enabling trigger source must be stable (either high or low) at least 2 ns after the transition of the edge trigger source
Set-up time, EDGE to itself	The edge trigger source must remain stable (either high or low) for at least 2 ns immediately before the transition
Hold time, EDGE to itself	The edge trigger source must remain stable (either high or low) for at least 2 ns immediately following the transition

Display Specifications

Characteristic	Specification
CRT	10 inch diagonal, color, magnetic deflection. Nominal screen size 168mm (6.6 inch) vertical by 130mm (5.1 inch) horizontal
Video resolution	704 pixel vertical by 552 pixel horizontal
Character display	44 lines of 55 characters
Character height	Minimum 2.6mm (upper case)
Character cell	16 pixel vertical by 10 pixel horizontal

AC Line Power Specifications

Characteristic	Specification
Voltage Ranges	90 to 132 V rms or 180 to 250 V rms Voltage ranges apply for waveform distortion, which reduces peak line voltage 5% or less
Frequency	48 Hz to 72 Hz
Power DSA 601 DSA 602	 465 W 585 W
Maximum Line Current DSA 601 DSA 602	 8 A rms at 50 Hz, 90 V line 9.5 A rms at 50 Hz, 90 V line
Fuse Rating	12 A, 250 V slow blow

Environmental Specifications

Characteristic	Specification
Temperature	Meets MIL-T-28800C, Type III, Class 5, tested per paragraphs 4.5.5.1.3 and 4.5.5.1.4
Operating	0 °C to 50 °C
Non-operating	-40 °C to +75 °C (Possible loss of nonvolatile memory and clock information below -40 °C
Humidity	Exceeds MIL-T-28800C, Type III, Class 5, tested per paragraph 4.5.5.1.2.2 Up to 95% relative humidity, at up to 50 °C
Altitude	Meets MIL-T-28800C, Type III, Class 5
Operating	Up to 4.5km (15,000 ft)
Non-operating	Up to 15km (50,000 ft)
Vibration	Operating, plug-in units not installed: meets MIL-T-28800C, Section 4.5.5.3.1, Type III, Class 5
Shock	Non-operating, plug-in units not installed: meets MIL-T-28800C, Section 4.5.5.4.1, Type III, Class 5, Equipment not operating
Bench handling	Operating: meets MIL-T-28800C, Type III, Section 4.5.5.4.3, Class 5
Packaged product vibration and bounce	Packaged product, plug-in units not installed: meets ASTM D99-75, Method A, Para 5 (NSTA Proj. 1A-B-1)

Environmental Specifications (Cont.)

Characteristic	Specification
Drop of packaged product	Packaged product, plug-in units not installed: meets ASTM D775-61, Method 1, Para 5 (NSTA Proj. 1A-B-2)
Electrostatic immunity	No disruption or degradation of performance from electrostatic discharge common in the office/ laboratory environment
Electromagnetic compatibility	Plug-in units or blank panels must be installed in all plug-in compartments

Appendix C: Safety

The following safety information is provided for your protection and to prevent damage to the DSA, and 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.

Terms 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

Symbols on Equipment

DANGER
High Voltage

Protective ground (earth) terminal

ATTENTION
Refer to manual

Power Source

This product is intended to operate from a power source that will not apply more than 250 V rms between the supply conductors or between either supply conductor and ground.

Grounding the DSA

The DSA is grounded through the power cord. To avoid electric shock, plug the power cord into a properly wired receptacle where earth ground has been verified by a qualified service person. Do this before making connections to the input or output terminals of the DSA.

Without the protective ground, all parts of the DSA are shock hazards. This includes knobs and controls that may appear to be insulators.

Use the Proper Fuse

Using an improper fuse can create a fire hazard. Always use fuses that exactly meet the specifications in the parts list. Match fuse type, voltage rating, and current rating.

Do Not Remove Covers or Panels

CAUTION

Operating the DSA without the covers in place may cause overheating and harm the DSA.

To avoid personal injury, do not operate the DSA without the panels or covers.

Do Not Operate in Explosive Atmospheres

The DSA provides no explosion protection from static discharges or arcing components. Do not operate the DSA in an atmosphere of explosive gases.

Electrostatic Discharge

CAUTION

Applying a voltage outside the range printed on the plug-in unit can result in damage. Static electricity is also a hazard.

Never apply a voltage to a plug-in unit that is outside the range printed on the front panel of the plug-in unit. Operate the DSA only in a static-controlled environment.

Packaging for Shipment

If you ship the DSA, pack it in the original shipping carton and packing material. If the original packing material is unavailable, package the DSA as follows:

- [ ] Step 1: Obtain a corrugated cardboard shipping carton with inside dimensions at least 15cm (6 in) taller, wider, and deeper than the DSA. The shipping carton must be constructed of cardboard with 375 pound test strength.
- [ ] Step 2: If you are shipping the DSA to a Tektronix field office for repair, attach a tag to the DSA showing the DSA owner and address, the name of the person to contact about the DSA, the DSA type, and the serial number.
- [ ] Step 3: Wrap the DSA with polyethylene sheeting or equivalent material to protect the finish.
- [ ] Step 4: Cushion the DSA on all sides by tightly packing dunnage or urethane foam between the carton and and the DSA, allowing 7.5cm (3 in) on each side.
- [ ] Step 5: Seal the carton with shipping tape or an industrial stapler.

Appendix D: Algorithms

Digitized waveforms are a sequence of samples stored as16-bit signed integers. The samples are numbered from 0 through the waveform record length less one; a 512-point waveform record numbers samples from 0 through 511.

Three sample values represent invalid data points:

- The value -32,768 (hexidecimal 8000) represents *null*, an unacquired data point. A waveform that is defined but has never been acquired contains null values. Clearing a waveform fills it with null values.

- The value -32,767 (hexidecimal 8001) represents a data value below the dynamic range of the digitizer. This is called *underrange*. Underrange values do not appear on a displayed waveform.

- The value +32,767 (hexidecimal 7FFF) represents a data value above the dynamic range of the digitizer. This is called *overrange*. Overrange values do not appear on a displayed waveform.

When a waveform function encounters one of these three data values, it passes the invalid data value as its output. When a measurement encounters one of these three data values, the measurement is qualified by $\leq$, $\geq$, **?**, or noted as an error. There are exceptions to these rules, as noted below. All waveform functions assume that the waveform record contains data other than these three values, unless specifically noted.

