54645D

Mixed Signal Oscilloscope

Created by Tom Labarr

Instructions for the use of the 54645D Mixed Signal Oscilloscope

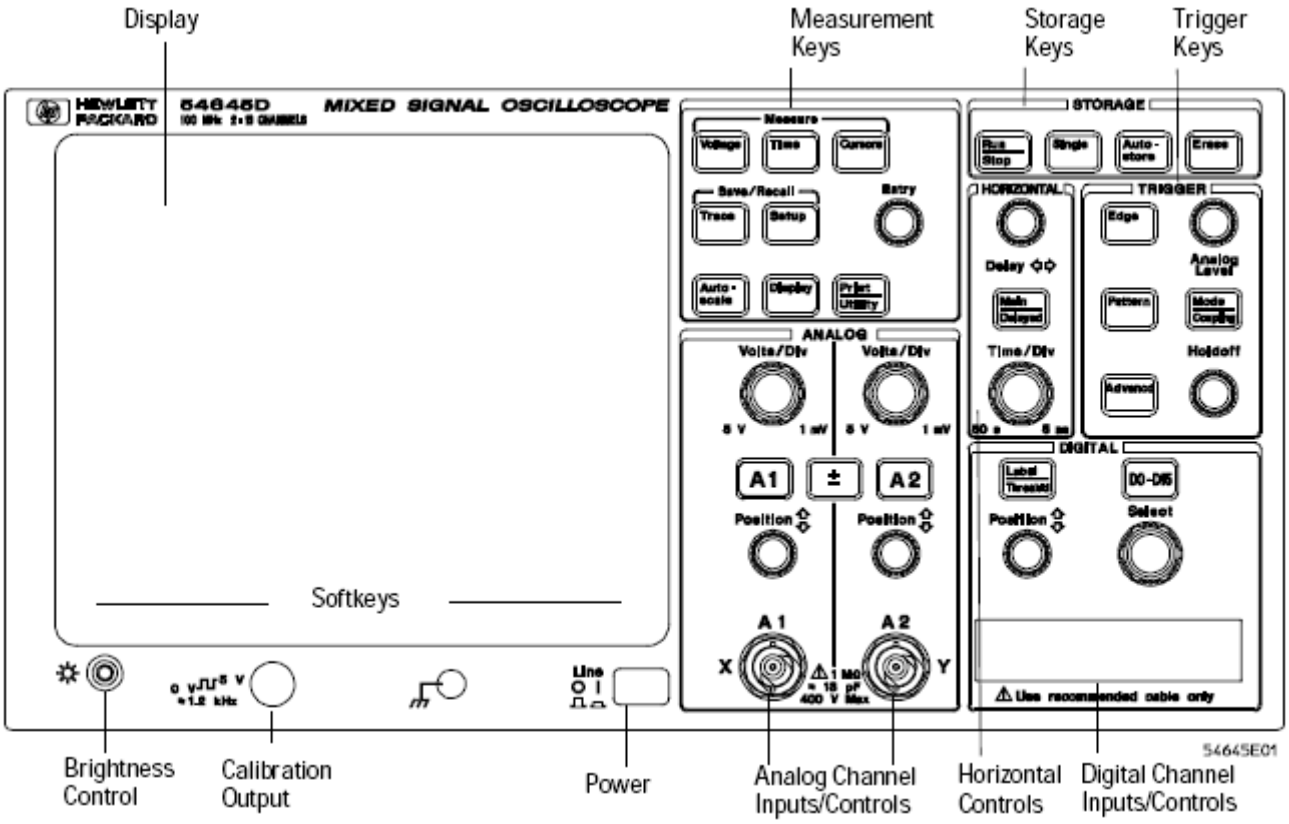
This pamphlet is intended to give you (the student) an overview on the use of the 54645D Mixed Signal Oscilloscope. This pamphlet will instruct you on how to setup the oscilloscope to view and measure various waveforms and signals.

Please visit the Agilent website http://www.home.agilent.com/agilent/home to view the complete user manual for more information.

Throughout this manual, the front-panel keys are denoted by **[ ]** around the name of the key, and softkeys are denoted by **( )**. For example, **[Display]** is the grey front-panel key on the front panel, and **(Normal)** is a softkey appearing at the bottom of the display directly above its corresponding softkey.

NOTE: This Oscilloscopes has automatic probe sensing. If you are using the probes supplied with the oscilloscope, or other probes with probe sensing, the probe attenuation factor will be automatically set up by the oscilloscope when automatic probe sensing is turned on. The default setting is to have automatic probe sensing turned on. This is indicated by the selection **(Auto n)** under the **(Probe)** softkey, where **n** is **1**, **10**, or **100**.
If you are not using automatic probe sensing, toggle the **(Probe)** softkey to change the attenuation factor to match the probe you are using.

54645D Front Panel



Display: Shows waveforms, measurement results and instrument configuration settings.
Softkeys: Set up various options for each major function, varying dynamically depending on the required function.
General Controls: Include various measurement functions, configuration, screen, and measurement results, save/recall, printing, Autoscale functions and ↻Entry knob.
ANALOG Channel Controls and Signal Inputs: Move or rearrange analog channels A1 and A2, turn them on or off, set coupling and inversion, and connect the acquisition system to the probes. ↻Volts/Div, Position Channel A1 ↻control knob & Volts/Div, Position Channel A2 ↻control knob

STORAGE Keys: Control start and stop of acquisition, single trace, persistent acquisition, and screen erasure.
HORIZONTAL Controls: Adjust the time base, horizontal mode, and main and delayed sweep functions. ↻Delay, Time/Div ↻control knobs.
TRIGGER Controls: Set up trigger mode and trigger conditions. ↻Analog Level, ↻Holdoff control knobs.
DIGITAL Channel Inputs/Controls: Move or rearrange digital channels D0-15, turn them on or off, set threshold, define labels, and connect the acquisition system to the probes. ↻Position knob, ↻Select control knob.
Brightness Control (Display Intensity Knob): Adjusts display brightness. ↻Display Intensity Front-Panel control knob.

