Front-Panel Operation Reference

HP 16530A/16531A
Digitizing Oscilloscope Module
for the HP 16500A Logic Analysis System

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Introduction

About this manual...

Welcome to the new generation of HP logic analyzers! The HP 16500A Logic Analysis System has been designed to be easier to use than any Hewlett-Packard logic analyzer before. In addition, because of its configurable architecture, it can easily be tailored to your specific logic design and debug needs.

The user interface of the HP 16500A was designed for the most intuitive operation as possible. Pop-up windows and color graphics help lead you through setups and measurements so you won't have to memorize a lot of steps. As you read this manual and the other manuals about the mainframe and acquisition modules, you will see just how easy the HP 16500A is to use.

This digitizing oscilloscope reference manual is divided as follows:

- Chapters 1 and 2 contain introductory information about the digitizing oscilloscope features and the user interface.

- Chapters 3 through 7 give you information on how to hook up the probes and how to set up the vertical, horizontal, and trigger in preparation for making measurements.

- Chapters 8 through 12 provide information on viewing waveforms and making measurements on the waveforms.

- Chapters 13 through Appendix C discuss other oscilloscope functions such as storing and recalling setups, printing, calibration, specifications, etc.

If you aren't familiar with the HP 16530A/16531A Digitizing Oscilloscope, we suggest you read the HP 16530A/16531A Getting Started Guide. This guide contains tutorial examples on the basic functions of the digitizing oscilloscope.

If you're new to digitizing oscilloscopes...or just need a refresher, we think you'll find Feeling Comfortable with Digitizing Oscilloscopes valuable reading. It will eliminate any misconceptions or confusion you may have about their application, and will show you how to get the most out of your new scope.
What is the HP 16530A/16531A?

Introduction

The HP 16530A/16531A module is a 400-megahertz, 100-MHz single-shot and repetitive bandwidth digitizing oscilloscope, can be installed in the HP 16500A Logic Analysis System mainframe. The HP 16530A is 400-megahertz/second timebase card and the HP 16531A is a 2-channel acquisition card.

Key Features

- 400 megahertz/second digitizing rate
- 100-MHz single-shot (real-time) bandwidth
- 4k samples per measurement per channel
- 2-channel simultaneous acquisition, expandable to 4, 8, or 8

User Convenience

- Automatic waveform scaling
- Hardcopy to graphics printers
- ECL and TTL presets

Measurement

- Automatic pulse parameter measurements
- Channel-to-channel time interval measurements
- Markers for time and voltage readouts

Vertical Channel

- 2, 4, 6, or 8 fully configured vertical channels
- Continuously variable sensitivity range of 40 mV to 16 V
- 6-bit resolution
- Probe attenuation from 1:1 to 1000:1
- 500Ω dc or 1 MΩ dc input coupling

Trigger

- Internal, external, or immediate modes
- Edge or pattern triggering
- Delayed trigger by events and/or time
- Trigger point marker displayed

Display

- Single, average, or cumulative acquisitions
- Connect-the-dots
- Chan-Chan, Chan-Chan, and waveform overlay
- Combine waveforms from other HP 16500A modules

What is the HP 16530A/16531A?
1-1
Accessories Supplied

The following accessories are supplied with the HP 16530A/31A Digitizing Oscilloscope Module:

- HP 16531A Acquisition card
  - 2 HP 10018A 10:1, 1 MΩ, 10 pF mini-probes, 2 m
  - 2 right angle BNC adapters (HP 1250-0076)

- HP 16530A Timebase card
  - 1 operating manual set (covers complete module)
  - 1 service manual (covers complete module)

Probe Accessories Available

The following probe accessories are not supplied with the HP 16530A/31A, but may be ordered separately:

- HP 10503A BNC-to-BNC cable, 1.2 m
- HP 10017A 10:1, 1 MΩ, 8 pF mini-probe, 1 m
- HP 10020A 10:1, 100:1, 10 MΩ, 10 pF resistive divider probe set, 1.5 m
- HP 10021A 1:1, 36 pF mini-probe, 1 m
- HP 10022A 1:1, 62 pF mini-probe, 1 m
- HP 10026A 1:1, 50Ω mini-probe, 1 m
- HP 10027A 1:1 50Ω mini-probe, 2 m
- HP 10032A 100:1, 3 MΩ, 3 pF mini-probe, 1 m
- HP 10240B BNC-to-BNC ac coupling capacitor
- HP 10211A 24-pin IC test clip
Menu Field Index

The following diagram shows the fields on the digitizing oscilloscope menus. The table lists the chapters where the fields are described.

<table>
<thead>
<tr>
<th>Item</th>
<th>Description</th>
<th>Chapter</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Module field</td>
<td>2</td>
</tr>
<tr>
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<td>Menu Field</td>
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<td></td>
<td>Auto-Measure menu</td>
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</tr>
<tr>
<td></td>
<td>Calibration menu</td>
<td>16</td>
</tr>
<tr>
<td>3</td>
<td>Autoscale</td>
<td>7</td>
</tr>
<tr>
<td>4</td>
<td>Print</td>
<td>14</td>
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<tr>
<td>5</td>
<td>Run/Stop</td>
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</tr>
<tr>
<td>6</td>
<td>Menu specific fields</td>
<td>See Item 2</td>
</tr>
<tr>
<td>7</td>
<td>Waveform selection</td>
<td>12</td>
</tr>
<tr>
<td>8</td>
<td>s/Div</td>
<td>5</td>
</tr>
<tr>
<td>9</td>
<td>Delay</td>
<td>5</td>
</tr>
<tr>
<td>10</td>
<td>Markers</td>
<td>9</td>
</tr>
</tbody>
</table>

What is the HP 16530/16531A?
1-3
Menu Maps

The following pages show the menu maps for all functions of the oscilloscope. Functions which are common to several menus are shown on separate menu maps at the end of this chapter.

Channel Menu Map

What is the HP 16530/16531A?
Trigger Menu Map
Display Menu Map

Auto-Measure Menu Map

What is the HP 16530/16531A?
1-6
Basic User Interface Information

User Interface Devices

The HP 16500A has three user interface devices: the knob on the front panel, the touch-sensitive screen, and the optional mouse. If you are unfamiliar with any of these, this chapter covers the basic concepts of their use. For more detailed information, refer to the HP 16500A reference manual.

System Power Up

When the HP 16500A system is powered up, the menu you see should look similar to the one shown below.
**Using the Touch Screen**

Any dark-blue field on screen is a "touchable" field. That is, if you touch a dark-blue field, the field will toggle to another value, or a pop-up will appear allowing you to select another function. For example, touch the dark-blue field labeled System in the upper left of the screen. A pop-up appears showing all the modules of the mainframe. The actual order and content of this pop-up may vary depending on the modules you have installed and which slots the modules are in.

Notice that the System field in the pop-up is highlighted in light blue. This tells you that you are in a system menu. To move to any module in the list, touch that field in the pop-up. The pop-up will close and the module chosen will appear on screen.

If you are in any other module menu, you can return to System by touching the module field in the upper left of the screen. When the pop-up appears, notice again that the module you are in is highlighted in light blue. Remember that the dark-blue field in the upper left of the screen allows you to move among the modules.
Module Menus

Each module may have several menus within it. To see these menu selections, touch the dark-blue field second from the left at the top of the screen.

This menu field works the same as the module field to the left of it, except instead of showing all the modules, the menus within each module are displayed. For instance, if you touch this menu field while you are in System, you'll get a pop-up that looks like the one shown below.
Moving to the Digitizing Scope

Touch the module field in the upper left of the screen. A pop-up will appear similar to that shown below displaying all the modules in the mainframe. The actual order and content of the pop-up will vary depending on the modules you have installed and their slots. The capitalized letter to the right of the module name refers to the slot in the mainframe where the module is installed.

In this example, to get to the digitizing scope menus, you would touch the Oscilloscope C field.

This will bring up the digitizing scope Channel menu.

---

Basic User Interface Information
2-4
Digitizing Scope Menus

The digitizing scope has five menus. You can access them by touching the menu field to the right of the Oscilloscope C field. Touch the Channel menu field which is currently being displayed.

A pop-up appears with all the digitizing scope menu selections.

The following chapters will familiarize you with these scope menus. For now, touch the Channel field in the pop-up menu to return to the Channel menu. Just remember that the field next to Oscilloscope always shows which scope menu is displayed.

Basic User Interface Information
2-5
Data Entry Fields

When you need to enter alphanumeric or numeric data in some fields, a pop-up keypad will appear on screen to allow you to enter the information. In this pop-up, there is a field labeled **DONE**. This field lets the instrument know that you are finished entering data. The keypad pop-up will not close until you touch the **DONE** field.

![Keypad Diagram](image)

What's the Knob For?

To the right of the screen is a knob. Turning the knob allows you to increment or decrement values in a selected numeric field in the digitizing scope menus.
Using the Mouse

Everything that can be done with the touch screen and knob on the HP 16500A can also be done with the optional mouse. The mouse plugs into the connector in the lower right of the front panel. As soon as the mouse is plugged in, it is active.

When the mouse is plugged in, a white cursor (cross) appears on screen. Moving the mouse causes the cursor to move. To "touch" a field with the mouse, move the cursor to the field and press the left mouse button.

To use the mouse to perform the functions of the front-panel knob, hold down the right mouse button and move the mouse. When you release the right button on the mouse, the function returns to the cursor.
Cables and Probes

Inputs and Output

Each HP 16531A Acquisition Card has two vertical signal inputs. The inputs are on the module at the rear of the mainframe. INPUT 1 is to the left.

The two connectors on the HP 16530A Timebase Card on the rear of the mainframe are the external trigger (EXT TRIG) input and the COMPENSATION SIGNAL output. The COMPENSATION SIGNAL 50Ω output is ~1.2 kHz square wave with high amplitude near -200 mV and low amplitude near -400 mV when connected to a 50Ω load. This square wave is used for probe compensation adjustment (see your probe operating note) and is also used in examples throughout this manual.
Connecting BNC Cables
BNC cables can be connected directly to the BNC connectors on the acquisition card or timebase card. The HP 10503A 1.2 metre BNC-to-BNC cable is not provided with the instrument, but can be ordered separately.

Connecting Probes
Probes may also be connected directly to the BNC input connectors on the acquisition card or external trigger input on the timebase card.

Two right-angle BNC adapters (HP 1250-0076) are supplied with each acquisition card. Connecting the right-angle adapters to the inputs, and then connecting the probes to the right-angle adapters keep the probes from protruding beyond the plastic standoffs on the rear of the instrument.
The Channel menu controls the vertical sensitivity, offset, probe attenuation factor, and input impedance of all input channels, as well as the probe attenuation factor and input impedance of the external trigger input. The Channel menu also allows you to preset vertical sensitivity, offset, and trigger level for ECL and TTL logic levels. The default Channel menu is shown below.
Channel Menu Map

The menu map for the Channel menu is shown below.

Channel Menu
4-2
Input Field

The Input field selects the input source for the channel parameters displayed on the Channel menu.

When you touch the Input field, a pop-up appears showing all available input channels and external trigger. Two inputs are available for each mainframe module slot A, B, C, and D; the actual pop-up contents is dependent upon which slots the HP 16530A Acquisition boards are installed. The HP 16531A Timebase board is identified by the slot shown in the Oscilloscope module field.

The default Input field selection is the lowest letter/number combination. For example, if an acquisition card is installed in mainframe slot A, the Input field will display A1.
V/Div Field

The V/Div field sets the vertical sensitivity of the channel selected in the input field. Vertical sensitivity determines the size of a waveform displayed on screen and is measured in volts/division. Each waveform display is divided into four vertical divisions. The divisions are marked by small tan tick marks at the left and right sides of the waveform display.

When the V/Div field is selected, the vertical sensitivity can be changed by turning the knob. As the vertical sensitivity is changed, the signal expands and compresses in both directions vertically from the center of the display. As you turn the knob, the vertical sensitivity changes in a 1-2-4 sequence from 10 mV/div to 4 V/div.

Vertical sensitivity can also be entered from the pop-up keypad. The keypad will appear when you touch the V/Div field when the field is light blue. Any value from 10 mV/div to 4 V/div can be entered from the keypad. The vertical sensitivity value can be set to the two most significant digits. For example, if you entered a value of 154 mV, the value would be truncated to 150 mV.

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

Note

*If acquisitions have been stopped (see chapter 8), vertical sensitivity changes will not be reflected on the waveform until Run is touched and the next acquisition is displayed.*
Offset Field

Offset is the voltage represented at the center vertical tick mark in the waveform display. Offset is a dc voltage that is added or subtracted from the input signal so that the waveform can be shown centered on the waveform display.

Offset range and resolution is dependent on vertical sensitivity:

<table>
<thead>
<tr>
<th>V/Div</th>
<th>Offset</th>
<th>Range</th>
<th>Resolution</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;200 mV</td>
<td>±800 mV</td>
<td>1 mV</td>
<td></td>
</tr>
<tr>
<td>≥200 mV</td>
<td>±16 V</td>
<td>10 mV</td>
<td></td>
</tr>
</tbody>
</table>

When the Offset field is selected, the offset value of the channel selected in the input field can be changed by turning the knob. As offset is changed, 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.
Offset can also be entered from the pop-up keypad. The keypad will appear when you touch the Offset field when the field is light blue. Any valid offset value can be entered from the keypad.

The default value for the Offset field is 2.5 V (TTL preset value).

**Note**

*If acquisitions have been stopped (see chapter 8), offset changes will not be reflected on the waveform until Run is touched and the next acquisition is displayed.*

---

**Probe Field**

The Probe field sets the probe attenuation factor for the channel or external trigger selected in the Input field. The probe attenuation factor can be set from 1:1 to 1000:1 in increments of 1. When the Probe field is selected, 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 used on the display (V/div, offset, marker values, trigger level, automatic measurements) are adjusted to reflect the attenuation factor.

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

---

**Channel Menu**

4-8
Impedance Field

The Impedance field sets the input impedance for the channel or external trigger selected in the Input field. When the Impedance field is touched, the Input impedance will toggle between 1 MOhm (dc) and 50 Ohms (dc). No pop-up keypad is available for this field.

The default value for the Impedance field is 1 MOhm.

<table>
<thead>
<tr>
<th>Input Bl</th>
<th>V/Div</th>
<th>Diffel</th>
<th>Probe</th>
<th>Impedance 1 MOhm</th>
<th>Preset TTL</th>
</tr>
</thead>
<tbody>
<tr>
<td>s/Div</td>
<td>Delay</td>
<td>Markers</td>
<td>Dif</td>
<td>Sample Period</td>
<td>40.000 ns</td>
</tr>
</tbody>
</table>

Channel Menu

4-7
The Preset field automatically sets offset, V/div, and trigger level values to properly display TTL and ECL logic levels.

When you touch the Preset field, a pop-up appears as shown below.
When you select TTL or ECL, the following values are set:

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Preset Value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>ECL</td>
</tr>
<tr>
<td>V/Div</td>
<td>500 mV</td>
</tr>
<tr>
<td>Offset</td>
<td>-1.000 V</td>
</tr>
<tr>
<td>Trig Level</td>
<td>-1.300 V</td>
</tr>
</tbody>
</table>

When any of these values are changed from the preset value, the Preset field will change to User defined. If User is selected from the pop-up, no values will be changed.

The default value for the Preset field is TTL.
Timebase Functions

Introduction

The s/Div and Delay timebase functions control the horizontal display on the oscilloscope. s/Div and Delay are displayed in the bottom row of fields and are displayed on all oscilloscope menus except Calibration. These fields as they appear on the Channel menu are shown below.