Waveform Functions

Absolute Value

$$Abs(n) = W(n)$$

$$\text{for } W(n) \geq 0$$

$$Abs(n) = -W(n)$$

$$\text{for } W(n) < 0$$

where:

n = index into the record of data points
$W(n)$ = input sampled data point

Average

$$Avg_p(n) = W(n)$$

$$\text{for } p = 1$$

$$Avg_p(n) = Avg_{p-1}(n) + \frac{W(n) - Avg_{p-1}(n)}{p}$$

$$\text{for } 1 < p < P$$

$$Avg_p(n) = Avg_{p-1}(n) + \frac{W(n) - Avg_{p-1}(n)}{P}$$

$$\text{for } p \geq P$$

where:

n = index into record of data points
$W(n)$ = input sampled data point
p = record number
P = total number of records specified for average

Dejitter

To perform the dejitter function, the DSA chooses a reference edge on the first acquisition of a waveform. This reference edge is found within the first 3/4 of the waveform record, excluding the first 1/8 of the record. On all subsequent acquisitions of the waveform, the DSA attempts to line up the appropriate edge of the waveform with the reference edge.

Edges are lined up to within a minimum tolerance that is determined by second argument (a number between 0 and 9) to the dejitter function. The smaller the number, the smaller the acceptable variation will be.

Differentiate

$$Diff(n) = [W(1) - W(0)]/T$$

$$\text{for } n = 0$$

$$Diff(n) = [W(n+1) - W(n-1)]/(2T)$$

$$\text{for } 1 \leq n \leq (R-1)$$

$$Diff(R-1) = [W(R-1) - W(R-2)]/T$$

$$\text{for } n = R-1$$

where:

n = index into the record of data points
$W(n)$ = input sampled data point
T = time interval between successive samples
R = record length

Envelope

$$Env_p(n) = \text{null}$$

$$\text{for } p = 0$$

$$Env_p(n) = Minimum\ of\ [Env_{p-1}(n), W(n-1), W(n)]$$

$$\text{for } p > 0 \text{ and } n \text{ odd}(1, 3, 5, \ldots, R-2)$$

$$Env_p(n) = Maximum\ of\ [Env_{p-1}(n), W(n), W(n+1)]$$

$$\text{for } p > 0 \text{ and } n \text{ even}(2, 4, 6, \ldots, R-1)$$

where:
n = index into record of data points
$W(n)$ = input sampled data point
p = record number
R = record length

P , the total number of records specified for enveloping, is used only to determine completion for conditional acquisition, when acquisition is stopped on envelope complete.

Exponential

$$Exp(n) = e^{W(n)}$$

where:
n = index into record of data points
$W(n)$ = input sampled data point

This function is implemented by a polynomial series approximation in the waveform processor.

Fast Fourier Transform

The DSA computes an integer radix-2 FFT of a complex sequence:

$$x(n) = W(n) + jb(n)$$

where

$W(n)$ = the time-domain waveform point
$b(n)$ = 0

$X(k)$, the complex sequence representing the Discrete Fourier Transform of the sequence $x(n)$, is computed as:

$$X(k) = \sum_{n=0}^{R-1} x(n) \times W_R^{k \times n}$$

$$\text{for } k = [0 \; . \; . \; . \; R-1]$$

where

R, the record length, is a power of 2

$W_R = e^{-j\frac{2\pi}{R}}$

The linear magnitude (FFT_{mag}) and the phase (FFT_{phase}) of the FFT are computed as:

$$FFT_{mag}(k) = \sqrt{A(k)^2 + B(k)^2}$$

$$FFT_{phase}(k) = \arctan\left(\frac{B(k)}{A(k)}\right)$$

where

$A(k)$ = real part of $X(k)$
$B(k)$ = imaginary part of $X(k)$

The magnitude and phase for negative frequencies are discarded, and linear interpolation is used to expand the positive frequencies to fill the entire record length.

The magnitude of the frequency spectrum in decibels is given as:

$$FFT_{magdB}(k) = 20\log(FFT_{mag}(k))$$

where the 0 dB point is defined as the sine wave of 0.316 V peak (0.224 V rms), which gives 1.0 mW into 50 Ω.

FFT Windowing Functions

The selected FFT windowing function is applied to the time-domain waveform before the FFT is computed. The FFT windowing functions are as follows:

Rectangular

$$x(n) = \sum_{n=0}^{R-1} 1$$

Triangular

$$x(n) = \sum_{n=0}^{\frac{R}{2}} (2\frac{n}{R}) \quad , \quad \sum_{n=\frac{R}{2}}^{R-1} (2 - 2\frac{n}{R})$$

Hanning

$$x(n) = \sum_{n=0}^{R-1} 0.5(1 - cos(2\pi\frac{n}{R}))$$

Hamming

$$x(n) = \sum_{n=0}^{R-1} 0.54 - 0.46(1 - cos(2\pi\frac{n}{R}))$$

Blackman

$$x(n) = \sum_{n=0}^{R-1} 0.42 - 0.5cos(2\pi\frac{n}{R}) + 0.08cos(4\pi\frac{n}{R})$$

Blackman-Harris

$$x(n) = \sum_{n=0}^{R-1} 0.35875 - 0.48829cos(2\pi\frac{n}{R}) + 0.14128cos(4\pi\frac{n}{R}) - 0.01168cos(6\pi\frac{n}{R})$$

where

R = the record length, which must be a power of 2.

The filter characteristics of the FFT windowing functions are summarized in the table below.

Filter Characteristics of FFT Windowing Functions

Windowing Function	Highest Side-lobe (dB)	Noise Band-width (bins)	3 dB Band-width (bins)	6 dB Band-width (bins)	Scallop Loss (dB)	Worst Loss (dB)
Rectang-ular	-13	1.00	0.89	1.21	3.92	3.92
Triangular	-27	1.33	1.28	1.78	1.82	3.07
Hanning	-32	1.50	1.44	2.00	1.42	3.18
Hamming	-43	1.36	1.30	1.81	1.78	3.10
Blackman	-58	1.73	1.68	2.35	1.10	3.47
Blackman-Harris	-92	2.00	1.90	2.72	0.83	3.85

These numbers are taken from a table in Frederic J Harris: *Handbook of Digital Signal Processing*, edited by Douglas F. Elliot, Academic Press, San Diego, 1987, pp. 254-255.

where

bins refers to the frequency bins, the even-numbered points in the FFT waveform

highest sidelobe is the minimum stopband attenuation, which indicates how well leakage is blocked.

noise bandwidth is the equivalent noise bandwidth (the width of an equivalent rectangular spectral response that would pass the same noise power as this windowing function).