Softkeys:
Softkeys are shown along the bottom of the display. Some softkeys have an immediate action, such as taking you to another menu or initiating a measurement. Other softkeys allow you to scroll through a list of choices, such as channels or trigger operators. You can scroll through the choices by pressing the softkey repeatedly or by using the ↻Entry knob. For some softkeys, you can use the ↻Entry knob to scroll through the choices. For channel lists, you can always use the ↻Select knob or ↻Entry knob to scroll through the choices. Occasionally a softkey label is displayed with two or more choices below it, one of which is highlighted. The highlighted choice is the one that is currently active. Pressing the softkey toggles the highlight to the other choice. When several softkeys are displayed with a labeled bar over them, it means that either the softkeys are related and/or that the choices are mutually exclusive.

Keypad and Softkeys:

White keys have an immediate action, such as starting or stopping the instrument. No menus are associated with white keys.
Gray keys display softkey menus, allowing you to modify the instrument's measurement configuration.
Softkeys below the display dynamically change to indicate currently valid menu selections. A blank softkey has no function in the selected menu.

Control Knobs:

- The ↻**Time/Div** knob changes the current time base setting (sweep speed) of the oscilloscope in Main or Delayed sweep. The setting of the time base affects sample rate and other instrument functions as well. This control knob allows you to zoom the waveform when the acquisition is stopped.
- The ↻**Delay** knob sets the delay time with respect to the time reference in either Main or Delayed sweep. This control knob allows you to pan through the waveform when the acquisition is stopped.
- The ↻**Select** knob chooses the digital channel on which the next action will operate.

General Front-Panel Areas:

- The ↻**Position** knob moves the selected analog channel to a new vertical position on the display. The ↻**Digital Position** knob for the DIGITAL channels.
- The ↻**Entry** knob selects from multiple choices in menus. It also occasionally duplicates the function of the Select knob.

- The ↻**Trigger Analog Level** knob sets the trigger level for stabilizing a waveform on the screen.
- The ↻**Trigger Holdoff** knob keeps the oscilloscope from triggering for a specified amount of time.
- The ↻**Display Intensity** knob adjusts display brightness.

Display Regions:

- Activity/status indicators are along the top of the display. These include channel status when selecting the Pattern and Advanced trigger menus, and show whether digital channels are turned on or off.
- Channel numbers and labels are on the left edge of the display.
- Waveforms are in the center of the display.
- Measurement results and messages are just below the waveform display area.
- Softkey labels are along the bottom of the display.

Status Indicators:

- Channels that are turned off are visible only if you select a channel that is off by using the ↻**Select** knob.
- Average mode is indicated by "**Av**". Peak detect mode is indicated by "**Pk**". These indicators are active when displayed in inverse video on the line above the display. When **[Time/Div]** is set to 5 ns, and **(Peak Detect)** display mode is selected, **Pk** is displayed at the top of the display, but has no effect, and is not highlighted.
- Delay includes the time reference indicator, the offset markers, and the delay measurement. The solid triangle marker (▼) points to the trigger event in both the main and delayed sweep; it moves with the ↻**Delay** knob.

- The ▽ symbol indicates the time reference point. The time reference indicator is a left arrow (←) if the trigger event is at the beginning of acquisition memory, a right arrow (→) if the event is at the end of acquisition memory, and a down arrow (↓) if it is at the center. The offset markers and delay measurement work together when you adjust the ↻**Delay** knob and **[Horizontal Mode]** is set to **(Main)**, to indicate how far you have delayed the trigger event from the initial time reference position.
- **[Time/Div]** shows the time base setting. Time per division is variable from 5 ns/div to 50 s/div.
- When **(Coupling)** is set to **(AC)**, a small sine wave is included in the top left area of the status line.

Front-Panel Areas:

- Trigger condition shows the current trigger mode. The Auto Level and Auto trigger modes display the "Auto" indicator. For Edge trigger mode, it also shows the trigger condition and channel number.
- In normal trigger mode, when the TV trigger mode is selected, "TV" is displayed; when in Auto level or Auto modes, "TV" is replaced by the "Auto" indicator. Glitch trigger mode displays a positive or negative glitch signal next to the channel number.
- Pattern trigger mode displays "Pat" and Advanced Pattern trigger mode displays "Adv".
- If the last acquisition was initiated by pressing the **[Single]** key, the letters “Sngl” appear in this position (unless the last single acquisition was auto triggered).

- The acquisition indicator shows the current acquisition condition, that is, whether the acquisition system is running, stopped, or in Autostore mode.
- When the instrument is in Normal trigger mode, the Trigger condition indicators flash while the instrument is searching for the trigger condition, which occurs after the pre-trigger buffer is full. When the instrument is in Auto trigger mode, the word “Auto” flashes to the left of the Trigger condition indicator if the instrument did not find the trigger and was therefore triggered automatically after a time-out.
- When the delayed horizontal mode is selected, a square symbol appears at the top center of the activity indicator line. The Time/Div next to this symbol is the delayed sweep s/div value. When you press the Main/Delayed key, the delay value is displayed briefly at the bottom of the display.

Digital Channel Numbers:

- The channel numbers are always shown along the left edge of the display.

