User's Reference

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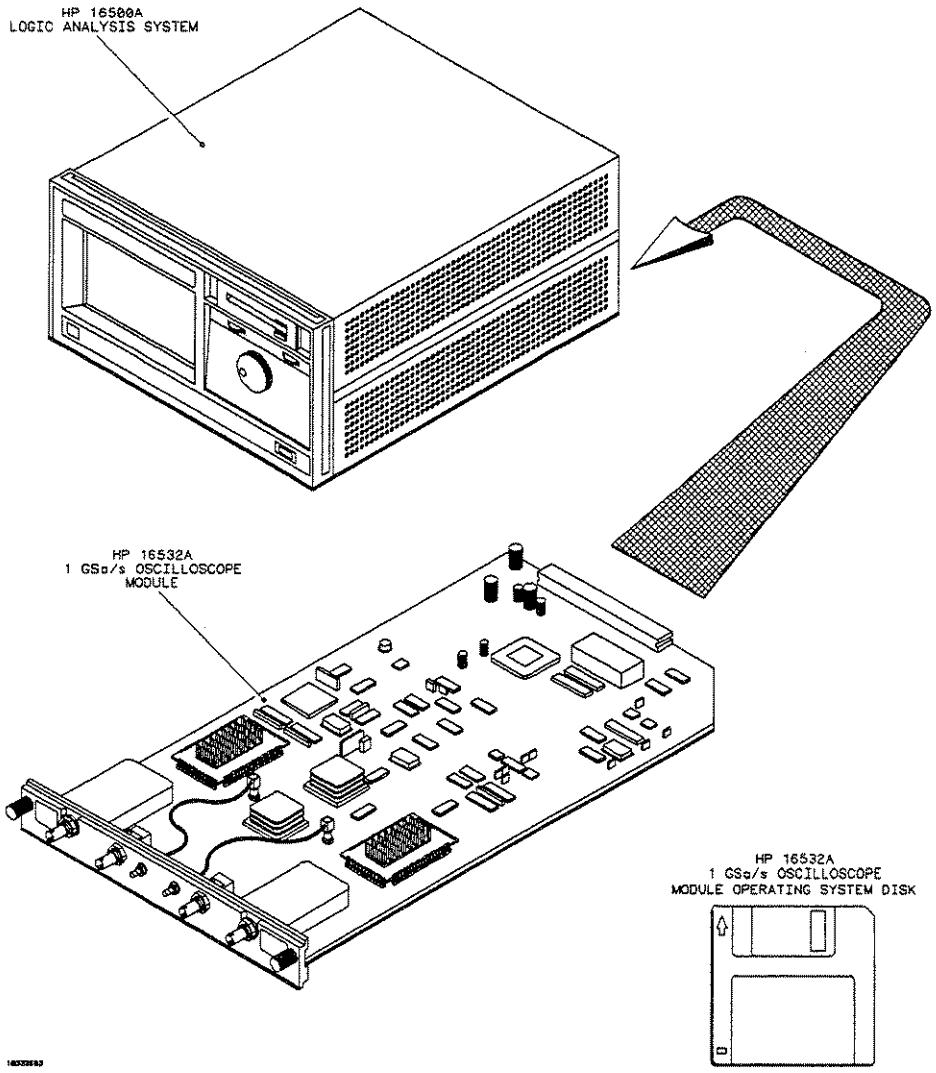
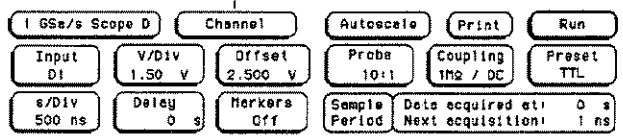
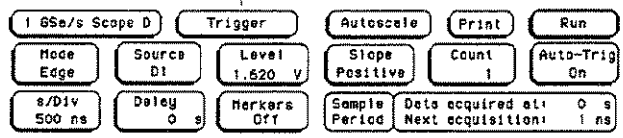
HP 16532A
1 GSa/s Oscilloscope Module

The 1 GSa/s Oscilloscope at a glance . . . . . .

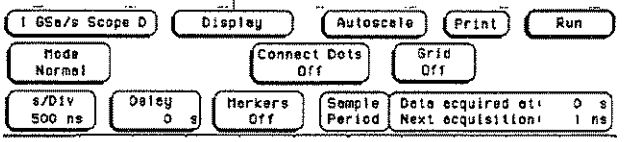




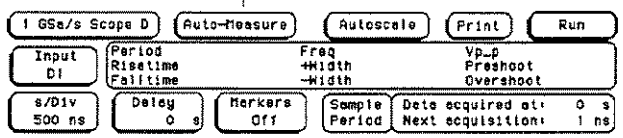
Channel Menu: Selects:
Time Base Parameters (s/Div, Delay);
Vert. Sensitivity/Position (V/Div & Offset);
Input Channel; Probe Factor; Coupling;
Markers; Autoscale; Preset Values; Print



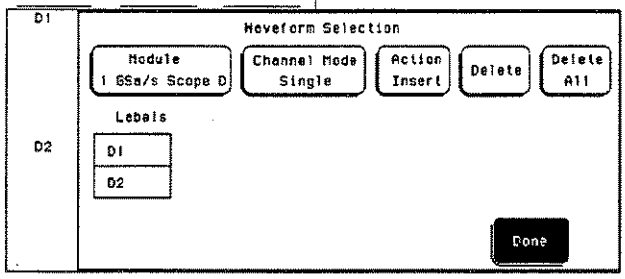
Trigger Menu: Selects:
Mode, Immediate-Pattern-Edge;
Source; Level; Slope; Count;
Auto-Trigger; Autoscale; Markers;
Time Base Parameters (s/Div, Delay); Print



Display Menu: Selects:
Mode, Normal-Average-Accumulate;
Connect Dots, On/Off; Grid, On/Off;
Time Base Parameters (s/Div, Delay);
Autoscale; Markers; Print



Auto-Measure Menu: Selects:
Field with parametric measurements of:
Period, Risetime, Falltime, Frequency,
+Width ,−Width, Vp_p, Preshoot, and
Overshoot;
Time Base Parameters (s/Div, Delay);
Input Channel; Autoscale; Markers; Print



Waveform Selection: Available all menus
except Calibration.
Selects: Module (current if not IMB meas.);
Channel Mode: Single, Overlay,
Chan+Chan, and Chan−Chan;
Action, Insert-Replace; Delete; Labels; Print

In This Book

This book provides a detailed description of the features of the HP 16532A 1 GSa/s Oscilloscope Module. It identifies the different menus available on the oscilloscope, and shows what options are available in the menus. It then explains what each of these options mean and what they do. The book is divided into the following chapters:

Chapter 1 describes the Run/Stop options and explains single and repetetive modes of operation.

Chapter 2 describes the Autoscale function—what it does, what signal it selects to trigger on, and what fields and menus are affected by the algorithm.

Chapter 3 describes the Channel menu options—input identification, vertical sensitivity and position, probe attenuation factor, coupling field selection, and preset values.

Chapter 4 describes time base functions—sweep speed, horizontal position, pan and zoom, and sample period display.

Chapter 5 describes marker options—both manual and automatic. It describes the capabilities of both manual and automatic marker options and the fields available in each, then describes the function of each of these fields.

Chapter 6 describes trigger options available—immediate, pattern, and edge. It describes their use, configurations available, and the fields controlling each option.

Chapter 7 describes the display options—normal, average, and accumulate. It then explains when each is used, and what the results are when each is used.

Chapter 8 describes the Auto-Measure feature and explains the algorithm for each of the nine automatic measurements taken. The measurements taken using this feature are: frequency, period, peak-to-peak voltage, positive pulse width, negative pulse width, rise time, fall time, preshoot, and overshoot.

Chapter 9 describes the Waveform Selection menu. This menu lets you select the following modes of operation: single channel, overlay, Chan + Chan, or Chan−Chan. It also allows you to insert, replace, or delete channels from the display.

Chapter 10 describes intermodule measurements. For a more detailed description of this type of measurement refer to the *HP 16500A/16501A Logic Analysis System Reference Manual.*

For a "fast track" introduction to the oscilloscope module, refer to the *HP 16532A 1 GSa/s Oscilloscope Module Quick Start Guide.* That manual will help you get comfortable with the oscilloscope features and some of its more basic measurements.

For specific user task-oriented information on the more commonly used oscilloscope measurements, refer to the *HP 16532A 1 GSa/s Oscilloscope Module User's Guide.*

Contents

1

Run/Stop Options

Run/Stop Options

When you first turn on the Logic Analysis System, all of the modules installed in the mainframe are inactive (that is, not running). Making the module inactive at system start-up prevents any unwanted interaction between the modules.

This chapter describes how to manually start the oscilloscope running. You can cause the oscilloscope to run automatically in an intermodule measurement setup. For information on intermodule measurements, refer to chapter 10 in the *HP 16500A/16501A Logic Analysis Reference* manual.

There are two ways you can manually cause the oscilloscope to run. One way is to touch the Autoscale field on the screen, then select Continue from the pop-up menu. The more obvious way to cause the oscilloscope to run (or stop) is to use the Run/Stop field options. All of the run and stop options are explained in this chapter.

Remember, when the Run/Stop field displays Run, the oscilloscope is stopped. You touch the Run field to start the oscilloscope running. Likewise, when the Run/Stop field displays Stop, the oscilloscope is running. You touch the Stop field to stop the oscilloscope. In short, the Run/Stop field displays your next option – not the action taking place.

Autoscale Run

You can use the autoscale feature to cause the oscilloscope to run. You may want to use this method when you have changed one or more of the signal input parameters and want to get back to a basic screen presentation of your waveform. Just touch the Autoscale field on the screen, then select Continue from the pop-up menu. When autoscaling is complete, the oscilloscope automatically starts running. It will run in the mode (single or repetitive) that was last selected using the Run field menu options. If no run mode is selected prior to selecting autoscale, the run mode defaults to single mode.

Manual Run/Stop

Manually running or stopping the oscilloscope is controlled by the Run/Stop field. The Run/Stop field is in the upper-right corner of all oscilloscope menus. In addition to the run and stop options available with the Run/Stop field, the Run field allows you to choose the acquisition mode of the run you want to make. The acquisition modes available are single mode and repetitive mode.

Run Field

When the green Run field is displayed, the oscilloscope is stopped. Touching the Run field, then removing your finger from the screen, starts the oscilloscope running. The oscilloscope runs using the parameters that are currently set. Additionally, it runs in the mode (single or repetitive) that was last selected. If no run mode is selected prior to selecting a run, the run mode defaults to single mode.

When you touch and hold your finger on the Run field, a pop-up menu appears. The pop-up contains the selections Single, Repetitive, and Cancel. To select one of the options, slide your finger down the screen until it is over the option you want to select, then remove your finger from the screen. These options are described in the following paragraphs.

Single Mode Option

When the system is turned on, the oscilloscope defaults to the Single mode. Single mode acquisition fills acquisition memory once with 8000 samples of the input waveform, automatically stops running, then displays the contents of acquisition memory. Each 8000-sample waveform record is acquired in a single acquisition.

To start the oscilloscope running in the single-shot mode after it has been running in repetitive mode, touch the green Run field. Slide your finger down to the Single field in the pop-up until the Single field turns white, then remove your finger from the screen. This starts the oscilloscope running in the Single mode. When single-shot acquisition is in process, the Run/Stop field will display Stop. When the acquisition is complete, the field display changes to Run. In Single mode, the oscilloscope makes a single acquisition and displays the results. The oscilloscope then waits until the Run field is touched again before making another acquisition.

Repetitive Mode Option

Repetitive mode acquisition fills acquisition memory with 8000 samples of the input waveform on continuing acquisitions. The display is updated each time a new acquisition is made. Repetitive mode continues acquiring data in this manner until you touch the Stop field. As in single mode, each 8000-sample waveform record is acquired in a single acquisition.

To start the oscilloscope running in the repetitive mode after it has been running in single mode, touch the green Run field. Slide your finger down to the Repetitive field in the pop-up until the Repetitive field turns white, then remove your finger from the screen. This starts the oscilloscope running in the Repetitive mode. While the real-time repetitive acquisitions are being made, the Run/Stop field will display Stop. When you want to stop making repetitive acquisitions, touch the Stop field. To resume making repetitive acquisitions, touch the Run field again.

Cancel Option

If you select the Cancel field in the pop-up, the oscilloscope returns to the state it was in before the Run field was touched. That is, it is stopped in either single or repetitive mode, whichever mode was selected last.

Stop Field

When the red Stop field is displayed, the oscilloscope is running. Touch the Stop field to cause the oscilloscope to stop running.

2

Autoscale

Autoscale

Autoscale is an algorithm built into the oscilloscope that automatically optimizes the display of one or more waveforms. When you touch the Autoscale field and select Continue, the autoscale algorithm starts, and the screen displays the advisory message "Autoscale is in progress."

When you are set up in a multimodule configuration, only the two master card input channels are recognized by the autoscale algorithm. The oscilloscope does not autoscale the inputs on the other boards in a multimodule configuration.

This chapter discusses how the autoscale algorithm works in a single module configuration or in relation to the master card in a multimodule configuration.

Autoscale Field Options

The Autoscale field is displayed in the top row of menu fields on every oscilloscope menu.

When you touch the Autoscale field, a pop-up appears that allows you to cancel or continue the autoscale.

Cancel

If you accidentally touch the Autoscale field, you can touch the Cancel field to cancel the autoscale process. The cancel feature keeps you from inadvertently changing your oscilloscope setup.

Continue

When you touch the Continue field, the autoscale algorithm starts, and the screen displays the advisory message "Autoscale is in progress."

Autoscale Algorithm

This section describes what the autoscale algorithm does when a signal, or signals, is present at the oscilloscope inputs. It also describes what occurs when signals are not present at the oscilloscope inputs.

When you are set up in a multimodule configuration, only the two master card input channels are recognized by the autoscale algorithm. The oscilloscope will not autoscale the inputs on the other boards in a multimodule configuration.

This section discusses how the autoscale algorithm works in a single module configuration or in relation to the master card in a multimodule configuration.

What the Autoscale Algorithm Does When a Signal is Found

The autoscale algorithm first checks both input channels to determine whether or not there are any signals present. If there are signals present, the autoscale algorithm first looks for the signal to use as the trigger source and sets the trigger parameters. It then performs automatic scaling of the signals found on both channels.

Finding the Trigger Source

If there is a signal present on only one of the two input channels, the autoscale algorithm recognizes that signal as the trigger source.

If there are signals present on both of the input channels, the autoscale algorithm recognizes only the signal on the lowest lettered and numbered input channel as the trigger source.

For example, if signals are present on both CHAN 1 and CHAN 2 inputs, the autoscale algorithm selects the signal on CHAN 1 input as the trigger source input. Similarly, if a signal is present only on the CHAN 2 input, then the CHAN 2 input is recognized as the trigger source input.

Setting the Display Parameters

When the oscilloscope finds a trigger source (input waveform), the autoscale algorithm measures its amplitude and period. Based on these parameters, the autoscale algorithm automatically sets the vertical sensitivity (V/Div), offset, horizontal sweep speed (s/Div), trigger level, trigger mode, and trigger slope for the trigger source input. Except for the s/Div parameter, these parameters are set for the other input if it is present. However, the primary information used to trigger the oscilloscope will come from parameters that are set for the trigger source input.

Displaying the Waveform

When the autoscale algorithm is complete, the oscilloscope automatically starts running, and displays waveforms for the inputs that are enabled. It runs in the mode (single or repetitive) that was last selected using the Run field menu options. If a run mode has not been selected prior to selecting autoscale, the run mode defaults to single mode.

The oscilloscope normally displays between 1 and 3 complete cycles of the trigger source waveform. Any other waveforms present are displayed as a result of the s/Div value set for the trigger source input.

The trigger point on the waveform is determined by the trigger level set by the autoscale algorithm. The trigger point is displayed as a dotted vertical red line at the center of the screen (Delay = 0 s).

What the Autoscale Algorithm Does When a Signal is Not Found

When a signal is not found on either of the vertical inputs, the oscilloscope displays the advisory messages "No signal found" and "Original setup restored." The autoscale algorithm toggles the Auto-Trig field to On, which places the oscilloscope in the automatic trigger mode. The oscilloscope then displays the message "Auto triggered." The automatic trigger mode allows the oscilloscope to sweep automatically and to display a baseline anytime a trigger signal is not present.

Menus and Fields Changed by the Autoscale Algorithm

The following table shows the menus and their fields that are changed by the autoscale algorithm.

When you are set up in a multimodule configuration, only the two master card input channels are recognized by the autoscale algorithm. The oscilloscope will not autoscale the inputs on the other boards in a multimodule configuration. The table below is based on how the autoscale algorithm works in a single module configuration or in relation to the master card in a multimodule configuration

Menu	Field	Autoscale Action
Channel	V/Div Offset	Scaled - depending on amplitude of input signal. Scaled - depending on offset of input signal.
Trigger	Mode Source Level Slope Count Auto-Trig	Defaults to Edge. Set to lowest numbered and lowest lettered input with signal present. Scaled - depending on amplitude of trigger source input signal. Defaults to Positive. Defaults to 1. Defaults to On.
All Applicable	s/Div Delay	Scaled - depending on frequency of trigger source input signal. Defaults to 0 s.

3

Channel Menu Options

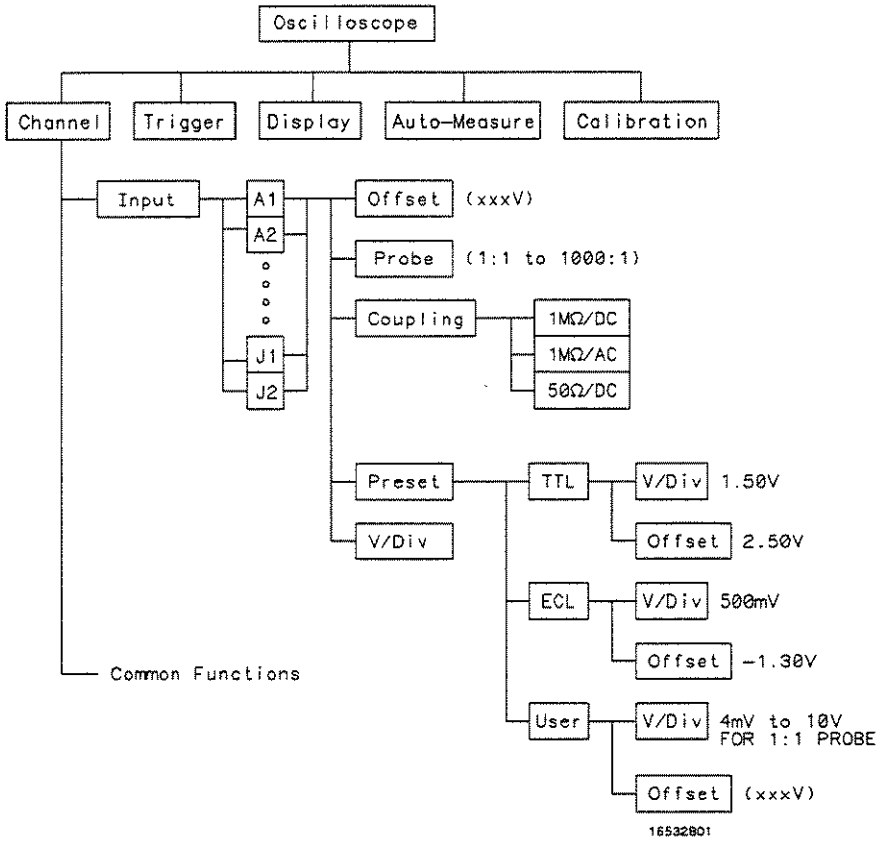
Channel Menu Options

The Channel menu lets you select the channel input for the module currently displayed in the module field. It lets you select values that control the vertical sensitivity, offset, probe attenuation factor, input impedance, and coupling of the input channel currently shown in the Input field. The Channel menu also gives you preset vertical sensitivity, offset, and trigger level values for ECL and TTL logic levels.