Instrument Setup

Set up the oscilloscope as described below. This setup will be used throughout this chapter.

1. Connect a BNC cable from the COMPENSATION SIGNAL output on the timebase board to INPUT 1 on an acquisition board.

2. Turn the power on to the instrument.

3. Touch the System module field and select Oscilloscope from the pop-up.

4. Touch the Autoscale field to autoscale the signal.

5. Touch the Run field and drag your finger to the Repetitive field in the pop-up.

The display should now look like this:

```
Oscilloscope C  Channel  Autoscale  Print  Run
Input  V/Div  Offset  Probe  Impedance  Preset
B1  2.00 V  5.000 V  10:1  1.0 MΩ  User
s/Div  Delay  Mentars  Sample Period
200 us  0  5  Diff  1.0000 us

B1

B2
```

Timebase Functions

5-1
The s/Div field sets the sweep speed or time scale on the horizontal axis of the display and is measured in seconds/division. The display is divided into 10 horizontal divisions. The divisions are marked by small tick marks at the top and bottom of the waveform display.

When the s/Div field is selected, the sweep speed can be changed by turning the knob. As the sweep speed is changed, the signal expands and compresses in both directions from the center of the display. As you turn the knob, the sweep speed changes in a 1-2-5 sequence from 5 ns/div to 10 s/div.

Sweep speed can also be entered from the pop-up keypad. The keypad will appear when you touch the s/Div field when the field is light blue. Any value from 5 ns/div to 10 s/div can be entered from the keypad. Sweep speed can be set to three-digit resolution. For example, if you entered a value of 15.45 ns, the value would be rounded up to 15.5 ns.
At sweep speeds 100 ms/div and slower, the time to acquire the 4096 sample points for acquisition memory is greater than 1 second. At these sweep speeds the screen will display Waiting for Prestore when acquiring the 2048 sample points prior to the delay time setting and Waiting for Poststore when acquiring the 2048 sample points after the delay time setting. This advises you the oscilloscope is still actively acquiring data. Acquisition times, which is memory depth in time, is shown in table 5-1 later in this chapter.

The default value for the s/Div field is 10 μs.

Zoom (Acquisition Stopped)

If acquisitions have been stopped (see chapter 8), the oscilloscope uses the 4096 sample points stored in acquisition memory to display the new data on screen when the sweep speed is changed. This function would normally be used to zoom in or zoom out on a waveform acquired in Single (single-shot) mode. Zooming either expands or compresses the waveform horizontally and is changed by adjusting the s/Div field.

Zoom Example. Touch the s/Div field and turn the knob to set the sweep speed to 200 us/div, then touch the Stop field to stop acquisitions. Now turn the knob to change the sweep speed and notice how the acquired waveform expands and compresses.

Normally 500 points of the 4k waveform record is displayed on screen. Change the sweep speed to 500 us/div. Now all 4k of the waveform record is compressed and displayed on screen as shown below.

<table>
<thead>
<tr>
<th>Oscilloscope C</th>
<th>Channel</th>
<th>Autoscale</th>
<th>Print</th>
<th>Run</th>
</tr>
</thead>
<tbody>
<tr>
<td>Input B1</td>
<td>V/Div</td>
<td>Offset</td>
<td>Probe</td>
<td>10:1</td>
</tr>
<tr>
<td>2.00 V</td>
<td>6.400 V</td>
<td>70.0 V</td>
<td>10:1</td>
<td></td>
</tr>
<tr>
<td>s/Div 300 us</td>
<td>Delay</td>
<td>Marker's</td>
<td>Sample Period</td>
<td>1.0000 us</td>
</tr>
<tr>
<td></td>
<td>Mode</td>
<td>Off</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Timebase Functions
5-3
Now change the sweep speed to 2 us/div. At 230 us/div, 500 points were displayed on screen; at 2 us/div, only 5 points are displayed on screen. When the waveform is expanded, the oscilloscope uses a reconstruction filter to fill in the waveform points to provide a more useable display.

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

Timebase Functions
5-4
Delay Field

Delay time is the time offset before or after the trigger point on the waveform and is always measured from the trigger point to the center of the screen. The dotted red line at the center of the display is the trigger point. When delay time is zero, the trigger point is at the center of the screen.

When the Delay field is selected, the delay time can be changed by turning the knob. Remember that the trigger point is always delay time zero and is marked by the dotted red line. When the trigger point moves to the right side of the screen, the delay time is negative. This means that what you are viewing at center screen is before the trigger point and is referred to as negative time.

When the trigger point is moved to the left side of the screen, the delay time is positive and what you are viewing at center screen is after the trigger point.

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 = 4096 X sample rate
- Post-trigger delay range = 5000 X sweep speed
Pre- and post-trigger delay time range is given for sweep speeds in table 5-1.

The default value for the Delay field is 0 s.

Scrolling (Acquisition Stopped)

If acquisitions have been stopped (see chapter 6), the Delay field controls the portion of the acquisition memory displayed on screen. When acquisition has been stopped:

- Pre-trigger delay range = delay time setting - (2048 X sample rate)
- Post-trigger delay range = delay time setting + (2048 X sample rate)

This means that one-half of data stored in acquisition memory is before the delay time setting and one-half of the data in memory is after the delay time setting.

This function would normally be used to scroll through a waveform acquired in Single (single-shot) mode. Scrolling allows you to view the entire waveform record by adjusting the Delay field.

Scroll Example. Touch the s/Div field and turn the knob to set the sweep speed to 200 us/div, then touch the Stop field to stop acquisitions. Touch the Delay field and turn the knob to change the delay time to approximately -1.5 ms. As shown below, you are now looking at the beginning of the waveform record. You can now scroll through the entire 4k waveform record, both before and after the trigger point. When used in conjunction with zooming (see "s/Div Field" paragraph), scrolling is very useful in displaying single-shot waveforms.
Table 5-1. Pre-trigger and Post-trigger Delay Range

<table>
<thead>
<tr>
<th>Sweep Speed</th>
<th>Sample Period</th>
<th>Sample Rate*</th>
<th>Pre-trigger Range</th>
<th>Post-trigger Range</th>
<th>Memory Depth</th>
</tr>
</thead>
<tbody>
<tr>
<td>5 ns/div</td>
<td>2.5 ns</td>
<td>400 Msa/s</td>
<td>10.240 us</td>
<td>25 us</td>
<td>10.240 us</td>
</tr>
<tr>
<td>10 ns/div</td>
<td>2.5 ns</td>
<td>400 Msa/s</td>
<td>10.240 us</td>
<td>50 us</td>
<td>10.240 us</td>
</tr>
<tr>
<td>20 ns/div</td>
<td>2.5 ns</td>
<td>400 Msa/s</td>
<td>10.240 us</td>
<td>100 us</td>
<td>10.240 us</td>
</tr>
<tr>
<td>50 ns/div</td>
<td>2.5 ns</td>
<td>400 Msa/s</td>
<td>10.240 us</td>
<td>250 us</td>
<td>10.240 us</td>
</tr>
<tr>
<td>100 ns/div</td>
<td>2.5 ns</td>
<td>400 Msa/s</td>
<td>10.240 us</td>
<td>500 us</td>
<td>10.240 us</td>
</tr>
<tr>
<td>200 ns/div</td>
<td>2.5 ns</td>
<td>400 Msa/s</td>
<td>10.240 us</td>
<td>1 ms</td>
<td>10.240 us</td>
</tr>
<tr>
<td>500 ns/div</td>
<td>2.5 ns</td>
<td>400 Msa/s</td>
<td>10.240 us</td>
<td>2.5 ms</td>
<td>10.240 us</td>
</tr>
<tr>
<td>1 us/div</td>
<td>2.5 ns</td>
<td>400 Msa/s</td>
<td>10.240 us</td>
<td>5 ms</td>
<td>10.240 us</td>
</tr>
<tr>
<td>2 us/div</td>
<td>5 ns</td>
<td>200 Msa/s</td>
<td>20.480 us</td>
<td>10 ms</td>
<td>20.480 us</td>
</tr>
<tr>
<td>5 us/div</td>
<td>20 ns</td>
<td>50 Msa/s</td>
<td>81.920 us</td>
<td>25 ms</td>
<td>81.920 us</td>
</tr>
<tr>
<td>10 us/div</td>
<td>40 ns</td>
<td>25 Msa/s</td>
<td>163.84 us</td>
<td>50 ms</td>
<td>163.84 us</td>
</tr>
<tr>
<td>20 us/div</td>
<td>100 ns</td>
<td>10 Msa/s</td>
<td>409.60 us</td>
<td>100 ms</td>
<td>409.60 us</td>
</tr>
<tr>
<td>50 us/div</td>
<td>200 ns</td>
<td>5 Msa/s</td>
<td>819.20 us</td>
<td>250 ms</td>
<td>819.20 us</td>
</tr>
<tr>
<td>100 us/div</td>
<td>400 ns</td>
<td>2.5 Msa/s</td>
<td>1.6384 ms</td>
<td>500 ms</td>
<td>1.6384 ms</td>
</tr>
<tr>
<td>200 us/div</td>
<td>1 us</td>
<td>1 Msa/s</td>
<td>4.0960 ms</td>
<td>1 s</td>
<td>4.0960 ms</td>
</tr>
<tr>
<td>500 us/div</td>
<td>2 us</td>
<td>500 ksa/s</td>
<td>8.1920 ms</td>
<td>2.5 s</td>
<td>8.1920 ms</td>
</tr>
<tr>
<td>1 ms/div</td>
<td>4 us</td>
<td>250 ksa/s</td>
<td>16.384 ms</td>
<td>5 s</td>
<td>16.384 ms</td>
</tr>
<tr>
<td>2 ms/div</td>
<td>10 us</td>
<td>100 ksa/s</td>
<td>40.960 ms</td>
<td>10 s</td>
<td>40.960 ms</td>
</tr>
<tr>
<td>5 ms/div</td>
<td>20 us</td>
<td>50 ksa/s</td>
<td>81.920 ms</td>
<td>25 s</td>
<td>81.920 ms</td>
</tr>
<tr>
<td>10 ms/div</td>
<td>40 us</td>
<td>25 ksa/s</td>
<td>163.84 ms</td>
<td>50 s</td>
<td>163.84 ms</td>
</tr>
<tr>
<td>20 ms/div</td>
<td>100 us</td>
<td>10 ksa/s</td>
<td>409.60 ms</td>
<td>100 s</td>
<td>409.60 ms</td>
</tr>
<tr>
<td>50 ms/div</td>
<td>200 us</td>
<td>5 ksa/s</td>
<td>819.20 ms</td>
<td>250 s</td>
<td>819.20 ms</td>
</tr>
<tr>
<td>100 ms/div</td>
<td>400 us</td>
<td>2.5 ksa/s</td>
<td>1.6384 s</td>
<td>500 s</td>
<td>1.6384 s</td>
</tr>
<tr>
<td>200 ms/div</td>
<td>1 ms</td>
<td>1 ksa/s</td>
<td>4.0960 s</td>
<td>1 ks</td>
<td>4.0960 s</td>
</tr>
<tr>
<td>500 ms/div</td>
<td>2 ms</td>
<td>500 sa/s</td>
<td>8.1920 s</td>
<td>2.5 ks</td>
<td>8.1920 s</td>
</tr>
<tr>
<td>1 s/div</td>
<td>4 ms</td>
<td>250 sa/s</td>
<td>16.384 s</td>
<td>2.5 ks</td>
<td>16.384 s</td>
</tr>
<tr>
<td>2 s/div</td>
<td>10 ms</td>
<td>100 sa/s</td>
<td>40.960 s</td>
<td>2.5 ks</td>
<td>40.960 s</td>
</tr>
<tr>
<td>5 s/div</td>
<td>20 ms</td>
<td>50 sa/s</td>
<td>81.920 s</td>
<td>2.5 ks</td>
<td>81.920 s</td>
</tr>
<tr>
<td>10 s/div</td>
<td>40 ms</td>
<td>25 sa/s</td>
<td>163.84 s</td>
<td>2.5 ks</td>
<td>163.84 s</td>
</tr>
</tbody>
</table>

* sa/s = samples/second
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 for sweep speeds in shown in table 5-1.

Timebase Functions

5-8
Trigger Menu

Introduction

The Trigger menu controls the selection of trigger modes for the oscilloscope. The Trigger menu has three modes:

- Edge
- Pattern
- Immediate

When the oscilloscope is powered up, the default trigger mode is Edge.
Trigger Menu Map  The menu map for the Trigger menu is shown below.
The Mode field selects the trigger mode for the oscilloscope. When you touch the Mode field, a pop-up appears showing the three trigger modes: edge, pattern, and immediate. To select a trigger mode, touch any selection in the pop-up field.

The default selection for the Mode field is Edge.
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 or trigger condition crosses the trigger marker is called the trigger point and always represents delay time of zero seconds.

If delay time is set to greater than ±5 times the sweep speed, the trigger marker will be moved off screen.
Immediate Trigger Mode

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

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

Immediate trigger mode can be used for dual timebase applications when one oscilloscope module arms another oscilloscope module, or another module such as a logic analyzer could arm the oscilloscope. More information about Intermodule applications can be found in the HP 16500A Logic Analysis System Reference Manual.
Edge Trigger Mode

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

Source Field

The trigger source can be set to any input signal. When you touch the Source field, a pop-up appears showing the inputs available as the trigger source. The source can be Input A1, A2, B1, B2, C1, C2, D1, D2, or external trigger (EXT TRIG) input. The inputs that appear in the Source field pop-up are dependent upon how many acquisition cards are installed in the mainframe and which slots they are installed in. The minimum sources displayed would be two channel inputs and external trigger as shown below.

The default selection for the Source field is the lowest letter/number input channel. For example, if acquisition cards were installed in mainframe slots A, B, and C, the Source field would default to A1.
Level Field

The voltage level at which the trigger source waveform crosses the trigger marker is set by the Level field. When the Level field is selected, the trigger level can be changed by turning the knob. When the trigger level is changed, the waveform moves on the display to maintain the trigger point (where the waveform edge crosses the trigger level line). If the trigger level is set above or below the waveform, trigger is lost and the waveform display will be unsynchronized.

Trigger level can be set to any voltage value contained within the waveform display window in increments of 1% of full scale horizontal voltage range (V/Div X 4). For example, if full scale voltage range were 400 mV, trigger level could be set in increments of 4 mV.

![Trigger Menu](image)

Trigger level can also be entered with the pop-up keypad. The keypad will appear when you touch the Level field when the field is light blue. Any value in 1% increments of full scale horizontal voltage range can be entered. Values entered that are not in this range will be rounded to the nearest 1% increment.

Since the trigger level range is limited by the voltage values displayed in the waveform window, the voltage window 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.

The default value for the Level field is 2.5 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 the Slope field is touched, the field will toggle between Positive and Negative. No pop-up field is available for this field.

The default selection for the Slope field is Positive.
Auto-Trig Field

The Auto-Trig field lets you specify whether or not the acquisitions should wait for the specified trigger condition to occur. When the Auto-Trig field is touched, the field will toggle between On and Off. No pop-up field is available for this field.

On. When auto-trigger is set to on, the oscilloscope waits for 25 ms (40 Hz rate) for a trigger to occur. If a trigger does not occur within that time, whatever is in the acquisition memory is displayed and "Auto triggered" is displayed:

- If no signal is on the Input, the oscilloscope will display a baseline.
- If there is a signal but the specified trigger condition has not been met within 25 ms, the waveform display will not be synchronized to a trigger point.