Digital Channel Labels:

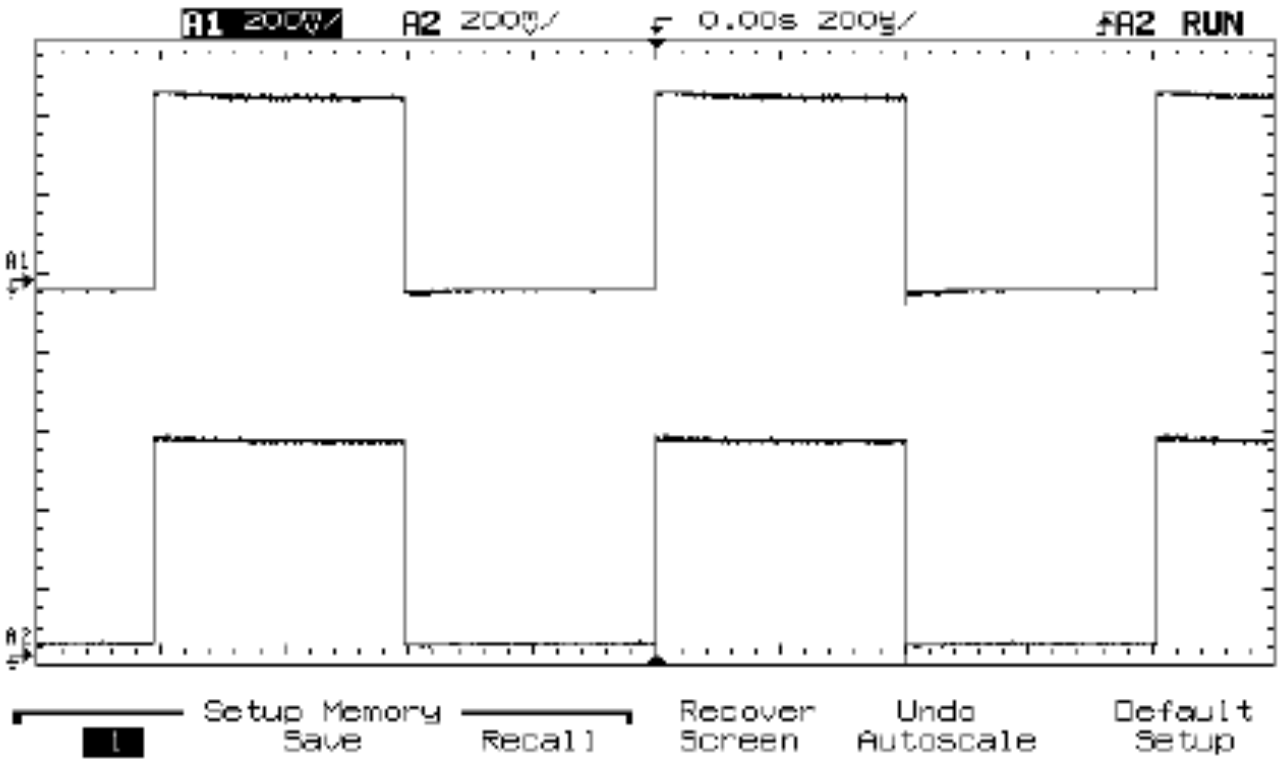
- You can assign channel labels to help you remember the function of each channel in your circuit, or disable the labels to increase the waveform display area.

Analog channel voltage levels:

- Analog Voltages for channels **[A1]** and **[A2]** are set to 100 mV by default, and range from 1.0 mV to 5.0 V.

Use oscilloscope to view signals

- To configure the instrument quickly, press **[Autoscale]**.
- To undo the effects of autoscale, press **[Setup]**, then press **(Undo Autoscale)**.
- To set the instrument to the factory-default measurement configuration, press **[Setup]**, then press **(Default Setup)**.



Adjust oscilloscope vertical scaling

1. Center the signal on the display using the ↻**Position** knob. The ↻**Position** knob moves the signal vertically; the signal is calibrated. Notice that as you turn the↻ **Position** knob, a voltage value is displayed for a short time, indicating how far the ground reference is located from the center of the screen. Also notice that the ground symbol moves with the Position knob.

2. Change the vertical setup and notice that each change affects the status line differently. You can quickly determine the vertical setup from the status line in the display.
   - Change the vertical sensitivity with the ↻**Volts/Div** knob and notice that it causes the status line to change.
   - Press **[A1]**.
     A softkey menu appears on the display, and the channel turns on (or remains on if it was already turned on).
   - Toggle each softkey and notice which keys cause the status line to change.
     Channels **[A1]** and **[A2]** have a vernier softkey that allows the ↻**Volts/Div** knob to change the vertical step size in smaller increments. These smaller increments are calibrated, which result in accurate measurements, even with the vernier turned on.
   - To turn the channel off, either press **[A1]** a second time or press the left-most softkey.

Turn analog channels on and off

- To turn off analog channel #1, press **[A1]**, then press the leftmost softkey until *Off* is highlighted.
- To turn off analog channel #2, press **[A2]** then press the leftmost softkey until *Off* is highlighted.

Rearrange the analog channels

- Rotate the channel **[A1]** or **[A2]** ↻**Position** knob to choose a new location for the analog channel.

NOTE: Turning the ↻**Position** knob counter-clockwise moves the channel down; turning the knob clockwise moves the channel up.

Turn digital channels on and off

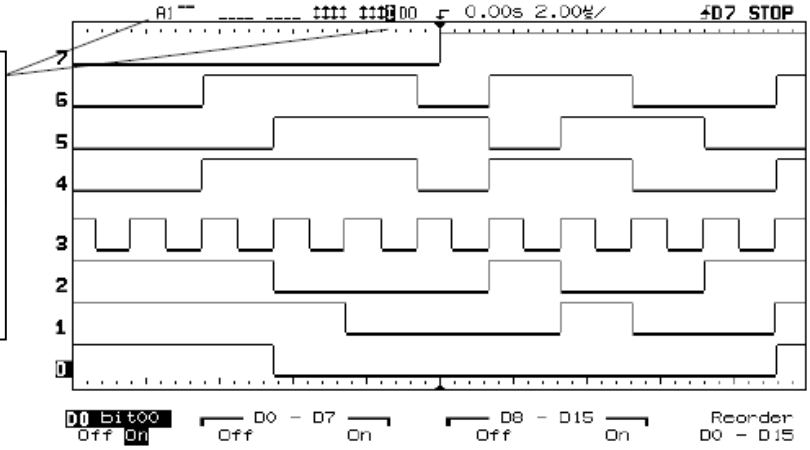
- To turn digital channels 0 through 7 on, press **[D0-D15]**, then press the **(D0 - D7 On)** softkey. To turn these channels off, press the **(Off)** softkey.
- To turn digital channels 8 through 15 on, press **[D0-D15]** , then press the **(D8 - D15 On)** softkey. To turn these channels off, press the **(Off)** softkey.
- To turn on an individual channel, press **[D0-D15]** . Rotate the ↻**Select** knob until the channel is selected. Then, press **(On)** or press **[D0-D15]** again to turn on the channel.