Channel Menu Map

Channel Field Menu Map

The menu map for the Channel field is shown below.



Input Field

You use the Input field to select the input source for the channel parameters displayed on the Channel menu. Each channel may be set independent of all other channels.

Input Identification

When you touch the Input field, a pop-up appears that shows the input channels for the module that is currently displayed in the module field. The input channels are shown as a letter/number combination: A1, for example. The letter A identifies the slot number in the mainframe which contains the module. The number 1 identifies the input connector on the rear of the module. For the 1 GSa/s Oscilloscope Module, A1 identifies the module location as slot A and the input location as CHAN 1. Likewise, A2 identifies the module location as slot A and the input location as CHAN 2.

For 1 GSa/s Oscilloscope Modules installed in an HP 16500A Logic Analyzer System mainframe, two inputs are available for each of the slots A, B, C, D, and E. If the HP 16501A Logic Analyzer System expander mainframe is used, additional slots F, G, H, I, and J are also available.

At system turn on, the Input field defaults to the lowest lettered and numbered input for the module selected. For example, if a module is installed in mainframe slot A, the Input field will display A1.

Vertical Sensitivity

You use the V/Div field to set the vertical sensitivity for the waveform on the screen. It is set for the channel currently displayed in the Input field. Vertical sensitivity determines the vertical size of a waveform displayed on the screen and it is measured in volts per division. Each waveform display area is divided into four vertical divisions. The divisions are marked by small tan-colored tick marks at the left and right sides of the waveform display area.

V/Div Field

When you select the V/Div field, you can change the vertical sensitivity by turning the knob. Turning the knob clockwise causes the waveform to expand vertically in both directions from the center of the display. Turning the knob counterclockwise causes the waveform to compress vertically in both directions toward the center of the display. As you turn the knob, the vertical sensitivity changes in a 1-2-4 sequence from 4 mV/Div to 10 V/Div (1:1 probe).

Vertical sensitivity can also be entered from the pop-up keypad. The keypad appears when you touch the V/Div field when the field is light blue. Any valid value from 4 mV/Div to 10 V/Div (1:1 probe) can be entered from the keypad. The vertical sensitivity value is set to the two most significant digits of the value entered. For example, if you enter a value of 154 mV, the value is rounded and then truncated to 150 mV.

If acquisitions have been stopped (either by touching the Stop field or by a completed measurement), vertical sensitivity changes will not be reflected on the waveform until Run is touched and the next acquisition is displayed. Changes to V/Div during a repetitive run will be seen on the next displayed acquisition because the hardware is reprogrammed between acquisitions.

The default value for the V/Div field is 1.5 V (TTL preset value).

Vertical Position

You use the Offset field to set the vertical position of the waveform on the screen. It is set for the channel currently displayed in the Input field. Vertical position determines the vertical placement of the waveform. Offset is measured in volts. Each waveform display area is divided into four vertical divisions. The divisions are marked by small tan-colored tick marks at the left and right sides of the waveform display area.

Offset Field

Offset is the voltage represented at the center vertical tick mark in the waveform display. It is a dc voltage that is added to or subtracted from the input signal so that the waveform can be centered on the waveform display. Offset range and resolution are dependent on vertical sensitivity (V/Div) as shown in the following table. The table values are based on a 1:1 probe setting.

V/Div	Offset	
	Range	Resolution
4 mV - 100 mV/Div	±2 V	1 mV
>100 mV - 500mV/Div	± 10 V	1 mV
>500mV - 2.5 V/Div	± 50 V	1 mV
>2.5 V - 10 V/Div	± 250 V	20 mV

When you select the Offset field, the offset value of the channel currently displayed in the Input field can be changed by turning the knob. As you turn the knob, the value in the Offset field changes, and the position of the waveform moves up or down on the waveform display. Offset works similar to the vertical position control of an analog oscilloscope, but offset is calibrated.

Any valid offset value can also be entered from the keypad. The keypad will appear when you touch the Offset field when the field is light blue. The default value for the Offset field is 2.5 V (TTL preset value).

If acquisitions have been stopped (either by touching the Stop field or by a completed measurement), offset changes will not be reflected on the waveform until Run is touched and the next acquisition is displayed. Changes to Offset during a repetitive run will be seen on the next displayed acquisition because the hardware is reprogrammed between acquisitions.

Probe Field

You use the Probe field to set the probe attenuation factor for the input channel currently displayed in the Input field.

Probe Attenuation Factor

The probe attenuation factor can be set from 1:1 to 1000:1 in increments of one. When you select the Probe field, the probe attenuation factor can be changed by turning the knob or by entering a value from the pop-up keypad.

When you select a probe attenuation factor, the actual sensitivity at the input does not change. The voltage values shown on the display (V/div, offset, trigger level) are automatically adjusted to reflect the attenuation factor. The marker and automatic measurement voltage values change when Run is touched and the next acquisition is displayed

The default value for the Probe field is 10:1 for 10:1 divider probes.

Coupling Field

You use the Coupling field to set the input impedance for the channel currently displayed in the Input field.

Coupling Field Selections

When you touch the Coupling field, a pop-up appears that shows the input impedance values available for selection. The selectable values are as follows:

- 1MΩ / DC
- 1MΩ / AC
- 50Ω / DC.

The default value for the Coupling field is 1MΩ / DC.

Caution The maximum input voltage for the 50Ω / DC Coupling field selection is 5 Vrms.

Preset Field

When you touch the Preset field, a pop-up appears. TTL, ECL, and User are the options available.

Preset Field Values

The Preset field automatically sets offset, V/div, and trigger level values to properly display TTL and ECL logic levels. Trigger level is in the Trigger menu and can be changed only when edge trigger is the selected trigger mode.

When you select TTL or ECL, the parameters are preset to the values shown in the following table:

Parameter	Preset Value	
	ECL	TTL
V/Div Offset Trig Level	500 mV −1.300 V −1.300 V	1.5 V 2.5 V 1.620 V

When any of the ECL or TTL preset values are changed from the preset values listed above, the Preset field will change to User and the new values become the new User values. The User values remain the same until you manually change the User values or you change the ECL or TTL preset values while in ECL or TTL Preset.

The default value for the Preset field is TTL.

4

Time Base Functions

Time Base Functions

The s/Div and Delay time base fields control the horizontal display on the oscilloscope. There are three rows of fields displayed on the oscilloscope. The s/Div and Delay fields are located in the bottom row of fields. These two fields are displayed on all of the oscilloscope menus, except for the Calibration menu.

s/Div Field

The s/Div field allows you to set the sweep speed (time scale) on the horizontal axis of the display. Sweep speed is measured in seconds per division.

Selecting Sweep Speed

The waveform display is divided into 10 horizontal divisions. The divisions are marked by small tan-colored tick marks at the top and bottom of the waveform display area.

If you have a multimodule oscilloscope configuration, the s/Div field is set on the master card. All other modules in the multimodule configuration will use the same s/Div setting as the master card.

When you select the s/Div field, you can change the sweep speed for the next acquisition by turning the knob. Turning the knob clockwise a small amount expands the displayed waveform horizontally in both directions from the center of the display. Turning the knob counter-clockwise a small amount compresses the displayed waveform horizontally in both directions toward the center of the display. As you turn the knob, the sweep speed changes in a 1-2-5 sequence (10.0 ns, 20.0 ns, 50.0 ns, etc.) from 1 ns/div to 5 s/div.

Sweep speed can also be entered from the pop-up keypad. The keypad appears when you touch the light-blue s/Div field. Any value from 1 ns/div to 5 s/div can be entered from the keypad. Sweep speed values are rounded and then truncated to the three most significant digits. For example, if you enter a value of 15.45 ns, the value is rounded and then truncated to 15.5 ns.

At sweep speeds of 100 ms/div and slower, the time to acquire the 8000 sample points for acquisition memory is greater than 1 second. At these sweep speeds the screen displays the message "Waiting for Prestore" when acquiring the sample points prior to the trigger. It displays the message "Waiting for Poststore" when acquiring the sample points after the trigger. These messages advise you that the oscilloscope is still actively acquiring data. Acquisition time and sample rate, as they compare to sweep time, are shown in the table at the end of this chapter.

The default value for the s/Div field is 500 ns.

Zooming (Acquisition Stopped)

When acquisitions are stopped, the oscilloscope displays the sample points stored in acquisition memory on the screen. When you change the sweep speed, the new screen display is a different presentation of the data retained in acquisition memory when acquisitions were stopped. Presenting the same data in a different form (zooming) is normally used on a waveform acquired in Single mode.

Zooming while in repetitive mode will change the sample rate and the display because the hardware is reprogrammed between acquisitions in response to the new timebase settings. Zooming is done by adjusting the value in the s/Div field. It causes the waveform to either expand horizontally (decrease sweep time value) or compress horizontally (increase sweep time value).

When used in conjunction with panning (see "Delay Field" paragraph), zooming is very useful in displaying waveforms.

Delay Field

The Delay field allows you to set the horizontal position of the displayed waveform in relation to the trigger. Delay time is measured in seconds.

Setting Horizontal Position

Delay time zero is always at the trigger point of the waveform. A delay time value is the time difference measured from before or after the trigger point on the waveform (delay time zero), to the center point of the screen. In other words, delay time is always measured from the trigger point on the waveform to the center of the screen. The vertical dotted red line on the screen is the trigger point. When delay time is zero, the trigger point will be at the center of the screen.

If you have a multimodule oscilloscope configuration, the Delay field is set on the master card. All other modules in the multimodule configuration will use the same Delay setting as the master card.

When you select the Delay field, delay time can be changed by turning the knob. Remember that the trigger point is always delay time zero and is marked by the vertical dotted red line. When you set the delay such that the trigger point is on the right side of the screen, delay time is negative. What you will see at the center of the screen will be the result of samples taken before the trigger point. They have occurred in what is referred to as negative time.

When you set the delay such that the trigger point is on the left side of the screen, delay time is positive. What you will see at the center of the screen will be the result of samples taken after the trigger point. They have occurred in what is referred to as positive time.

Delay time resolution is equal to 2% of the sweep speed setting when using the knob. When using the pop-up keypad, resolution is 10 ps at sweep speeds of 99.99 ns/div and faster, and can be set to 5-digit resolution at sweep speeds of 100 ns/div and slower.

When run mode is set to Repetitive, the valid Delay range is:

Pre-trigger delay range = 4000 X sample period
Post-trigger delay range is equal to the following:

Time/Div Setting	Available Delay
100 ms to 5 s/Div	2.5 ks
1 μs to 50 ms/Div	33,500 X (s/Div)
1 ns to 500 ns/Div	16.7 ms

Pre- and post-trigger delay time ranges, as they compare with sweep speeds, are shown in the table at the end of this chapter.

The default value for the Delay field is 0 s.

Panning (Acquisition Stopped)

When acquisitions are stopped, the Delay field can be used to control what portion of acquisition memory will be displayed on screen. Acquisition memory is comprised of the following sections:

Pre-trigger delay range = delay time setting − (4000 X sample period)
Post-trigger delay range = delay time setting + (4000 X sample period)

This shows that one-half of the data stored in acquisition memory was stored before the delay time setting and one-half of the data in memory was stored after the delay time setting. Panning allows you to view the entire waveform record by adjusting the Delay field. Normally, using the delay function to view all of the acquired waveform (panning) is done on a waveform acquired in Single (single-shot) mode.

Sample Period Display

Any time the Markers field is Off, the sample period of the acquired waveform is displayed in the bottom row of the menu fields. Sample period is the time period between acquired sample points and is the inverse of sample rate (digitizing rate). Sample period is a function of sweep speed and can only be changed by changing the s/Div field. Sample period and sample rates, as they compare with sweep speed, are shown in the following table.

There are two fields to the right of the Sample Period field which pertain to the sample rate. These fields are the Data acquired at: field and the Next acquisition: field. When acquisitions are stopped, the Data acquired at: field shows the sample rate at which the last acquisition was taken. When the s/Div field is light-blue, you can turn the knob to change the timebase setting. When you do this, the value in the Next acquisition: field changes to reflect the sample rate at which the next acquisition will be taken if the Run field is touched.

During a repetitive run, the Data acquired at: field and the Next acquisition: field will display the same value on the first acquisition following a s/Div setting change. This happens because the hardware is reprogrammed between acquisitions in response to the new timebase setting.

Sample Period Display

s/Div	Sample Rate	Sample Period	Trace Length	Percent on Screen
5 s	100 Sa/s	10 ms	80.000 s	62%
2 s	250 Sa/s	4 ms	32.000 s	62%
1 s	500 Sa/s	2 ms	16.000 s	62%
500 ms	1 KSa/s	1 ms	8.000 s	62%
200 ms	2.5 KSa/s	400 µs	3.200 s	62%
100 ms	5 KSa/s	200 µs	1.600 s	62%
50 ms	10 KSa/s	100 µs	800.0 ms	62%
20 ms	25 KSa/s	40 µs	320.0 ms	62%
10 ms	50 KSa/s	20 µs	160.0 ms	62%
5 ms	100 KSa/s	10 µs	80.000 ms	62%
2 ms	250 KSa/s	4 µs	32.000 ms	62%
1 ms	500 KSa/s	2 µs	16.000 ms	62%
500 µs	1 MSa/s	1 µs	8000 µs	62%
200 µs	2.5 MSa/s	400 ns	3200 µs	62%
100 µs	5 MSa/s	200 ns	1600 µs	62%
50 µs	10 MSa/s	100 ns	800.0 µs	62%
20 µs	25 MSa/s	40 ns	320.0 µs	62%
10 µs	50 MSa/s	20 ns	160.0 µs	62%
5 µs	100 MSa/s	10 ns	80.000 µs	62%
2 µs	250 MSa/s	4 ns	32.000 µs	62%
1 µs	500 MSa/s	2 ns	16.000 µs	62%
500 ns	1 GSa/s	1 ns	8000 ns	62%
200 ns	1 GSa/s	1 ns	8000 ns	25%
100 ns	1 GSa/s	1 ns	8000 ns	12%
50 ns	1 GSa/s	1 ns	8000ns	6%
20 ns	1 GSa/s	1 ns	8000 ns	2%
10 ns	1 GSa/s	1 ns	8000 ns	1%
5 ns	1 GSa/s	1 ns	8000 ns	0.6%
2 ns	1 GSa/s	1 ns	8000 ns	0.2%
1 ns	1 GSa/s	1 ns	8000 ns	0.1%

Notes:

Sa/s = Samples per second.

Trace length = 8000 × sample period.

Percent on screen assumes zero delay and is calculated by $\frac{10 \times \text{s/Div}}{\text{trace length}}$. It is the percentage of the total acquired samples that are seen on screen when the acquired data is displayed.

Sample Period Display

s/Div	Sample Period	*Max. Negative Delay @ Acquisition	**Max. Positive Delay @ Acquisition	Max. Negative Delay	Max. Positive Delay
5 s	10 ms	−40 s	2.5 Ks	−55.0 s	2.5 Ks
2 s	4 ms	−16 s	2.5 Ks	−70.0 s	2.5 Ks
1 s	2 ms	−8 s	2.5 Ks	−75.0 s	2.5 Ks
500 ms	1 ms	−4 s	2.5 Ks	−77.5 s	2.5 Ks
200 ms	400 µs	−1.6 s	2.5 Ks	−79.0 s	2.5 Ks
100 ms	200 µs	−800 ms	2.5 Ks	−79.5 s	2.5 Ks
50 ms	100 µs	−400 ms	1.675 Ks	−79.7 s	2.5 Ks
20 ms	40 µs	−160 ms	670 s	−79.9 s	2.5 Ks
10 ms	20 µs	−80 ms	335 s	−79.9 s	2.5 Ks
5 ms	10 µs	−40 ms	167.5 s	−79.9 s	2.5 Ks
2 ms	4 µs	−16 ms	67.0 s	−79.9 s	2.5 Ks
1 ms	2 µs	−8 ms	33.5 s	−79.9 s	2.5 Ks
500 µs	1 µs	−4 ms	16.75 s	−79.9 s	2.5 Ks
200 µs	400 ns	−1.6 ms	6.70 s	−79.9 s	2.5 Ks
100 µs	200 ns	−800 µs	3.35 s	−79.9 s	2.5 Ks
50 µs	100 ns	−400 µs	1.67 s	−79.9 s	2.5 Ks
20 µs	40 ns	−160 µs	671 ms	−79.9 s	2.5 Ks
10 µs	20 ns	−80 µs	335 ms	−79.9 s	2.5 Ks
5 µs	10 ns	−40 µs	167 ms	−79.9 s	2.5 Ks
2 µs	4 ns	−16 µs	67.0 ms	−79.9 s	2.5 Ks
1 µs	2 ns	−8 µs	33.5 ms	−79.9 s	2.5 Ks
500 ns	1 ns	−4 µs	16.7 ms	−79.9 s	2.5 Ks
200 ns	1 ns	−4 µs	16.7 ms	−79.9 s	2.5 Ks
100 ns	1 ns	−4 µs	16.7 ms	−79.9 s	2.5 Ks
50 ns	1 ns	−4 µs	16.7 ms	−79.9 s	2.5 Ks
20 ns	1 ns	−4 µs	16.7 ms	−79.9 s	2.5 Ks
10 ns	1 ns	−4 µs	16.7 ms	−79.9 s	2.5 Ks
5 ns	1 ns	−4 µs	16.7 ms	−79.9 s	2.5 Ks
2 ns	1 ns	−4 µs	16.7 ms	−79.9 s	2.5 Ks
1 ns	1 ns	−4 µs	16.7 ms	−79.9 s	2.5 Ks

Notes:

@ Acquisition = maximum ± delay when you press Run.

Maximum negative delay = 80.0 s minus $\frac{1}{2}$ SD where1/2 screen diameter (1/2 SD) = 5 × s/Div .