Off. When auto-trigger is set 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 "Waiting for Trigger" is displayed. Use this mode when:

- the trigger source signal is less than a 40-Hz repetition rate.
- the trigger events counter (see Count field) is set so that the number of trigger events would not occur before 25 ms.

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

![Oscilloscope C Trigger Autoscale Print Run](image)

![Trigger Menu](image)
In edge trigger mode, you can define a positive or negative edge and trigger level as a trigger qualifier. When the oscilloscope detects the trigger qualifier, it will trigger after a user-defined number of edges (Count field) on any input.

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

Count can be set to any integer from 1 to 32000. The event number set by the Count field will be displayed at the trigger marker when the acquisition is displayed. 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

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

When you touch the Mode field, Pattern can be selected from the pop-up field. The default pattern trigger menu is shown below.
Channel-Pattern Field

The Channel-Pattern field allows you to enter a pattern for input channels and external trigger.

Channel: The Channel row of the field lists the inputs available in the mainframe. Channels are numbered from 1 through 8 and Ex for external trigger. The field will only display the actual number of input channels installed in the mainframe. The lowest channel number is assigned to the lowest letter/number combination input. For example, if acquisition cards were installed in mainframe slots B, C, and D:

Channel 1 = B1
2 = B2
3 = C1
4 = C2
5 = D1
6 = D2
Ex = EXT TRIG

Trigger Menu

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**Pattern.** The Pattern row of the field lists the trigger condition of the input above it in the Channel row.

**Note**

You must set the trigger level for each input you want to use in the pattern by using the Level field in Edge trigger mode. This 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** - the input channel's voltage must be greater than the edge trigger level of that input.
- **L** - the input channel's voltage must be less than the edge trigger level of that input.
- **X** - is a "don't care" condition. The associated input channel will not be used in the pattern for the trigger qualifier.

The default condition for all patterns is "don't care". To change the pattern, touch the Channel-Pattern field. A pop-up will appear which allows you to assign the pattern conditions.
To enter a pattern, touch either X, L, or H on the pop-up. The entries appear at the top of the pop-up as they are entered. If you make a mistake, turn the knob to move the highlight to the entry to be corrected or touch CLEAR to change all entries back to X. If the pattern is correct, touch DONE.

**When Field**

When this field is touched, it toggles between When Entered and When Exited.

**When Entered.** The oscilloscope will trigger on the first transition that makes the pattern specification true for every input the number of times specified by the Count field.

**When Exited.** The oscilloscope will trigger on the first transition that causes the pattern specification to be false after the pattern has been true the number of times specified by the Count field.

The default selection for the When field is When Entered.
**Auto-Trig Field**

The Auto-Trig field lets you specify whether or not the acquisitions should wait for the specified pattern condition to occur. When the Auto-Trig field is touched, the field will toggle between On and Off. No pop-up field is available for this field.

**On.** When auto-trigger is set to on, the oscilloscope waits for 25 ms (40 Hz rate) for a trigger to occur. If a trigger does not occur within that time, whatever is in the acquisition memory is displayed and "Auto triggered" is displayed:

- If no signal is on the input, the oscilloscope will display a baseline.
- If there is a signal but the specified pattern condition has not been met within 25 ms, the waveform display will not be synchronized to a trigger point.

**Off.** When auto-trigger is set 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 "Waiting for Trigger" is displayed. Use this mode when:

- the trigger source signal is less than a 40-Hz repetition rate.
- the trigger events counter (see Count field) is set so that the number of trigger pattern events would not occur before 25 ms.

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 after a user-defined number of patterns has occurred (Count field) on all inputs.

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

Count can be set to any integer from 1 to 32000. The event number set by the Count field will be displayed at the trigger marker when the acquisition is displayed. When the Count field is selected, the pattern 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.
Pattern Trigger Exercise

This exercise demonstrates how the input signals can be used in a pattern combination to generate a trigger.

Connecting the Equipment

Connect one BNC tee adapter and two 1-metre BNC cables to the oscilloscope as shown below. Connecting the cables in this manner will delay the signal to INPUT 1 by a few nanoseconds. This will allow you to set up different pattern trigger combinations.

Setting Up the Oscilloscope

1. Turn the power on to the instrument.
2. Touch the System module field and select Oscilloscope from the pop-up.
3. From the default oscilloscope Channel menu, make the following changes:
   - Input 1 Probe field to 1:1
   - Input 1 Impedance field to 50 Ohms
   - Input 2 Probe field to 1:1
   - Input 2 Impedance field remains at 1 MΩm
4. Touch the Autoscale field to autoscale the signal.
5. Touch the Run field and drag your finger to the Repetitive field in the pop-up.
6. Set the s/Div field to 5.00 ns.

Trigger Menu

8-17
The oscilloscope display should now look like this:

Touch the Channel menu field and select Trigger from the pop-up. Touch the Mode field and select Pattern from the pop-up. The display will not be synchronized to a trigger point at this time because all of the Channel-Pattern terms are set to X ("don't cares").
Entering a Trigger Pattern

The Channel-Pattern field shows the inputs available and the pattern assigned to each input. At this point, input 1, input 2, and external trigger (Ex) are assigned "don't cares". Touch the Channel-Pattern field. A pop-up appears as shown below.

Change the pattern to HHX by touching H, H, then X in the pop-up. The letters appear at the top of the pop-up as they are entered. If you make a mistake, turn the knob to move the highlight to the entry to be corrected, or touch CLEAR to change all entries back to X and start over again. When the pattern is entered correctly, touch DONE to return to the pattern trigger menu.
The waveform display should now look like this. The When field is set to Entered so the oscilloscope is triggering on the first transition that makes the pattern specification true for input 1 and input 2 (external trigger is "don't care"). Input 2 is high first, then the trigger occurs as input 1 crosses above it's trigger threshold.

Note

The trigger level for each input in the pattern specification must be set using the Level field in Edge trigger mode. This sets the threshold of each input for high and low levels in the pattern. In this exercise, input 1 and input 2 trigger levels were set to the correct levels by using Autoscale.

Touch the When Entered field to toggle to When Exited. The waveform should now look like the one at the top of the next page. The oscilloscope is triggering on the first transition that causes the pattern specification to be false after the pattern has been true one time (Count=1). At the beginning of the waveform trace, Input 1 and input 2 are high and the pattern specification is true. When input 2 crosses below it's trigger threshold, the pattern becomes false and the oscilloscope triggers.
Change the Channel-Pattern field to LHX. The waveform display should now look like this. Approximately 7 ns before the trigger marker input 1 is low, input 2 crosses above its trigger threshold, and the pattern specification becomes true. At the trigger marker, input 1 crosses above its trigger threshold and the pattern specification becomes false. At this point the trigger occurs because the oscilloscope was set to trigger when the pattern was Exitied.
Autoscale Field

Autoscale is a function built into the digitizing oscilloscope that automatically displays one or more waveforms. The Autoscale field is displayed in the top row of menu fields on every oscilloscope menu.
When the **Autoscale** field is touched, a pop-up appears allowing you to cancel or continue the autoscale. If you accidently touch the **Autoscale** field, touching the **Cancel** field will cancel autoscale to keep you from inadvertently changing your oscilloscope setup.

If the **Continue** field is touched, the autoscale function is started and the advisory **Autoscale is in progress** is displayed. The oscilloscope automatically sets **V/Div** (vertical sensitivity), channel **Offset**, **s/Div** (sweep speed), and trigger **Level** so that the input signals are displayed on screen. The oscilloscope checks all vertical inputs and looks for the trigger on the input channel with the lowest number. The following fields are changed when autoscale is complete:

**Channel menu**
- **V/Div** - scaled
- **Offset** - scaled

**Trigger menu**
- **Mode** - Edge
- **Source** - set to lowest number input with signal present
- **Level** - scaled
- **Slope** - Positive
- **Count** - 1
- **Auto-Trig** - On

**Any menu**
- **s/Div** - scaled
- **Delay** - 0 s
When a Signal is Found

If a signal is found on any of the vertical inputs, the oscilloscope determines the frequency of the signals and automatically scales the vertical sensitivity, offset, sweep speed, and trigger level to display the waveform on screen. The oscilloscope will normally display between 1 and 3 complete cycles of the waveform.

If a signal is present at more than one input, the trigger source is always assigned to the signal input with the lowest number. This input is also used to scale the sweep speed. If only one vertical input has a signal present, that signal is the trigger source. The trigger point on the waveform is displayed as a dotted vertical red line at the center of the screen (Delay = 0 s).

When autoscaling is complete, the display should look something like this:

![Oscilloscope Settings](image)

Autoscale

7-3
If No Signal is Found

If no signal is found on any of the vertical inputs, the oscilloscope displays the advisory **No signal found**, then displays **Auto Triggered**, and the oscilloscope is placed in an auto-trigger mode. The auto-trigger mode allows the oscilloscope to auto-sweep and display a baseline anytime a trigger signal is not present.

<table>
<thead>
<tr>
<th>Oscilloscope C</th>
<th>Channel</th>
<th>Autoscale</th>
<th>Print</th>
<th>Stop</th>
</tr>
</thead>
<tbody>
<tr>
<td>Input</td>
<td>V/Div</td>
<td>Auto triggered</td>
<td>Probe</td>
<td>Impedance</td>
</tr>
<tr>
<td>52</td>
<td>100 nV</td>
<td>127 nV</td>
<td>1:1</td>
<td>1 MΩ</td>
</tr>
<tr>
<td>s/Div</td>
<td>Delay</td>
<td>Marker</td>
<td>Sample Period</td>
<td>1.0000 us</td>
</tr>
<tr>
<td>200 ns</td>
<td>0 s</td>
<td>Off</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

---

**Autoscale**

7-4
Running the Oscilloscope

Introduction
The oscilloscope module is a 400-megasample/second, real-time digitizing oscilloscope with 100-MHz bandwidth. Each 4k-sample waveform record is acquired on a single acquisition. Multiple channels (2, 4, 8, or 16) are acquired simultaneously so you can determine relationships between infrequent events. For more information on real-time sampling, refer to chapter 4 of the book *Feeling Comfortable with Digitizing Oscilloscopes*.

Run/Stop Field
The Run/Stop field controls how the oscilloscope acquires waveform data. The field is in the upper-right corner of all oscilloscope menus as shown below. The oscilloscope can acquire waveforms in Single (single-shot) mode or in Repetitive mode. Single mode acquires a waveform on a single acquisition and then stops running. Repetitive mode acquires a waveform on a single acquisition, then updates the display each time a new acquisition is made. Repetitive mode continues acquiring data in this manner until stopped by the user. Each 4k-sample waveform record is acquired in a single acquisition in both Single and Repetitive mode.
When the green Run field is displayed, the oscilloscope is stopped and touching the Run field will start the oscilloscope running. When the red Stop field is displayed, the oscilloscope is running and touching the Stop field will stop the oscilloscope.

When powered on, the oscilloscope defaults to the Single mode.

Single Mode

When the mainframe is first powered up, none of the modules installed in the mainframe are running. This prevents any unwanted interaction between the modules.

To start the oscilloscope running in the single-shot mode, touch the green Run field, then 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. If the Cancel field in the pop-up is selected, the oscilloscope would return to the state it was in before the Run field was touched.

This starts the oscilloscope running the Single mode. When the single-shot acquisition is being made, the Run/Stop field will display Stop. When the acquisition is completed, the field will display Run. In this mode, the oscilloscope makes a single acquisition, displays the results, then waits until the Run field is touched again before making another acquisition.

Running the Oscilloscope

0:2
Repetitive Mode

To start the oscilloscope running in the repetitive mode, touch the green Run field, then 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. If the Cancel field in the pop-up is selected, the oscilloscope would return to the state it was in before the Run field was touched.

This starts the oscilloscope running in the Repetitive mode. In this mode, the display is updated each time a new acquisition is made. 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.

Reminder

Remember, when the Run/Stop field displays Run, the oscilloscope is stopped and touching the Run field will start the oscilloscope running. Likewise, when the Run/Stop field displays Stop, the oscilloscope is running and touching the Stop field will stop the oscilloscope.
Introduction

In addition to automatic parametric measurements, the oscilloscope also has two markers for making time and voltage measurements either manually or automatically. These markers are accessed by touching the Markers field on any of the oscilloscope menus except Calibration.

The default selection for the Markers field is Off.
Markers Field
Menu Map

The menu map for the Markers field is shown below.
Marker Measurements

To demonstrate how to make marker measurements, set up the oscilloscope as described below. This setup will be used throughout the remainder of this chapter.

Connecting the Equipment

Connect one BNC tee adapter and two 1-metre BNC cables to the oscilloscope as shown below.

![Diagram of oscilloscope setup]

Setting Up the Oscilloscope

1. Turn the power on to the instrument.
2. Touch the System module field and select Oscilloscope from the pop-up.
3. From the default oscilloscope Channel menu, make the following changes:
   - Input 1 Probe field to 1:1
   - Input 1 Impedance field to 50 Ohms
   - Input 2 Probe field to 1:1
   - Input 2 Impedance field remains at 1 MOhm
4. Touch the Autoscale field to autoscale the signal.
5. Touch the Run field and drag your finger to the Repetitive field in the pop-up.
6. The display should now look like this:

Manual Marker Measurements

Touch the Markers field on the display. When the pop-up appears, touch the On field. With Markers set to On, you can manually move the X and O markers to make time and voltage measurements.
Three new fields will 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 an X marker and an O marker by entering time values for these markers.

**Trig to X Field**  
The X marker is shown on the waveform display as a dashed green line. The time displayed in the Trig to X field is measured from the trigger point to the X marker. The trigger point is marked with a dotted red line on the waveform display and is always time 0. A green border around the Trig to X field reminds you that the X marker is green.

When the Trig to X field is selected, the time value can be changed by turning the knob or by entering a time value from the pop-up keypad. The keypad will appear when you touch the Trig to X field when the field is light blue.

Resolution for the 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 dashed yellow line. The time displayed in the Trig to O field is measured from the trigger point to the O marker. A yellow border around the Trig to O field reminds you that the O marker is yellow.

Marker Measurements

9-5
When the **Trig to O** field is selected, the time value can be changed by turning the knob or by entering a time value from the pop-up keypad. The keypad will appear 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**.

**X to O Field**

The **X to O** field displays the time (delta time) between the **X** marker and the **O** marker. When the **X to O** field is selected, turning the knob will move both the **X** and **O** marker 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.

The value in the **X to O** field can be changed 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 will appear when you touch the **X to O** field when the field is light blue.

When the time value of **X to O** is changed using the keypad, half the difference of the new value and old value is subtracted from the **X** marker and half is added to the **O** marker.

**Channel Label Field**

The channel label field is the dark blue field to the left of the waveform display. When the markers are turned on, the voltage values where the **X** and **O** markers intersect each waveform are displayed under each channel label.
Touch the Trig to X field. Now turn the knob and notice how the X marker (green) moves 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.

<table>
<thead>
<tr>
<th>Oscilloscope C</th>
<th>Channel</th>
<th>Autoscale</th>
<th>Print</th>
<th>Step</th>
</tr>
</thead>
<tbody>
<tr>
<td>Input 93</td>
<td>V/Div</td>
<td>Offset</td>
<td>Probe</td>
<td>Impedance</td>
</tr>
<tr>
<td>200 us</td>
<td>100 mV</td>
<td>-0.0 mV</td>
<td>1:1</td>
<td>1 MΩ</td>
</tr>
<tr>
<td>Delay 0</td>
<td>Markers on</td>
<td>X to 0</td>
<td>400.00 us</td>
<td>Trigger to 0</td>
</tr>
</tbody>
</table>

As you turn the knob, 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 C marker is to the left of the X marker.