Rearrange the digital channels

1. Turn the ↻**Select** knob to choose the digital channel you want to move. Only channels that are currently on may be moved.
2. Turn the ↻**Position** knob to move the selected channel to a new position. Turning the ↻**Position** knob counter-clockwise moves the channel down; turning the knob clockwise moves the channel up.
   NOTE: The combination of the ↻**Select** and ↻**Move** knobs gives you a feature similar to that of a waveform position control on an oscilloscope, except that you can only move the waveform to certain discrete locations.
3. To change the general order in which channels are displayed, press **[D0-D15]**. Then press the **(Off/On)** softkey or the **(Reorder D15-D0)** softkey.

When **(Reorder D15-D0)** is pressed, the digital channels are displayed in descending order, and the **(Reorder)** softkey is relabeled **D0-D15**. When the **(D0-D15)** softkey is pressed, the digital channels are displayed in ascending order, and the (**Reorder)** softkey is relabeled **D15-D0**.

Channel activity indicators appear temporarily when you access the D0-D15 menu, pattern menu, and advanced pattern menu.



Operating the time base controls

1. Connect a signal to the oscilloscope and obtain a stable display.

- Turn the ↻**Time/Div** knob and notice the change it makes to the status line. The ↻**Time/Div** knob changes the sweep speed from 2 ns to 50 s (HP 54645A) and from 5 ns to 50 s (HP 54645D) in a 1-2-5 step sequence, and the value is displayed in the status line.

- You can access the horizontal **(Vernier)** softkey by pressing the **[Main/Delayed]** key.
  The **(Vernier)** softkey allows you to change the sweep speed in smaller increments with the ↻**Time/Div** knob. These smaller increments are calibrated, which result in accurate measurements, even with the vernier turned on.

- You can check the sample rate by pressing the **[Main/Delayed]** key when the instrument is running, during a single run, or when the instrument is stopped. The sample rate is also displayed when the acquisition stops or ends.

- Turn the ↻**Delay** knob and notice that its value is displayed in the status line.
  The ↻**Delay** knob moves the main sweep horizontally, and it pauses at 0.00 s, mimicking a mechanical detent. At the top and bottom of the graticule is a solid triangle (▼) symbol and an open triangle (▽) symbol. The ▼ symbol indicates the trigger point and it moves with the ▽ ↻**Delay** knob. The ▽ symbol indicates the time reference point. If the time reference softkey is set to left, the ▽ is located one graticule in from the left side of the display. If the time

reference softkey is set to center, the ▽ is located at the center of the display. The delay number tells you how far the reference point ▽ is located from the trigger point ▼. All events displayed left of the trigger point ▼ happened before the trigger occurred, and these events are called pre-trigger information. You will find this feature very useful because you can now see the events that led up to the trigger point. Everything to the right of the trigger point ▼ is called post-trigger information. The amount of delay range (pre-trigger and post-trigger information) available depends on the sweep speed selected.

Starting and stopping an acquisition

- To begin an acquisition, press the **[Run/Stop]** key.

- To begin a single acquisition, press the **[Single]** key.
  The instrument begins acquiring data while searching for a trigger condition. The RUN indicator is shown in the upper-right corner of the display. If a trigger occurs, the acquired data is shown in the display.
- To stop an acquisition in process, press the **[Run/Stop]** key.
  The instrument stops acquiring data, and the STOP indicator is shown in the upper-right corner of the display. If the instrument was triggered (even by auto triggering) and the pre-trigger and post-trigger buffers are full, the results are displayed on the screen. If the buffers are not full, the waveform display area will show nothing.

Entry and Select knobs

The ↻**Select** knob always changes the selected channel. In most menus, its order is screen-oriented. In the simple pattern and advanced pattern definition menus, it moves from the lowest to highest number on clockwise rotation.

The ↻**Entry** knob increments and decrements the selected field—for example, glitch time and setup memory number. It also moves the selected cursor when cursors are on. In menus where it doesn't need to do these things (for example, there is no field to increment or decrement, or cursors are turned off), it adjusts the selected channel increment/decrement in a non-screen but numerical order.

The ↻**Entry** knob also occasionally duplicates the function of the ↻**Select** knob. Use the ↻**Entry** knob to select channels, set trigger durations (ranges), and select labels.

Cursor measurements

The following steps guide you through the front-panel Cursors key. You can use the cursors to make custom voltage or time measurements on scope signals, and timing measurements on digital channels.

1. Connect a signal to the oscilloscope and obtain a stable display.
2. Press **[Cursors]**. View the cursor functions in the softkey menu:

   (**Source)** selects a channel for the voltage cursor measurements A1 and A2. If a Measurement/Storage module is installed in the oscilloscope, and Function 2 is set to FFT and is turned on, you can select f1 or f2 for the source.

   (Active Cursor) includes voltage cursors V1 and V2, and time cursors t1 and t2. Pressing the voltage cursors alternates between V1 or V2, or both V1 and V2. Pressing the time cursors alternates between t1 or t2, or both t1 and t2. When both voltage cursors or both time cursors are highlighted, they are selected, and they will move together on the screen.

   Voltage cursors do not apply to the digital channels.

   If a Measurement/Storage module is installed in the oscilloscope, and you select F2 as the source with F2 set to FFT, the active cursors include f1 and f2. Use the ↻**Entry** knob to change the active cursor.