3 dB bandwidth and **6 dB bandwidth** apply to the major lobe. These affect the frequency resolution.

scallop loss is the attenuation of the windowing function at the odd-numbered (interpolated) points in the FFT waveform.

worst loss is the worst-case processing loss (the sum of the scallop loss and the equivalent noise bandwidth, in dB.)

Integrate

$$Intg(n) = 0$$

$$\text{for } n = 0$$

$$Intg(n) = \left[1/2 \;\; W(0) + \sum_{m=1}^{n-1} W(m) + 1/2 \;\; W(n) \right] \times T$$

$$\text{for } 1 \leq n \leq R$$

where:

n = index into record of data points
$W(n)$ = input sampled data point
T = time interval between successive samples
R = record length in points

Interpolate

$$Intp(n) = W(l) + \left[\frac{W(r) - W(l)}{r - l}\right] \times (n - l)$$

for all n ; $l \geq 0$ and $r \leq R - 1$

$$Intp(n) = W(r)$$

for all n ; $l < 0$ and $r \leq R - 1$

$$Intp(n) = W(l)$$

for all n ; $l \geq 0$ and $r > R - 1$

$$Intp(n) = W(n)$$

otherwise

where
- n = index into record of data points
- $W(n)$ = input sampled data point
- R = record length in points
- l = index of the acquired data point preceding the unacquired data
- r = index of the acquired data point following the unacquired data

Logarithm

$$Log(n) = \log_{10} W(n)$$

where:
- n = index into record of data points
- $W(n)$ = input sampled data point

This function is implemented by a polynomial series approximation in the waveform processor.

Natural Logarithm

$$Ln(n) = \log_e W(n)$$

where:

n = index into record of data points
$W(n)$ = input sampled data point

This function is implemented by a polynomial series approximation in the waveform processor.

Signum

$$Signum(n) = 1$$
$$\text{for } W(n) > 0$$
$$Signum(n) = 0$$
$$\text{for } W(n) = 0$$
$$Signum(n) = -1$$
$$\text{for } W(n) < 0$$

where:

n = index into record of data points
$W(n)$ = input sampled data point

Smooth

$$Smooth(n) = (1/s)\left[\sum_{m=0}^{n+h} W(m) + (h - n) \times W(0)\right]$$

for $n < h$

$$Smooth(n) = (1/s)\left[\sum_{m=n-h}^{n+h} W(m)\right]$$

for $h \leq n \leq R - 1 - h$

$$Smooth(n) = (1/s)\left[\sum_{m=n-h}^{R-1} W(m) + (R - 1 - n) \times W(R - 1)\right]$$

for $n > R - 1 - h$

where:

n = index into record of data points
$W(n)$ = input sampled data point
s = smoothing interval in samples; the second argument
h = half interval: (s − 1)/2 rounded down
R = record length in points

The smoothed waveform is derived by computing the average value of the corresponding point of the original waveform and some number of points of the original waveform on either side of the corresponding point. The number of points on either side is derived from the smoothing interval, the second argument of the Smooth function.

Near the ends of the waveform, nonexistent points beyond the ends of the waveform are required for averaging. The nonexistent points are assumed to be the value of the corresponding end points. This method of extending the waveform is arbitrary, so the results within a smoothing interval of the ends of the waveform must be interpreted accordingly.

Square Root

$$Sqrt(n) = W(n)^{1/2}$$

where:

n = index into record of data points

$W(n)$ = input sampled data point

This function is implemented by a polynomial series approximation in the waveform processor.

Measurements

Measurements are taken using the measurement parameters. You can directly set many the measurement parameters, or you can specify that some are to be determined automatically by the DSA. It is common to have the DSA dynamically measure topline and baseline.

You specify automatic topline and baseline positioning by turning tracking on in the individual measurement pop-up menus. The mesial level, when topline and baseline are automatically positioned by tracking, is calculated:

$$mesial = [(m\%/100) \times (topline - baseline)] + baseline$$

where $m\%$ is the percentage of topline to baseline height to use for mesial level. Proximal and distal levels are calculated similarly from percentage levels. These percentage levels are set using the knobs.

When you use tracking, the topline and baseline are determined from a histogram of the waveform, as follows:

1. Create a histogram of the waveform data points. For each possible vertical value, count the number of data points having that value.

2. The largest value that has a non-zero point count is the maximum value.

3. The smallest value that has a non-zero point count is the minimum value.

4. Determine the median value, halfway between the maximum and minimum values.

5. Examine the point counts between the median value and the maximum value, to find the largest point count. If this point count is greater than the *Floor* value (defined below), the value associated with the point count is the topline. If the largest point count is not greater than *Floor* , then the maximum value is used as the topline.

6. Examine the point counts between the median value and the minimum value, to find the largest point count. If this point count is greater than the *Floor* value (defined below), the value associated with the point count is the baseline. If the largest point count is not greater than *Floor*, then the minimum value is used as the baseline.

   The *Floor* value is calculated as the maximum of two values, *AVE* and *Correction*, to insure that the topline or baseline calculated is appropriate for the waveform measurement zone.

$$AVE = \frac{2}{n} \sum_{j=1}^{n} count_j$$

where:

$count_j$ = the j th non-zero point count in the waveform histogram

n = the number of non-zero point counts in the waveform histogram

$$Correction = 8 + MULT\frac{n}{512}$$

where:

n = the number of points in the measurement zone

$MULT$ is determined by signal amplitude:

$MULT$ = 1 for signal amplitude > 7.5 divisions

$MULT$ = 2,
5.0 divisions < signal amplitude < 7.5 divisions

$MULT$ = 3,
2.5 divisions < signal amplitude < 5.0 divisions

$MULT$ = 4,
signal amplitude < 2.5 divisions.

Measurements

Measurements are taken using the measurement parameters. You can directly set many the measurement parameters, or you can specify that some are to be determined automatically by the DSA. It is common to have the DSA dynamically measure topline and baseline.

You specify automatic topline and baseline positioning by turning tracking to Both in the individual measurement pop-up menus. The mesial level, once the topline and baseline values have been determined, is calculated:

$$mesial = [(m\%/100) \times (topline - baseline)] + baseline$$

where $m\%$ is the percentage of topline to baseline height to use for mesial level. Proximal and distal levels are calculated similarly from percentage levels. These percentage levels are set using the knobs.