Now touch the Trig to O field. Turn the knob and notice how the O marker (yellow) moves, and how the time values change.

Also notice that as you move the X or O marker from a low portion on the square wave to a high portion, the voltage values in the channel label field also change.

Touch the X to O field and turn the knob. The X and O markers now move together and maintain the preset X to O time value.

Marker Measurements
9-7
Automatic Marker Measurements

Touch the Markers field. When the pop-up appears touch the Auto field. This selects the automatic markers measurements.

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 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 voltage found on the waveform.
The default auto markers pop-up menu is shown below.

Set on Field  The Set on field assigns an input waveform (B1 or B2 in this example) to the X or O marker, or allows the marker to be set manually. When you touch the Set on field, a pop-up appears showing all waveform sources available.

What is displayed on the pop-up is dependent upon how many acquisition boards are installed in the mainframe and in which slots they are installed. If MANUAL is selected from the Set on pop-up, that marker will be controlled by the knob.

Marker Measurements
9-9
The default selection for the Set on field is the lowest letter/number combination. For example, if acquisition boards are installed in mainframe slots B and C, the Set on field will default to B1 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 the at Level field is selected, the percentage can be changed by turning the knob or by entering a value from the pop-up keypad. The keypad will appear when you touch the at Level field when the field is light blue. Any percentage from 10% to 90% in increments of 1% can be entered.

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 the Slope field is touched, the slope will toggle 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 edge on the waveform. The edge may be the 1st displayed up to the 100th displayed. The count of edge occurrences is made starting with the first edge displayed on screen, either partial or full.

**Note**

Auto-marker measurements are made with data that is displayed on screen. Make sure the data of interest is fully displayed on screen. For example, if only part of a positive edge is displayed, the 0%-point and 100%-point of the edge is calculated from what is actually displayed on screen. This could cause measurement errors.

When the Occur field is selected, the occurrence can be changed by turning the knob or by entering a new value from the pop-up keypad. The keypad will appear 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.
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 will toggle between On and Off. The default selection for the Statistics field is On.

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

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

1. Autoscale is executed.
2. Auto-marker parameters are changed.
3. Statistics is set to Off.
4. Repetitive Run mode is stopped.

When Statistics is set to Off, the default 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 lets you set up a stop condition for the time interval between the X marker and O marker. When this condition is met, the oscilloscope will stop making acquisitions and will display Stop condition satisfied. These stop conditions will appear when you touch the Run Until Time X-O field. The default selection for this field is Off.

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

Done field. Touch this field when you are done entering data in the auto-markers pop-up and would like to return to the waveform display.
**Less Than field.** When this field is selected from the pop-up, a time value field appears next to the Run Until Time X-O Less Than field.

When the time value field is selected, the time can be entered by turning the knob or by entering a value from the pop-up keypad. The keypad will appear when you touch the time value field when the field is light blue. When using the keypad, resolution is 10 ps at times up to ±99.99 ts and can be set to 5-digit resolution for other times up to ±100 Megaseconds. Positive times would be used when the X marker is displayed before the O marker, and negative times would be used when the O marker is displayed before the X marker.

When **Less Than** is selected, the oscilloscope will run 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 will stop acquisitions and display **Stop condition satisfied.**

**Greater Than field.** When this field is selected from the pop-up, a time value field appears next to the Run Until Time X-O Greater Than field. When the time value field is selected, the time can be entered the same as for the **Less Than** field.

When **Greater Than** is selected, the oscilloscope will run 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 will stop acquisitions and display **Stop condition satisfied.**

Marker Measurements
9-13
**In Range field.** When this field is selected from the pop-up, two time value fields appear next to the Run Until Time X-O In Range field. The time range for the stop condition is entered in these time fields. When either time value field is selected, the time can be entered the same as for the Less Than field.

When **In Range** is selected, the oscilloscope will run 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 will stop acquisitions and display **Stop condition satisfied**.

**Not In Range field.** When this field is selected from the pop-up, two time value fields appear next to the Run Until Time X-O Not In Range field. The time range for the stop condition is entered in these time fields. When either time value field is selected, the time can be entered the same as for the Less Than field.

When **Not In Range** is selected, the oscilloscope will run 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 will stop acquisitions and display **Stop condition satisfied**.

---

Marker Measurements
9-14
Auto-Marker Exercise

Set up the oscilloscope as shown in "Marker Measurements" on page 9-3. Let’s set up the auto marker pop-up to make an X-O marker measurement on the B1 and B2 input waveforms. We want to measure the time between the falling edge of the 2nd displayed pulse on B1 to the rising edge of the 5th displayed pulse on B2. We’ll perform the measurement from the 10% point on B1 to the 90% point on B2.

1. Touch the Markers field. When the pop-up appears, touch the Auto field. The auto-markers pop-up menu is now displayed.

2. Set the X marker (green) to the 10% point of the 2nd negative edge of B2.
   a. Touch the Set on field and select B2 (2nd pulse) from the pop-up.
   b. Touch the at Level field and turn the knob until the field displays 10%.
   c. Touch the Slope field until the field displays Negative.
   d. Touch the Occur field and turn the knob until the field displays 2.

3. Set the O marker (yellow) to the 90% point of the 5th positive edge of B1.


5. The auto-marker pop-up should now look like the screen below.

Marker Measurements
9-15
Touch the **Done** field to return to the waveform display. There aren't enough cycles of the waveform being displayed at this time to display the O marker on the 5th B2 pulse, so the oscilloscope displays **No level** found for the O-marker. Touch the s/Div field and set the sweep speed to 500 μs/division. The X marker is on the falling edge of the 2nd displayed pulse and the O marker is on the rising edge of the 5th displayed pulse. The statistical minimum, maximum, and mean time interval measurements between the X and the O markers are displayed in the tan field next to the **Markers** field. The voltage measurements of where the markers intersect the waveforms are displayed in the channel label field under the B1 and B2 labels.

![Oscilloscope Interface](image)

Touch the **Delay** field, and turn the knob. Notice that as the waveform is moved across the display, the X and O markers also move to the edges specified in the auto-markers pop-up menu.

Set the **Delay** time back to 0 s.

---

**Marker Measurements**

9-18
Let's go back to the auto-marker pop-up menu and set up an X-O measurement using the Run Until Time X-O feature.

1. Touch the u/Div field and turn the knob to change the sweep speed to 5 ns/div.

2. Touch the Markers field and select Auto from the pop-up.

3. Change the X marker fields to:
   - Set on B1
   - at Level 50%
   - Slope Positive
   - Occur 1

4. Change the O marker field to:
   - Set on B2
   - at Level 50%
   - Slope Positive
   - Occur 1

5. Touch Run Until Time X-O field and select Less Than from the pop-up.

6. Touch the time field next to the Less Than field. Turn the knob to set the time to 5.00 ns.

7. The auto-marker pop-up should now look like the screen below.

Marker Measurements
9-17
Touch the Done field to return to the waveform display. The display now looks like that shown below. The time interval from X-O in this example is -6.7171 ns. The time is negative because the O marker is displayed before the X marker. The oscilloscope was instructed to run until the time interval was less than 5 ns. When the stop condition was satisfied, the oscilloscope stops acquisition and displays the advisory Stop condition satisfied.

Touch the Markers field and select the Auto field from the pop-up. Touch the Set on field for the X marker. Notice the pop-up field can be set to manual. This allows you to have one marker set automatically and one marker set to be controlled manually with the knob.

Touch the MANUAL field in the pop-up. Now touch Done in the auto-markers pop-up to return to the waveform display. Touch the Markers field again and select On from the pop-up. The X marker is now set to the manual mode and the O marker is set to the automatic mode.
10 Display Menu

Introduction
The Display menu controls how the oscilloscope acquires and displays waveforms. The waveforms may be displayed in normal, averaged, or accumulated mode. This menu also controls the connect-the-dots display feature. The default Display menu is shown below.

Display Menu Map
The menu map for the Display menu is shown below.
Mode Field

The Mode field determines how waveform information is acquired and displayed.

When you touch the Mode field, a pop-up field will appear as shown below. Normal, Average, or Accumulate mode can be selected from the pop-up. The default selection for the Mode field is Normal.
Normal Mode

In Normal mode, the oscilloscope acquires waveform data and then displays the waveform. When the oscilloscope makes a new acquisition, the previously acquired waveform is erased from the display and replaced by the newly acquired waveform.
Average Mode

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

When the Average mode is selected, a new field appears next to the Mode field which allows you to select the number of averages to make. When the Average # field is selected, the number of averages can be changed by turning the knob. The number of averages can be set to 2, 4, 8, 16, 32, 64, 128, or 256.
As an example, assume the Average # field is set to 16. If the Run mode is set to Repetitive, the oscilloscope will immediately start acquiring waveform data and average them together. When the initial 16 waveforms have been acquired, the oscilloscope will momentarily display the advisory Number of averages have been met. Once the initial 16 waveforms have been acquired, the oscilloscope will only average the last 16 waveforms acquired; all other data will be discarded.

If the Run mode is set to Single, an acquisition is not made until the Run field has been touched. If Average # is set to 16, as in the previous example, Number of averages have been met would not be displayed until Run has been touched 16 times.

Average # can also be entered with the pop-up keypad. The keypad will appear when you touch the Average # field when the field is light blue. Any power of 2 from 2 to 256 can be entered.

The default value for the Average # field is 8.

**Accumulate Mode**

In Accumulate mode, the oscilloscope accumulates all waveform acquisitions on 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 or V/Div.
**Connect Dots Field**

What you see on the display below looks like two parallel dashed lines, because each sample is displayed as a single dot.

<table>
<thead>
<tr>
<th>Oscilloscope C</th>
<th>Display</th>
<th>Autoscale</th>
<th>Print</th>
<th>Stop</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mode Normal</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>s/Div 2.00 ms</th>
<th>Delay 0 s</th>
<th>Markers Off</th>
<th>Sample Period</th>
<th>10.000 us</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>B1</th>
<th>B2</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

To give you a better idea of what the waveform looks like, the oscilloscope has a feature that connects the sample dots together. When **Connect Dots** is On, each displayed dot will be connected to the adjacent dot by a straight line. The same waveform with **Connect Dots** set to On, is now well defined and easier to see.

<table>
<thead>
<tr>
<th>Oscilloscope C</th>
<th>Display</th>
<th>Autoscale</th>
<th>Print</th>
<th>Stop</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mode Normal</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>s/Div 2.00 ms</th>
<th>Delay 0 s</th>
<th>Markers Off</th>
<th>Sample Period</th>
<th>10.000 us</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>B1</th>
<th>B2</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The default setting for the **Connect Dots** field is Off.
Auto-Measure Menu

Introduction
Automatic parametric measurements are functions built into the digitizing oscilloscope that make parametric measurements on a displayed waveform. There are nine automatic measurements available in the automatic measurement menu:

- Period
- Rise time
- Fall time
- Frequency
- +Width
- -Width
- Vp-p
- Preshoot
- Overshoot

Auto-Measure Menu Map
The menu map for the Auto-Measure menu is shown below.
Top and Base Voltages

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

The digitizing oscilloscope displays 8-bit vertical voltage resolution. This means the vertical display is divided up into $2^8$ voltage levels. Each of these 64 levels is called a quantization level. Each waveform has 500 data points displayed horizontally on screen. Each of these 500 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 $V_{100\%}$ level. The quantization level with the greatest number of occurrences in the bottom half of the waveform corresponds to the $V_{0\%}$ level.

If $V_{100\%}$ and $V_{0\%}$ do not contain at least 5% of the 500 data points displayed on screen, $V_{100\%}$ defaults to the maximum voltage ($V_{\text{maximum}}$) and $V_{0\%}$ defaults to the minimum voltage ($V_{\text{minimum}}$) found on the display. An example of this case would be measurements made on sine or triangle waves.

From this information the instrument can determined the 10, 50, and 90% points, which are used in most automatic measurements. The $V_{100\%}$ or $V_{0\%}$ 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 since the waveform normally rests below the perturbation.
Automatic Measurement Setup

To demonstrate how to make automatic measurements, set up the oscilloscope as described below. This setup will be used throughout the remainder of this chapter.

Connecting the Equipment

Connect one BNC tee adapter and two 1-metre BNC cables to the oscilloscope as shown below.

Setting Up the Oscilloscope

1. Turn the power on to the instrument.
2. Touch the System module field and select Oscilloscope from the pop-up.
3. From the default oscilloscope Channel menu, make the following changes:
   - Input 1 Probe field to 1:1
   - Input 1 Impedance field to 50 Ohms
   - Input 2 Probe field to 1:1
   - Input 2 Impedance field remains at 1 MOhm
4. Touch the Autoscale field to autoscale the signal.
5. Touch the Run field and drag your finger to the Repetitive field in the pop-up.
6. The display should now look like this:

**Auto-Measure Menu** The Auto-Measure menu is accessed by touching the menu field (top row, second from the left), then selecting Auto-Measure from the pop-up. The default Auto-Measure menu is shown below.
Input Field

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

What is displayed in the Input pop-up is dependent upon how many acquisition boards are installed in the mainframe and in which slots they are installed. In this example the Inputs are B1 and B2.

The default selection for for the Input field is the lowest letter/number input channel. For example, if acquisition cards were installed in mainframe slots B, C, and D, the Input field would default to B1.

Measurement Field

The tan field in the middle row of the menu displays the nine automatic measurements that can be made. Automatic measurements are made only with data that is currently being displayed in the waveform display. 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, and a complete negative pulse must be displayed to make a -Width measurement.

- Risetime, Falltime, Preshoot, and Overshoot measurements will be more accurate if you expand the edge of the waveform by selecting a faster sweep speed.

Auto-Measure Menu

11-5
Rise Time Measurement

Touch the s/Div field and turn the knob to change the sweep speed to 5 ns/div. Expanding the edge on the waveform will give more accurate results because more data points on the rising edge will be displayed.

Risetime is measured on the positive-going edge of the waveform and is the time it takes the waveform to transition between the 10% voltage point and the 90% voltage point. The risetime value is displayed in the Risetime field.

Notice that Period, Falltime, Freq, +Width, and -Width fields are blank. Because only the rising edge of the waveform is displayed, there is insufficient data at this time to make these measurements.
Fall Time Measurement

Fall time is measured on the negative-going edge of the waveform and is the time it takes the waveform to transition between the 90% voltage point and 10% voltage point. You are currently displaying the positive-going edge of the waveform, so you need to change it to the negative-going edge.

1. Touch the Auto-Measure field.
2. When the pop-up appears, touch the Trigger field to display the Trigger menu.
3. Touch the Slope field to change the displayed slope from Positive to Negative.

Notice the negative-going edge of the waveform is now displayed.
Now touch the Trigger field and select Auto-Measure from the pop-up to return to the Auto-Measure menu.

The fall time value is displayed in the Falltime field.

Now measure the Falltime on Input B2.

1. Touch the Input field.
2. Select B2 from the pop-up.

Falltime is now being measured on B2.
**Vp_p Measurement**

The peak-to-peak voltage measurement uses the maximum voltage and the minimum voltage found in the data displayed on screen for the selected source.

\[ V_{p-p} = V_{\text{maximum}} - V_{\text{minimum}} \]

The \( V_{p-p} \) measurement is displayed in the upper left corner of the auto-measurement field.
Period and Freq (frequency) measurements are made using the first two like edges of an input displayed on screen. At least one full cycle of the waveform must be displayed to make the measurements. If a full cycle is not present, the Period and Freq measurements in the auto-measure field will be blank. Period and Freq are measured using the time (t) at the 50% level of the edges.