   (Clear Cursors) erases the cursor readings and removes the cursors from the display.

The (**Readout)** softkey gives a reading of the time or voltage cursor measurement.

- For the time cursor readout, you can select **Time**, **Hex**, **Binary**, or **Degrees**. Binary displays all digital channels by channel number. Hex shows only the displayed channels, with the top channel displayed as the most significant bit. When **Active Cursor** is **t1/t2**, the **Readout Time** softkey sets the display to show the cursor positions in seconds, and the **Readout Degrees** softkey shows the cursor positions in relative number of degrees.
- For the voltage cursor readout, you can select Volts or %. When **Active Cursor** is **V1/V2**, the **Readout Volts %** softkey sets the display to show the cursor positions in volts when **Volts** is highlighted, and as a percentage when **%** is highlighted.

You can expand the display with delayed sweep, and then characterize the event of interest with the cursors.

Pressing the **(Active Cursor)** softkey until both time cursors or both voltage cursors are highlighted allows you to move them together when rotating the ↻**Entry** knob. You can move the cursors together to check for pulse width variations in a pulse train.

Delayed sweep

Delayed sweep is a magnified portion of the main sweep. You can use delayed sweep to locate and horizontally expand part of the main sweep for a more detailed (high-resolution) analysis of signals.

The following steps show you how to use delayed sweep. Notice that the steps are very similar to operating the delayed sweep in analog oscilloscopes.

1. Connect a signal to the oscilloscope and obtain a stable display.
2. Press **[Main/Delayed]**.
3. Press the **(Delayed)** softkey.

   The screen divides in half. The top half displays the main sweep, and the bottom half displays an expanded portion of the main sweep. This expanded portion of the main sweep is called the delayed sweep. Since both the main and delayed sweeps are displayed, there are half as many vertical divisions so the vertical scaling is doubled. Notice the changes in the status line. The top half also has two solid vertical lines called markers. These markers show what portion of the main sweep is expanded in the lower half. The size and position of the delayed sweep are controlled by the Time/Div and Delay knobs. The Time/Div next to the symbol is the delayed sweep sec/div. The delay value is displayed temporarily at the bottom of the display.

   - To display the delay value of the delayed time base temporarily at the bottom of the screen, press **[Main/Delayed]**.

- To change the delay for the delayed sweep window, turn the ↻**Delay** knob.
- To change the Time/Div for the delayed sweep window, turn the ↻**Time/Div** knob.
- To change the Time/Div for the main sweep window, select the main sweep mode. Then turn the ↻**Time/Div** knob.

Modify the graticule

1. Press **[Display]**.
2. Press one of the **(Grid)** softkeys to define the graticule used for the waveform area on the display.
   - **(Frame)** has a set of hash marks along the top and bottom of the display only.
     Major divisions are indicated by longer hash marks.
   - **(Full)** has a set of hash marks through the center of the waveform display area with major divisions indicated by a full-height dotted line through the waveform display.
   - **(None)** has only a border around the waveform display area.

   Each major division in the graticule corresponds to the time given by the Time/Div setting shown to the right of the delay value on the display.

Triggering

Trigger types include edge, pattern, and advanced, allowing you to match the complexity of the trigger to that of the data you want to capture. The triggering modes include **Auto Lvl**, **Auto**, and **Normal**.

Advanced triggering consists of **Glitch**, Advanced Pattern, and **TV**. Depending on the trigger selections and conditions, you can use analog channels A1 or A2, Line, or D0-D15 for the trigger source.

NOTE: With the built-in MegaZoom technology, you can simply Autoscale the waveforms, then stop the scope to capture a waveform. You can then pan and zoom through the data to find a stable trigger point. Autoscale often produces a triggered display.

Trigger types

- **Edge** trigger
- **Pattern** trigger
- **Advanced** trigger

Changes to the trigger specification are applied when you make them. If the oscilloscope is stopped when you change a trigger specification, the scope will use the new specification when you press **Run/Stop**, **Single**, or **Autostore**. If the oscilloscope is running when you change a triggering specification, it uses the new trigger definition when it starts the next acquisition. You select the trigger type by pressing the key associated with the desired trigger type.

Edge Trigger

In *edge trigger*, you define a single rising or falling edge that must be recognized on any input channel to satisfy the trigger condition.

Edge trigger is best when there is a unique waveform edge that defines the events you want to capture. For example, a pulse that defines the beginning of a pulse train on another channel will often make a good edge trigger.

Edge triggering is the simplest trigger mode, and the easiest to use. However, its simplicity can lead to situations where more triggering power is needed. Often the device under test needs more than a single rising or falling edge to locate a specific point in its operation.

Glitch Trigger

The advanced glitch trigger menu lets you select the analog (A1 or A2) or digital (D0-D15) channel on which to capture a glitch event. You specify the polarity and duration qualifier—either less than (<), greater than (>), or a range—for the glitch. The oscilloscope can capture glitches >8 nanoseconds and <100 seconds.

Pattern Trigger

In *pattern trigger*, you define a pattern of highs, lows, and don't care levels that must be recognized across the input channels. The pattern may be combined with one edge on any one input channel to form the complete trigger specification.

A Pattern trigger is best when there is a unique pattern that occurs across a group of signals, and the pattern defines the

events you want to capture. For example, suppose you have a state machine that outputs a series of hex digits, and only outputs the digit “A” once in every sequence. You can use a pattern trigger to capture this event, perhaps qualified with the state machine clock.

Pattern trigger is less useful when the same pattern occurs many times, and most of those occurrences have little to do with the events you want to capture. For example, suppose that this same state machine generates hundreds of states, and the state “C” occurs several times in the sequence, with a different sequence of states after each occurrence. A pattern trigger will not provide a stable waveform display.