When you use tracking, the topline and baseline are determined from a histogram of the waveform, as follows:

1. Create a histogram of the waveform data points. For each possible vertical value, count the number of data points having that value.
2. The largest value that has a non-zero point count is the maximum value.
3. The smallest value that has a non-zero point count is the minimum value.
4. Determine the median value, halfway between the maximum and minimum values.
5. Examine the point counts between the median value and the maximum value, to find the largest point count. If this point count is greater than the *Floor* value (defined below), the value associated with the point count is the topline. If the largest point count is not greater than *Floor* , then the maximum value is used as the topline.

6. Examine the point counts between the median value and the minimum value, to find the largest point count. If this point count is greater than the *Floor* value (defined below), the value associated with the point count is the baseline. If the largest point count is not greater than *Floor*, then the minimum value is used as the baseline.

   The *Floor* value is calculated as the maximum of two values, *AVE* and *Correction*, to insure that the topline or baseline calculated is appropriate for the waveform measurement zone.

$$AVE = \frac{2}{n} \sum_{j=1}^{n} count_j$$

where:

$count_j$ = the j th non-zero point count in the waveform histogram

n = the number of non-zero point counts in the waveform histogram

$$Correction = 8 + MULT \frac{n}{512}$$

where:

n = the number of points in the measurement zone

$MULT$ is determined by signal amplitude:

$MULT = 1$ for signal amplitude $>$ 7.5 divisions

$MULT = 2$,
5.0 divisions $<$ signal amplitude $<$ 7.5 divisions

$MULT = 3$,
2.5 divisions $<$ signal amplitude $<$ 5.0 divisions

$MULT = 4$,
signal amplitude $<$ 2.5 divisions.

Area+

$$Area+ \ = \sum_{j=m}^{n-1} \frac{Abs[W(j\ +\ 1) - R]\ +\ ABS[w(j) - R]}{2} \times T$$

where:

m = index of left-most measurement zone sample
n = index of right-most measurement zone sample
$W(j)$ = input sampled data point
R = reference level measurement parameter
T = time interval between successive samples
Abs = the absolute value function

Area–

$$Area- = \sum_{j=m}^{n-1} \frac{[W(j+1) - R] + [w(j) - R]}{2} \times T$$

where:

m = index of left-most measurement zone sample
n = index of right-most measurement zone sample
$W(j)$ = input sampled data point
R = reference level measurement parameter
T = time interval between successive samples

Cross

The cross measurement finds the left-most crossing of the reference level of the proper slope that is within the measurement zone. The horizontal position of the crossing point is displayed.

Linear interpolation between vertical points and between time intervals is necessary to determine the crossing time, when the reference level value does not correspond to acquired data.

Delay

1. On the selected waveform, search the measurement zone for the left-most mesial crossing. The horizontal position is $Cross_1$.

2. On the same waveform, search the measurement zone for the right-most mesial crossing. The horizontal position is $Cross_2$.

3. Calculate the delay:

   $Delay = Cross_2 - Cross_1$

Linear interpolation between vertical points and between time intervals is necessary to determine the crossing time, when the mesial value does not correspond to acquired data.

Energy

$$Energy = \sum_{j=m}^{n-1} \frac{W(j+1)^2 + w(j)^2}{2} \times T$$

where:

m = index of left-most measurement zone sample
n = index of right-most measurement zone sample
$W(j)$ = input sampled data point
T = time interval between successive samples

Area+

$$Area+ \;=\; \sum_{j=m}^{n-1} \frac{Abs[W(j\,+\,1) - R] \,+\, ABS[w(j) - R]}{2} \times T$$

where:

m = index of left-most measurement zone sample
n = index of right-most measurement zone sample
$W(j)$ = input sampled data point
R = reference level measurement parameter
T = time interval between successive samples
Abs = the absolute value function

Area–

$$Area- = \sum_{j=m}^{n-1} \frac{[W(j + 1) - R] + [w(j) - R]}{2} \times T$$

where:

m = index of left-most measurement zone sample
n = index of right-most measurement zone sample
$W(j)$ = input sampled data point
R = reference level measurement parameter
T = time interval between successive samples

Cross

The cross measurement finds the left-most crossing of the reference level of the proper slope that is within the measurement zone. The horizontal position of the crossing point is displayed.

Linear interpolation between vertical points and between time intervals is necessary to determine the crossing time, when the reference level value does not correspond to acquired data.

Delay

1. On the selected waveform, search the measurement zone for the left-most mesial crossing. The horizontal position is $Cross_1$.

2. On the same waveform, search the measurement zone for the right-most mesial crossing. The horizontal position is $Cross_2$.

3. Calculate the delay:

   $$Delay = Cross_2 - Cross_1$$

Linear interpolation between vertical points and between time intervals is necessary to determine the crossing time, when the mesial value does not correspond to acquired data.

Duty Cycle

1. Calculate the *Period* of the selected waveform (perform a period measurement).

2. Calculate the pulse width of the selected waveform (perform a width measurement). This value is *Width* .

3. If the positive portion of the part of the waveform measured for the *Period* measurement lies between the first two mesial crossings in the measurement zone, then:

   $$DutyCycle = \frac{100 \times Width}{Period}$$

   If the positive portion of the part of the waveform measured for the *Period* measurement lies between the second and third mesial crossings in the measurement zone, then:

   $$DutyCycle = 100 - \frac{100 \times Width}{Period}$$

Fall

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 to the right, looking for the proximal crossing t_p. Update t_d if subsequent distal crossings are found.

4. Calculate the fall time:

   $$Fall = t_p - t_d$$

Linear interpolation between vertical points and between time intervals is necessary to determine the crossing times, when the proximal and distal values do not correspond to acquired data.

Frequency

1. Search the measurement zone for the left-most mesial crossing of positive slope. Continue the search to the right to find the first upper signal/noise ratio level crossing to the right of the first mesial crossing. The horizontal coordinate of this crossing is $Cross_p$.

2. Search the measurement zone for the left-most mesial crossing of negative slope. Continue the search to the right to find the first lower signal/noise ration level crossing to the right of the second mesial crossing. The horizontal coordinate of this crossing is $Cross_n$.

3. If $Cross_p < Cross_n$, set $Cross_1 = Cross_p$, $Cross_2 = Cross_n$, and $Slope$ = positive.
   If $Cross_p > Cross_n$, set $Cross_1 = Cross_n$, $Cross_2 = Cross_p$, and $Slope$ = negative.

4. If $Slope$ = positive, search for the third left-most mesial crossing, and continue the search to find the next upper signal/noise ratio level crossing to the right. If $Slope$ = negative, use the next lower signal/noise ratio level crossing to the right. The horizontal coordinate of this crossing is $Cross_3$.