If the first edge on the display is rising then

\[
\text{Period} = \text{rising edge 2} - \text{rising edge 1} \\
\text{Freq} = 1/(\text{rising edge 2} - \text{rising edge 1})
\]

If the first edge on the display is falling then

\[
\text{Period} = \text{falling edge 2} - \text{falling edge 1} \\
\text{Freq} = 1/(\text{falling edge 2} - \text{falling edge 1})
\]

Rescale the waveform to display at least one full cycle of the waveform, then make a Period and Freq measurement on B1.

1. Touch Autoscale.
2. Select Continue from the pop-up.
3. Change s/Div field to 100 us to display only one full cycle of the waveform.

Period and Freq measurements are displayed in the top row of the auto-measurement field.
+Width and -Width Measurements

+Width (positive pulse width) and -Width (negative pulse width) measurements are made using the time (t) at the 50% level of the waveform edges. At least one positive-going edge followed by a negative-going edge of the waveform must be present to make a +Width measurement and at least one negative-going edge followed by a positive-going edge must be present to make a -Width measurement.

If these conditions are not present, the +Width and/or -Width measurements in the auto-measure field will be blank.

If the first edge on the display is rising then

+Width = Trailing edge 1 - Trailing edge 1
-Width = Trailing edge 2 - Trailing edge 1

If the first edge on the display is falling then

+Width = Trailing edge 2 - Trailing edge 1
-Width = Trailing edge 1 - Trailing edge 1

Rescale the waveform to display at least one full cycle of the waveform, then make a +Width and -Width measurement on B1.

1. Touch Autoscale.
2. Select Continue from the pop-up.
3. Change s/Div field to 100 us to display only one full cycle of the waveform.

+Width and -Width measurements are displayed in the top row of the auto-measurement field.

Auto-Measure Menu
11-11
Preshoot and Overshoot Measurements

Preshoot and Overshoot measure the perturbation on a waveform above or below the top and base voltages (see "Top and Base Voltages" section earlier in this chapter). These measurements use all data displayed on 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 is measured as a percentage of the top-base voltage.

If the measured edge is rising then

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

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

If the measured edge is falling then

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

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

Rescale the waveform, display a rising edge, then make a Preshoot and Overshoot measurement on B1.

1. Touch Autoscale.
2. Select Continue from the pop-up.
3. Change s/Div field to 5 ns to display a rising edge.
Preshoot and Overshoot measurements are displayed in the right side of the auto-measurement field. Preshoot is measured at the bottom of the rising edge and Overshoot is measured at the top of the rising edge.

---

Go the Trigger menu, change the Slope field to Negative, then return to the Auto-Measure menu. The negative-going edge of the waveform is now displayed.

---

Preshoot now is measured at the top of the falling edge and Overshoot is measured at the bottom of the falling edge.
Waveform Selection

Introduction

This chapter will show 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.

The dark-blue channel label field to the left of the waveform display shows the input channels that are being displayed. In this example, B1 and B2 signify INPUT 1 and INPUT 2 from the acquisition card in mainframe slot B.

When you touch the channel label field, the WAVEFORM SELECTION pop-up menu will appear as shown below. This menu allows you to insert, delete, or replace an input channel and choose channel modes.
Waveform Selection Menu Map

The menu map for the WAVEFORM SELECTION pop-up is shown below:

```
Waveform Selection Pop-up

Channel Mode
  - Single
  - Overlay
  - Chan + Chan
  - Chan - Chan

Action
  - Insert
  - Replace

Delete

Labels

Module
  - xxx A
  - xxx B
  - xxx C
  - xxx D
  - xxx E

Done

*Intermodule Group Run only

A1
A2
B1
B2
C1
C2
D1
D2

12-2
```
Waveform Selection Setup

Set up the oscilloscope as described below. This setup will be used throughout the remainder of this chapter.

Connecting the Equipment

Connect one BNC tee adapter and two 1-metre BNC cables to the oscilloscope as shown below.

![Diagram of oscilloscope setup]

Setting Up the Oscilloscope

1. Turn the power on to the instrument.
2. Touch the System module field and select Oscilloscope from the pop-up.
3. From the default oscilloscope Channel menu, make the following changes:
   - Input 1 Probe field to 1:1
   - Input 1 Impedance field to 50 Ohms
   - Input 2 Probe field to 1:1
   - Input 2 Impedance field remains at 1 MOhm
4. Touch the Autoscale field to autoscale the signal.
5. Touch the Run field and drag your finger to the Repetitive field in the pop-up.
6. The display should now look like this:

[Diagram of an oscilloscope setup showing channels and settings]

Waveform Selection
12-4
Replacing a Channel

Touch the **Action** field in the pop-up; each time you touch this field, the action will alternate between **Insert** and **Replace**. This field allows you to insert a channel or replace a channel being displayed.

Now turn the knob both directions and notice that **B1** or **B2** in the channel label field is highlighted in white. The area highlighted in white tells you where the channel will be inserted or replaced.

1. Touch the **Action** field until **Replace** is displayed.
2. Turn the knob so that **B1** is highlighted in white.
3. Touch the label **B2** as shown below.
Input channel B2 has now replaced B1. Remember, when you replace an input channel, the new channel replaces the input highlighted in white.

Turn the knob so that the top B2 is highlighted in white. Touch the label B1 to replace B2 with B1.
Inserting an input channel works similar to replacing a channel.

1. Touch the Action field until Insert is displayed.
2. Turn the knob so that B1 is highlighted in white.
3. Touch the label B2 as shown below.

Input channel B2 has now been inserted between the original B1 and B2. Remember, when you insert an channel, the inserted channel will always appear below the input highlighted in white.
Alternately touch the labels B1 and B2 until eight labels have been added to the channel label field. Now press the Done field in the pop-up to return to the waveform display.

The waveform display should now look like this. Eight waveforms are displayed; INPUT 1 is yellow and INPUT 2 is green.
Deleting a Channel

Touch the channel label field at the left of the waveform display to return the the WAVEFORM SELECTION pop-up. Use the knob to select the waveform label to delete. Touch the Delete field in the pop-up. The input channel highlighted in white will be deleted when the Delete field is touched.

Continue touching the Delete field until all but two input channels are deleted.

Waveform Selection
12-9
Waveform Math and Overlay

While you are still in the WAVEFORM SELECTION pop-up, touch the Channel Mode field. A pop up will appear showing the channel mode selections available. The Channel Mode field selects how the waveform will be displayed.

**Single**

What we have been displaying so far in this chapter are examples of Single channel mode. This mode displays a single input channel in each waveform display.
Overlay  Suppose you wanted to take the signal from Input 1 and compare it to the signal from Input 2. The easiest way to do this would be to put both waveforms on the same waveform display, or overlay the waveforms. Touch the Overlay field.

Let's overlay Input 1 with Input 2 in the top waveform display.

1. Turn the knob so that B1 is highlighted in white.
2. Touch the Action field until Replace is displayed.
3. Touch the label B1 in the pop-up, then touch B2 in the pop-up. B1, B2 is now displayed in the top channel label field.
1. Touch the Done key in the pop-up.
2. Touch the s/Div field and change the sweep speed to 5 ns/div.
   This will allow us to see the overlayed waveforms easier.

The display should now look like this. Input 2 (green) is now overlayed on Input 1 (yellow) in the top waveform display.

Touch the channel label field at the left of the waveform display to return to the WAVEFORM SELECTION pop-up.
Waveform Math (Chan+Chan, Chan-Chan) Suppose you wanted to take the signal from input 2 and add it to or subtract it from the signal from input 1. Let's try subtracting input 2 from input 1. Touch the Channel Mode field on the display. When the pop-up appears, touch the Chan - Chan field.

Let's subtract input 2 from input 1 in the bottom waveform display.

1. Turn the knob so that B2 is highlighted in white.
2. Touch the Action field until Replace is displayed.
3. Touch the label B1 in the pop-up, then touch the label B2 in the pop-up. B1-B2 is now displayed in the bottom channel label field.
Touch the **Done** key in the pop-up. The display should now look like this:

Input 2 has been subtracted from Input 1. The resultant waveform is displayed in white in the top waveform display. Notice now that both waveform overlay and A-B are displayed in the waveform display at the same time.
13

Saving and Recalling Setups

Introduction
You can store an oscilloscope configuration and all waveform display and measurement data to a floppy disc in the mainframe, then recall that information at a later time. Since the data is stored on floppy disc, you can store an unlimited number of configurations.

Besides recalling measurement data, recalling a configuration is a convenient way to return to a default condition without cycling the power on the mainframe.

You can also use the Autoload feature in the disc menu to automatically load a configuration other than the default oscilloscope configuration at power up.

Storing a Configuration
When you have an oscilloscope configuration you want to store to disc, you must go to a System disc menu to store the data. For this example, assume you are in an Oscilloscope menu.

1. Insert a floppy disc into either the front or rear disc drive of the mainframe. If the disc has not been formatted, do so at this time. Refer to the HP 16500A Reference Manual.

2. Touch the Oscilloscope module field in the upper left corner of the display, then select System from the pop-up.

3. Touch the menu field next to the System field and select either Front Disc or Rear Disc from the pop-up, depending on where you inserted the floppy disc.

A disc menu similar to that shown on the next page should be displayed. The list of files shown in this example are already stored on the disc.
Choose the Store operation from the disc menu.

1. Touch the disc operation field at the left of the display (Load in this example).

2. Select Store from the pop-up.

Store the configuration for the oscilloscope module only.

1. Touch the module field to the right of the Store field.

Saving and Recalling Setups

13-2
2. Select the Oscilloscope field in the pop-up. If you have two oscilloscope modules in the mainframe (dual timebase), make sure you select the one you want to save the configuration for.

Enter a filename to save the configuration to.

1. Touch the field to the right of to file and a pop-up keyboard will appear.

2. Enter the name of a file. The filename must start with a letter and can contain up to eight characters with no blank spaces between characters. In this example, touch the appropriate keys to enter the filename SCOPE1. If you make a mistake, turn the knob to move the cursor to the incorrect entry, then touch the correct character on the keypad. Or if you want, touch the CLEAR key and start over again.

3. When you have entered the filename, touch the DONE field in the pop-up to return to the disc menu.

```
System    Front Disc    Print

Store    Oscilloscope C to file    SYSTEM

SCOPE1

1  2  3  4  5  6  7  8  9  0
Q W E R T Y U I O P
A S D F G H J K L
Z X C V B N M
CLEAR    SPACE    DONE
```

Saving and Recalling Setups
13-3
Notice that the filename you entered is appended with an underscore character and the letter of the mainframe slot the oscilloscope timebase board is in.

Note

If you enter the name of a file that already exists on the disc, the oscilloscope will display STORE WILL OVERWRITE SELECTED FILE(S).

Enter a file description.

1. Touch the field to the right of file description and a pop-up keypad will appear.

Note

Entering a file description is optional and for your convenience. This description will make it easier for you to identify the type of data in each file. If you do not want to enter a description, touch the CLEAR field in the pop-up, then touch the DONE field to return to the disc menu.

2. Enter a description for the file. The description can be any combination of letters or numbers up the 32 characters long.

3. When you have entered the file description, make sure the description is correct since there is no way to change the description once the file has been saved. If the description is correct, touch the DONE field in the pop-up to return to the disc menu.
Store the file to disc.

**CAUTION**

If you store a new configuration to an existing file, the new configuration is written over the original information and will **DESTROY** the original information in that file.

1. Touch the Execute field.

2. Select Continue from the pop-up to store the file.

The file is now stored on the disc and is highlighted in the list of files on disc. The oscilloscope assigns file type 16530A_config to the file. All oscilloscope configuration files saved to the disc will have this file type.

<table>
<thead>
<tr>
<th>Filename</th>
<th>File Type</th>
<th>File Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>SYSTEM_001</td>
<td>10000_System</td>
<td>HP1000A System Software V00.01</td>
</tr>
<tr>
<td>SYSTEM_01</td>
<td>001_System</td>
<td>1000 Hz Timing Analyzer V00.01</td>
</tr>
<tr>
<td>SYSTEM_01</td>
<td>10000_System</td>
<td>4000Sample/s Dig. Scope V00.01</td>
</tr>
<tr>
<td>SYSTEM_02</td>
<td>021_System</td>
<td>50kHz1/2 Pattern Gen. V00.01</td>
</tr>
<tr>
<td>SYSTEM_03</td>
<td>031_System</td>
<td>25MHz Sine/100kHz Timing V00.01</td>
</tr>
</tbody>
</table>

**Saving and Recalling Setups**

13-5
Loading a Configuration

When you have an oscilloscope configuration stored on disc that you want to load into the oscilloscope, you must go to the System disc menu to load the data. For this example, assume you in an Oscilloscope menu.

1. Insert the floppy disc that contains the stored configuration file into either the front or rear disc drive of the mainframe.

2. Touch the Oscilloscope module field in the upper left corner of the display, then select System from the pop-up.

3. Touch the menu field next to the System field and select either Front Disc or Rear Disc from the pop-up, depending on where you inserted the floppy disc.

A disc menu similar to that shown on the next page should be displayed.

<table>
<thead>
<tr>
<th>Fcn</th>
<th>File Type</th>
<th>File Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>LOAD</td>
<td>All from file</td>
<td>SYSTEM</td>
</tr>
</tbody>
</table>
Choose the Load operation from the disc menu.

1. Touch the disc operation field at the left of the display if the Load field is not already displayed.

2. Select Load from the pop-up.

Load the configuration file for the oscilloscope module only.

1. Touch the module field to the right of the Load field.

   System       Front Disc       Print

   Load         All or from file (SYSTEM)

   Filename     File Type        File:...

   SCOPE1.C     16530A.config    COMP SIGNAL 32MB.
   SYSTEM       16550A.system     HP16550A System Soft.
   SYSTEM001    001.system        1 GHz Timing Analyzer
   SYSTEM01     16550A.system     4CM denotes/Dig. Scope .01
   SYSTEM021    021.system        50MHz/S Pattern Gen. V00.01
   SYSTEM031    031.system        25MHz/Sat/100MHz Timing V00.01

2. Select the Oscilloscope field in the pop-up. If you have two oscilloscope modules in the mainframe (dual timebase), make sure you select the one you want to load the configuration for.

Turn the knob to move the cursor to the file you want to load, then touch the Execute field to Load the configuration file into the oscilloscope.

The configuration file has now been loaded into the oscilloscope. The waveform data will stay in the oscilloscope memory the same as if it were acquired in the Single mode. As soon as you touch the Run field, the oscilloscope will acquire new waveform data.

Saving and Recalling Setups

13-7
Autoloading a Configuration

The Autoload feature in the System disc menu lets you automatically load a configuration other than the default oscilloscope configuration at power up. For this example, we will use the configuration file (SCOPE1.C) we stored at the beginning of the chapter for the autoload configuration.

1. Insert the floppy disc that contains the configuration file you want to use as an autoload file into either the front or the rear disc drive of the mainframe.

2. Touch the module key in the upper left corner of the menu, then select System from the pop-up.

3. Touch the menu field next to the System field and select either Front Disc or Rear Disc from the pop-up, depending on where you inserted the floppy disc.

A disc menu similar to that shown below should be displayed.