*Maximum negative delay @ acquisition = −(4000 × *sample period*)

**Maximum positive delay without a sample rate change = 2^{24} × sample period.

5

Marker Options

Marker Options

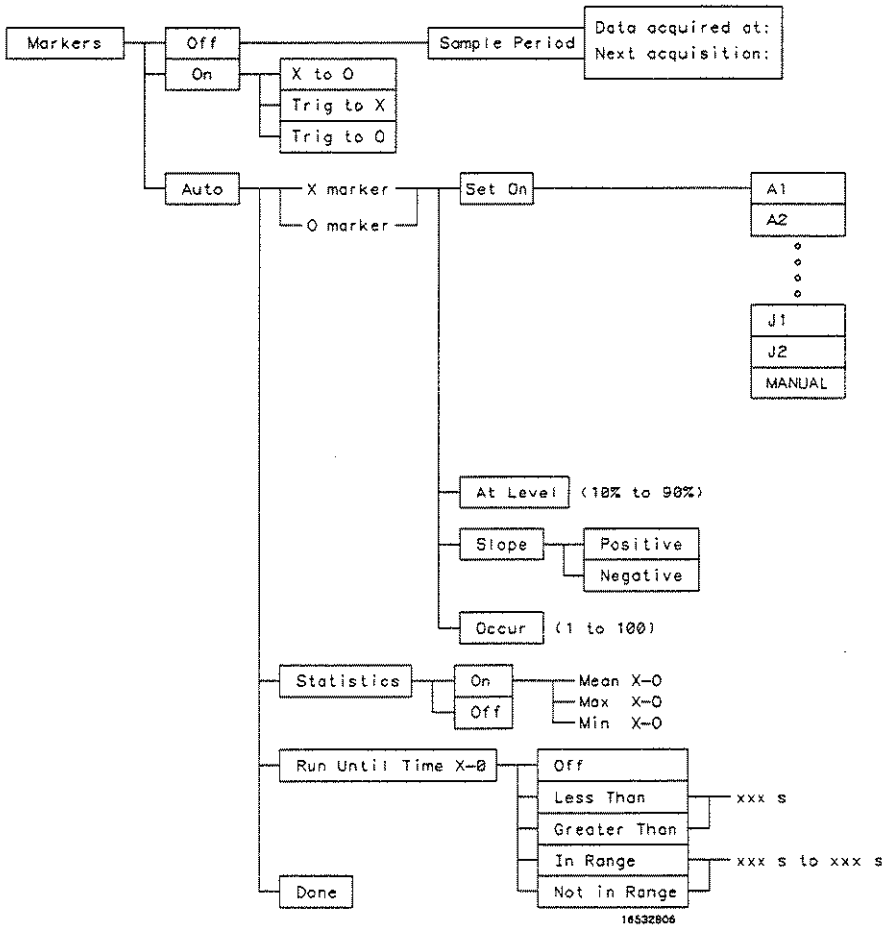
The oscilloscope has two markers that allow you to make time and voltage measurements. These measurements can be made either manually or automatically. The markers are accessed when you touch the Markers field on any of the oscilloscope menus except the Calibration menu.

The default selection for the Markers field is Off.

Markers Menu Map

Markers Field Menu Map

The menu map for the Markers field is shown below.



Manual Markers Options

When you touch the Markers field on the display a pop-up menu appears. When you touch the On field in the pop-up to turn Markers On, you can manually move the X and O markers to make time and voltage measurements.

When you touch the On field in the Markers menu, three new fields appear to the right of the Markers field: X to O, Trig to X, and Trig to O fields. These fields allow you to position the X marker and the O marker by entering time values for these markers. When markers are turned on, the channel label field displays voltage values for the X and O markers except for waveforms where Overlay mode has been selected in the Waveform Selection menu.

X to O Field

The X to O field displays the time difference (delta time) between the X marker and the O marker. When you select the X to O field, turning the knob moves both the X and O markers across the display without changing the value in the X to O field. However, the values in the Trig to X and Trig to O fields will change to reflect the movement of the X and O markers.

You can change the value in the X to O field by changing the Trig to X or Trig to O values, or by changing the X to O value from the pop-up keypad. The keypad appears when you touch the X to O field when the field is light blue.

When you change the time value of X to O by using the keypad, the difference between the new value and old value is divided in half. Each half is then either added to or subtracted fromthe X marker while the other half is either added to or subtracted from the O marker, depending on one of four possibilities.

- If the X marker is to the left of the O marker and you are increasing the time between markers, subtract one half from the X marker value and add the other half to the O marker value.
- If the X marker is to the left of the O marker and you are decreasing the time between markers, add one half to the X marker value and subtract the other half from the O marker value.
- If the O marker is to the left of the X marker and you are increasing the time between markers, subtract one half from the O marker value and add the other half to the X marker value.
- If the O marker is to the left of the X marker and you are decreasing the time between markers, add one half to the O marker value and subtract the other half from the O marker value.

If, for example:

The X marker is to the left of the O marker

The X to O marker is originally set to 352 μs

The Trig to X field is originally 8 μs

The Trig to O field is originally 360 μs

Then, using the keypad, decrease the value of X to O to 200 μs. The difference between the original value (352) and the new value (200) is 152. Half that value is 76. Adding 76 to the the old Trig to X value (76 + 8) = 84. Subtracting 76 from the old Trig to O value (360 - 76) = 284.

Trig to X Field

The X marker is shown on the waveform display as a vertical dashed green line. The green border around the Trig to X field is also green so that you can correlate the value in that field to the green X marker. The time displayed in the Trig to X field is measured from the trigger point to the X marker. The trigger point is shown as a vertical dotted red line at the center of the waveform display when Delay equals zero. The trigger point is always time 0.

When you select the Trig to X field, you can change the time value by turning the knob or by entering a time value from the pop-up keypad. The keypad appears when you touch the Trig to X field when the field is light blue.

Resolution for Trig to X time values is 2% of the sweep speed setting. The default value for the Trig to X field is 0 s.

Trig to O Field

The O marker is shown on the waveform display as a vertical dashed yellow line. The yellow border around the Trig to O field is also yellow so that you can correlate the value in that field to the yellow O marker. The time displayed in the Trig to O field is measured from the trigger point to the O marker.

When you select the Trig to O field, you can change the time value by turning the knob or by entering a time value from the pop-up keypad. The keypad appears when you touch the Trig to O field when the field is light blue.

Resolution for Trig to O time values is 2% of the sweep speed setting. The default value for the Trig to O field is 0 s.

Channel Label Field

The channel label field is the dark blue field to the left of the waveform display. When you turn markers on, the voltage values where the X and O markers intersect each waveform are displayed under each channel label.

When you touch the Trig to X field and turn the knob, the X marker (green) will move across the display. As you move the marker, the time value in the Trig to X field changes. A negative time value indicates the marker is placed before the trigger point, and a positive time value indicates the marker is placed after the trigger point.

As you turn the knob when either the Trig to X or Trig to O field is selected, the time value in the X to O field also changes, showing the time difference between the X and O markers. If the time displayed in the X to O field is negative, the O marker is to the left of the X marker.

As you move the X marker from a low portion on the waveform to a high portion, the X voltage value under the input label in the channel label field also changes.

When you touch the Trig to O field and turn the knob, the O marker (yellow) will move, and the time and voltage values will change just as they did for the X marker.

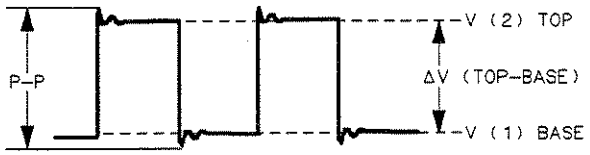
When you touch the X to O field and turn the knob, the X and O markers will move in unison and maintain the preset X to O time value.

You can also change the X to O, Trig to X, and Trig to O fields with the pop-up keypad. Refer to the earlier paragraph entitled "X to O Field" for a description and results of keypad entries in the X to O field.

Automatic Marker Options

When you touch the Markers field a pop-up menu appears. When you touch the Auto field in the pop-up another pop-up menu for automatic-marker measurements is displayed.

The automatic-marker measurements are made by setting the markers to levels that are a percentage of the top-to-base voltage value of a waveform. The top-to-base voltage value of a square wave is typically not the same as the peak-to-peak voltage value. The oscilloscope determines the top and base voltages by finding the flattest portions of the top and bottom of the waveform. The top and base values do not typically include preshoot or overshoot of the waveform. The peak-to-peak voltage is the difference between the minimum and maximum voltages found on the waveform.



If the signal is clipped, the markers will not be automatically placed.

The default Auto markers pop-up menu options are discussed in the following paragraphs.

Done Field

You touch the Done field when you are done entering data in the auto-markers pop-up and want to return to the waveform display.

Set on Field

The Set on field assigns an input waveform to the X or O marker, or allows the marker to be set manually (with the MANUAL selection in the pop-up). When you touch the Set on field, a pop-up appears showing all waveform sources available.

What is displayed on the pop-up depends on how many oscilloscope boards are installed in the mainframe and in which slots they are installed.

The default selection for the Set on field is the lowest letter and number combination. For example, if oscilloscope boards are installed in mainframe slots C and D, the Set on field will default to C1 for both the X and O markers.

at Level Field

The at Level field sets the X or O marker to a percentage level (from 10% to 90%) of the top-base voltage on the waveform selected by the Set on field. When you select the at Level field, you can change the percentage by turning the knob or by entering a value from the pop-up keypad. The keypad appears when you touch the at Level field when the field is light blue. You can enter any percentage from 10% to 90% in increments of 1%.

The default value for the at Level field is 50%.

Slope Field

The Slope field sets the X or O marker on either the positive or negative edge of the selected occurrence of a waveform. When you touch the Slope field, the slope toggles between Positive and Negative.

The default selection for the Slope field is Positive.

Occur Field

The Occur field sets the X or O marker on a specific occurrence of a displayed edge on the waveform. You can define the edge to be displayed all the way from the 1st edge up to the 100th edge. The count of edge occurrences is made starting with the first edge displayed on the screen.

Auto-marker measurements are made with data that is displayed on the screen. Make sure the data of interest is fully displayed on the screen.

When the Occur field is selected, you can change the occurrence by turning the knob or by entering a new value from the pop-up keypad. The keypad appears when you touch the Occur field when the field is light blue. Any number from 1 to 100 in increments of 1 can be entered.

The default value for the Occur field is 1.

Statistics Field

The Statistics field allows you to make minimum, maximum, and mean time interval measurements from marker X to marker O. When you touch the Statistics field, it toggles between On and Off. The default selection for the Statistics field is On.

On

When Statistics is set to On, Min X-O, Max X-O, and Mean X-O appear together in a tan-colored field to the right of the Markers field on the main menu.

When Statistics is set to On, the minimum, maximum, and mean (average) X to O marker time interval data is accumulated and displayed until one of the following happens:

- Auto is deselected as the marker option.
- Auto-marker parameters are changed.
- Statistics is set to Off.
- Run Repetitive mode is stopped.

Off

When Statistics is set to Off, the X to O, Trig to X, and Trig to O fields appear next to the Markers field on the main display.

Run Until Time X-O Field

This field allows you to set up a stop condition for the time interval between the X marker and O marker. When the stop condition is met, the oscilloscope stops making acquisitions and displays the message "Stop condition satisfied." You define the stop conditions with selections you make after you touch the Run Until Time X-O field. The default selection for this field is Off.

The Run Until Time X-O feature is only valid if the Run field is set to Repetitive.

Less Than Field

When you select this field from the pop-up, a time value field appears next to the Run Until Time X-O Less Than field. The time value field default value is 0 s.

When you select the time value field, you can enter the time by turning the knob or by entering a value from the pop-up keypad. The keypad appears when you touch the time value field when the field is light blue. For keypad entries, resolution is 10 ps at times up to ±99.99 ns and can be set to 5-digit resolution for other times up to ±100 megaseconds. Positive times are used when the X marker is displayed before the O marker, and negative times are used when the O marker is displayed before the X marker.

When you select Less Than, the oscilloscope runs until the X-O time interval is less than the value entered for the Less Than time field. When the condition is met, the oscilloscope stops making acquisitions and displays the message "Stop condition satisfied."

Greater Than Field

When you select this field from the pop-up, a time value field appears next to the Run Until Time X-O Greater Than field. The time value field default value is 0 s. When you select the time value field, you can enter the time in the same manner as for the Less Than field.

When you select Greater Than, the oscilloscope runs until the X-O time interval is greater than the value entered for the Greater Than time field. When the condition is met, the oscilloscope stops making acquisitions and displays the message "Stop condition satisfied."

In Range Field

When you select this field from the pop-up, two time value fields appear next to the Run Until Time X-O In Range field. You need to enter the time range values for the stop condition in these two time fields. Select each time value field, in turn, and enter the time value in the same manner as for the Less Than field.

When you select In Range, the oscilloscope runs until the X-O time interval is in the range of the time values entered for the In Range time fields. When the condition is met, the oscilloscope stops making acquisitions and displays the message "Stop condition satisfied."

Not In Range Field

When you select this field from the pop-up, two time value fields appear next to the Run Until Time X-O Not In Range field. You need to enter the time range values for the stop condition in these two time fields. Select each time value field, in turn, and enter the time values in the same manner as for the Less Than field.

When Not In Range is selected, the oscilloscope runs until the X-O time interval is not in the range of the time values entered for the Not In Range time fields. When the condition is met, the oscilloscope stops acquisitions and displays the message "Stop condition satisfied."

Manual/Automatic Markers Option

The manual/automatic combination allows you to have one marker set to automatic mode and one marker set to be controlled manually with the knob.

Setting the Manual/Automatic Markers Option

To set the manual/automatic option you touch the Markers field and select the Auto field from the pop-up. You then touch the Set on field for either the X or O marker, and then select MANUAL from the pop-up menu.

When you touch Done in the auto-markers pop-up menu, you return to the waveform display. Now when you touch the Markers field again and select On from the pop-up menu, the marker you selected with the MANUAL field is set to the manual mode and the other marker is set to fall on the parameters you set while in the automatic mode.

For example:

While in Auto markers mode set the conditions to:

X>: X1, positive slope, occur 1
O>: MANUAL

Now set the Marker Mode to On and Run Repetitively. You can now control the O marker with the knob, but the X marker is controlled by the setup you made in Auto Markers (that is, it will fall on the leading edge of the first displayed positive pulse). If you move the X marker, it will default to MANUAL mode and will no longer be set automatically.

6

Trigger Options

Trigger Options

When you are set up in a multimodule configuration, only the master card input channels are recognized as the trigger source. The oscilloscope will not trigger on inputs from the other boards in a multimodule setup.

This chapter discusses how triggering works in a single module configuration or in the master card in a multimodule configuration.

You access the trigger options through the Mode field which is located at the leftmost position of the middle row of fields in the Trigger menu. The Mode field allows you to select the method you want to use to trigger the oscilloscope for a particular application. When you touch the Mode field, a pop-up menu appears, showing the three modes that are available:

- Edge
- Pattern
- Immediate

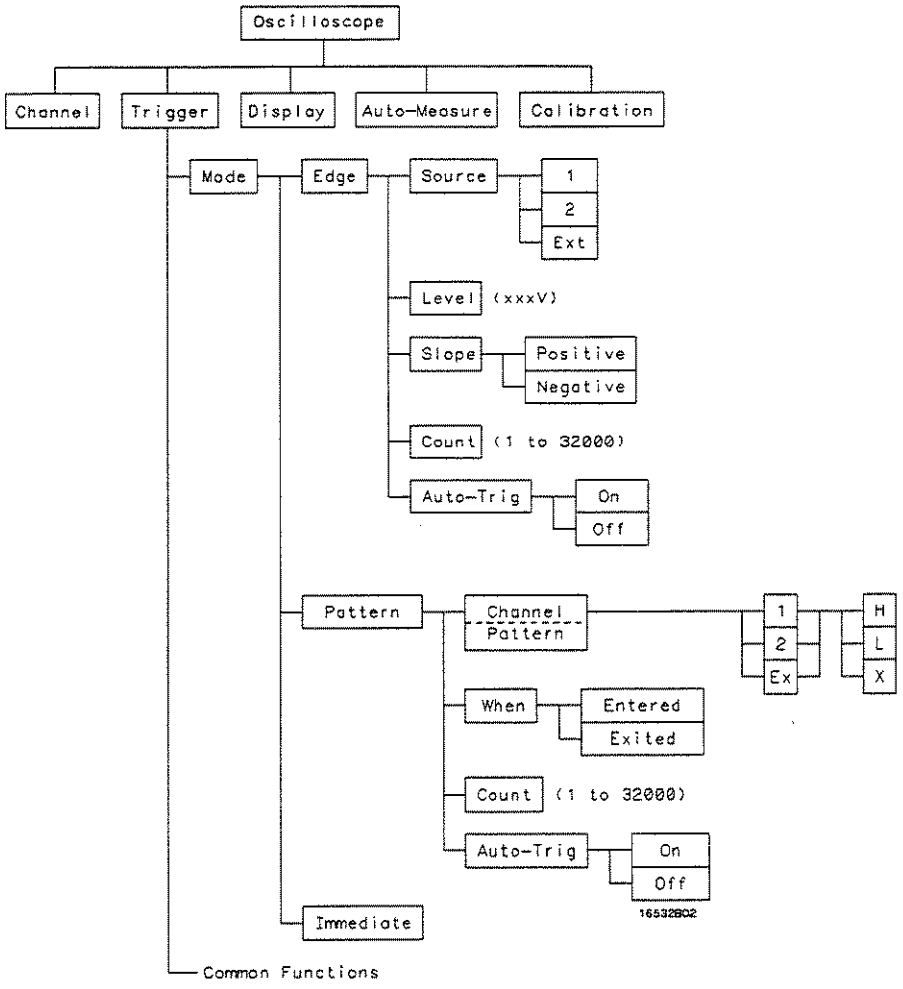
This chapter explains what the trigger marker is, how to access the different trigger modes, and what each trigger mode does.

The default selection for the Trigger field is Edge.

Trigger Menu Map

Trigger Field Menu Map

The menu map for the Trigger field is shown below.



Trigger Marker

The trigger marker is the dotted vertical red line at the center of the waveform display. The point where the waveform from the trigger source crosses the trigger marker is called the trigger point. The trigger point always represents a delay time of zero seconds.

If you set delay time to greater than ±5 times the sweep speed, the trigger marker will move off the screen.

Edge Trigger Mode

When you are set up in a multimodule configuration, only the master card input channels are recognized as the trigger source. The oscilloscope will not edge trigger on inputs from the other boards in a multimodule setup.

This section discusses how edge triggering works in a single module configuration or in the master card in a multimodule configuration.

Edge triggering is the type of triggering found in all oscilloscopes. In the edge trigger mode, the oscilloscope triggers at a specified voltage level on a rising or falling edge of one of the input channels or the external trigger input. In this mode you can specify which input is the trigger source, set a trigger level voltage (except for Ext, which is set to −1.3 V), and specify which edge to trigger on.

When you touch the Mode field, Edge can be selected from the pop-up menu. Menu selections for the edge trigger mode are discussed in the following paragraphs.