5. Calculate the frequency:

$$Frequency = \frac{1}{Cross_3 - Cross_1}$$

Linear interpolation between vertical points and between time intervals is necessary to determine the crossing time, when the mesial value does not correspond to acquired data.

Energy

$$Energy = \sum_{j=m}^{n-1} \frac{W(j+1)^2 + w(j)^2}{2} \times T$$

where:

m = index of left-most measurement zone sample
n = index of right-most measurement zone sample
$W(j)$ = input sampled data point
T = time interval between successive samples

Fall

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 to the right, looking for the proximal crossing t_p . Update t_d if subsequent distal crossings are found.

4. Calculate the fall time:

   $Fall = t_p - t_d$

Linear interpolation between vertical points and between time intervals is necessary to determine the crossing times, when the proximal and distal values do not correspond to acquired data.

Frequency

1. Search the measurement zone for the left-most mesial crossing of positive slope. Continue the search to the right to find the first upper signal/noise ratio level crossing to the right of the first mesial crossing. The horizontal coordinate of this crossing is $Cross_p$.

2. Search the measurement zone for the left-most mesial crossing of negative slope. Continue the search to the right to find the first lower signal/noise ration level crossing to the right of the second mesial crossing. The horizontal coordinate of this crossing is $Cross_n$.

3. If $Cross_p < Cross_n$, set $Cross_1 = Cross_p$, $Cross_2 = Cross_n$, and $Slope =$ positive.
   If $Cross_p > Cross_n$, set $Cross_1 = Cross_n$, $Cross_2 = Cross_p$, and $Slope =$ negative.

4. If $Slope =$ positive, search for the third left-most mesial crossing, and continue the search to find the next upper signal/noise ratio level crossing to the right. If $Slope =$ negative, use the next lower signal/noise ratio level crossing to the right. The horizontal coordinate of this crossing is $Cross_3$.

5. Calculate the frequency:

$$Frequency = \frac{1}{Cross_3 - Cross_1}$$

Linear interpolation between vertical points and between time intervals is necessary to determine the crossing time, when the mesial value does not correspond to acquired data.

Gain

1. Calculate the peak-to-peak value of the reference waveform. (Perform a Peak-Peak measurement). This value is $PeakPeak_{ref}$.

2. Calculate the peak-to-peak value of the selected waveform. (Perform a Peak-Peak measurement). This value is $PeakPeak_{sel}$.

3. Calculate the gain:

   $$Gain = PeakPeak_{sel} \;/\; PeakPeak_{ref}$$

Main→Window Trigger Time

The Main→Window trigger time measurement is performed in the digitizer. The value reported is the time from the trigger event for the Main time base to the trigger event for the Window time base.

Max

The maximum digitized or calculated data point in the measurement zone of the waveform record. An overrange value in the waveform record will qualify the measurement readout with "≥". If the waveform is null, the measurement value will show "error".

Mean

$$Mean = \sum_{j=m}^{n-1} \frac{W(j+1) + W(j)}{[2(n-m)]}$$

where:

m = index of left-most measurement zone sample
n = index of right-most measurement zone sample
$W(j)$ = sampled data point

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 the entire zone.

Mid

$$Mid = \frac{Max + Min}{2}$$

An overrange value in the waveform record will qualify the measurement with "≥", and an underrange value in the waveform record will qualify the measurement with "≤". If the waveform record has both underrange and overrange values, the measurement readout will be "0.0000 ?V". If the waveform is null, the measurement value will show "error".

Min

The minimum digitized or calculated data point in the measurement zone of the waveform record. An underrange value in the waveform record will qualify the measurement readout with "≤". If the waveform is null, the measurement value will show "error".

Peak–Peak

$$PeakPeak = Max - Min$$

An overrange or underrange value in the waveform record will qualify the measurement with "≥". If the waveform record has both underrange and overrange values, the measurement readout will be qualified with "≥". If the waveform is null, the measurement value will show "error".

Gain

1. Calculate the peak-to-peak value of the reference waveform. (Perform a Peak-Peak measurement). This value is $PeakPeak_{ref}$.

2. Calculate the peak-to-peak value of the selected waveform. (Perform a Peak-Peak measurement). This value is $PeakPeak_{sel}$.

3. Calculate the gain:

   $Gain = PeakPeak_{sel} \ / \ PeakPeak_{ref}$

Main→Window Trigger Time

The Main→Window trigger time measurement is performed in the digitizer. The value reported is the time from the trigger event for the Main time base to the trigger event for the Window time base.

Max

The maximum digitized or calculated data point in the measurement zone of the waveform record. An overrange value in the waveform record will qualify the measurement readout with "≥". If the waveform is null, the measurement value will show "error".

Mean

$$Mean = \sum_{j=m}^{n-1} \frac{W(j+1) + W(j)}{[2(n-m)]}$$

where:

m = index of left-most measurement zone sample
n = index of right-most measurement zone sample
$W(j)$ = sampled data point

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 the entire zone.

Mid

$$Mid = \frac{Max + Min}{2}$$

An overrange value in the waveform record will qualify the measurement with "≥", and an underrange value in the waveform record will qualify the measurement with "≤". If the waveform record has both underrange and overrange values, the measurement readout will be "0.0000 ?V". If the waveform is null, the measurement value will show "error".

Min

The minimum digitized or calculated data point in the measurement zone of the waveform record. An underrange value in the waveform record will qualify the measurement readout with "≤". If the waveform is null, the measurement value will show "error".

Overshoot

$$OverShoot = 100 \frac{Max - topline}{topline - baseline}$$

If the values of *topline* and *baseline* are equal, the measurement value will show "error".

Peak-Peak

$$PeakPeak = Max - Min$$

An overrange or underrange value in the waveform record will qualify the measurement with "≥". If the waveform record has both underrange and overrange values, the measurement readout will be qualified with "≥". If the waveform is null, the measurement value will show "error".

Period

1. Search the measurement zone for the left-most mesial crossing of positive slope. Continue the search to the right to find the first upper signal/noise ratio level crossing to the right of the first mesial crossing. The horizontal coordinate of this crossing is $Cross_p$.

2. Search the measurement zone for the left-most mesial crossing of negative slope. Continue the search to the right to find the first lower signal/noise ration level crossing to the right of the second mesial crossing. The horizontal coordinate of this crossing is $Cross_n$.

3. If $Cross_p < Cross_n$, set $Cross_1 = Cross_p$, $Cross_2 = Cross_n$, and $Slope$ = positive. If $Cross_p > Cross_n$, set $Cross_1 = Cross_n$, $Cross_2 = Cross_p$, and $Slope$ = negative.