<table>
<thead>
<tr>
<th>File Type</th>
<th>File Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>SCOPE1.C</td>
<td>COMP SIGNAL SETUP</td>
</tr>
<tr>
<td>SYSTEM_1</td>
<td>165500 System Set up</td>
</tr>
<tr>
<td>SYSTEM_001</td>
<td>165500 System Set up</td>
</tr>
<tr>
<td>SYSTEM_01</td>
<td>001, System 5000A Dig. Scope V0.01</td>
</tr>
<tr>
<td>SYSTEM_02</td>
<td>012, System 5000A Dig. Scope V0.01</td>
</tr>
<tr>
<td>SYSTEM_03</td>
<td>031, System 5000A Dig. Scope V0.01</td>
</tr>
</tbody>
</table>

Saving and Recalling Setups

13-8
Choose the Autoload operation from the disc menu.

1. Touch the disc operation field at the left of the display.

2. Select Autoload from the pop-up.

Enable the Autoload function.

1. Touch the Disable field next to the Autoload field.

2. Select Enable from the pop-up.

Turn the knob to move the cursor to the file you want to become the autoload file (SCOPE1_C in this example). The name in the field to the right of File: should be SCOPE1_C. Now touch the Execute field to enable SCOPE1_C as the autoload file.
The oscilloscope adds a new file named AUTOLOAD to the listing as shown below.

```
  System  Front Disk  Print

  Autoload  Enable  File: SCOPE1.C

  Current AUTOLOAD status: ENABLED
  Current AUTOLOAD file: SCOPE1.C

  Filename  File Type  File Description
  AUTOLOAD  autload_file  status: ENABLED file: SCOPE1.C
  SCOPE1.C  16530N.config  CORP SIGNAL SETUP
  SYSTEM...  16500N.system  HP16500A System Software V00.01
  SYSTEM.001  001.system  1 GHz Timing Analyzer V00.01
  SYSTEM.011  16530N.system  400Sample/S Dig. Scope V00.01
  SYSTEM.021  021.system  50MHz Pattern Gen V00.01
  SYSTEM.031  031.system  25MHz Sine/100MHz Timing V00.01
```

Two status lines are displayed under the Autoload field. The first line gives the status of Autoload (ENABLED), and the second line give the file name of the autoload file (SCOPE_?). The question mark (?) after the filename indicates that all files that start with the characters SCOPE_ will be loaded at power-on when Autoload is enabled. This allows you to autoload configurations for any number of modules as long as the file names are the same. The letter at the end the file name tells the mainframe which slots the modules are located in.

As long as Autoload is enabled before the instrument is shut off, Autoload will remain enabled when you power-up the instrument and the autoload configuration file(s) will be loaded.
To disable the Autoload operation:

1. Touch the Enable field next to Autoload, and select Disable from the pop-up.

2. Touch the Execute field.

Autoload is now disabled. The status of the AUTOLOAD file is now DISABLED.

<table>
<thead>
<tr>
<th>System</th>
<th>Front Disc</th>
<th>Print</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Autoload</th>
<th>Disable</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Current AUTOLOAD status: DISABLED
Current AUTOLOAD file: AUTOLOAD

<table>
<thead>
<tr>
<th>Filename</th>
<th>File Type</th>
<th>File Description</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

AUTOLOAD: autload/file status: DISABLED
SCAPEL.C: 16530A_config: COMP SIGNAL SETUP
SYSTEM: 16500R:system: HP 16500R System Software V00.01
SYSTEM_001: 001:system: 1 GHz Timing Analyzer V00.01
SYSTEM_01: 16530A:system: 400MHz EMPIRE/4 Dig. Scope V00.01
SYSTEM_021: 001:system: Some::/ Pattern Gen. V00.01
SYSTEM_031: 031:system: 25MHz State/100MHz Timing V00.01

Saving and Recalling Setups

13-11
Using a Printer

Setting Printer Configuration

All printer parameters are set in the System Configuration menu. If you have just connected your printer and are unsure of how to set the configuration, refer to the HP 16500A Reference Manual chapter entitled Connecting a Printer.

The HP 16500A supports HP-IB and selected RS-232C printers.

All the pictures in this manual were taken from an HP 16500A with one HP 16530A timebase card and one HP 16531A acquisition card. If the screens on your instrument differ from the pictures in this manual, it simply means that you have a different card configuration. All other functions will work the same except where noted.

Printing Options

All oscilloscope menus include a Print field in the upper right of the screen.

<table>
<thead>
<tr>
<th>Oscilloscope</th>
<th>Channel</th>
<th>Autoscale</th>
<th>Print</th>
<th>Run</th>
</tr>
</thead>
<tbody>
<tr>
<td>Input B1</td>
<td>V/Div</td>
<td>Offset</td>
<td>Probe</td>
<td>Impedence</td>
</tr>
<tr>
<td></td>
<td>1.50 V</td>
<td>2.500 V</td>
<td>TTL</td>
<td>1.1 MΩ</td>
</tr>
<tr>
<td>f/Div</td>
<td>Delay</td>
<td>Mirror</td>
<td>Sample Period</td>
<td></td>
</tr>
<tr>
<td></td>
<td>10.0 ns</td>
<td>Off</td>
<td>40.000 ns</td>
<td></td>
</tr>
</tbody>
</table>

Using a Printer

14-1
When you touch the Print field, a pop-up like the one shown below appears.

There are two fields in the pop-up, Cancel and Print Screen. If you touch the Cancel field, the print will be cancelled.

Printing On-Screen Data

If you want a hardcopy record of the screen, touch the Print field and then the Print Screen field from the pop-up. This will send a copy of the screen to the printer in graphics mode. When the print is complete, the advisory Print Completed is displayed.
Using a Dual-Timebase Oscilloscope

Introduction

The HP 16500A can be configured as a dual-timebase oscilloscope by installing two HP 16530A/16531A oscilloscope modules into the mainframe. The oscilloscope are installed as two independent instruments -- two timebase cards, with each timebase card having an acquisition card. If the fifth mainframe slot does not contain another Instrument module, an additional acquisition card can be added to one of the timebase cards. For more information on installing oscilloscope modules, refer to chapter 16, "Installing New Oscilloscope Boards into the Mainframe".

In this chapter, we will show you how to configure and make a measurement using a dual-timebase oscilloscope. In this example, one oscilloscope module is installed in slots B and C, and the other oscilloscope module is installed in slots D and E. The module field pop-up will display the modules as Oscilloscope C and Oscilloscope E.

When the mainframe is first powered up, the default System Configuration menu will look like the display shown below.

![Diagram of Oscilloscope Configuration](image-url)
Setting Up the Intermodule Menu

Any time one module must be configured to arm another module, the connection must be made using the Intermodule menu. For this example, we will configure Oscilloscope C to arm Oscilloscope E. If you need additional information on the Intermodule menu, refer to "Intermodule Measurements" in the HP 16500A Logic Analysis System Reference Manual.

Go to the the Intermodule menu and configure the oscilloscope modules.

1. Touch the module menu key in the upper left corner of the display. A pop-up will appear showing System, Intermodule, and the two oscilloscope modules.

2. Select Intermodule from the pop-up. The Intermodule menu will appear like the display shown below.

```
Intermodule     Print
                 Group Run   Skew
```

Using a Dual-Timebase Oscilloscope
15-2
3. Touch the Oscilloscope C field. A pop-up appears allowing you to configure Oscilloscope C to run independently or to group run with other modules.

4. Select Group Run from the pop-up. A yellow box with the letter C is now displayed under the large blue Group Run field. A new green Group Run field appears in the upper right corner of the display. This field will now replace the normal green Run field in the oscilloscope menus.

5. Touch the Oscilloscope E field. A pop-up will appears as shown below. This pop-up has an additional field. You can now specify oscilloscope C to arm oscilloscope E.

Using a Dual-Timebase Oscilloscope
15-3
6. Select Oscilloscope C from the pop-up. A yellow box with the letter E appears below the yellow C box. This tells you that Oscilloscope C will arm Oscilloscope E will Oscilloscope C triggers.

Status: Both oscilloscope fields in the Intermodule menu display the run/stop status of the oscilloscope module. At this point, both oscilloscope modules display Stopped.

Time Correlation Bars: The two light-blue fields at the bottom of the display are time correlation bars. When the oscilloscopes are running and acquiring data, these bars display the start and stop time of Oscilloscope C in relation to Oscilloscope E. At this time the oscilloscopes are not running and no time relationship is displayed.
Skew  Touch the Skew field. A pop-up appears which allows you to adjust skew between the oscilloscope modules. This adjustments allows you to compensate for variances in internal probing delays between oscilloscope modules.

To determine the value of skew time to be entered, use the Markers On field in any of the oscilloscope menus. Measure the time between the edge of a waveform on Oscilloscope C and the edge on the same signal on an input to Oscilloscope E. The time difference between the two edges is the skew value you should enter. A positive time value moves the waveform for that oscilloscope to the right; and a negative value moves the waveform to the left. In this example, since Oscilloscope C is arming Oscilloscope E, the trigger point is set by Oscilloscope C. Since Oscilloscope C is the reference for trigger, change the skew time of Oscilloscope E.

To adjust the skew between oscilloscopes, touch either oscilloscope field in the pop-up menu and turn the knob. Resolution is 1 ns for times up to 99.999 us, and can be set to 5-digit resolution at times above 99.999 us. Skew can also be set by using the pop-up keypad. The keypad will appear when you touch either Oscilloscope field when the field is light blue.

Using a Dual-Timebase Oscilloscope
15-5
Setting Up the Oscilloscopes

Set up the oscilloscope modules as described in the following paragraphs.

Connect a Signal

1. Connect a BNC tee to the COMPENSATION SIGNAL output of either of the timebase cards at the rear of the instrument.
2. Connect a BNC cable from the BNC tee to INPUT 1 of the acquisition card in slot B.
3. Connect a BNC cable from the BNC tee to INPUT 1 of the acquisition card in slot D.

Acquire a Waveform with Oscilloscope E

1. Touch the Intermodule field and select Oscilloscope E from the pop-up.
2. Touch the Autoscale field and select Continue from the pop-up. The compensation signal should now be displayed on D1.
3. Select the $$/Div field and set the sweep speed to 20 us/div.

Using a Dual-Timebase Oscilloscope

15-6
Set the Trigger Mode

Since Oscilloscope E is armed by Oscilloscope C, you need to set the trigger mode of Oscilloscope E to Immediate. Immediate trigger mode allows Oscilloscope E to trigger immediately after Oscilloscope C receives its trigger. If not set to Immediate, Oscilloscope C would wait to trigger on an edge or pattern condition.

1. Go to the Trigger menu.

2. Touch the Mode field and select Immediate from the pop-up.

Note

Anytime you autoscale a signal, the trigger mode is automatic set to Edge trigger mode. Make sure you set trigger mode back to Immediate before continuing.

Using a Dual-Timebase Oscilloscope

16-7
Add Input Labels  

1. Go to any Oscilloscope C menu and touch the channel label field to select the Waveform Selection pop-up. Notice that a field not normally present in this pop-up is displayed. The new Module field allows you to add labels from Oscilloscope E to the channel label field.

2. Touch the Module field and select Oscilloscope E from the pop-up. Notice that the labels under the Module field have changed from B1 and B2 to D1 and D2.

3. Turn the knob to move the highlight to B2 in the channel label field. Touch the Delete field to delete B2.

4. Touch the Action field until Insert is displayed. Now touch label D1 to insert D1 into the channel label field.

5. The display should now look like the one shown at the top of the next page. Touch Done to return to the oscilloscope menu.
B1 and D1 are now displayed in the channel label field. No waveforms are displayed and the D1 waveform area displays the advisory Not Correlated since no waveform data has been acquired.

Acquire Waveforms

Touch the Autoscale field, then select Continue from the pop-up. Waveforms have now been acquired on both input channels B1 and D1.

Using a Dual-Timebase Oscilloscope

15-9
Notice the waveform for input D1 is compressed in the waveform display. B1 was acquired at 200 us/div. D1 was acquired at 20 us/div.

Select s/Div, then turn the knob to set the sweep speed to 200 ns/div. Dual-timebase allows you to acquire waveforms at different sweep speeds, then examine the data in further detail by changing sweep speed and delay time.
Time Correlation Bars

Touch the Oscilloscope C module field in the upper left corner of the display, then select Intermodule from the pop-up. Notice the time relationship of Oscilloscope C to Oscilloscope E in the time correlation bars at the bottom of the display. This reflects the relationship of the sweep speeds (20 us/div and 200 us/div) of the two oscilloscope modules.

![Diagram of time correlation bars]

Using a Dual-Timebase Oscilloscope
15-11
Introduction

This section provides information on when and how to calibrate the digitizing oscilloscope module.

Calibration Interval

The HP 16530A/31A Oscilloscope Module can be calibrated from the front panel without access to the interior of the instrument. This procedure sets the oscilloscope calibration factors and stores them on the operating disc in a file named CAL_FACT_X, where X is the slot (B, C, D, or E) in the mainframe where the timebase card is installed.

To maintain proper calibration, this calibration should be performed at approximately two year intervals when the instrument is being used under normal operating conditions. If the instrument is used more than one shift per day the calibration interval may need to be shorter.

Immediate calibration is required if one of the following occurs:

- Oscilloscope module is installed or replaced
- Operating disc is changed
- Card configuration is changed
- Oscilloscope module is repaired
- Ambient temperature changes more than 10° C

Before the the adjustment procedures in section IV of the HP 16530A/31A Service Manual are performed, the oscilloscope should be calibrated using the Calibration menu, then the performance tests in section III of the HP 16530A/31A Service Manual should be done. If the performance tests are within specifications, then adjustments are not necessary.

If either card is repaired, the oscilloscope module should be adjusted.

New modules are pre-adjusted at the factory to meet the specifications in Appendix B. If adjustments are required, refer to section IV of the HP 16530A/31A Service Manual.
Calibration Menu Map

The menu map for the Calibration menu is shown below.

Instrument Warmup

Calibrate the instrument at its environmental ambient temperature and after a 15 minute warm-up.
The **Calibration** menu allows you to perform automatic calibration procedures. When the calibration procedures are performed, the results are automatically stored on floppy disc. The default **Calibration** menu is shown below.

When you touch the **Cal Choice** field, a pop-up appears showing all the calibration choices. **Balance Adjust** and **Set to Default** fields in the pop-up are service functions used in adjustment procedures. Refer to adjustment section IV in the *HP 16510A/31A Service Manual* for further information.
Maintaining Calibration Integrity

Calibration factors depend on the system disc, mainframe, acquisition cards and module configuration all staying together. If the system disc or acquisition cards are interchanged between mainframes or the oscilloscope module is moved to different slots in the mainframe, calibration must be repeated. In an environment in which the possibility of sharing oscilloscope modules and system discs exist, we recommend taking the following precautions in order to maintain calibration integrity:

1. Install oscilloscope module in bottom slots.
2. Boot system using rear disc drive.
3. Perform calibration procedures in Calibration menu.
4. Seal oscilloscope module to mainframe.
5. Remove floppy disc and write protect it.
6. Reinstall floppy disc and seal it in the rear disc drive.

Calibration Prerequisites

The calibration procedures in this section should be followed in their entirety and in the following sequence:

1. Vertical
2. Trigger Level
3. Delay
4. Ch_ch_skew

When calibrating the HP 16530A/31A Oscilloscope Module, the cards must be installed in the instrument and the instrument covers and filler panels must be in place.