Intermodule Measurements

If you set the oscilloscope module to Independent in the Intermodule module menu, the oscilloscope will be in the free-run mode and the waveform display will be synchronized to a trigger point.

If you set the oscilloscope module to Group Run in the Intermodule module menu, the oscilloscope triggers itself when its own trigger specification is met after being armed by the input port or by another module from the Intermodule menu.

More information about intermodule applications can be found in the *HP 16500A/16501A Logic Analysis System Reference manual.*

Source Field

When you touch the Source field, a pop-up menu appears showing the inputs available as the trigger source. You can set the trigger source to be any one of the input signals for the oscilloscope module. The source can be input X1, X2, or Ext, where X equals the mainframe slot letter and Ext equals an ECL level external trigger.

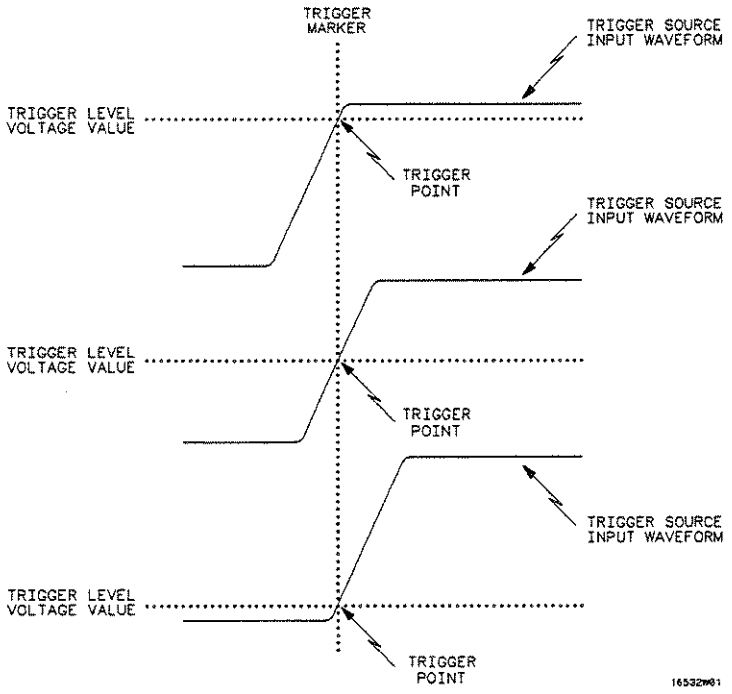
When you have two or more HP 16532A modules connected together, you can only specify the channels on the master HP 16532A module as the trigger source.

At power-up, the default channel input selection for the Source field is the lowest numbered input channel on the selected module. For example, if the oscilloscope module you selected is installed in mainframe slot A and inputs are connected to both channels 1 and 2, the Source field defaults to A1. However, if an input signal is only connected to channel 2, the Source field defaults to A2 when you automatically scale with Autoscale, even though channel 1 is the default at power-up.

Level Field

The Level field shows the trigger level voltage value. When the voltage value on the trigger source input waveform equals the trigger level voltage value, the oscilloscope triggers. The point at which the oscilloscope triggers is called the trigger point (see the illustration below). The trigger point is shown on the screen as a vertical dotted red line, called the trigger marker. At zero delay time, the trigger marker is located at the horizontal center of the screen. At delay time T_d, the trigger point is offset left (positive delay) or right (negative delay) from the horizontal center of the screen by time T_d.

When you change the trigger level voltage value, the waveform moves horizontally on the display to maintain the trigger point. (That is, the point where the waveform voltage value equals the trigger point voltage value.) This is illustrated below.



If the trigger point voltage level is set above or below the waveform amplitude, the trigger point cannot be found. If Auto-Trig is set to On, this causes the waveform display to become unsynchronized and to "float" on the display. If Auto-Trig is set to Off, the message "Waiting for trigger" is displayed.

The trigger point voltage can be set, either by the autoscale function, or by a voltage value set into the Level field. When you touch the Level field and turn it light blue, you can change the value of the trigger level voltage by turning the knob.

The trigger level can be set to any voltage value contained within the waveform display window, in increments of 0.05% of full scale vertical voltage range (V/Div X 4 divisions = full scale). For example, if full scale voltage range were 400 mV, trigger level would be set in increments of 2 mV (V/Div = 100 mV x 4 x 0.005 = 2 mV).

Trigger level values can also be entered with the pop-up keypad. The keypad appears when you touch the Level field when the field is light blue. You can enter any value, in 0.05% increments of full scale vertical voltage range. Values entered that are not in this range will be rounded to the nearest 0.05% increment.

Since the trigger level range is limited by the voltage values displayed in the waveform window, the voltage window limits can be easily determined. Turn the knob in both directions until the Level field reads minimum and maximum voltage. These voltage values are the limits of the waveform window. However, if the level is set at the edge of a window and offset for that channel is changed, the trigger level will track that change, thereby changing the window limits.

The default value for the Level field is 1.620 V (TTL preset value).

Slope Field

You can set the trigger slope to trigger on either the positive or negative edge of the trigger source waveform. When you touch the Slope field, the field toggles between Positive and Negative.

The default selection for the Slope field is Positive.

Auto-Trig Field

The Auto-Trig field allows you to specify whether or not the acquisitions should wait for the specified trigger condition to occur. When you touch the Auto-Trig field, the field toggles between On and Off. The On and Off fields are discussed below.

The default selection for the Auto-Trig field is On.

On

When you set auto-trigger to On, the oscilloscope waits 50 ms (20-Hz rate) for a trigger to occur. If a trigger does not occur within that time, the current contents of acquisition memory are displayed. The message "Auto triggered" is displayed if one of the following conditions occurs:

- If no signal is on the input. In this case, the oscilloscope will display a baseline.
- If there is a signal but the specified trigger condition has not been met within 50 ms. In this case, the waveform display will not be synchronized to a trigger point.

Off

When you set auto-trigger to Off, the oscilloscope waits until a trigger is received before the waveform display is updated. If a trigger does not occur, the screen is not updated and the message "Waiting for Trigger" is displayed. Use this mode when:

- The trigger source signal has less than a 20-Hz repetition rate.
- The trigger events counter (refer to Count field, below) is set so that the number of trigger events would not occur before 50 ms.
- When you want to trigger on a specific event only.

Count Field

In edge trigger mode, you can define a positive or negative edge and the trigger level as a trigger qualifier. When the oscilloscope detects the trigger qualifier, it will trigger at a user-specified number of edges (Count field) on the waveform.

The Count field defines the number of trigger events that must occur after the first trigger qualifier before the oscilloscope will trigger and acquire a waveform.

Count can be set to any integer from 1 to 32,000. When the Count field is selected, the trigger events count can be changed by turning the knob or by entering a value from the pop-up keypad.

This type of triggering is commonly referred to as "events triggering" or delay-by-events triggering". It is very useful when trying to trigger on a specific pulse in a burst of pulses, with a long time delay, before the next burst occurs.

The default value for the Count field is 1.

Pattern Trigger Mode

When you are set up in a multimodule configuration, only the master card input channels are recognized as the trigger source. The oscilloscope will not pattern trigger on inputs from the other boards in a multimodule setup.

This chapter discusses how pattern triggering works in a single module configuration or in the master card in a multimodule configuration.

Pattern trigger mode allows you to trigger the oscilloscope upon entering or exiting a specified pattern of the trigger channels and the external trigger input.

When you have two or more HP 16532A modules connected together, you can only specify the channels on the master HP 16532A module as the trigger source.

When you touch the Mode field, Pattern can be selected from the pop-up menu.

Intermodule Measurements

If you set the oscilloscope module to Independent in the Intermodule module menu, the oscilloscope will be in the free-run mode and the waveform display will be synchronized to a trigger point.

If you set the oscilloscope module to Group Run in the Intermodule module menu, the oscilloscope triggers itself when its own trigger specification is met after being armed by the input port or by another module from the Intermodule menu.

More information about intermodule applications can be found in the *HP 16500A/16501A Logic Analysis System Reference manual.*

Channel/Pattern Field

The Channel/Pattern field is located next to the Mode field. It allows you to enter a pattern for the combination of the input channels and the ECL external trigger.

Channel

The Channel row lists the inputs available on the oscilloscope module being used. Channels are numbered 1, 2, and Ex. Ex is for the ECL external trigger.

Pattern

Each entry in the pattern shown in the Pattern row shows the trigger condition of the input above it in the Channel row.

You must set the trigger level for each input you want to use in the pattern. You set the trigger levels using the knob or keypad to set the value in the Level field in the Edge trigger mode. Setting these levels sets the threshold of each input for high and low levels in the pattern.

The pattern for each input may be specified as high (H), low (L), or "don't care" (X). H, L, and X conditions are as follows:

- H—the voltage value of this input channel must be greater than the edge trigger level of this input.
- L—the voltage level of this input channel must be less than the edge trigger level of this input.
- X—is a "don't care" condition. The "don't care" means the associated input channel will not be used in the pattern for the trigger qualifier. It does not equate to "trigger on anything."

The default condition for all patterns is X "don't care." To change the pattern, touch the Channel/Pattern field. A pop-up keypad will appear which allows you to assign the pattern conditions.

To enter a pattern, touch either X, L, or H on the pop-up keypad. The entries you make appear at the top of the pop-up keypad as they are entered. If you make a mistake, turn the knob to move the highlight to the entry to be corrected and select the correct entry, or touch CLEAR to change all entries back to X and enter the correct values. If the pattern is correct, touch DONE.

A pattern of XXX says to use NO channels to find the trigger. It does not equate to Immediate Mode when Auto-Trig is set to Off. This event will never occur in the hardware. Do not confuse XXX with "don't care, trigger on anything."

When Field

When you touch this field, the entry toggles between When Entered and When Exited.

When Entered

When this field is active, the oscilloscope triggers on the first transition that makes the pattern specification true for every input used in the pattern trigger specification. If the count set in the Count field is more than 1, the pattern must be true for the number of times set in the count field.

When Exited

When this field is active, the oscilloscope triggers on the first transition that causes the pattern specification to be false for every input used in the pattern trigger specification. If the count set in the Count field is more than 1, the pattern must be true for the number of times set in the count field before turning false.

The default selection for the When field is When Entered.

Auto-Trig Field

The Auto-Trig field allows you to specify whether or not the acquisitions should wait for the specified pattern condition to occur. When you touch the Auto-Trig field, the field toggles between On and Off.

On

When you set auto-trigger to On, the oscilloscope waits for 50 ms (20 Hz rate) for a trigger to occur. If a trigger does not occur within that time, the current contents of acquisition memory are displayed. The message "Auto triggered" is displayed if one of the following conditions occurs:

- If no signal is on the input. In this case, the oscilloscope will display a baseline.
- If there is a signal but the specified pattern condition is not met within 50 ms. In this case, the waveform display is not synchronized to a trigger point.

Off

When you set auto-trigger to Off, the oscilloscope waits until a trigger is received before the waveform display is updated. If a trigger does not occur, the screen is not updated and the message "Waiting for Trigger" is displayed. Use this mode when:

- The trigger source signal has less than a 20-Hz repetition rate.
- The trigger events counter (refer to Count field, below) is set so that the number of trigger pattern events would not occur before 50 ms.
- When you want to trigger on a specific event only.

The default selection for the Auto-Trig field is On.

Count Field

In pattern trigger mode, you can define a pattern as a trigger qualifier. When the oscilloscope detects the trigger qualifier, it will trigger when a user-specified number of patterns have occurred (Count field) on all inputs.

The Count field defines the number of events that must occur after the first trigger qualifier before the oscilloscope will trigger and acquire a waveform.

Count can be set to any integer from 1 to 32,000. When the Count field is selected, the events count can be changed by turning the knob or by entering a value from the pop-up keypad.

The default value for the Count field is 1.

Immediate Trigger Mode

When you are set up in a multimodule configuration, only the master card input channels are recognized as the trigger source. The oscilloscope will not trigger on inputs from the other boards in a multimodule setup.

This section discusses how immediate triggering works in a single module configuration or in the master card in a multimodule configuration.

Immediate trigger mode causes the oscilloscope to trigger by itself. When you touch the Mode field, Immediate can be selected from the pop-up menu.

Immediate trigger mode can be used for dual timebase (inter-module) applications where, for instance, one oscilloscope module arms another oscilloscope module, or another module (such as a logic analyzer) arms the oscilloscope.

This mode is very similar to Auto-Trig On, but immediate mode does not wait for a specified event to occur.

Intermodule Measurements

If you set the oscilloscope module to Independent in the Intermodule module menu, the oscilloscope will be in the free-run mode and the waveform display will not be synchronized to a trigger point.

If you set the oscilloscope module to Group Run in the Intermodule module menu, the oscilloscope triggers itself as soon as it is armed by the input port or by another module from the Intermodule menu.

More information about intermodule applications can be found in the *HP 16500A/16501A Logic Analysis System Reference* manual and the *HP 16532A User's Guide.*

7

Display Options

Display Options

The Display options control how the oscilloscope acquires and displays waveforms. You can cause the oscilloscope to acquire and display the waveforms in one of the following modes:

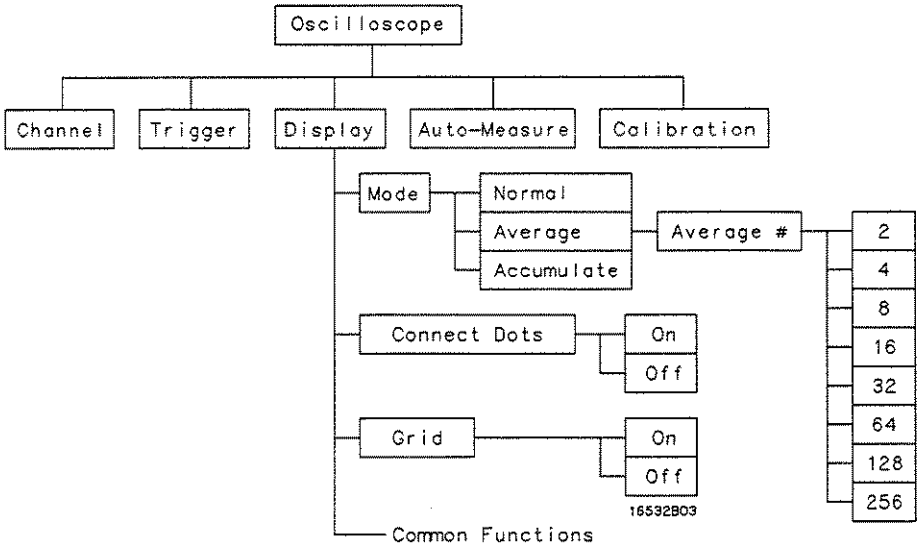
- Normal
- Average
- Accumulate

The Display options also control the connect-the-dots display and grid display features.

Display Menu Map

Display Field Menu Map

The menu map for the Display field is shown below.



Mode Field Options

The Mode field determines how waveform information is acquired and displayed. When you touch the Mode field, a pop-up menu appears. You can select Normal, Average, or Accumulate from the pop-up. The default selection for the Mode field is Normal.

Normal Mode

In Normal mode, the oscilloscope acquires waveform data and displays the waveform acquired from that data. When the oscilloscope makes a new acquisition, it erases the previously acquired waveform from the display, and displays the newly acquired waveform. This is an on-going process for as long as the oscilloscope is running repetitively, or whenever you make a single mode run. That is; acquire data, erase display, display new data, acquire data, erase display, display new data, etc.

Average Mode

In Average mode, the oscilloscope averages the most recently acquired data points on a waveform with previously acquired data. Averaging helps eliminate random noise from your displayed waveforms.

When you select Average mode, a new field appears next to the Mode field which allows you to select the number of waveform acquisitions to average. When you touch the Average # field, the field will turn a light-blue color. When the field is light blue, you can change the number in the field by turning the knob. The number of averages can be set to 2, 4, 8, 16, 32, 64, 128, or 256. The default value for the Average # field is 8.

You can also change the value in the Average # field with the pop-up keypad. The keypad appears when you touch the Average # field when that field is light blue. The numbers you can enter are the same as with the knob (any power of two from 2 to 256). Any value entered from the keypad that is not a power of two will be rounded to the nearest power of two (from the choices available).

As an example of average mode usage, assume the Average # field is set to 16 and the Run mode is set to Repetitive. When you touch the Run field, the oscilloscope starts acquiring waveform data and averaging it. After the initial 16 waveforms are acquired, the oscilloscope momentarily displays the advisory message "Number of averages has been met." Once the initial 16 waveforms are acquired, all new data is weighed at 1/N and is averaged with the previous data. All data is retained.

If you set the Run mode to Single, acquisitions are not made until you touch the Run field. If Average # is set to 16, as in the previous example, the "Number of averages has been met" message will not be displayed until you have touched the Run field 16 times.

Accumulate Mode

In Accumulate mode, the oscilloscope accumulates all waveform acquisitions and displays them on the screen without erasing the previously acquired waveforms. This is similar to infinite persistence on an analog storage oscilloscope. These acquisitions will stay on the display until Mode is changed, or until the waveform is adjusted by a control that causes the display to change, such as s/Div, Delay, or Connect Dots from On to Off.

Display Enhancement

The oscilloscope display can optionally be enhanced to show a better picture of a waveform. This is done by using the Connect Dots On or Connect Dots Off feature of the display. The default setting for the Connect Dots field is Off.

Connect Dots Field Options

If an edge is fast enough (relative to the sample rate), the signal may begin to look like dots scattered around the display. This is because each sample is displayed as a single dot.

To give you a better idea of what the waveform looks like, the oscilloscope has a feature that connects the sample dots together. Touching the Connect Dots field will toggle the field between On and Off.

On

With Connect Dots On, each displayed sample is connected to the adjacent sample. The waveform displayed with Connect Dots set to On is better defined and easier to see.

Off

With Connect Dots Off, each sample is displayed separately; that is, it is not connected to the adjacent sample. The waveform displayed with Connect Dots set to Off is the default mode of operation.

Horizontal and Vertical Grids

The oscilloscope display can optionally be divided into horizontal and vertical grids by using the Grid On or Grid Off feature of the display.

Grid Field Options

The Grid field allows you to turn the horizontal and vertical grid pattern on or off. Touching the Grid field will toggle the field between On and Off. The default setting for the Grid field is Off.

On

Touching the Grid field when it reads Off will toggle the field to On, and will cause the screen to display a horizontal and vertical grid pattern.

Off

Touching the Grid field when it reads On will toggle the field to Off, and will remove the grid pattern from the screen, except in Accumulate mode (see below).

While running either singly or repetitively in Accumulate mode, the Grid field will toggle from Off to On, and Grids will be displayed. However, when the Grid field is toggled from On to Off, the display will not delete the grids (Grid Off) until the Stop field is touched and a Repetitive Run is initiated or the settings (s/Div, Delay, etc.) are changed.