4. If $Slope$ = positive, search for the third left-most mesial crossing, and continue the search to find the next upper signal/noise ratio level crossing to the right. If $Slope$ = negative, use the next lower signal/noise ratio level crossing to the right. The horizontal coordinate of this crossing is $Cross_3$.

5. Calculate the period:

   $$Period = Cross_3 - Cross_1$$

Linear interpolation between vertical points and between time intervals is necessary to determine the crossing time, when the mesial value does not correspond to acquired data.

Phase

1. Calculate the period value of the reference waveform. (Perform a Period measurement). This value is *Period* .

2. Calculate the delay from the reference waveform to the selected waveform. (Perform a Skew measurement). This value is *Skew* .

3. Calculate the phase shift:

$$Phase = \frac{Skew}{360 \times Period} \bmod 360$$

If the measurement of either *Period* or *Skew* results in an error, the *Phase* measurement will show "error".

Prop Delay

1. On the selected waveform, search the measurement zone for the left-most mesial crossing of the specified slope. The horizontal position is $Cross_{sel}$.

2. On the delayed waveform, search the measurement zone for the left-most mesial crossing of the specified slope. The horizontal position is $Cross_{dly}$.

3. Calculate the delay:

$$PropDelay = Cross_{sel} - Cross_{dly}$$

Linear interpolation between vertical points and between time intervals is necessary to determine the crossing time, when the mesial value does not correspond to acquired data.

Rise

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 to the right, looking for the distal crossing t_d . Update t_p if subsequent proximal crossings are found.

4. Calculate the rise time:

   $Rise = t_d - t_p$

Linear interpolation between vertical points and between time intervals is necessary to determine the crossing times, when the proximal and distal values do not correspond to acquired data.

RMS

$$RMS = \sum_{j=m}^{n-1} \frac{[W(j+1)^2 + W(j)^2]^{1/2}}{2(n-m)}$$

where: :

m = index of left-most measurement zone sample
n = index of right-most measurement zone sample
$W(j)$ = sampled data point

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 the entire zone.

Width

1. Search the measurement zone for the leftmost mesial crossing of positive slope. Continue the search to the right to find the first upper signal/noise ratio level crossing to the right of the first mesial crossing. The horizontal coordinate of this crossing is $Cross_p$.

2. Search the measurement zone for the leftmost mesial crossing of negative slope. Continue the search to the right to find the first lower signal/noise ratio level crossing to the right of the second mesial crossing. The horizontal coordinate of this crossing is $Cross_n$.

3. If $Cross_p < Cross_n$, set $Cross_1 = Cross_p$, $Cross_2 = Cross_n$, and $Slope$ = positive. If $Cross_p > Cross_n$, set $Cross_1 = Cross_n$, $Cross_2 = Cross_p$, and $Slope$ = negative.

4. Calculate the width:

   $Width = Cross_2 - Cross_1$

Linear interpolation between vertical points and between time intervals is necessary to determine the crossing time, when the mesial value does not correspond to acquired data.

Rise

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 to the right, looking for the distal crossing t_d . Update t_p if subsequent proximal crossings are found.

4. Calculate the rise time:

   $Rise = t_d - t_p$

Linear interpolation between vertical points and between time intervals is necessary to determine the crossing times, when the proximal and distal values do not correspond to acquired data.

RMS

$$RMS = \sum_{j=m}^{n-1} \frac{[W(j+1)^2 + W(j)^2]^{1/2}}{2(n-m)}$$

where: :

m = index of left-most measurement zone sample
n = index of right-most measurement zone sample
$W(j)$ = sampled data point

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 the entire zone.

Skew

1. On the reference waveform, search the measurement zone for the left-most mesial crossing of the specified slope. The horizontal position is $Cross_{ref}$.

2. On the selected waveform, search the measurement zone for the left-most mesial crossing of the specified slope. The horizontal position is $Cross_{sel}$.

3. Calculate the skew:

   $$Skew = Cross_{sel} - Cross_{ref}$$

Linear interpolation between vertical points and between time intervals is necessary to determine the crossing time when the mesial value does not correspond to acquired data.

Under Shoot

$$UnderShoot = 100 \frac{baseline - Min}{topline - baseline}$$

If the values of *topline* and *baseline* are equal, the measurement value will show “error”.

Width

1. Search the measurement zone for the leftmost mesial crossing of positive slope. Continue the search to the right to find the first upper signal/noise ratio level crossing to the right of the first mesial crossing. The horizontal coordinate of this crossing is $Cross_p$.

2. Search the measurement zone for the leftmost mesial crossing of negative slope. Continue the search to the right to find the first lower signal/noise ratio level crossing to the right of the second mesial crossing. The horizontal coordinate of this crossing is $Cross_n$.

3. If $Cross_p < Cross_n$, set $Cross_1 = Cross_p$, $Cross_2 = Cross_n$, and $Slope$ = positive. If $Cross_p > Cross_n$, set $Cross_1 = Cross_n$, $Cross_2 = Cross_p$, and $Slope$ = negative.

4. Calculate the width:

   $Width = Cross_2 - Cross_1$

Linear interpolation between vertical points and between time intervals is necessary to determine the crossing time, when the mesial value does not correspond to acquired data.

Appendix E: Hardcopy Defaults

The following table summarizes the factory default settings associated with each printer selection in the **Hardcopy Options** pop-up menu. These settings are not affected by initialization.

Hardcopy Defaults

Printer	Screen Format	Direction	Data Format	Output Port
8 pin	HiRes	N/A	N/A	Centronics
24 pin	HiRes	N/A	N/A	Centronics
Tek 4692	Screen	Vertical	N/A	Centronics
Tek 4696	Dithered	Vertical	N/A	Centronics
Bitmap Dump	Screen	Vertical	BinHex Compacted	Centronics
Alt Inkjet	Draft	Horizontal	N/A	Centronics
HPGL	Screen	N/A	N/A	Centronics

The default settings for the color map associated with a color printer setting may be recovered by selecting **Default Color Map** in the **Hardcopy Options** pop-upmenu.

Appendix E: Hardcopy Defaults

The following table summarizes the factory default settings associated with each printer selection in the **Hardcopy** pop-up menu. These settings are not affected by initialization.