Calibration factors for all calibrations except channel-to-channel skew are stored on the system disc in a file named CAL_FACT_X, where X is the slot (B, C, D, or E) in the mainframe where the timebase card is installed. The channel-to-channel skew is stored only when the oscilloscope's measurement parameters are stored in a configuration file.

Before starting these procedures, make sure the system disc is inserted in either of the mainframe disc drives.

Calibration Menu

16-4
**Vertical Calibration**

A known offset voltage internal to the instrument is digitized. The preamplifier gain and offset are then corrected to obtain digitized data equivalent to the known input voltage.

**Procedure**

1. Disconnect signals from all inputs or the acquisition card(s).
2. Touch the Cal Choice field.
3. Select the Vertical field from the pop-up.
4. Touch the Start field.

While the vertical calibration is being performed, the following advisories are displayed on screen, in this order:

- Vertical cal is in progress
- Vertical calibration on X1 is completed, where X = mainframe slot
- Vertical calibration on X2 is completed, and so on for all inputs
- Vertical cal completed
- Storing cal factors on disc
- Storing cal factors completed

The vertical calibration factors have now been stored on the floppy disc.

*Calibration Menu*

16-5
**Trigger Level Calibration**

A known offset voltage internal to the instrument is digitized. The trigger level is then corrected to trigger at the input voltage.

**Procedure**

1. Disconnect signals from all inputs on the acquisition card(s).
2. Touch the **Cal Choice** field.
3. Select the **Trigger Level** field from the pop-up.

![Diagram of oscilloscope interface]

4. Touch the **Start** field.

While the trigger level calibration is being performed, the following advisories are displayed on screen, in this order:

- **Trigger cal is in progress**
- Trigger level calibration on X1 is completed, where X = mainframe slot
- Trigger level calibration on X2 is completed, and so on for all inputs
- Trigger level cal completed
- Storing cal factors on disc
- Storing cal factors completed

The trigger level calibration factors have now been stored on the floppy disc.
Delay Calibration

The rising edge of the COMPENSATION SIGNAL output is set to Time = 0 (midscreen) for each input.

Procedure

1. Touch the Cal Choice field.

2. Select the Delay field from the pop-up.

3. Connect a BNC cable from the COMPENSATION SIGNAL output on the timebase card to the acquisition card input shown in the green advisory message.

4. Touch the Start field.

When the delay calibration on the first input is completed the following advisory is displayed on screen:

Delay cal passed on X1, where X = mainframe slot
Connect compensation signal ONLY to X2
and then press 'Start'

If additional acquisition cards are installed, advisories will continue to be displayed telling you which input to connect the compensation signal to. Follow the instructions displayed on screen until all inputs have been delay calibrated. When delay calibration is complete, the following advisories will be displayed:

Delay cal completed
Storing cal factors completed

The delay calibration factors have now been stored on the floppy disc.

Calibration Menu
16-7
Channel-to-Channel Skew

The channel-to-channel skew adjustment nulls any time delays caused by the lead lengths of the probes or cables used for a measurement. INPUT 1 of one of the acquisition cards is used as the reference against which all other channels are nulled.

Channel-to-channel skew calibration factors are not automatically stored to the system disk. These factors are only stored when you save an oscilloscope configuration to a disc. See chapter 13 "Saving and Recalling Setups" for more information.

Note

This procedure uses the compensation signal and BNC cables to simulate a signal and probes. Consider this procedure as an example only. In this example, acquisitions cards are shown in mainframe slots B and C and a timebase card in slot D.

Procedure

1. Go to the Display menu and change the Mode field to Average. Set Average # to 4.

Calibration Menu
16-4
2. Go to the Channel menu and change the Impedance field to 50 Ohms for all inputs that you want calibrated. Inputs are selected by touching the Input field in the Channel menu.

3. Overlay all inputs you want calibrated on one waveform display.
   a. Touch the channel label field and the WAVEFORM SELECTION pop-up menu will appear.
   b. Touch the Channel Mode field, then select the Overlay field from the pop-up.
   c. Delete all input labels by touching the Delete field until all labels in the channel label field are gone.
   d. Touch the Action field until Insert is displayed in the field.
   e. Touch each input in the Label field until all inputs are overlayed together in the channel label field.
   f. Touch the Done field when you are finished. The display should now look similar to the screen on the following page.
4. Using two BNC cables of equal length and a BNC tee, connect COMPENSATION SIGNAL output from the timebase card as shown below to INPUT 1 and INPUT 2 of the top acquisition card. For your reference, the figure below shows four acquisition cards installed in the mainframe. INPUT 1 of the top acquisition card will be the reference for all other channels. INPUT 2 of the top acquisition card will be the first channel to be calibrated.
5. Touch the **Run** field and drag your finger to the **Repetitive** field in the pop-up.

6. Touch the **Autoscale** field, then select **Continue** from the pop-up.

7. Touch the **s/Div** field and turn the knob to set the sweep speed to 5 ns/div. The display should now look similar to screen shown below. Reference input B1 is the yellow waveform.

8. Go to the **Calibration** menu.

9. Turn the knob until both waveforms are overlayed at approximately the 50% point.
10. If there are multiple acquisition cards, leave the compensation signal connected to the reference input and move the other BNC cable to the next input to be calibrated as shown below.

![Diagram showing connections]

11. Touch the label of next channel to be calibrated as shown below.

![Oscilloscope menu]

12. Repeat steps 6 through 11 until all channels are calibrated to the reference channel. The s/Div field appears in any oscilloscope menu except Calibration.
Installing New Oscilloscope Boards into the Mainframe

Introduction
This chapter explains how to add additional oscilloscope cards to the mainframe. Also included is initial inspection, preparation for use, storage, and shipment.

Initial Inspection
Inspect the shipping container for damage. If the shipping container or cushioning material is damaged, it should be kept until the contents of the shipment have been checked for completeness and the module has been checked mechanically and electrically. The contents of the shipment should be as listed in "Accessories Supplied" in Chapter 1.

If the contents are incomplete, if there is mechanical damage or a defect, or if the instrument does not pass the performance tests, notify the nearest Hewlett-Packard office. Procedures for checking electrical performance are given in Section III of the HP 16530A/31A Service Manual.

If the shipping container is damaged, or the cushioning material shows signs of stress, notify the carrier as well as the Hewlett-Packard office. Keep the shipping material for carrier's inspection. The Hewlett-Packard office will arrange for repair or replacement at Hewlett-Packard's option without waiting for claim settlement.

Power Requirements
All power supplies needed to operate the HP 16530A/31A Oscilloscope Module are supplied to the cards through the backplane connector of the HP 16500A Logic Analysis System mainframe.

Dual Timebase Installation
If you want to configure the mainframe with a dual-timebase oscilloscope, follow the installation instructions. Each timebase/acquisition card set is considered to be a separate oscilloscope module. No interconnecting cables are required between the two modules.
Installation

CAUTION

Do not install, remove or replace the module in the instrument unless the instrument power is removed.

The HP 16530A/31A Oscilloscope Module consists of two or more cards. The HP 16530A Timebase Card may have as many as four HP 16531A Acquisition Cards connected to it. For every additional acquisition card connected, an extra slot will be used in the card cage. Procedures for installing the oscilloscope module and adding acquisition cards are shown in the step-by-step procedure in the following paragraphs.

Module Installation

The following procedure is for the Installation of the HP 16530A/31A Oscilloscope Module. If the system already has an HP 16530A/31A Oscilloscope Module installed, and you are adding additional acquisition cards, follow the "Adding Acquisition Cards" procedure later in this section.

Installation

Considerations

- Acquisition cards must be positioned above the timebase card.
- Use one cable per acquisition card. See figure A-2.
- If there are not enough empty slots to install the module correctly, existing modules must be repositioned in card cage.
- Cards below the slots to be filled by oscilloscope module do not have to be removed.

CAUTION

The effects of ELECTROSTATIC DISCHARGE can damage electronic components. Grounded wriststraps and mats should be used when you perform any kind of service to this instrument or the cards in it.

Installing New Oscilloscope Boards into the Mainframe
A-2
Procedure

a. Turn Instrument power switch off, unplug power cord and disconnect any input BNCs.

b. Starting from the top of the Instrument rear panel, loosen thumb screws on filler panel(s) and card(s).

c. Starting from the top, begin pulling card(s) and filler panel(s) out halfway. See figure A-1.

![Figure A-1. Endplate Overhang](image)

Some modules are hooked together by intercard connecting cables.

d. Noting "Installation Considerations" on page A-2, use figure A-2 to plan the card configuration and cable connection.

![Figure A-2. Card and Cable Configuration](image)

Installing New Oscilloscope Boards into the Mainframe

A-3
e. Remove the filler panels covering the slots to be filled by the oscilloscope module.

f. Push all other card(s) into the card cage, but not completely in, so they won't be in the way when you install the scope module.

g. Install one cable per acquisition card into the correct timebase card connector (see figure A-2), making sure to install the correct cable end. Use figure A-3 to identify the correct cable end.

---

![Figure A-3. Cable End](image1)

h. Lay cable(s) flat and pointing out to rear of card. See figure A-4.

---

![Figure A-4. Cable Position](image2)
i. Slide timebase card approximately half way into lowest slot being used for the oscilloscope module.

j. Slide acquisition card in half way, feeding cable up through square hole in acquisition card.

k. Plug in other end of cable to connector on acquisition card. See figure A-5.

l. If you have additional acquisition cards, repeat steps j through l until all cards are in half way and all cables are connected.

Figure A-5. Installation Summary
m. Firmly seat bottom card into backplane connector. **Keep applying pressure to the center of card endplate while tightening thumb screws finger tight.**

n. Repeat for all cards and filler panels in a bottom to top order. See figure A-6.

![Diagram](image)

**Figure A-6. Endplate Overhang**

o. Any filler panels that are not used should be kept for future use. Filler panels must be installed in all unused card slots for correct air circulation.
Adding Acquisition Cards

Use this procedure if you are adding acquisition cards to a system that already has an HP 16530A/31A Oscilloscope Module installed. Make note of the "Installation Considerations" on page A-2 before starting.

a. Turn instrument power switch off, unplug power cord and disconnect all input BNCs.

b. Starting from the top, loosen thumb screws on filler panel(s) and card(s).

c. Starting from the top, begin pulling all cards out half way. See figure A-7.

**CAUTION**

*Some modules are hooked together by intercard connecting cables.*

![Diagram](image)

*Figure A-7. Endplate Overhang*

Installing New Oscilloscope Boards into the Mainframe

A-7
d. Pull all cards in oscilloscope module completely out and disconnect all cable(s) from acquisition card(s).

e. Push all other cards into card cage, but not completely in. This will get them out of the way for oscilloscope module installation.

f. Use figure A-8 to plan the card configuration and cable connection.

Figure A-8. Card and Cable Configuration

g. Install one cable per acquisition card in the correct timebase card connector, making sure that you install the correct end. See figure A-9.

Figure A-9. Cable End

Installing New Oscilloscope Boards into the Mainframe
A-8
h. Lay cable(s) flat and pointing out to rear of card. See figure A-10.

Figure A-10. Cable Position

i. Slide timebase card approximately half way into lowest slot being used for the scope module.

j. Slide acquisition card in half way, feeding cable(s) up through square hole in acquisition card.

k. Plug in other end of cable to connector on acquisition card.

l. Slide next acquisition card in half way, feeding cable(s) up through square hole in acquisition card.

m. Plug in other end of next cable to connector on acquisition card.

n. If you have additional acquisition cards, repeat steps i through n until all cards are in half way and all cables are connected.

c. Firmly seat bottom card in backplane connector. Keep applying pressure to the center of card endplate while tightening thumb screws finger tight.
p. Repeat for all cards and filler panels in a bottom to top order. See figure A-11.

Figure A-11. Endplate Overhang

q. Any filler panels that are not used should be kept for future use. Filler panels must be installed in all unused card slots for correct air circulation.

---

Operating Environment

The operating environment is listed in "General Characteristics" in Appendix B. Note should be made of the non-condensing humidity limitation. Condensation within the instrument can cause poor operation or malfunction. Protection should be provided against internal condensation.

The HP 16530A/31A will operate at all specifications within the temperature and humidity range given in Appendix B. However, reliability is enhanced by operating the instrument within the following ranges:

Temperature: +20 to +35°C (+68 to +95°F)
Humidity: 20% to 80% non-condensing
Storage

The module may be stored or shipped in environments within the following limits:

Temperature: -40° C to +75° C
Humidity: Up to 90% at 85° C
Altitude: Up to 15,300 meters (50,000 Feet)

The module should also be protected from temperature extremes which cause condensation on the module.

Packaging

The following general instructions should be used for repacking the module with commercially available materials.

- Wrap module in anti-static plastic.
- Use a strong shipping container. A double-wall carton made of 350 lb. test material is adequate.
- Use a layer of shock-absorbing material 70 to 100 mm (3 to 4 inch) thick around all sides of the module to provide firm cushioning and prevent movement inside the container.
- Seal shipping container securely.
- Mark shipping container FRAGILE to ensure careful handling.
- In any correspondence, refer to module by model number and board number.

Tagging for Service

If the module is to be shipped to a Hewlett-Packard office for service or repair, attach a tag showing owner (with address), complete board number, and a description of the service required.
## Specifications and Characteristics

### Specifications

<table>
<thead>
<tr>
<th>Vertical (at BNC)</th>
<th>Bandwidth (-3 dB)</th>
<th>dc to 100 MHz (dc-coupled)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Range</td>
<td>40 mV to 16 V full scale (adjustable with 2-digit resolution)</td>
<td></td>
</tr>
<tr>
<td>DC Gain Accuracy</td>
<td>±3% of full scale (valid within ±10°C of auto-calibration temperature)</td>
<td></td>
</tr>
<tr>
<td>Analog-to-Digital Conversion (ADC) Resolution</td>
<td>±1.8% of full scale (8 bits)</td>
<td></td>
</tr>
<tr>
<td>DC Offset Accuracy</td>
<td>±1% of offset ±3.2% of full scale (valid within ±10°C of auto-calibration temperature)</td>
<td></td>
</tr>
</tbody>
</table>

### DC Offset Range/Resolution

<table>
<thead>
<tr>
<th></th>
<th>Vertical Range</th>
<th>Offset Range</th>
<th>Offset Resolution</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;800 mV</td>
<td>±600 mV</td>
<td>±6 mV</td>
<td>1 mV</td>
</tr>
<tr>
<td>≥800 mV</td>
<td>±16 mV</td>
<td>±6 mV</td>
<td>20 mV</td>
</tr>
</tbody>
</table>

### Voltage Measurement Accuracy (DC)

- **Single Cursor (X or O)**: Gain accuracy + ADC resolution + offset accuracy
- **Dual Cursor (X to O measurements on the same waveform)**: Gain accuracy + 2 (ADC resolution)