8

Auto-Measure Options

Auto-Measure Options

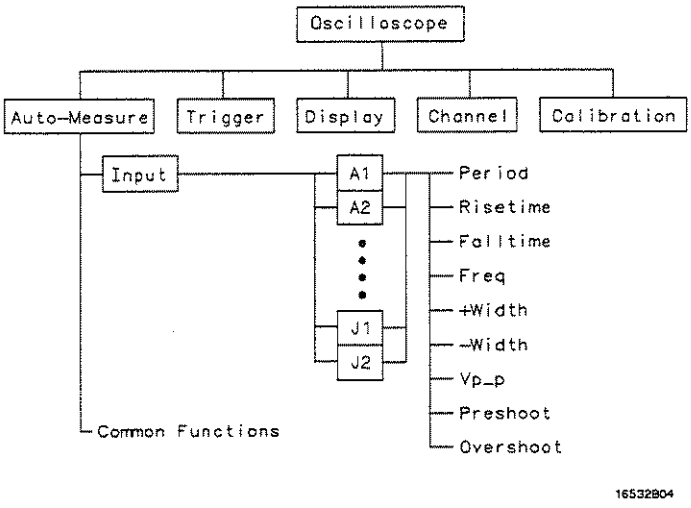
One of the primary features of the oscilloscope is its ability to make parametric measurements on displayed waveforms. This chapter provides details on how automatic measurements are performed and gives some tips on how to improve automatic measurement results.

There are nine automatic measurements available in the automatic measurement menu:

Period
Risetime
Falltime
Frequency
+Width
−Width
Vp_p
Preshoot
Overshoot

Auto-Measure Menu Map

The menu map for the Auto-Measure menu is shown below.



Auto-Measure Menu

You access the Auto-Measure menu by touching the menu field (top row, second from the left), then by selecting Auto-Measure from the pop-up menu that appears.

Input Field

The Input field allows you to select the source of the waveform to be measured. When you touch this field, a pop-up menu appears which shows the input sources. Make sure the proper source is selected for the input you are using.

The options displayed in the Input pop-up is dependent upon how many 1 GSa/s oscilloscope modules are installed in the mainframe and in which slots they are installed.

The default selection for the Input field is the lowest lettered and numbered input channel of the module you select to use to make a measurement. For example, if oscilloscope modules are installed in mainframe slots A, C, and E, the Input field defaults to A1 when you select the module in slot A as the module you will use. Similarly, if you select the module in slot E, the Input field defaults to E1.

Automatic Measurements Field

The tan-colored field in the middle row of the menu is called the automatic measurements field. This field displays the nine automatic measurements that you can make. The measurements that this field displays are:

Period,
Risetime,
Falltime,
Freq,
+Width,
−Width,
Vp_p,
Preshoot, and
Overshoot

Automatic Measurement Prerequisites

This section gives you some helpful pointers to help you make automatic measurements easier.

Measurement Setup Requirements

Measurements typically should be made at the fastest possible sweep speed in order to obtain the most accurate measurement possible. You can only make automatic measurements with data that is currently being displayed in the waveform display area. Keep the following in mind when making measurements:

- At least one full cycle of the waveform, with at least two like edges, must be displayed for Period and Freq measurements.
- A complete positive pulse must be displayed to make a +Width measurement.
- A complete negative pulse must be displayed to make a −Width measurement.
- The leading (rising) edge of the waveform must be displayed for Risetime, and rising edge Preshoot and Overshoot measurements.
- The trailing (falling) edge of the waveform must be displayed for Falltime, and falling edge Preshoot and Overshoot measurements.
- Risetime, Falltime, Preshoot, and Overshoot measurements will be more accurate if you expand the edge of the waveform by selecting a faster sweep speed.
- If the signal is clipped, the automatic measurements cannot be made.

Criteria Used for Making Automatic Measurements

If more than one waveform, edge, or pulse is displayed, the measurements are made on the first (leftmost) portion of the displayed waveform that can be used. When any of the defined measurements are requested, the oscilloscope first determines the top (100%) and base (0%) voltages of the waveform. From this information, it can determine the other important voltage values (10% voltage, 90% voltage, and 50% voltage) required to make the measurements. The 10% and 90% voltage values are used in the rise time and fall time measurements. The 50% voltage value is used for measuring frequency, period, and pulse width.

Automatic Measurement Algorithms

This section explains top and base voltages, then defines the measurement algorithms.

Top and Base Voltages

All measurements except Vp_p are calculated using the $\mathbf{V_{top}}$ (100% voltage) and $\mathbf{V_{base}}$ (0% voltage) levels of the displayed waveform. The $\mathbf{V_{top}}$ and $\mathbf{V_{base}}$ levels are determined from an occurrence density histogram of the data points displayed on the screen.

The digitizing oscilloscope displays 8-bit vertical voltage resolution. That is, the vertical axis of the display is divided into 2^8 voltage levels. Each of these 256 levels is called a quantization level. Each waveform has 500 data points displayed on the horizontal axis of the screen. Each of these 500 data points has one quantization level assigned to it. The histogram is calculated by adding the number of occurrences of each quantization level of the 500 displayed points on the displayed waveform.

The quantization level with the greatest number of occurrences in the top half of the waveform corresponds to the $\mathbf{V_{top}}$ level. The quantization level with the greatest number of occurrences in the bottom half of the waveform corresponds to the $\mathbf{V_{base}}$ level.

If V_{top} and V_{base} do not contain at least 5% of the 500 data points displayed on screen, V_{top} defaults to the maximum voltage ($V_{maximum}$) and V_{base} defaults to the minimum voltage ($V_{minimum}$) found on the display. An example of this case would be measurements made on sine or triangle waves.

From this information, the instrument can determine the 10%, 50%, and 90% points, which are used in most automatic measurements. The V_{top} or V_{base} of the waveform is not necessarily the maximum or minimum voltage present on the waveform. If a pulse has a slight amount of overshoot, it would be wrong to select the highest peak of the waveform as the top because the waveform proper rests below the perturbation.

Measurement Algorithms

Frequency (Freq)

The frequency of the first complete cycle displayed is measured using the 50% levels.

If the first edge on the display is rising, then

$$\text{Freq} = \frac{1}{t_{\textit{rising edge 2}} - t_{\textit{rising edge 1}}}.$$

If the first edge on the display is falling, then

$$\text{Freq} = \frac{1}{t_{\textit{falling edge 2}} - t_{\textit{falling edge 1}}}.$$

Period

The period is measured at the 50% voltage level of the waveform.

If the first edge on the display is rising, then

$$\text{Period} = t_{\textit{rising edge 2}} - t_{\textit{rising edge 1}}.$$

If the first edge on the display is falling, then

$$\text{Period} = t_{\textit{falling edge 2}} - t_{\textit{falling edge 1}}.$$

Peak-to-Peak Voltage (Vp_p)

The maximum and minimum voltages for the selected source are measured:

$$\text{Vp\_p} = V_{\textit{maximum}} - V_{\textit{minimum}},$$

where $V_{maximum}$ and $V_{minimum}$ are the maximum and minimum voltages present on the selected source.

Positive Pulse Width (+Width)

Pulse width is measured at the 50% voltage level.

If the first edge on the display is rising, then

$$+\text{Width} = t_{falling\ edge\ 1} - t_{rising\ edge\ 1}.$$

If the first edge on the display is falling, then

$$+\text{Width} = t_{falling\ edge\ 2} - t_{rising\ edge\ 1}.$$

Negative Pulse Width (−Width)

Negative pulse width is the width of the first negative pulse on screen using the 50% levels.

If the first edge on the display is rising, then

$$-\text{Width} = t_{rising\ edge\ 2} - t_{falling\ edge\ 1}.$$

If the first edge on the display is falling, then

$$-\text{Width} = t_{rising\ edge\ 1} - t_{falling\ edge\ 1}.$$

Rise time

The rise time of the first displayed rising edge is measured. To obtain the best possible measurement accuracy, set the sweep speed as fast as possible while leaving the full leading edge of the waveform on the display. The rise time is determined by measuring time at the 10% and 90% voltage points on the rising edge:

$$\text{Rise time} = t_{90\%} - t_{10\%}.$$

Fall time

Fall time is measured between the 10% and 90% points of the falling edge. To obtain the best possible measurement accuracy, set the sweep speed as fast as possible while leaving the falling edge of the waveform on the display:

Fall time = $t_{10\%} - t_{90\%}$.

Preshoot and Overshoot

Preshoot and Overshoot measure the perturbation on a waveform above or below the top and base voltages (see the "Top and Base Voltages" section earlier in this chapter). These measurements use all data displayed on the screen; therefore, it is very important that only the data of interest be displayed. If you want to measure preshoot and overshoot on one edge of a waveform, then only display that edge. If you want to measure the maximum preshoot and overshoot on a waveform, then display several cycles of the waveform.

Preshoot is a perturbation before a rising or a falling edge and is measured as a percentage of the top-base voltage.

Overshoot is a perturbation after a rising or a falling edge and it is measured as a percentage of the top-base voltage.

If the measured edge is rising, then

$$\text{Preshoot} = \left[\frac{V_{base} - V_{minimum}}{V_{top} - V_{base}} \right] \times 100$$

and,

$$\text{Overshoot} = \left[\frac{V_{maximum} - V_{top}}{V_{top} - V_{base}} \right] \times 100.$$

If the measured edge is falling, then

$$\text{Preshoot} = \left[\frac{V_{maximum} - V_{top}}{V_{top} - V_{base}} \right] \times 100$$

and,

$$\text{Overshoot} = \left[\frac{V_{base} - V_{minimum}}{V_{top} - V_{base}} \right] \times 100.$$

9

Waveform Selection Options

Waveform Selection Options

This chapter shows you how to insert, replace, and delete input channels on the waveform display, and how to perform waveform math and overlay functions. Any of these operations can be performed from any of the oscilloscope menus except calibration.

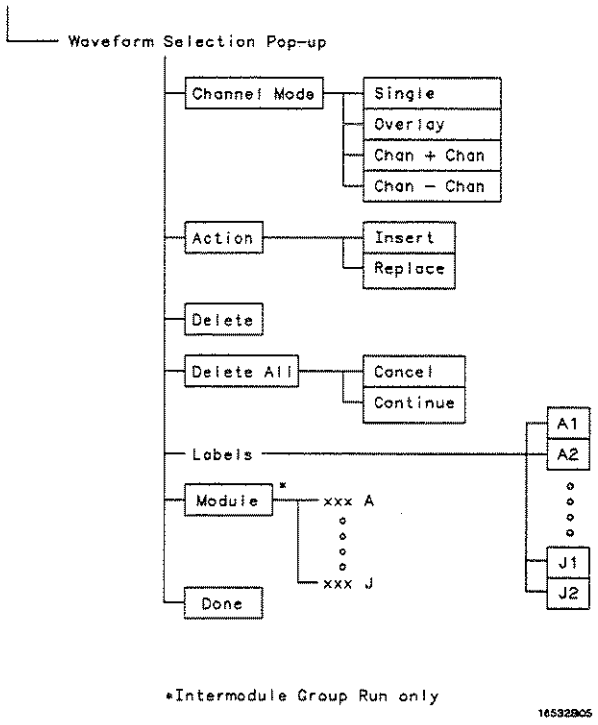
The dark-blue channel label field to the left of the waveform display area shows the input channels that are being displayed. To access the Waveform Selection pop-up menu, you touch the channel label field twice (once to turn it light-blue then once more to access the menu). The menu lets you insert, delete, or replace an input channel, and choose channel modes. It also lets you select to view a waveform from another module when you are making intermodule measurements.

The oscilloscope module has the capability to display 96 waveforms– eight at any one time. When you have made more than eight waveforms accessible for display, some of them will not be in the waveform display area. To display them you touch the dark-blue channel label field once to turn it light-blue then use the knob to scroll through all of the waveforms and select the ones you want displayed.

Waveform Selection Menu Map

Waveform Selection Menu Map

The menu map for the Waveform Selection pop-up is shown below.



Module Field Options

The Module field in the waveform selection menu lets you select to view waveforms from more than one module when you are making intermodule measurements. The use of this field is also described in chapter 10, which deals with intermodule measurements.

Selecting a Module in the Module Field

If you are running your modules in the mainframe independently, and you touch the Module field, the name of the module you are currently running will be displayed as the only option in the pop-up menu. When you touch that field, the message "Data correlatable only for modules under group run" is displayed. This will remind you that this field is only used in intermodule measurements.

If you are running intermodule measurements between modules in the mainframe, and you touch the Module field, the name of the modules you are running as part of the intermodule measurement will be displayed as options in the pop-up menu. The input labels for the module that you select from the pop-up menu will appear in the Labels field. Using the Action options (Replace and Insert) and the Delete option, you can select the input, or inputs, you wish to view, and where you wish to place them on the screen.

You can select up to 96 waveforms or combinations of waveforms for viewing on the display. You can view up to eight waveforms in the display area at any one time. To view selected waveforms that are off the screen, you touch the field to the left of the waveform display area to turn it light-blue. Then use the knob to scroll through the waveforms to find the one you want displayed. Refer to the section in chapter 10 entitled "Displaying Multiple Module Data on One Screen" for more details.

Channel Mode Field Options

Touching the Channel Mode field in the Waveform Selection field causes a pop-up menu to appear. This pop-up shows the channel mode selections available. The Channel Mode field lets you select how the waveform will be displayed. The options are Single mode, Overlay mode, Chan+Chan mode, and Chan−Chan mode.

Single Mode

This mode displays a single input channel in each waveform display area for which it is selected. It is the default mode for the oscilloscope module.

Overlay Mode

This is a waveform mode that lets you take the signal from one channel input and compare it to the signal from another (or several other) channel input. It lets you put multiple waveforms on the same waveform display area—or overlay the waveforms.

Waveforms from separate modules cannot be overlaid when making an intermodule measurement.

For example, to overlay the waveform on Input 1 with the waveform on Input 2:

Touch the Channel Mode field on the display, then when the pop-up appears, touch the Overlay field.

Turn the knob so that the bottom input in the channel label field is highlighted in white.

Then touch the Action field until Insert is displayed.

Next, touch the Input 1 label in the Labels field, then touch Input 2 in the Labels field.

Input 1 and Input 2 waveforms, shown as X1,X2 (where X is the slot letter of the module) are then displayed in the top channel label field.

After you have touched the Done key in the pop-up, you may need to touch the s/Div field and change the sweep speed in order to more easily see differences in the overlaid waveforms.

Input 1 will now be overlaid on Input 2 in the waveform display area.

If markers are turned on, no voltage values for the overlaid waveforms will appear in the channel label field to the left of the waveform display area.

Overlaid waveforms are scaled and offset (respectively), or in relationship to each other, but the value in the V/Div field does not necessarily correlate to the overlay waveform display tick marks.

Waveform Math (Chan+Chan Mode)

This is a waveform mode that lets you take the signal from one channel input and add it to the signal from another channel input.

Waveforms from separate modules cannot be added together when making an intermodule measurement.

For example, to add the waveform on Input 1 to the waveform on Input 2:

Touch the Channel Mode field on the display, then when the pop-up appears, touch the Chan+Chan field.

Turn the knob so that the bottom input in the channel label field is highlighted in white.

Then touch the Action field until Insert is displayed.

Touch the Input 1 label in the Labels field, then touch Input 2 in the Labels field.

Input 1 and Input 2 waveforms, shown as X1+X2 (where X is the slot letter of the module) are then displayed in the channel label field.

Now touch the Done key in the pop-up to display the waveform. The display now shows input 2 added to input 1. The resultant waveform is displayed in white in the waveform display.

If markers are turned on, voltage values for this waveform will appear in the channel label field to the left of the waveform display area.

Waveform Math (Chan–Chan Mode)

This is a waveform math mode that lets you take the signal on one channel and subtract it from the signal on the other channel.

Waveforms from separate modules cannot be subtracted from each other when making an intermodule measurement.

For example, to subtract the waveform on Input 2 from the waveform on Input 1:

Touch the Channel Mode field on the display, then when the pop-up appears, touch the Chan–Chan field.

Turn the knob so that the bottom input in the channel label field is highlighted in white.

Then touch the Action field until Insert is displayed.

Next touch the Input 1 label in the Labels field, then touch Input 2 in the Labels field.

Input 1 and Input 2 waveforms, shown as X1–X2 (where X is the slot letter of the module) are then displayed in the channel label field.

Touch the Done key in the pop-up to display the waveform. The display now shows input 2 subtracted from input 1. The resultant waveform is displayed in white in the waveform display.

If markers are turned on, voltage values for this waveform will appear in the channel label field to the left of the waveform display area.

Action Field Options

The Action field is a toggle field that toggles between Replace and Insert. These options let you choose to replace or to insert an input channel in the waveform display area.

Replacing a Channel

Touching the Action field in the Waveform Selection pop-up causes the Action field to toggle between Insert and Replace. To replace a channel, you touch the Action field to toggle it to Replace.

Turning the knob slightly in each direction controls which input channel in the channel label field is highlighted in white. The channel highlighted in white is the channel that will be replaced. You replace the channel highlighted in white with the channel you touch in the Labels field.

In single module configurations the waveform display shows input 1 as yellow and input 2 as green. If two cards are connected as one unit, the second card input 1 is shown as blue and input 2 is shown as red.

Inserting a Channel

Inserting an input channel works similar to replacing a channel. Touching the Action field in the Waveform Selection pop-up causes the Action field to toggle between Insert and Replace. To insert a channel, you touch the Action field to toggle it to Insert.

Turning the knob slightly in each direction controls which input channel in the channel label field is highlighted in white. The channel you insert will be inserted below the channel highlighted in white. To insert a channel, you touch the channel in the Labels field that you want to insert below the channel highlighted in white.

In single module configurations the waveform display shows input 1 as yellow and input 2 as green. If two cards are connected as one unit, the second card input 1 is shown as blue and input 2 is shown as red.

Delete All Option

The Delete All field in the Waveform Selection pop-up menu lets you delete all of the currently displayed channel inputs from the waveform display area. The pop-up selections for this field are Continue and Cancel

Cancel

Selecting Cancel from the Delete All pop-up menu allows you to change your mind about deleting all currently displayed inputs. Touching this field causes the pop-up to disappear. No changes are made to the display choices made prior to touching the Delete All field.

Continue

Selecting Continue from the Delete All pop-up menu causes all of the currently displayed inputs to be deleted. Touching this field also causes the pop-up to disappear.

Delete Field Option

The Delete field in the Waveform Selection pop-up menu lets you delete channel inputs from the waveform display area.

Deleting a Channel

You use the knob to highlight the input channel in the channel label field that you want to delete. You then touch the Delete field in the Waveform Selection pop-up to delete the highlighted channel input from the channel label field, and hence, from the waveform display area. The input channel highlighted in white will be deleted when you remove your finger from the Delete field.

Labels Field Options

The Labels field in the Waveform Selection pop-up menu lets you pick the channels you wish to display on the screen. You use this field in conjunction with the Action and Channel Mode fields to make your display choices when running your mainframe modules independently. For intermodule runs, you also use the Module field to choose the module that contains the input channels you wish to display.

Done Field Option

When you are finished making all of your selections in the Waveform Selection pop-up menu, you touch the Done field to enter the selections and return to the waveform display. The choices you made while in the Waveform Selection pop-up will be implemented on the screen.