The pattern trigger occurs when the pattern is entered; that is, the trigger condition is satisfied as soon as the input waveforms have transitioned from a condition not matching the pattern to a condition matching the pattern. You can use an edge to further qualify the trigger condition. For example, you may want the oscilloscope to trigger when a certain pattern is present and a clock edge occurs.

The trigger pattern can include high and low values on the oscilloscope A1 and A2 channels. You control the trigger level with the Analog Level knob.

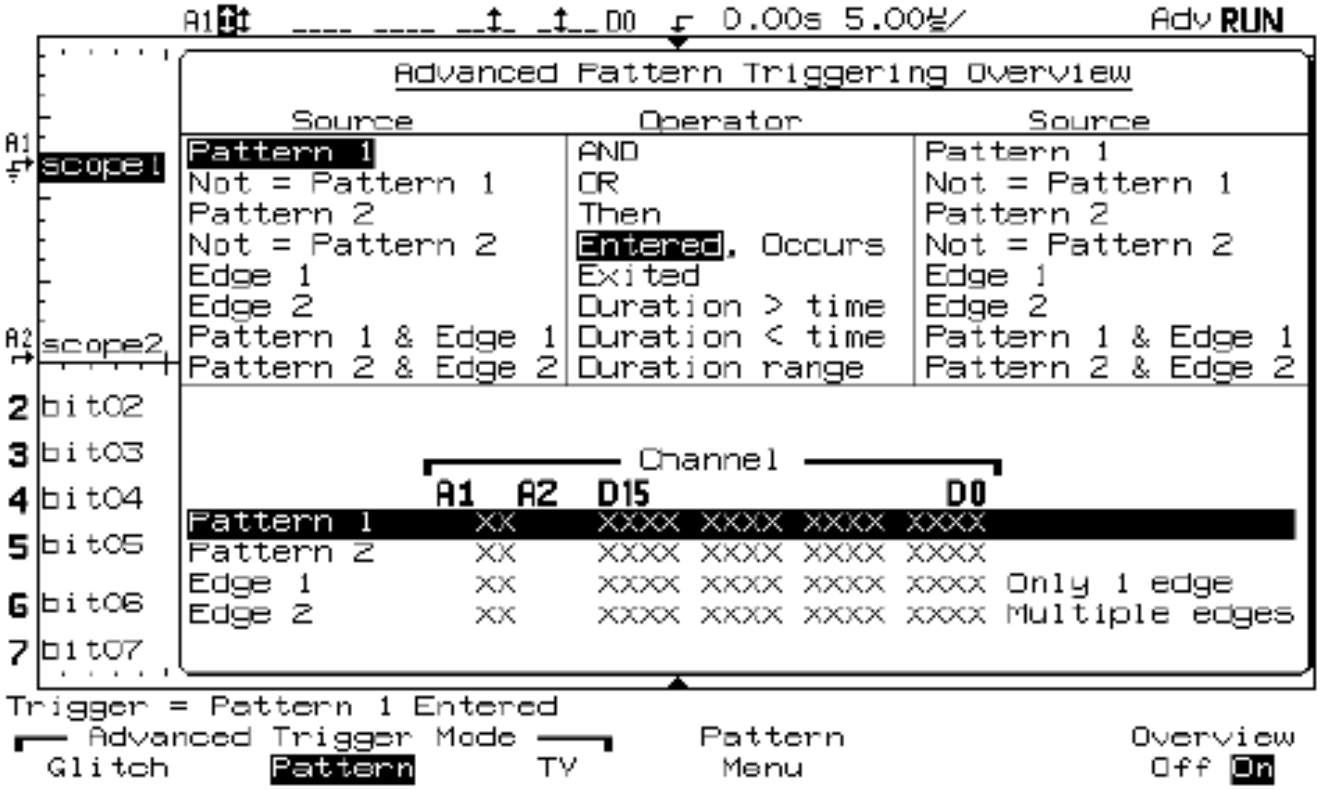
Logical Combination within Terms

In the pattern trigger, all settings within the pattern are logically ANDed; that is, all conditions on the pattern, AND the edge if specified, must be satisfied before the oscilloscope will trigger.

Advanced Pattern Trigger

In *advanced pattern trigger*, you define a maximum of two pattern and edge sources that are combined with a variety of operators to form the complete trigger specification.

Advanced pattern trigger is best when the events you want to capture are defined by a series of waveform events in the system, and neither pattern mode nor edge mode are capable of clearly resolving the necessary sequence. For example, suppose the events you want to capture are defined by a pattern with a certain minimum duration, or by a pattern followed by another pattern. Advanced pattern trigger gives you this and more.



Define an edge trigger

1. Press **[Edge]**.
2. Select a channel as the trigger source using either the ↻**Select** knob or by pressing a **(Trigger Source)** softkey.

   NOTE: You can choose a channel that is turned off as the source for the edge trigger.
3. Press one of the **(Edge)** softkeys to choose whether the trigger will occur on the rising or falling edge.

Line triggering

This power line edge triggering, when selected, overrides any other settings.

1. Press **[Edge]**. Then select (**Line)**.
2. Select the **(Rising)** or **(Falling)** edge softkey.

Define a pattern trigger

1. Press **[Pattern]**.
2. For each analog channel (A1 or A2) or digital channel (D0-D15) you want to include in the desired pattern, press the **(Source)** softkey to select the channel, or rotate the ↻**Entry** knob or the ↻**Select** knob.
3. Then, press one of the following softkey to set the condition the oscilloscope will recognize as part of the pattern for that channel:
   - **(L)** for a logic low
   - **(H)** for a logic high

- **(X)** to ignore this channel
- **(Rising)** or **(Falling)** edge

Glitch triggering

1. Press **[Advancd]**. Then select **(Glitch)**.
2. Select (**Glitch Menu)**.
3. Select the analog channel **[A1]** or **[A2]** or digital channel **[D0-D15]** source for the trigger by pressing the **(Source)** softkey until the desired source is highlighted.
4. Select **(Positive)** or **(Negative)** polarity for the glitch to capture.
5. Select the time qualifier (<, less than a specified width; >, greater than a specified width; or ><, within minimum and maximum limits) for the glitch, and rotate the ↻**Entry** knob or press the softkey to increase the duration time.