---

Specifications and Characteristics

B-1
<table>
<thead>
<tr>
<th>Feature</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Horizontal</strong></td>
<td></td>
</tr>
<tr>
<td>Range</td>
<td>50 ns to 100 s full scale, adjustable with 3-digit resolution</td>
</tr>
<tr>
<td>Time Interval Measurement Accuracy (dual channel for deskewed channels with equal rise time and fall times)</td>
<td>±0.75 ns ±0.2% of timebase range ±0.02% of reading (2.5 ns sample period)</td>
</tr>
<tr>
<td>Delay (Time Offset)</td>
<td></td>
</tr>
<tr>
<td>Pre-trigger Range</td>
<td>4096 x sample period</td>
</tr>
<tr>
<td>Post-trigger Range</td>
<td>500 screen diameters</td>
</tr>
<tr>
<td>Resolution</td>
<td>Fine adjustment to 0.2% of screen diameter</td>
</tr>
<tr>
<td><strong>Trigger</strong></td>
<td></td>
</tr>
<tr>
<td>Sources</td>
<td>Any internal channel, or external trigger input</td>
</tr>
<tr>
<td>Internal Trigger</td>
<td></td>
</tr>
<tr>
<td>Sensitivity</td>
<td>±12% of full scale (dc to 100 MHz)</td>
</tr>
<tr>
<td>Range</td>
<td>Within display window (full scale and offset)</td>
</tr>
<tr>
<td>Resolution</td>
<td>1% of full scale</td>
</tr>
<tr>
<td>External Trigger Input (rear panel input BNC)</td>
<td></td>
</tr>
<tr>
<td>Sensitivity</td>
<td>±20 mV (dc to 100 MHz)</td>
</tr>
<tr>
<td>Range</td>
<td>±2 V</td>
</tr>
<tr>
<td>Resolution</td>
<td>2 mV</td>
</tr>
<tr>
<td>Input coupling</td>
<td>dc</td>
</tr>
</tbody>
</table>
## Characteristics

<table>
<thead>
<tr>
<th>Vertical</th>
<th>Transition Time</th>
<th>≤3.5 ns</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(10% to 99%)</td>
<td></td>
</tr>
<tr>
<td>Input Coupling</td>
<td>do</td>
<td></td>
</tr>
<tr>
<td>Input RC</td>
<td>1 MΩ ±2% or 50 Ω ±3%, shunted by approximately 13 pF</td>
<td></td>
</tr>
<tr>
<td>Maximum Safe Input Voltage</td>
<td>1 MΩ input, ±40 V (dc + peak ac)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>50 Ω input, ±5 V (dc + peak ac)</td>
<td></td>
</tr>
<tr>
<td>Probe Factors</td>
<td>Any integer ratio from 1:1 to 1:1000, to scale the oscilloscope to represent voltages seen at the probe tip</td>
<td></td>
</tr>
</tbody>
</table>

| Timebase       | Deskewinng            | Skew between channels can be nulled out to compensate for probe/cable lengths. |

<table>
<thead>
<tr>
<th>Trigger</th>
<th>External Trigger Input (Rear panel input BNC)</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Input RC</td>
<td>1 MΩ ±2% or 50 Ω ±3%, shunted by approximately 12 pF</td>
</tr>
<tr>
<td></td>
<td>Maximum Safe Input Voltage</td>
<td>1 MΩ input ±40 V (dc + peak ac)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>50 Ω input ±5 V (dc + peak ac)</td>
</tr>
<tr>
<td>Trigger Modes</td>
<td>Immediate</td>
<td>Allows oscilloscope to be triggered by port-in, or another HP 16500-series measurement module.</td>
</tr>
<tr>
<td></td>
<td>Edge</td>
<td>Triggers on rising or falling edge of any internal channel or external trigger, count adjustable from 1 to 32,000.</td>
</tr>
<tr>
<td></td>
<td>Pattern</td>
<td>Triggers on entering or exiting a specified pattern of all internal channels and external trigger, count adjustable from 1 to 32,000.</td>
</tr>
</tbody>
</table>

Specifications and Characteristics
B-3
<table>
<thead>
<tr>
<th><strong>Trigger (cont)</strong></th>
<th><strong>Auto-Trigger</strong></th>
<th>If enabled, the timebase will self-trigger if the trigger rate is below 40 Hz.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Events Delay</strong></td>
<td></td>
<td>The trigger can be set to occur on the nth edge or pattern, as specified by the user. The number of events (n) can be set from 1 to 32,000 events.</td>
</tr>
<tr>
<td><strong>Outputs/Rear-panel BNC</strong></td>
<td></td>
<td>HP 16530A output BNC provides a probe compensation source ± 1 kHz square wave, switching between -0.4 V and -0.8 V, with 50 Ω output resistance.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Digitizer</strong></th>
<th><strong>Resolution</strong></th>
<th>6 bits (1 part in 64)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Digitizing Rate</strong></td>
<td></td>
<td>Up to 400 megasamples/second</td>
</tr>
<tr>
<td><strong>Digitizing Technique</strong></td>
<td></td>
<td>Real-time digitizing; each 4k record is acquired on a single acquisition</td>
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<tr>
<td><strong>Acquisition Memory Size</strong></td>
<td></td>
<td>4096 samples per channel</td>
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<th><strong>Waveform Display</strong></th>
<th><strong>Display Formats</strong></th>
<th>Waveforms can be displayed in an overlapping and/or non-overlapping format.</th>
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<td></td>
<td><strong>Display Resolution</strong></td>
<td>500 points horizontally</td>
</tr>
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<td><strong>Display Modes</strong></td>
<td><strong>Single</strong></td>
<td>New acquisitions replace old acquisitions on screen.</td>
</tr>
<tr>
<td></td>
<td><strong>Accumulate</strong></td>
<td>New acquisitions are added to the screen and displayed with older acquisitions until screen is erased.</td>
</tr>
<tr>
<td></td>
<td><strong>Average</strong></td>
<td>New acquisitions are averaged with older acquisitions with updated waveform displayed until erased.</td>
</tr>
<tr>
<td></td>
<td><strong>Overlay</strong></td>
<td>Up to 8 acquired waveforms can be overlayed in the same display area.</td>
</tr>
<tr>
<td></td>
<td><strong>Connect-the-dots</strong></td>
<td>Provides a display of the sample points connected by straight lines.</td>
</tr>
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**Specifications and Characteristics**

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<th>Waveform Display (cont)</th>
<th>Waveform Reconstruction</th>
<th>When there is insufficient data to fill every horizontal location, a post acquisition reconstruction filter fills in the missing locations.</th>
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<td>Waveform Math</td>
<td></td>
<td>Display capability of A-B and A+B functions is provided.                                                                 homage:</td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Measurement Aids</strong></td>
<td><strong>Markers</strong></td>
<td>Two vertical markers are provided for measurements of time and voltage. Capabilities are: measure voltage of X and O on each analog waveform; measure time from X to trigger, O to trigger, and X to O; automatic marker placement by specifying percentage of edge, edge number, and rising or falling edge type; run until X to O &gt; than, &lt; than, in range, and not in range provides selective event search; X to O statistics (mean, max, and min) provide analysis of time interval deviation.</td>
</tr>
<tr>
<td><strong>Automatic Measurements</strong></td>
<td></td>
<td>The following pulse parameter measurements can be performed automatically:</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Frequency Rise time Overshoot Period Fall time + pulse width V p-p Preeshoul - pulse width</td>
</tr>
<tr>
<td><strong>Setup Aids</strong></td>
<td><strong>Autoscale</strong></td>
<td>Auto sets the vertical and horizontal ranges, offset, and trigger level to display the input signals. Requires an amplitude above 10 mV peak, and a frequency between 50 Hz and 100 MHz.</td>
</tr>
<tr>
<td></td>
<td><strong>Preset</strong></td>
<td>Scales the vertical range, offset, and trigger level to predetermined values for displaying ECL or TTL waveforms.</td>
</tr>
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### General Characteristics

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<th>Operating Environment</th>
<th>Temperature</th>
<th>Instrument, 0° to 55° C (+32° to 131° F). Probes and cables, 0° to 65° C (+32° to 149° F).</th>
</tr>
</thead>
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<tr>
<td></td>
<td>Humidity</td>
<td>Instrument, up to 95% relative humidity at +40°C (+104°F). Recommended disc media, 5% to 80% relative humidity at +40°C (+104°F).</td>
</tr>
<tr>
<td></td>
<td>Altitude</td>
<td>To 4600 m (15 000 ft).</td>
</tr>
<tr>
<td>Vibration</td>
<td>Operation</td>
<td>Random vibration 5-500 Hz, 10 minutes per axis, ~0.3 g (rms).</td>
</tr>
<tr>
<td></td>
<td>Non-operating</td>
<td>Random vibration 5-500 Hz, 10 minutes per axis, ~2.41 g (rms); and swept sine resonant search, 5-500 Hz, 0.75 g (0.peak), 5 minute resonant dwell @ 4 resonances per axis.</td>
</tr>
</tbody>
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---

**Specifications and Characteristics**

B-6
Automatic Measurement Algorithms

Introduction
One of the HP 16530A/16531A’s primary features is its ability to make parametric measurements on displayed waveforms. This chapter provides details on how automatic measurements are performed and some tips on how to improve automatic measurement results.

Measurement Setup
Measurements typically should be made at the fastest possible sweep speed to obtain the most measurement accuracy possible. For any measurement to be made, the portion of the waveform required for that measurement must be displayed on the oscilloscope. That is:

- at least one complete cycle must be displayed for period or frequency measurements.
- the entire pulse must be displayed for pulse width measurements.
- the leading (rising) edge of the waveform must be displayed for risetime measurements.
- the trailing (falling) edge of the waveform must be displayed for falltime measurements.

Making 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 risetime and falltime measurements. The 50% voltage value is used for measuring frequency, period, pulse width, and duty cycle.
Top and Base Voltages

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

The digitizing oscilloscope displays 6-bit vertical voltage resolution. This means the vertical display is divided up into $2^6$ voltage levels. Each of these 64 levels is called a quantization level. Each waveform has 500 data points displayed horizontally on screen. Each of these 500 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 $V_{top}$ level. The quantization level with the greatest number of occurrences in the bottom half of the waveform corresponds to the $V_{base}$ 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 since the waveform normally rests below the perturbation.
Measurement Algorithms
The following is a condensed explanation of the automatic measurements discussed in chapter 11.

**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
\[ \text{Freq} = \frac{1}{(\text{rising edge 2} - \text{rising edge 1})} \]

If the first edge on the display is falling then
\[ \text{Freq} = \frac{1}{(\text{falling edge 2} - \text{falling edge 1})} \]

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

If the first edge on the display is rising then
\[ \text{Period} = \text{rising edge 2} - \text{rising edge 1} \]

If the first edge on the display is falling then
\[ \text{Period} = \text{falling edge 2} - \text{falling edge 1} \]

**Peak-to-Peak Voltage (Vp_p)**
The maximum and minimum voltages for the selected source are measured.
\[ V_{p-p} = V_{\text{maximum}} - V_{\text{minimum}} \]

where \(V_{\text{maximum}}\) and \(V_{\text{minimum}}\) 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

\[ +\text{Width} = \text{trailing edge 2} - \text{rising edge 1} \]

If the first edge on the display is falling then

\[ +\text{Width} = \text{trailing edge 2} - \text{rising edge 1} \]

**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

\[ -\text{Width} = \text{trailing edge 2} - \text{rising edge 1} \]

If the first edge on the display is falling then

\[ -\text{Width} = \text{trailing edge 1} - \text{rising edge 1} \]

**Risetime**

The risetime 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 leading edge of the waveform on the display. The risetime is determined by measuring time at the 10% and 90% voltage points on the rising edge.

\[ \text{Risetime} = 10\% - 90\% \]

**Falltime**

Falltime 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.

\[ \text{Falltime} = 10\% - 90\% \]

Automatic Measurement Algorithms
C-4
Preshoot and Overshoot

Preshoot and Overshoot measure the perturbation on a waveform above or below the top and base voltages (see "Top and Base Voltages" section earlier in this appendix). These measurements use all data displayed on 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 is measured as a percentage of the top-base voltage.

If the measured edge is rising then

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

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

If the measured edge is falling then

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

\[
\text{Overshoot} = \left[ \frac{V_{\text{base}} - V_{\text{minimum}}}{V_{\text{top-base}}} \right] \times 100
\]
This index covers the HP 16530A/16531A Reference Manual. Sequences of pages are represented with a slash (for example, 6-9/6-17)

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- To contact one of the more than 240 HP Sales and Service Offices worldwide, check your telephone directory or contact one of the major HP offices listed.

- Argentina
  - Martinez
    Phone: 798-6066

- Australia
  - North Ryde, N.S.W.
    Phone: 02/887-1611

- Blackburn, Victoria
  Phone: 03/890-6551

- Austria
  - Vienna
    Phone: 222/3516210

- Belgium
  - Brussels
    Phone: 02/762-3200

- Brazil
  - Alphaville, Barueri
    Phone: 011/421-1511

- Canada
  - Edmonton, Alberta
    Phone: 403/452-3670

- Richmond, British Columbia
  Phone: 604/270-2277

- Mississauga, Ontario
  Phone: 416/878-9430

- Denmark
  - Birkeroed
    Phone: 2/61-66-40

- Finland
  - Espoo
    Phone: 90/455-0211

- Jyvaskyla
  Phone: 41/216318

- Oulu
  Phone: 81/338785

- France
  - Les Ulis
    Phone: 1/9077825

- Hong Kong
  - Wan Chai
    Phone: 5832-3211

- Italy
  - Cernusco Sul Naviglio
    Phone: 2/903891

- Japan
  - Yokogawa-Hewlett Packard

- Osaka
  Phone: 6/304-6021

- Sagamihara
  Phone: 427/59-1311

- Tokyo
  Phone: 3/331-6111

- Malaysia
  - Kuala Lumpur
    Phone: 03/943-022

- Mexico
  - Xochimilco, Mexico City
    Phone: 905/876-8896

- The Netherlands
  - Amstelveen
    Phone: 020/472021

- New Zealand
  - Pakuranga
    Phone: 9/68-7159

- Full Field Repair Center capabilities.
Norway  ■  Oestenesas  
Phone: 2/17-11-80

Puerto Rico  ■  Carolina  
Phone: 809/762-725

Saudi Arabia  ■  HP Distributor;  
Modern Electronics  
Riyadh  
Phone: 01/4919715

Singapore  ■  Singapore  
Phone: 631788

South Africa  ■  Sandton, Transvaal  
Phone: 11/822-511

Spain  ■  Miraskerra, Madrid  
Phone: 91/734-1182

Sweden  ■  Spanga  
Phone: 8/5750-2000

Switzerland  ■  Widen  
Phone: 57/31-21-11

Taiwan  ■  Taipei  
Phone: 2/712-0404

United Kingdom  ■  Altrincham  
Phone: 61/922-6422

Winnersh, Wokingham  
Phone: 734/784-774

United States  ■  Santa Clara, California  
Phone: 408/988-7000

Los Angeles, California  
Phone: 213/870-7500

Englewood, Colorado  
Phone: 303/771-3455

Atlanta, Georgia  
Phone: 404/865-1500

Rolling Meadows, Illinois  
Phone: 312/255-9800

Rockville, Maryland  ■  Phone: 301/948-6370

Andover, Massachusetts  ■  Phone: 617/861-8960

Novi, Michigan  ■  Phone: 313/349-9200

Paramus, New Jersey  ■  Phone: 201/265-5000

King of Prussia, Pennsylvania  ■  Phone: 215/265-7000

Richardson, Texas  ■  Phone: 214/231-6101

Bellevue, Washington  ■  Phone: 206/843-4000

Venezuela  ■  Caracas  
Phone: 2/239-4133

West Germany  ■  Boeblingen  
Phone: 7031/667750

Full field Repair Center capabilities.

Other European Locations
For information on European locations other than those listed, contact:

Hewlett-Packard, S.A.  
150, Route du Nant-d'Avril  
P.O. Box  
1217 Meyrin 2  
Geneva, Switzerland

Other International Locations
For information on locations outside the U.S. and Europe that are not listed, contact:

Hewlett-Packard Intercontinental  
3495 Deer Creek Road  
Palo Alto, CA 94304 U.S.A.