10

Intermodule Measurement Options

Intermodule Measurement Options

Intermodule measurements can be used when you need the acquisition capabilities of one module to look at a signal, but you need the triggering capabilities of another module to properly trigger the measurement.

The HP 16500A/16501A can be configured with several different modules inside the instrument at one time. The Intermodule menu allows you to make interactive measurements between these modules. This also includes making measurements that use one or more modules in conjunction with an external instrument.

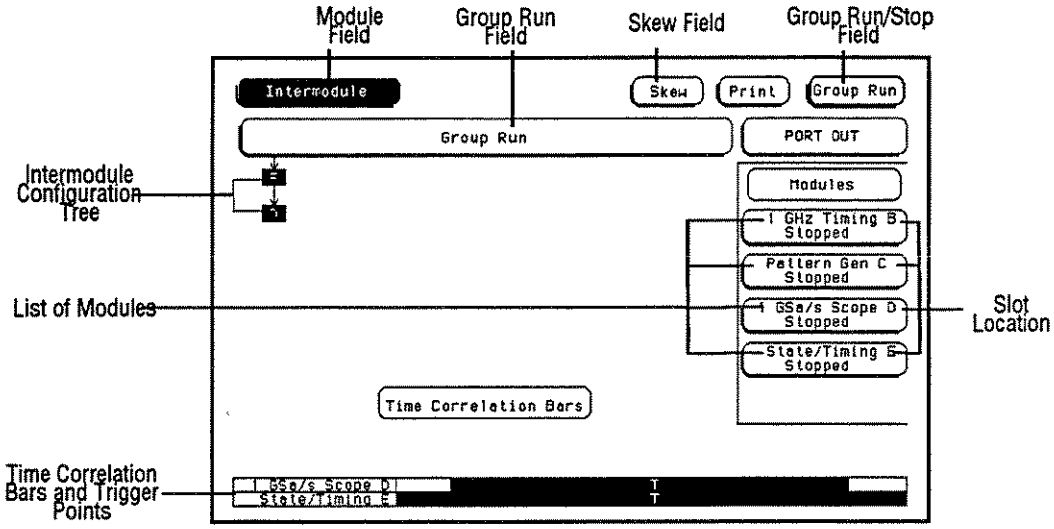
The basic functions of the Intermodule menu give you the ability to configure modules to run simultaneously, to set up arming sequences between modules, to adjust skew between modules, and to synchronize with external equipment. The Intermodule menu also lets you set up to display the resulting waveforms and state listings for several modules together on one screen.

Operation

There are three different types of operations that can be performed from the Intermodule menu.

1. You can set up modules to run independently or within an intermodule measurement. Initially, the intermodule configuration tree is empty, with all the modules running independently. Intermodule measurements are configured by adding modules to the intermodule configuration tree (see the following figure). Modules that appear directly below the large Group Run field are armed immediately after the Group Run/Stop field in the upper-right corner is touched. Modules that appear below other modules are armed when the preceding module finds its trigger.

The HP 16500A, with the HP 16501A attached, functions as a single mainframe. Modules in either the HP 16500A, the HP 16501A, or both, can be added to the same intermodule configuration tree (refer to "System Arming and Triggering" in chapter 6 of the *HP 16500A/16501A Logic Analysis System Reference Manual).*

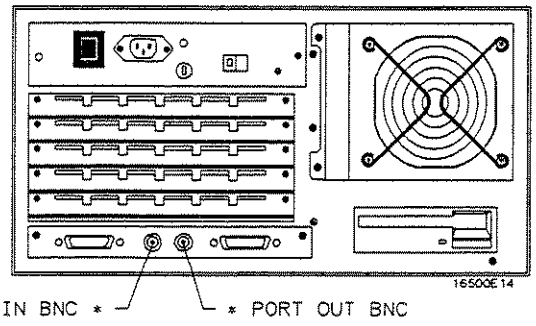


2. You can synchronize with external equipment.

- Once a module is added to the intermodule configuration tree, the PORT OUT signal can be added beneath that module or any other module appearing on the tree. When the module preceding PORT OUT triggers, a signal is sent to the PORT OUT BNC of the instrument to arm an external device. The actual BNC connection for the PORT OUT feature is on the rear panel of the HP 16500A. When activated, PORT OUT outputs a positive-going TTL pulse whose width varies depending on the module that is driving it. This port may be terminated by a 50 ohm load to reduce ringing on the signal. If terminated, the signal will be less than or equal to 0.4 V when low and at least 2.0 V when high.

- The PORT IN signal can be selected to arm the intermodule configurations in conjunction with the Group Run/Stop field. You select to arm the measurement with an external (PORT IN) signal by touching the Group Run field and selecting Group Run Armed from PORT IN from the pop-up menu. The actual BNC connection for the PORT IN feature is on the rear panel of the HP 16500A. When PORT IN is activated and the measurement configuration has been set up, touching the Group Run/Stop field puts the instrument in a standby condition. The intermodule measurement begins when the proper signal is sent to the PORT IN BNC on the rear panel of the HP 16500A. This input requires a minimum input of 2.4 V for a high and a maximum of 0.4 V for a low. It is active high.

Although the rear panels of the HP 16500A and HP 16501A are nearly identical, only the HP 16500A has the PORT IN BNC and PORT OUT BNC connectors, as shown in the figure below. However, the PORT IN and PORT OUT signals are available to modules in both the HP 16500A and HP 16501A mainframes.



3. You can modify the intermodule skew offsets with the Skew pop-up of the Intermodule menu to adjust skew or timing deviation between the modules within the intermodule measurement. This allows you to compensate for any known delay of the system under test or compare two signals by removing any displayed skew between the signals.

Helpful Hints

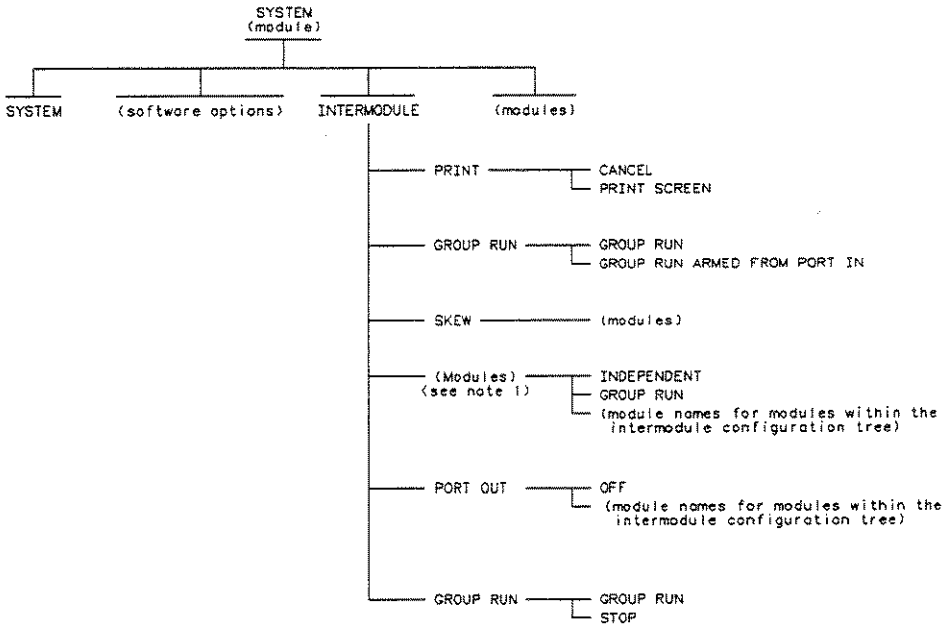
1 When setting up measurements, start with simple setups and work up to more complex ones. For example, set up the module that will trigger first and take a measurement with only this module. Once you have verified that this first trigger works properly, start adding additional modules to be armed by this trigger.

2 Before starting the measurement, set all modules to store data while they search for the trigger condition. This way, you can see information on both sides of the trigger condition as you fine-tune the measurement.

3 When the oscilloscope module is part of the measurement, to get time correlation between modules, initially set the modules that are armed from the intermodule bus to automatically trigger (Auto-Trig set to On) or to "trigger immediately." Then increase the triggering requirements in stages. That is, start with the first modules that are armed and work from the top to the bottom of the intermodule configuration tree.

Intermodule Menu Map

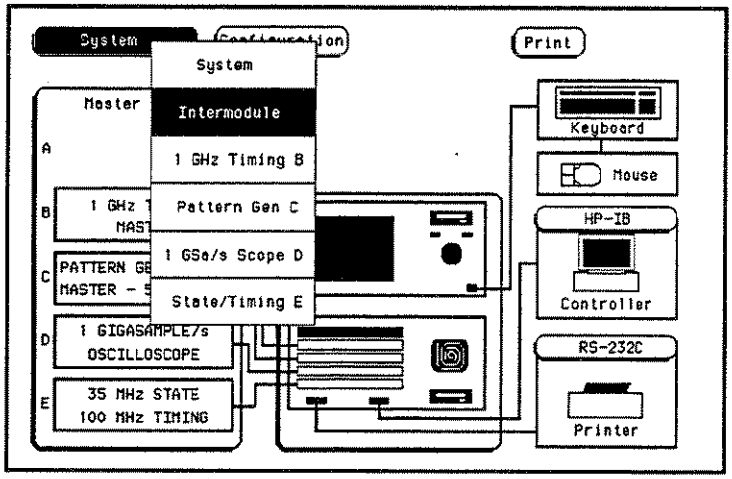
The menu map for the Intermodule menu is shown below



NOTE 1: THE WORD MODULE IN PARANTHESES REPRESENTS THE NAME OF THE MODULES CONFIGURED IN YOUR SYSTEM. THIS PART OF THE MENU MAP REPEATS ITSELF FOR EACH MODULE.

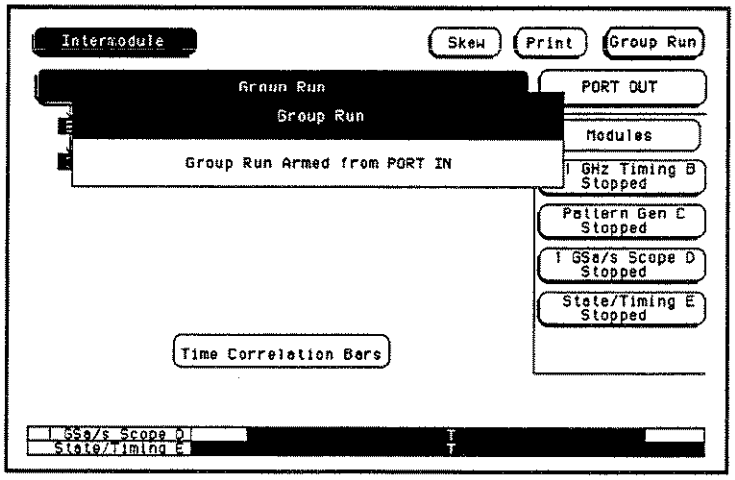
Intermodule Menu

You access the Intermodule menu by touching the Module field (leftmost field in the top row), then selecting Intermodule from the pop-up menu that appears as shown below.



Group Run Field

The large Group Run field (see the figure below) is used in the configuration of the Intermodule menu. This field is the base of the intermodule configuration tree. The configuration tree displays how the modules interact and it shows the sequence in which the modules are armed when the intermodule measurement is initiated. Modules that appear directly below the large Group Run field are armed immediately after the Group Run/Stop field in the upper-right corner is touched to start a run. A module that appears below another module is armed when the module that is above it, and that it is attached to, finds its trigger.



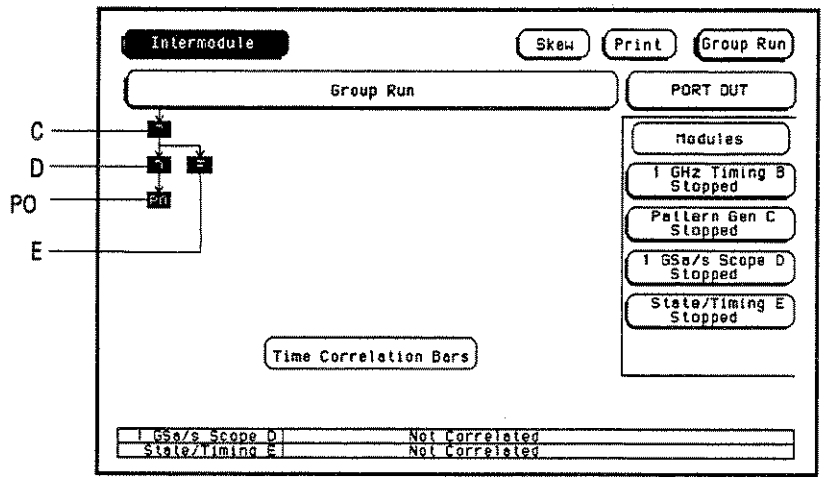
Touch the large dark-blue Group Run field. The pop-up that appears will display:

- Group Run and
- Group Run Armed from PORT IN which allows you to use an external input to arm the Group Run measurement. This input requires a minimum input of 2.4 V for a high and a maximum of 0.4 V for a low. It is active high and the actual PORT IN BNC input is located on the rear panel of the HP 16500A.

Touch Group Run and the pop-up disappears.

To use PORT IN, an external device must be connected to the PORT IN BNC on the rear panel of the HP 16500A. If an external device isn't connected, or is accidently disconnected from the PORT IN BNC, the instrument will display the message "Waiting for IMB arm."

Following is a brief overview of the operation of an intermodule measurement when the HP 16500A Logic Analysis System is configured as shown below.



When you touch the Group Run/Stop field in the upper-right corner:

1 The status for each module involved changes to Running (as shown in the individual module fields).

2 Module C is armed immediately and begins looking for its pre-trigger conditions.

3 Once the pre-trigger conditions for module C are satisfied, the module triggers, and modules D and E are armed. Modules D and E begin looking for their pre-trigger conditions.

4 Once the pre-trigger conditions for modules D and E are satisfied, the modules trigger and complete their measurements.

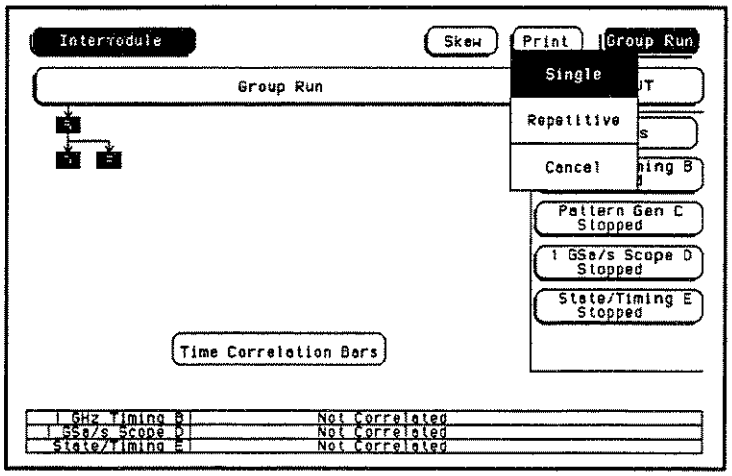
5 When module C triggers, it sends a signal to an external device through PO (PORT OUT).

6 The status indicator of each module changes to Stopped when the module finishes its measurement. After all the modules are finished with their measurements, the data is displayed in the individual waveforms or display menus of the modules.

After an actual measurement, the time correlation bars at the bottom of the menu display the trigger points (T) and the start and stop acquisition windows of each module relative to the other modules.

The Group Run/Stop Field

When a module is added to the intermodule configuration tree, the module's Run/Stop field changes to the Group Run/Stop field (see the following figure). The Group Run/Stop field is the Run/Stop field for the modules in the Intermodule menu. This field appears in the Intermodule menu so that the measurement can be started from this menu and the results monitored with the Running/Stopped status indicators and time correlation bars.



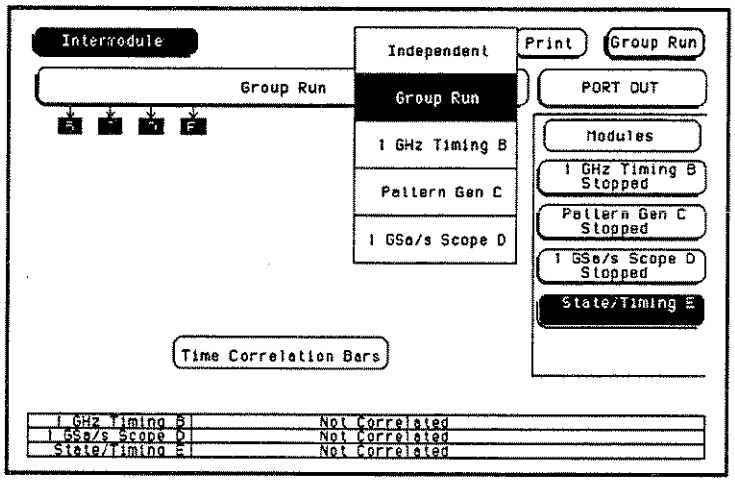
If you touch and hold the Group Run/Stop field, a pop-up menu appears with your choices for acquiring data.

- Single, which is the default, allows you to run the measurement once.
- Repetitive, which allows you to run the measurement as many times as you want to collect data for statistical measurements, etc. Press Stop when you want to stop collecting data.
- Cancel, which allows you to cancel the measurement.

When you touch and hold your finger on the Group Run field, the current selection is displayed with a light-blue background. When you touch the Group Run field and slide your finger to one of the selections in the pop-up, that selection is then displayed with a white background. Releasing the Group Run/Stop field before making a selection or without changing the selection, results in the instrument running the measurement according to the last input to this field.

The Modules

On the right side of the screen are fields listing the different modules that can be configured in the Intermodule menu. When you touch one of the module fields, a pop-up appears displaying the possible locations of the module in the intermodule configuration tree (see the figure below).

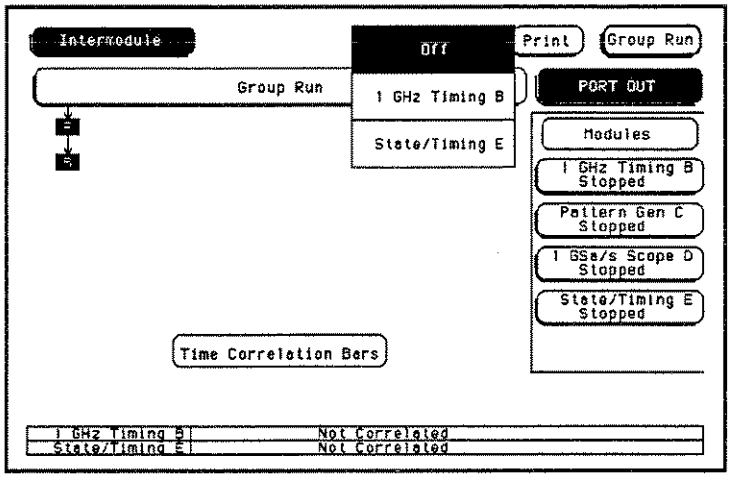


- Independent allows the module to run independently of the other modules and removes it from the intermodule configuration tree.
- Group Run places the module directly below the large Group Run field. This module is armed immediately after the Group Run/Stop field is touched.
- The other fields in the pop-up list the name of the modules that are already part of the intermodule configuration tree and can be used to arm this module. Touching one of these fields places the current module below the module indicated by the field you selected. The current module is then armed when the preceding module finds its trigger.