Hardcopy Defaults

Printer	Screen Format	Direction	Data Format	Output Port
8 pin	HiRes	N/A	N/A	Centronics
24 pin	HiRes	N/A	N/A	Centronics
Tek 4692	Screen	Vertical	N/A	Centronics
Tek 4696	Dithered	Vertical	N/A	Centronics
Tek 4697	Dithered	Horizontal	N/A	Centronics
Bitmap Dump	Screen	Vertical	BinHex Compacted	Centronics
Alt Inkjet	Draft	Horizontal	N/A	Centronics
HPGL	Screen	N/A	N/A	Centronics

The default settings for the color map associated with a color printer setting may be recovered by selecting **Default Color Map** in the **Hardcopy** pop-up menu.

Appendix F: Messages

The DSA displays a message at the top of the display whenever one of the following events occurs:

- Errors indicate that the DSA cannot perform a requested operation.
- Warnings are displayed when the DSA performs the requested operation, but warns you that the results may be corrupted or meaningless.
- Ready Messages indicate that the DSA is waiting for your response to complete the task.
- Operation Complete Messages indicate that an operation is complete.

When a message appears on the display, you can remove it by performing any operation: touching the graticule area, making a menu selection, or pressing a button.

When a hardcopy is made, any message on the display is removed immediately before making the copy.

Selected Message Descriptions

The meaning of most messages is self-evident. This section lists some of the messages that might be unclear, and gives more information about the cause of the message.

Autoset – not functional with this waveform type.

The selected waveform is a window waveform that has no "parent" waveform on the Main time base, and the Main time base is not triggered.

That XY waveform has incompatible components.

You cannot create an XY waveform that compares a Fast waveform (a waveform acquired using integer arithmetic) to a High Precision waveform.

Front panel locked out.

A command from a computer on a remote interface (GPIB or RS-232-C) has disabled the touch panel. The DSA will ignore front panel selections until the remote computer restores touch panel operation.

Hardcopy absent or off-line.

The **PRINTER** (Centronics) output port is selected, and there is no printer connected to the **PRINTER** port, or the printer is off-line. Be sure you have selected the appropriate output port from the **Hardcopy Options** pop-up menu, and check the printer.

Glossary

Acquisition
The process of sampling the signals coming through the input channels and accumulating the samples into waveforms.

Act On Delta
An acquisition mode in which the DSA monitors an active waveform for variations outside an enveloped waveform.

Active Graticule
In a dual-graticule display, the graticule that shows the selected waveform.

Annotation Lines
Lines that appear on a waveform to show the measurement parameters.

Autoset
A means of letting the DSA set itself to provide a stable and meaningful display of a given waveform.

Averaging
Displaying a waveform that is the combined result of several acquisitions, thereby reducing apparent noise.

Axis Label
There are three notations on each axis. The first and last notation on each axis show the numeric value of the graticule edge (*not* the edge of the displayed points, which are slightly outside the graticule). The center notation is the scale factor expressed in units per division.

Bandwidth
The frequency range within which an instrument's performance with regard to a particular characteristic falls within specified limits. For DSAs and plug-in amplifiers, bandwidth is usually given as an upper limit (the lower limit is DC).

Base Label
The first one to seven characters of the labels of waveforms acquired in the repetitive single trigger or Act on Delta acquisition mode. The label of each such waveform consists of the base label followed by a sequentially assigned number.

Bitmap Dump
A hardcopy mode in which an image of the display is sent, usually to a computer, as a series of binary or binhex data.

Calibration
Fine-tuning of the system for vertical and horizontal (time base) accuracy. The DSA, plug-in units, and probes or cables must be calibrated together as a system for best accuracy.

Channel
The input connector on a plug-in unit, to which you attach a probe or cable connected to the signal source. Also, the smallest component of a waveform expression.

Channel Number
The number assigned to a specific signal input connector.

Compensation
For probes, the adjustment of controlling elements that compensate for undesirable characteristics.

Complex Waveform
A waveform with a waveform description beyond a single channel specification. Any waveform using a numeric value, a function, a reference to a stored waveform, or an arithmetic operator is a complex waveform. However, using the average function does not make a waveform complex.

Control Knob
see Knob.

Coupling
The association of two or more systems or circuits for the transfer of power or information from one to the other.

Cursor
Any of four styles of paired markers that you position with the knobs. The DSA displays the positions of the cursors and the distance between them in axis units.

Default Measurement Parameter
A value from the default set of measurement parameters. You can change the default values. Whenever a waveform is created, the measurement parameters are copied from the default set.

Dejitter
A waveform function that compensates for horizontal jitter in a waveform by aligning waveform records horizontally.

Delayed Sweep
See Window.

Display
The face of the screen on which waveforms, menus, icons, and messages appear. The display also includes the touch panel for user input and selection.

Distal
The most distant point from a reference point. As used in the DSA 601 and DSA 602, the ending measurement point for timing measurements.

Dithered
A hardcopy mode in which black-and-white patterns are used to produce varying shades of gray corresponding to the different display colors.

Dragging
The act of changing your touch panel selection by moving your finger without removing it from the screen. The selection that is activated is the last one that you were touching before removing your finger from the display.

Dual Graticule
A display with two graticules. Each one is half the height of the single graticule.

Enhanced Accuracy
An automatic self-calibration of the DSA and any installed plug-in units as a system. Probes or cables must also be calibrated as part of the system for best accuracy.

Entry Line
A text line that shows your input as you enter selections in a pop-up menu.

Enveloping
Displaying a waveform that shows the extremes of variation of the input signal(s) over several acquisitions.

Equivalent Time
An acquisition mode in which waveform data from several triggered sweeps of the time base are combined into a single waveform record.

Fast Fourier Transform (FFT)
A function that produces a display of the frequency spectrum of a waveform. The DSA can display the magnitude and the phase of components in the frequency spectrum.

GPIB (General Purpose Interface Bus)
An interface (IEEE standard 488) that can be used for remote computer control of, and data capture from, the DSA.

Graticule
The grid where waveforms are displayed.

Hardcopy
A paper print of the display.

Holdoff
The interval between acquisitions during which the time base and trigger circuit are inhibited.

Horizontal Size
See Main Size.

Icon
A marker near the edge of the graticule that performs a specific function when touched.

Initialization
Setting the DSA to a known, default condition.

Interpolation
A function used to derive values for points between known sampled values.

Keypad Menu
A pop-up menu that controls knob resolution and lets you enter specific numeric values for any control to which a knob is assigned.

Knob
One of the two large rotary controls below the DSA screen.

Knob Assignment
The value that a knob will adjust at a given time.

Knob Menu
The on-screen menu that always displays the current knob assignment. The knob menu also lets you display the Keypad menu.