Define an advanced pattern trigger

1. Press **[Advancd]**. Then select **(Pattern)**.
2. Press the **(Overview)** softkey to turn on the trigger overview, if desired.

   NOTE: The trigger overview display shows all the choices available in this menu.
3. Select **(Pattern Menu)**.
4. Choose the trigger operator by pressing the **(Operator)** softkey until the desired operator is shown.

5. Select the source(s) for the trigger operator by pressing the leftmost **(Source)** softkey until the desired source is highlighted.

Refer to the table of trigger operators and sources to see the sources and operators with which they can be used.

Operator	**# of Sources**	**Valid Sources**
Duration (> time, < time, Range)	One	Pat 1, Not = Pat 1 Pat 2, Not = Pat 2
Entered, Exited	One	Pat 1, Not = Pat 1 Pat 2, Not = Pat 2
AND, OR, Then	Two	Pat 1, Not = Pat 1 Pat 2, Not = Pat 2 Edge 1, Edge 2 Pat 1 & Edge 1 Pat 2 & Edge 2

The oscilloscope will allow you to choose combinations of sources that are redundant, such as “Pattern 1 AND Pattern 1”, or combinations that will create a null trigger condition, such as “Pattern 1 AND Not Pattern 1”.

6. Define the source pattern(s) by pressing the **(Source Define)** softkey.

   If you combined patterns and edges in the same source term, you must separately select each as the source, set up the source, then select the combined pattern and edge again.

7. Set the parameters for the trigger operator, if necessary. For the Duration operators (> time, < time, range), press/hold the **(Duration value)** softkey or rotate the ↻**Entry** knob to set the duration.

8. To set up an edge trigger source, do the following:

    a. Select a channel for the source.

        - To choose whether the trigger will occur on the rising or falling edge, press one of the **(Edge Select)** softkeys.
        - To set a channel to a don't care trigger state, press the **(X)** softkey.
        - To clear all edge settings, press the **(Clear Edge)(s)** softkey.

        NOTE: In Edge1, you can select only one edge. You may select multiple edges in Edge2; those edges are logically ORed.

    b. Repeat step a for all channel sources you want to define.

    c. Press **(Previous Menu)** to return to the Advanced Pattern Trigger menu.

9. To set up a pattern trigger source, do the following:

    a. Select a channel for the source.

- To set the condition for that channel, press the **(L)**,**(H)**, or **(X)** softkey.
- To clear the conditions for all channels, press **(Clear Pattern)**.

b. Repeat step a for all channel sources you want to define.

c. Press **(Previous Menu)** to return to the Advanced Pattern Trigger menu.

Entered and Exited

In the table of trigger operators and sources:

- *Entered* means that the trigger qualifier is satisfied as soon as the input waveforms have transitioned from a state not matching the pattern to a state matching that pattern. In an edge term, or a pattern and edge term, the edge transition is where "entered" is defined.
- *Exited* means that the trigger qualifier is satisfied when the input waveforms transition out of a state matching the pattern to a state not matching the pattern.

Advanced pattern trigger can help you solve difficult data acquisition problems. When setting up an advanced trigger, remember:

- Follow the setup rules.
- Have a clear picture of the event sequence you are trying to capture, and understand how the advanced trigger capabilities relate to those events. The MegaZoom

technology's deep memory and pan and zoom capabilities greatly simplify this.

Setup rules

Remembering the following rules will make it easier to work with the advanced triggering capabilities:

- Duration operators are valid when only pattern terms are involved. Duration is *not* selectable when any edge term is selected as a source.
- When you have selected a combination source, like Pattern 1 AND Edge 1, you cannot directly define the pattern or edge. You must instead select Pattern 1 as the source, define the pattern, then select Edge 1 as the source and define the edge. The softkeys change to reflect this.

Understand and relate waveform events to oscilloscope capabilities

The key to setting up a useful waveform display is choosing a known sequence of waveform events to which you can apply the advanced trigger capabilities. The HP MegaZoom technology greatly simplifies this task. You simply press **Stop**, then pan and zoom through the waveform to find a good trigger event.

To find these events, you can also ask questions about the waveform, keeping in mind the capabilities of the oscilloscope.

- Does the input data always repeat with respect to a particular waveform's high or low period of constant duration?

- Is there a sequence of waveform events that define the data of interest?

For example, is there a state machine, where the hypothetical sequence “ac” leads to the events of interest, where “ab” does not?

Measurements with the Oscilloscope

Measuring Waveform Data

You can measure waveform data using Voltage, Time, and Cursor keys.

Cursor measurements

1. Connect a signal to the oscilloscope and obtain a stable display.
2. Press **[Cursors]**. View the cursor functions in the softkey menu:

(Source) selects a channel for the voltage cursor measurements. If a Measurement/Storage module is installed in the oscilloscope, and Function 2 is selected, you can select F1 or F2 for the source.

(Active Cursor) includes voltage cursors **(V1)** and **(V2)**, and time cursors **(t1)** and **(t2)**. Pressing the voltage cursors alternates between V1 or V2, or both V1 and V2. Pressing the time cursors alternates between t1 or t2,
or both t1 and t2.

If a Measurement/Storage module is installed in the oscilloscope, and you select F2 as the source with FFT turned on, the active cursors include f1 and f2. Use the ↻**Entry** knob to change the active cursor.