After you make your selection, a box appears in the intermodule configuration tree with the module's slot location (A through E for the HP 16500A alone, or A through J for the HP 16500A with the HP 16501A attached) representing the location of the module in the tree.

PORT OUT

PORT OUT is used to signal an external device from a module in the intermodule configuration tree. This field only appears when a module is present in the intermodule configuration tree (see the figure below).



To use the PORT OUT feature:

1 Touch the field of the module that you want to control the group run and select Group Run from the pop-up menu.

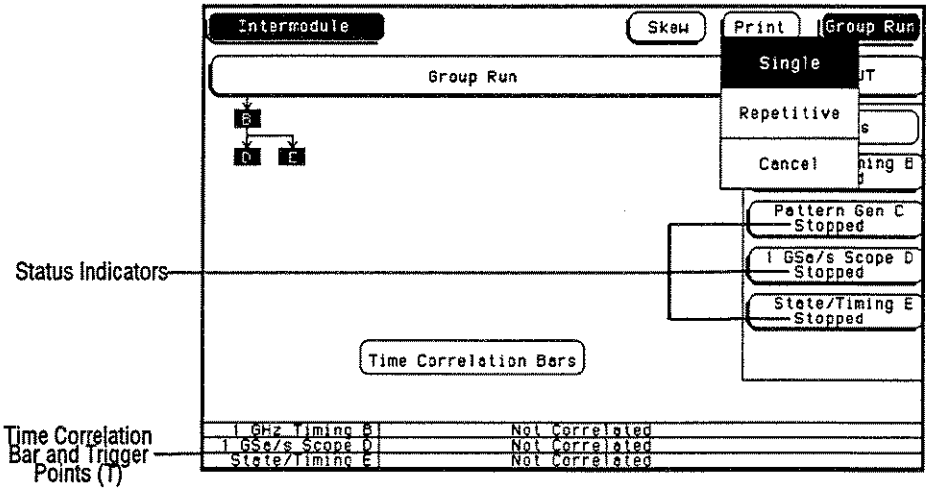
2 Touch the PORT OUT field above the Modules field on the right side of the display and a pop-up appears listing all of the modules that appear in the intermodule configuration tree.

3 Touch the field displaying the name of the module that you want to arm the external device and the pop-up disappears. PO (for PORT OUT) now appears in the intermodule configuration tree below the module you selected.

The actual BNC connection for the PORT OUT feature is on the rear panel of the HP 16500A. When activated, PORT OUT outputs a positive-going TTL pulse whose width varies depending on the module that is driving it. This port may be terminated by a 50 ohm load to reduce ringing on the signal. If terminated, the signal will be less than or equal to 0.4 V when low and at least 2.0 V when high.

Status Indicators and Time Correlation Bars

Running or Stopped appears below the names of the individual modules that are listed on the right side of the Intermodule menu (as shown below). This indicates the current status for each module and can be used to monitor the intermodule measurement. If there is a problem with the measurement, a quick check of these status indicators can show you which modules have completed their operations (Stopped) and which ones are still Running.



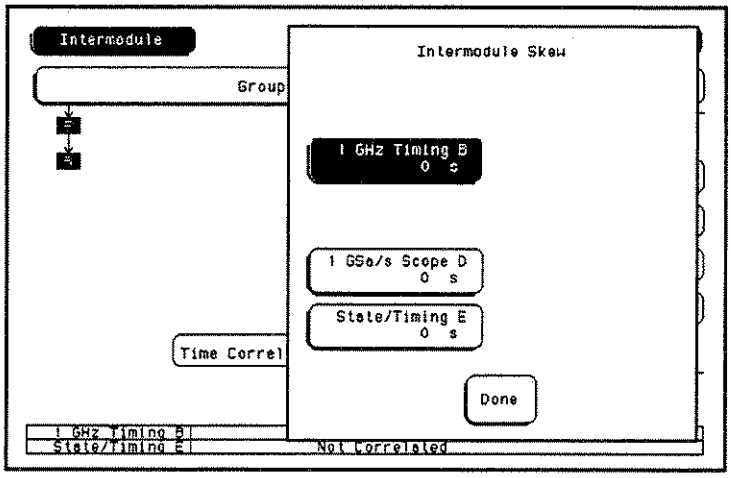
Generally:

- If a module was running and is stopped now, you can assume it received its arming signal and triggered properly.
- A module below a stopped module on the intermodule configuration tree has received its arming signal. If it's still running, then it may have trouble triggering or completing its task.
- A module below a running module on the intermodule configuration tree has not received its arming signal yet.

The time correlation bars at the bottom of the menu display the trigger point (T) and the start and stop time of each module relative to the other modules.

The Skew Menu

Touch the Skew field to bring up the Skew pop-up menu as shown below).



The Skew pop-up of the Intermodule menu is used to de-skew waveforms or state listings between modules on the display. This allows for display adjustment to within one nanosecond between modules. The major purpose of this adjustment is to compensate for variances in internal probing delays across modules.

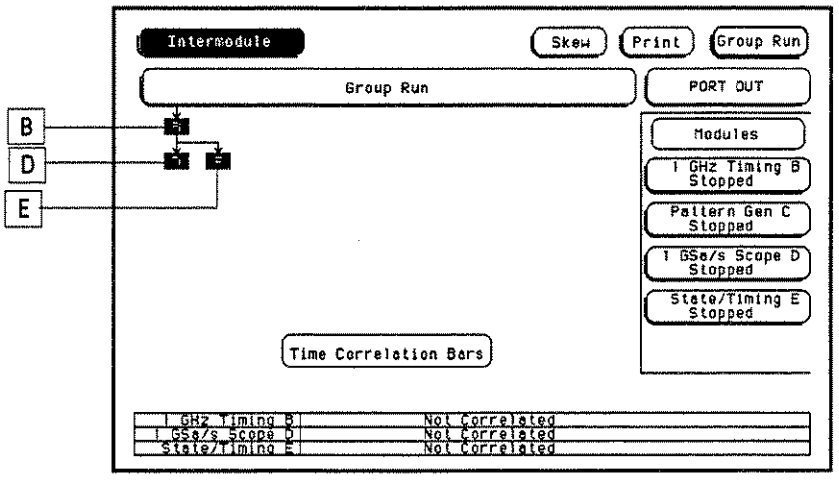
To adjust the skew of the module, use the Skew pop-up to add or subtract a known skew value. This value may be calculated with the markers by measuring the skew between some common signal sampled by both modules.

To enter a value of skew, touch the field for the module you want and, after it turns light blue, input the skew with the knob. If you touch the field a second time, a pop-up keypad appears to input the skew.

Displaying Multiple Module Data on One Screen

When you are making intermodule measurements, you can display the resulting waveforms or state listings for several modules together on one screen.

The example in this section is based on the setup shown in the figure below. This setup has a 1 GHz Timing Analyzer in slot B, which is set up for Group Run. Slot D contains a 1 GSa/s Oscilloscope, which is set to be armed by the 1 GHz Timing Analyzer. Slot E contains a State/Timing Analyzer which is also set to be armed by the 1 GHz Timing Analyzer. It is assumed that you have already set up the instrument to run a measurement. The example shows the procedure for getting the waveforms on the display. Since there are no signals connected to the instrument in this example, there are no waveforms displayed.



To display multiple module data on one screen

1 Touch the module field in the upper-left corner of the screen. When the pop-up appears, select 1 GSa/s Scope D.

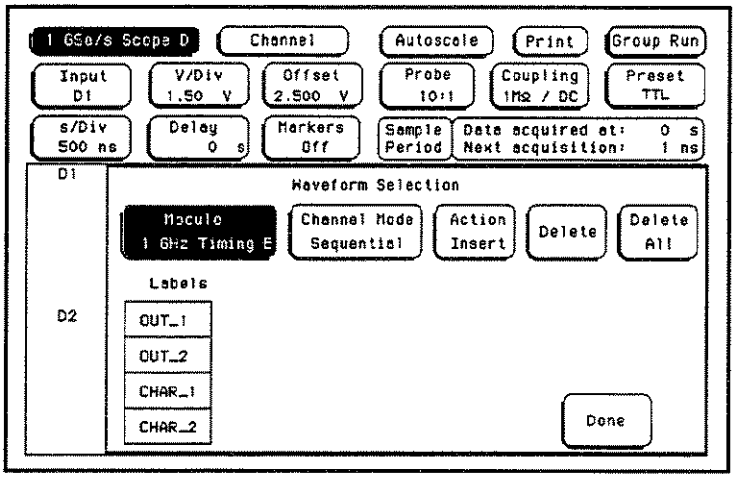
2 When the 1 GSa/s Scope D menu appears, touch the menu field and select the menu in which you want to view the data. For this example, Channel is selected.

3 Touch the channel label field to the left of the waveform display once to turn it light blue. Then touch it again to access the display parameters.

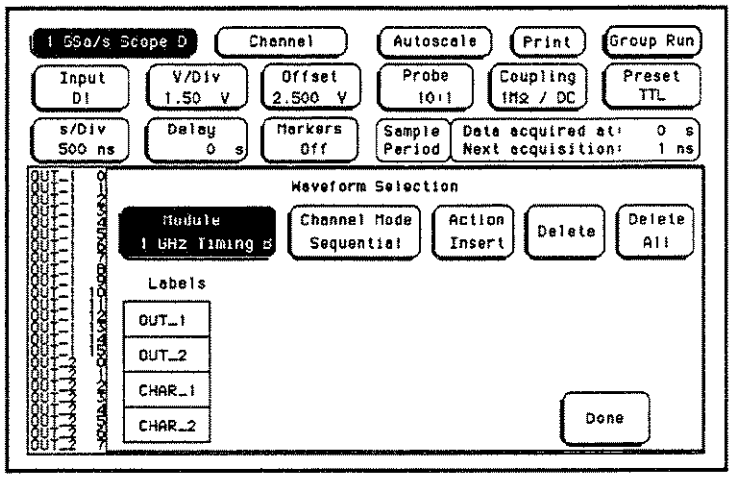
4 Note that the two 1 GSa/s Scope D labels (D1 and D2) appear under the Labels field.

5 Touch the Module field displaying 1 GSa/s Scope D.

6 When the pop-up menu appears, touch 1 GHz Timing B. After the pop-up disappears, the appropriate labels for the channels of the HP 16515A 1 GHz Timing Analyzer will be listed in the Labels field under the 1 GHz Timing B field (see the figure below).

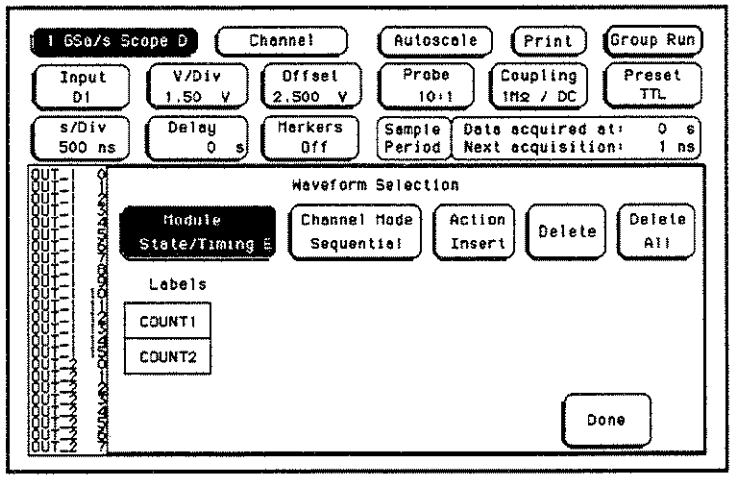


7 Turn the knob so that D2 is highlighted, then touch the labels for the channels that you want displayed. For this example, touch OUT_1, then OUT_2 as shown below.



8 Touch the Module field displaying 1 GHz Timing B.

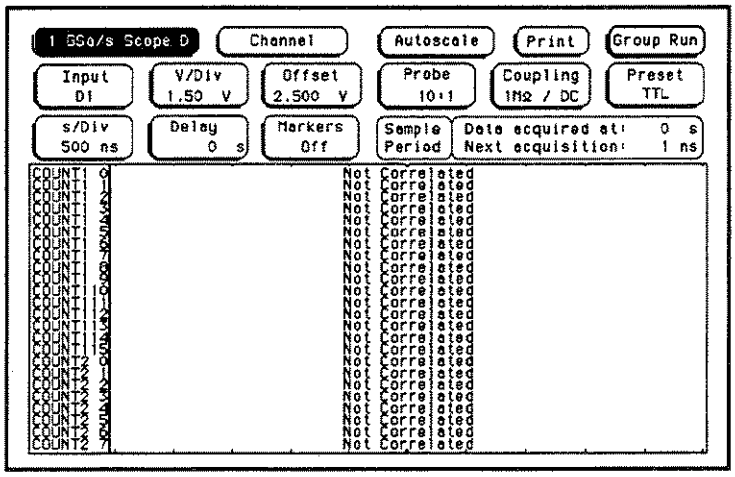
9 When the pop-up menu appears, touch State/Timing E. After the pop-up disappears, the appropriate labels for the channels of the HP 16510B State/Timing Analyzer will be listed in the Labels field under the State/Timing E field as shown below.



10 Touch the labels for the channels that you want displayed. For this example, touch COUNT1, then COUNT2 as shown below.

11 Touch Done and the Waveform Selection pop-up will disappear, returning you to the waveform display. As shown in the figure below, the HP 16510B State/Timing Analyzer channels COUNT1 and COUNT2 are now displayed.

> Using the Waveform Selection menu, you can select up to 96 waveforms or combinations of waveforms for viewing on the display. You can view up to eight waveforms on a single display at any one time. To view selected waveforms that are off the screen, you touch the field to the left of the waveform display area to turn it light-blue. Then you use the knob to scroll through the waveforms to find the one you want displayed.



The waveform display area shows the message "Not Correlated" for all channel inputs because there are no signals connected to the inputs of the instrument. With the proper setup, the actual waveforms would be displayed for each line that contains the message.

Some Typical Intermodule Measurement Setups

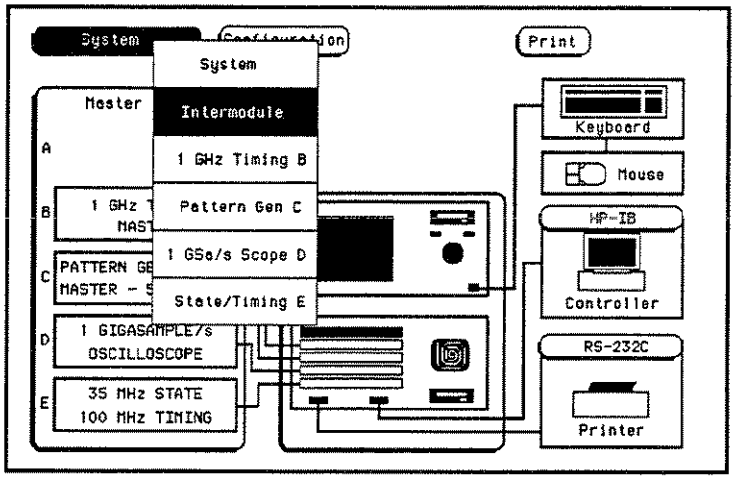
Intermodule measurements are set up in the Intermodule menu of the HP 16500A/16501A by arranging the modules in the desired sequence. Each module may be used only once and any unused modules can be left to run independent of the intermodule measurement.

Intermodule measurements may be as simple as configuring the Intermodule menu to start several modules at once, or they may be very complex, with multiple arming sequences between modules and external equipment. Example 1 is a basic exercise just to help you become familiar with the intermodule measurement menu and its use. Examples 2 through 4 explain some typical intermodule measurements and show you how to set up the instrument to make the measurements.

To select the Intermodule menu:

1 Touch the module field in the upper-left corner of the display.

2 When the pop-up appears, touch Intermodule to bring up the Intermodule menu (see the figure below).



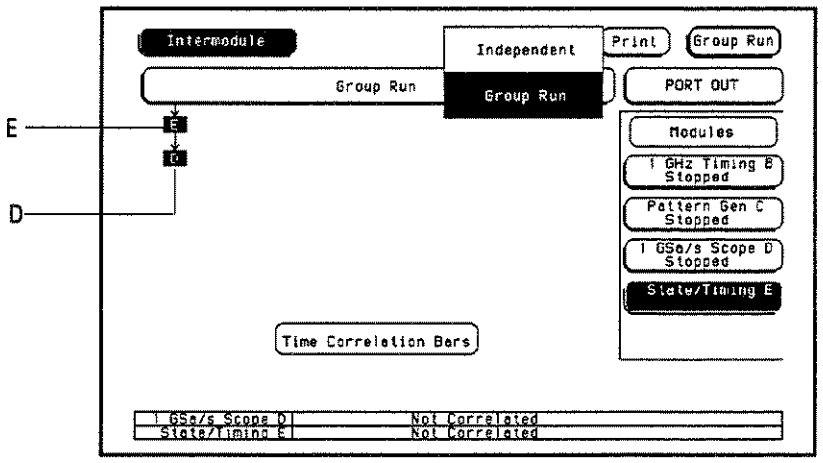
Example 1: A Basic Exercise

The following is a brief exercise to help you become more familiar with the Intermodule menu of the HP 16500A/16501A. The steps are both numbered and bulleted. The numbered steps state the objective and the bulleted steps explain how to accomplish each step objective. You may be able to go through the exercise by just following the numbered steps. When you need more information on how to accomplish the step objective, refer to the bulleted steps.

For this example, assume that you are using an external device to arm the intermodule measurement. When the arm signal is received, use the module in slot B (the 1 GHz Timing Analyzer) to capture the data. Then use the acquisition capabilities of the modules in slot D and E (the 1 GSa/s Scope and State/Timing Analyzer) to analyze the data.

1 Remove any previous assignments from the intermodule configuration tree.

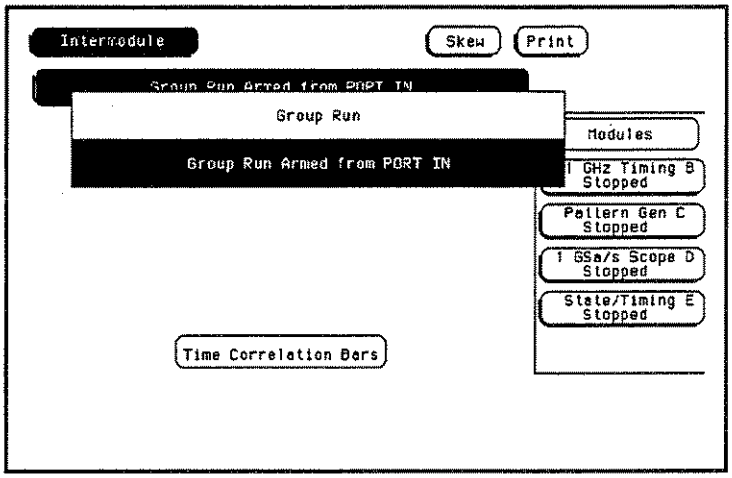
- Touch the field for the upper-most module in the intermodule configuration tree (E as shown in the figure below).