Knob Resolution
The amount of change caused by each click of a knob.

Main Size

The span of time displayed within each horizontal graticule division on the Main time base.

Main Time Base

The time base on which waveforms other than window waveforms are acquired.

Major Menu

A menu that is displayed across the bottom of the screen. One of the major menus is always displayed.

Major Menu Button

A labeled button to the right of the display that determines which major menu is displayed.

Measurement

An automated numeric readout that the DSA provides and updates directly from the displayed waveform in real time.

Measurement Parameter

One of several controls, including reference values and limits, that determine how measurements are taken. You can change these parameters to control the automated measurements.

Measurement Tracking

The process of automatically adjusting the measurement parameters to reflect changes in the waveform.

Mesial

The middle point of a range of points. As used in the DSA, the middle measurement point between proximal and distal points for timing measurements, and the intermediate height between baseline and topline for amplitude measurements.

Hardcopy
A paper print of the display.

Holdoff
The interval between acquisitions during which the time base and trigger circuit are inhibited.

Horizontal Size
See Main Size.

Icon
A marker near the edge of the graticule that performs a specific function when touched.

Initialization
Setting the DSA to a known, default condition.

Interpolation
A function used to derive values for points between known sampled values.

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The value that a knob will adjust at a given time.

Knob Menu
The on-screen menu that always displays the current knob assignment. The knob menu also lets you display the Keypad menu.

Knob Resolution
The amount of change caused by each click of a knob.

Main Size
The span of time displayed within each horizontal graticule division on the Main time base.

Main Time Base
The time base on which waveforms other than window waveforms are acquired.

Major Menu
A menu that is displayed across the bottom of the screen. One of the major menus is always displayed.

Major Menu Button
A labeled button to the right of the display that determines which major menu is displayed.

Measurement
An automated numeric readout that the DSA provides and updates directly from the displayed waveform in real time.

Measurement Parameter
One of several controls, including reference values and limits, that determine how measurements are taken. You can change these parameters to control the automated measurements.

Measurement Statistics
The accumulation of a history of individual measurement readouts, showing the maximum, minimum, mean, and standard deviation values of a selected number of measurement samples.

Measurement Tracking
The process of automatically adjusting the measurement parameters to reflect changes in the waveform.

Mesial
The middle point of a range of points. As used in the DSA, the middle measurement point between proximal and distal points for timing measurements, and the intermediate height between baseline and topline for amplitude measurements.

Outline Box

A visual feedback mechanism of the touch panel. Your potential selection is always indicated by a box while your finger is touching the screen.

Pixel

A visible point on the display. The DSA display is 552 pixels wide and 704 pixels high. Each pixel may be set to any of the display colors.

Point Accumulate Mode

A mode of operation where the DSA displays newly acquired waveform data points while keeping the previously acquired data points on the screen.

Pop-up Menu

A temporary menu that provides an interactive dialog for a specific function. A sub-menu of a major menu.

Principal Power Switch

The master power switch located on the rear panel of the DSA.

Proximal

The point closest to a reference point. As used in the DSA 601 and DSA 602, the beginning measurement point for timing measurements.

Queuing (Spooling)

The temporary storage of data in preparation for output to an external device, for example a printer or computer.

Real Time

An acquisition mode in which all the samples for a waveform record are taken from a single triggered sweep of the time base.

Record Length
The number of samples (data points) that make up a waveform record.

RS-232-C
An interface that can be used for remote computer control of and data capture from, the DSA.

Sample Interval
The time interval between successive samples in a waveform record.

Sample Rate
The speed with which the DSA acquires samples, expressed in samples per second.

Selected Waveform
The waveform that is acted on by the knobs and menu selectors, and to which measurement readouts apply.

Selector
An area of a menu that performs some action when you touch it.

Setting
The state of the front panel and system at a given time.

Single Trigger
An acquisition mode in which acquisition is stopped after a single trigger is detected and the time base duration has expired.

Single Sweep
See Single Trigger.

Single Shot
See Single Trigger.

Spooling
See Queuing.

Standby
A condition in which input power is disconnected from all but a few of the DSA's circuits. Standby is generally used when the DSA is not in use.

Stored Waveform
A collection of sampled points that constitute a single waveform record that is saved in memory.

Time Base
The time-dependent specifications that control the acquisition of a waveform. The time base determines when and for how long to acquire and digitize signal data points.

Time/Division
See Main Size.

Trace
See Waveform.

Tracking
The process of automatically adjusting the measurement parameters or window position to reflect changes in the waveform.

Trigger
An electrical event that is used as a horizontal reference for acquired waveform samples.

Uptime
The cumulative number of hours the DSA has been powered on.

Vertical Description
see Waveform Description.

Vertical Size
The number of vertical axis units displayed within a vertical division of the graticule. Usually the vertical units are volts, and the vertical size corresponds to plug-in amplifier sensitivity.

Volts/Division
See Vertical Size.

Waveform
The visible representation of an input signal or combination of signals.

Waveform Description
The definition of what the waveform displays. It can include one or more channels combined arithmetically and modified by functions.

Waveform Number
A number assigned by the DSA to identify a waveform. Displayed waveforms are numbered 1 through 8. A new waveform is always given the lowest available number.

Waveform Record
The data points that make up a waveform on the display or in memory.

Window
A waveform that represents a horizontally expanded portion of another waveform.

XY Waveform
A graphical comparison of two waveforms. Both horizontal and vertical position of the data points in an XY waveform reflect signal data.

Yt Waveform

A waveform where the vertical position of the waveform data points reflects signal data, and the horizontal position of the waveform data points reflects time.

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MANUAL CHANGE INFORMATION

At Tektronix, we continually strive to keep up with latest electronic developments by adding circuit and component improvements to our instruments as soon as they are developed and tested.

Sometimes, due to printing and shipping requirements, we can't get these changes immediately into printed manuals. Hence, your manual may contain new change information on following pages.

A single change may affect several sections. Since the change information sheets are carried in the manual until all changes are permanently entered, some duplication may occur. If no such change pages appear following this page, your manual is correct as printed.

Tektronix
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MANUAL CHANGE INFORMATION

Date: 9/89 Change Reference: C1/0989

Product: DSA 601 & DSA 602 User Reference Manual Part No: 070-7250-00

Product Group: 47

These changes are for instruments with firmware version 1.2 or above (including all new instruments). For earlier firmware versions, simply discard these insert pages.

TEXT CHANGES

Pull and replace the following pages with the pages attached to this insert:

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