- When the pop-up appears, touch Independent.
- Repeat the above bulleted steps for each of the upper-most modules in the intermodule configuration tree, if there are more in your previous setup.

2 Select Group Run Armed from PORT IN.

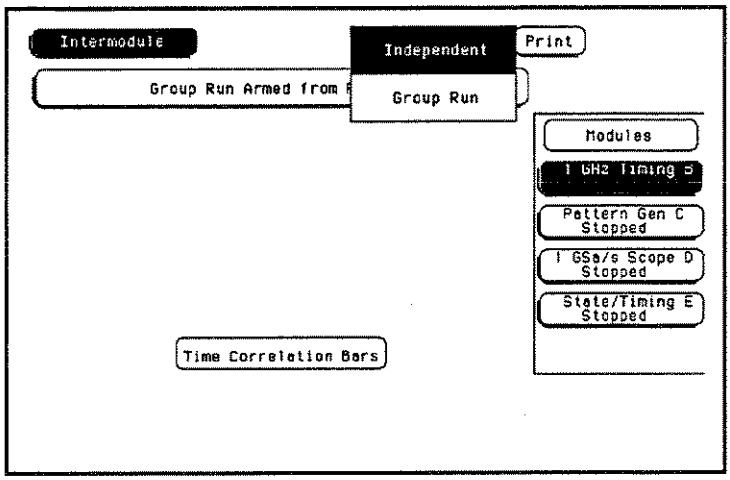
- Touch the large Group Run field (see the figure below).
- When the pop-up appears, touch Group Run Armed from PORT IN.



3 Configure the module in slot B (1 GHz Timing B) to be armed by the Group Run field.

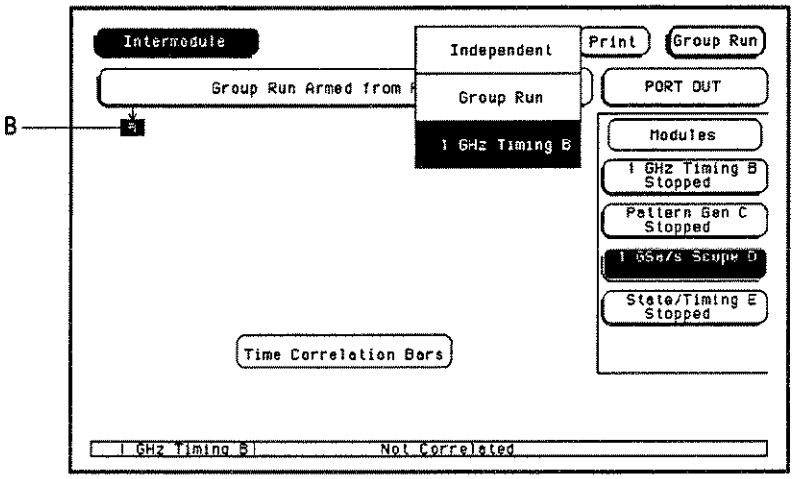
- Touch the field for the module in slot E, in this case 1 GHz Timing B, (see the figure below).
- When the pop-up appears, touch Group Run.

Notice that the PORT OUT field appears when the module in slot B appears in the intermodule configuration tree.



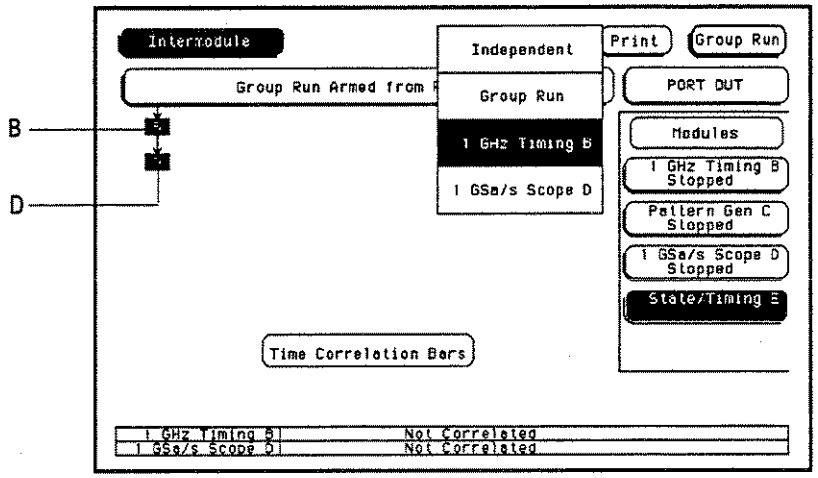
4 Configure the module in slot D (1 GSa/s Scope D) to be armed by the module in slot B (1 GHz Timing B).

- Touch the field for the module in slot D, in this case 1 GSa/s Scope D, (see the figure below).
- When the pop-up appears, touch the field displaying the name of the module in slot B (1 GHz Timing B).

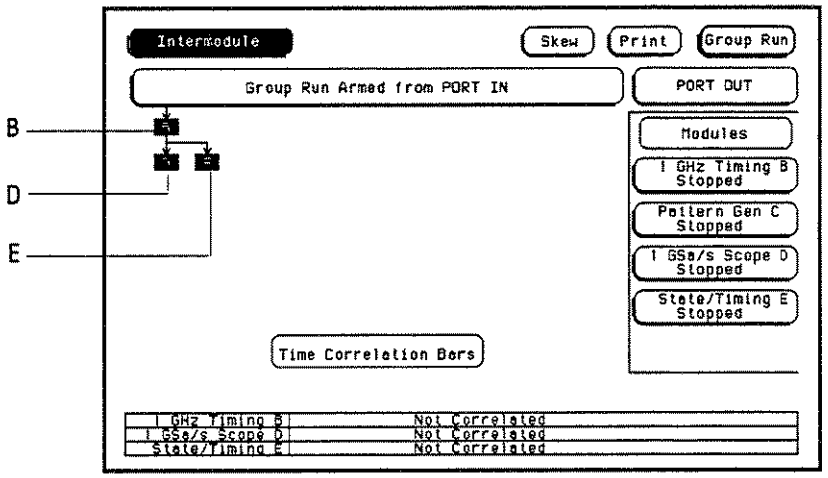


5 Configure the module in slot E (State/Timing E) to be armed by the module in slot B (1 Ghz Timing B).

- Touch the field for the module in slot E, in this case State/Timing E , (see the figure below).
- When the pop-up appears, touch the field displaying the name of the module in slot B (1 GHz Timing B)



The figure below shows the Intermodule menu configured for this example.



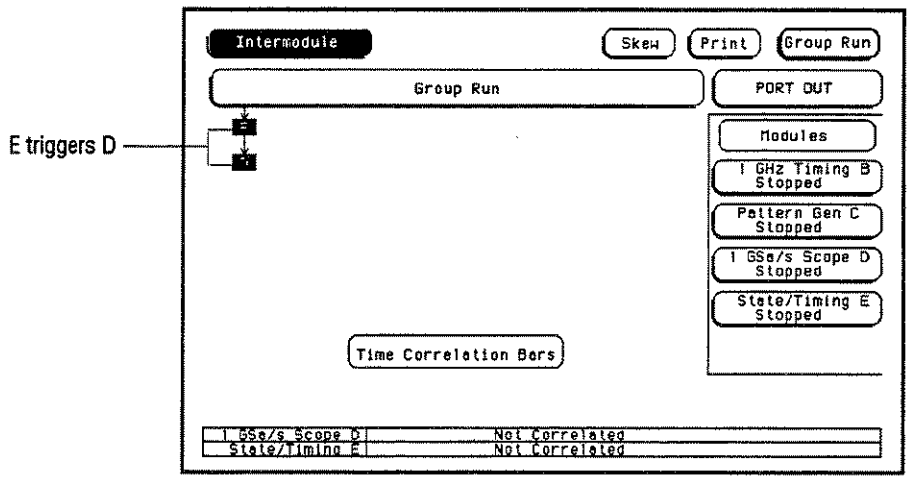
Example 2: Analyzing a Glitch

A glitch is defined as two or more transitions between the samples of a timing analyzer that cross the logic threshold. A timing analyzer can trigger on a glitch and capture it, but doesn't have the voltage or timing resolution to look at the glitch in detail.

On the other hand, an oscilloscope can acquire waveforms with a great deal of resolution, but it doesn't trigger on glitches, combinations of glitches, or patterns nearly as well as a timing analyzer.

To analyze a glitch, you would use a timing analyzer and an oscilloscope interactively (see the figure below). Set up the timing analyzer to trigger on a glitch and when the timing analyzer triggers, capture the glitch with the oscilloscope. Then use the oscilloscope to look at the waveform parameters of the glitch, including its width, shape, and amplitude.

For this intermodule measurement, you are using the triggering capabilities of the timing analyzer and the acquisition capabilities of the oscilloscope.



Example 3: Analyzing Interrupt Handling in a CPU System

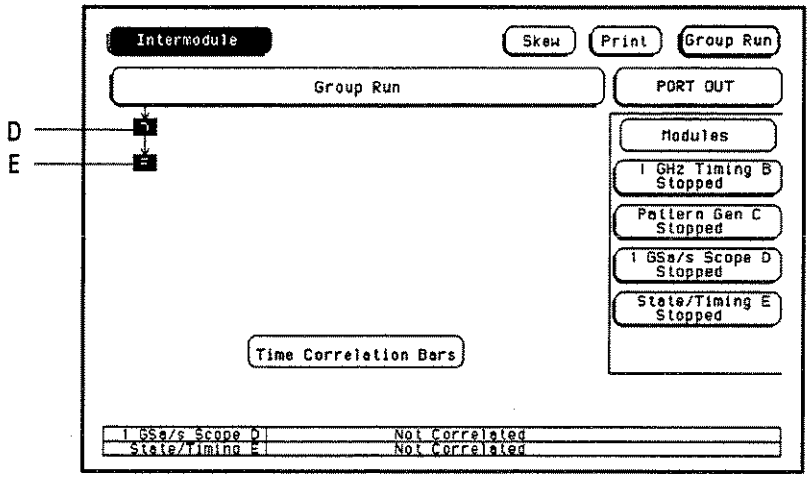
Most microprocessor programs can be interrupted by an asynchronous hardware signal. Software designers are interested in the processor's real-time response to interrupts. In particular, they need to answer these kinds of questions:

- Does the processor branch to the proper interrupt handling routine?
- Are registers and status information saved properly?
- How long does it take to service the interrupt?
- Is the interrupt acknowledged properly?
- After the interrupt is serviced, does the processor restore registers and status information and continue with the previous routine as expected?

Usually, software designers want to look at the program flow of their microprocessor system around an asynchronous event.

A state analyzer, coupled with a preprocessor and an inverse assembler, is useful for tracing the flow of a microprocessor program. A timing analyzer or an oscilloscope is designed to trigger on asynchronous events like edges.

In this example, use an oscilloscope with a sample rate faster than the microprocessor clock to trigger on the asynchronous event and to arm the state analyzer (see the figure below). Then use the state analyzer to check the address of the interrupt routine. You may also use the state analyzer to see if the microprocessor is properly servicing interrupts and returning to the correct address after each interrupt routine.



Set up the oscilloscope to trigger on the asynchronous interrupt line. This is usually an edge-sensitive line on which the oscilloscope can trigger.

The state analyzer should be armed by the oscilloscope. Set the state analyzer to trigger on all "don't cares" and it will capture the interrupt service routine when the arm signal is received. For this intermodule measurement, arming the state analyzer with the oscilloscope allows a software designer to track the flow of a microprocessor program around a hardware interrupt.

Example 4: A Simple Stimulus/Response System

During system development, designers are often faced with verifying a part of a design when the input signals for that part are unavailable. Here are some common examples of this problem:

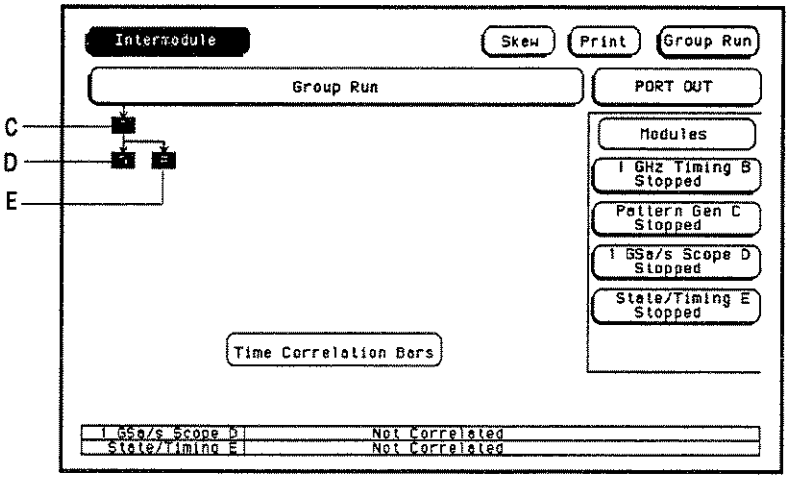
- Verifying hardware operation when a part of the hardware is unavailable to drive the circuit.
- Testing a PC board without a board test system.

The traditional solution is to use word generators to emulate the missing part of the design, and to use logic analyzers and oscilloscopes to capture the system response. Unfortunately, the user is often faced with an awkward solution of stacking several boxes on top of each other, with a maze of cables tying them together, and a different interface for each instrument.

The HP 16520A/16521A Pattern Generator in the HP 16500A/16501A can act as the stack of word generators in this problem. State, timing, and analog modules can all be used to capture the response of the system.

The HP 16520A/16521A Pattern Generator is loaded with the proper patterns and when it starts sending patterns, it sends an arm signal over the intermodule bus.

The acquisition modules are armed from the pattern generator module and set to trigger on the appropriate event in the system (see the figure below).



Glossary

acquisition Denotes one complete cycle of data gathering. One complete cycle gathers 8000 samples of information and stores them in acquisition memory.

attenuation factor *See* probe field

autoscale algorithm An algorithm that, based on the amplitude and period of the signals found, sets the vertical sensitivity in volts per division, offset, horizontal sweep speed in seconds per division, trigger level, and trigger slope for the trigger source input. Its purpose is to provide two to five cycles of a waveform that is displayed on the screen. The waveform is from the lowest numbered and lettered channel with a signal.

cancel autoscale The field that allows you to cancel doing an automatic scaling of the input signals. This is particularly important if you inadvertently touch the Autoscale field when you have your measurement configuration set. Automatically scaling your signals at this point could change your present configuration.

cancel run The field that allows you to cancel making an oscilloscope run for any reason once you have touched the Run field.

coupling field The field that sets the input impedance for the signal applied to channel 1 or channel 2 of the oscilloscope. Selectable values for each channel are 1MΩ / DC, 1MΩ / AC, and 50Ω / DC.

delay field The field that sets the horizontal position of the waveform on the screen. Delay time is measured from the trigger point. It is measured in seconds and is viewed in the Delay field. It can be set by using the knob or the keypad .

don't care Signifies that the state of the signal (high or low) is not pertinent to the measurement being performed.

edge mode The trigger mode that causes a trigger based on a single channel edge (either rising or falling).

high The positive-going portion of a logic signal. Used in pattern trigger measurements, it is represented by an H in the pattern selector.

horizontal position *See* delay field.

horizontal sweep speed The time value that determines the horizontal scaling of the waveform to be displayed on the screen. It is measured in seconds per division and and is viewed in the s/Div field. It is set by using the knob or the keypad.

immediate mode The trigger mode that does not require a specific trigger condition (that is; an edge or a pattern).

input field The field that allows you to select a channel for vertical scaling.

input impedance *See* coupling field.

intermodule menu The menu that lets you set up the instrument to make interactive measurements, either with other modules in the mainframe or with external modules.

low The negative-going portion of a logic signal. Used in pattern trigger measurements, it is represented by an L in the pattern selector.

manual markers mode The marker mode that lets you manually move the markers using the knob or the keypad. It is accessed by touching the Markers field, then selecting On.

menu field The field to the immediate right of the module field (see below). It allows you to choose the menus related to the module shown in the module field.

module field The field in the upper-left corner of the screen. It allows you to choose any of the modules in the mainframe as your working module. It also allows you to choose system options and intermodule options.

offset field The field that sets the vertical position of the waveform on the screen. Offset is the voltage represented at the center vertical tick mark in the waveform display. It is measured in volts and is viewed in the Offset field. It is set by the using knob or the keypad.

panning The action of moving the waveform along the timebase by varying the delay value in the Delay field. This action allows you to control the portion of acquisition memory that will be displayed on the screen. If you choose, you can view the entire waveform record in acquisition memory. This is normally done in single-shot mode.

pattern mode The trigger mode that allows you to set the oscilloscope to trigger on a specified combination of input signal levels.

probe field The field that sets the probe attenuation factor for the input signal applied to the oscilloscope. Selectable values from 1:1 to 1000:1 in increments of 1.

repetitive mode The field that causes the oscilloscope to start the next acquisition as soon as the previous acquisition has been completed and the data has been displayed (that is, to take single acquisitions repetitively).

run, repetitive mode *See* repetitive mode.

run, single mode *See* single mode

s/Div *See* horizontal sweep speed.

single mode The field that causes the oscilloscope to make a single data acquisition and display the results of that acquisition on the screen. In this mode, the Run field must be touched each time you want a new acquisition and, consequently, a new screen update.

source field The field that allows you to select a channel for edge triggering and trigger level setting.

toggle field A dark-blue field that has only two options. When the field is touched, the current option in that field will change (toggle) to its other option.

touch-sensitive screen Any dark-blue field on the screen is a "touchable" field. When you touch a dark-blue field, the field toggles to another option, a pop-up menu appears, or the field turns light-blue to activate the knob for that field.

trigger point The point at which the voltage on the signal source input waveform equals the trigger level voltage value set in the Level field of the trigger menu.

vertical position *See* offset field.

V/Div *See* vertical sensitivity.

vertical sensitivity The voltage value that determines the amplitude of the waveform on the screen. It is measured in volts per division and is viewed in the V/Div field. It is set by using the knob or the keypad .

when field This field is part of the Pattern Mode menu. It is a toggle field that allows you to choose whether to trigger on the selected pattern when it is entered or exited.

Zooming The action of expanding and contracting the waveform along the timebase by varying the value in the s/Div field. This action allows you to select specific portions of a particular waveform in acquisition memory that will be displayed on the screen. You can view any portion of the waveform record in acquisition memory. When used in conjunction with panning, zooming is very useful in displaying single-shot waveforms.

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