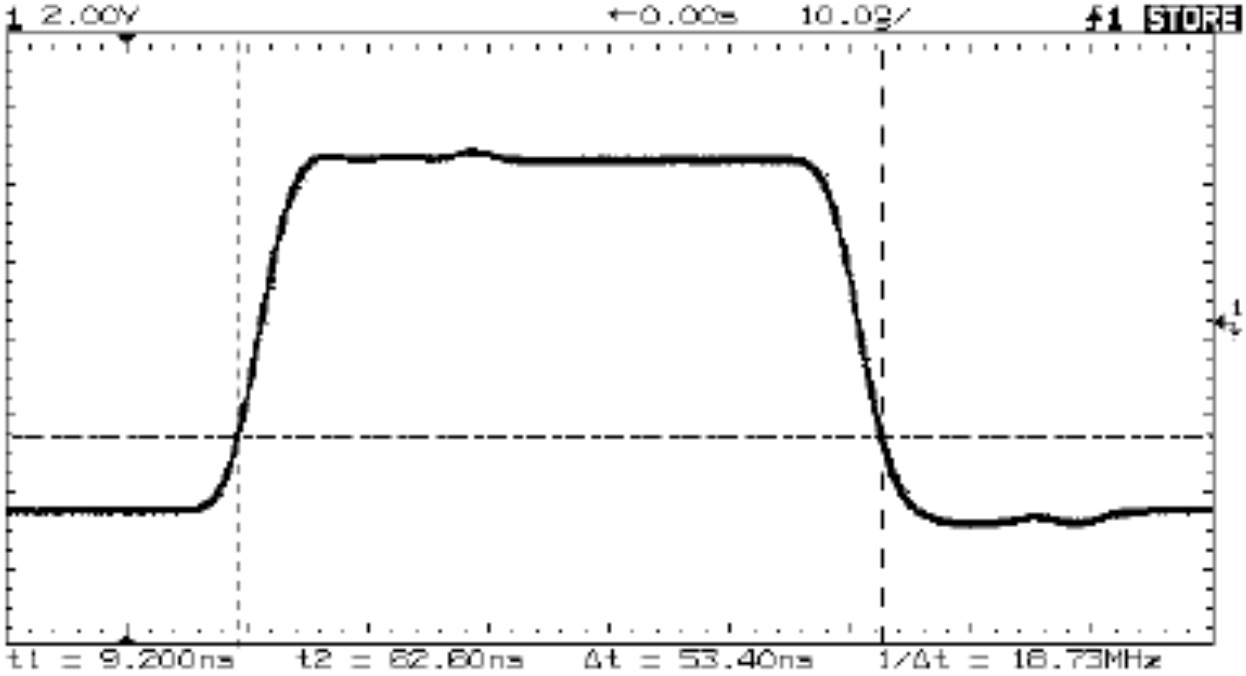
(Clear Cursors) erases the cursor readings and removes the cursors from the display.

On HP 54645D, the **(Readout)** softkey gives a reading of the time or voltage cursor measurement.

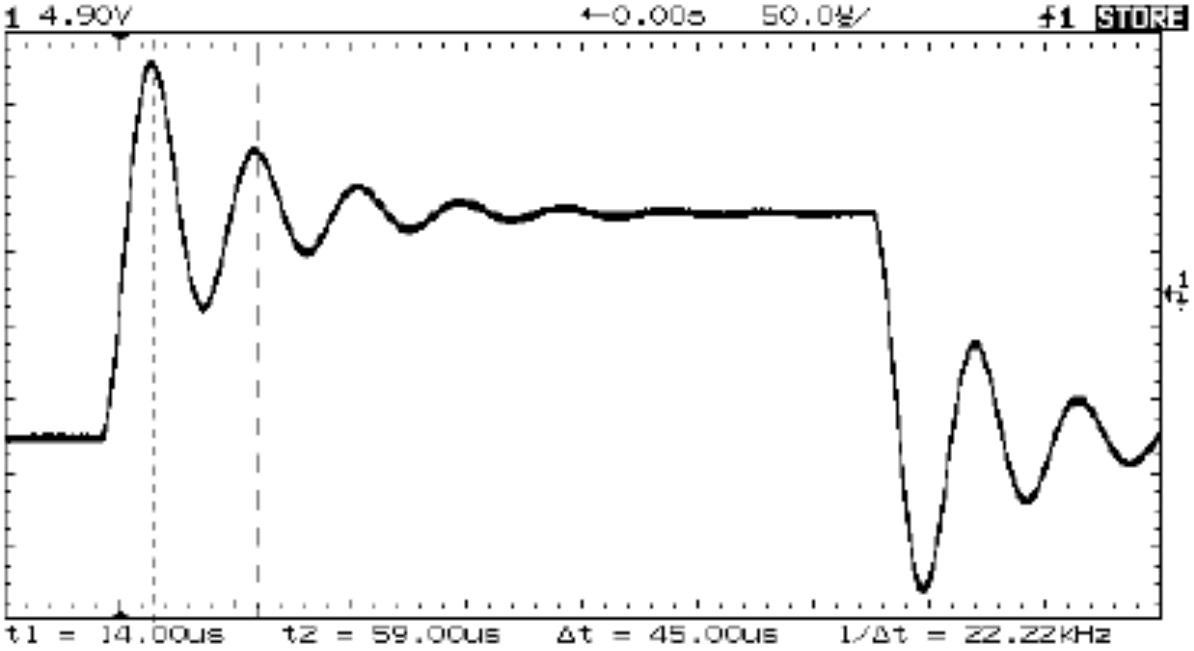
- For the time cursor readout, you can select Time, Hex, Binary, or Degrees. Binary displays all digital channels by channel number. Hex shows only the displayed channels, with the top channel displayed as the most significant bit. When **Active Cursor** is **t1/t2**, the **(Readout Time)** softkey sets the display to show the cursor positions in seconds, and the **(Readout Degrees)** softkey shows the cursor positions in relative number of degrees.
- For the voltage cursor readout, you can select Volts or %. When **Active Cursor** is **V1/V2**, the **(Readout Volts) %** softkey sets the display to show the cursor positions in volts when **Volts** is highlighted, and as a percentage when **%** is highlighted.

*Use the ↻**Entry** knob to move the cursors. You can toggle the active cursor by pressing the cursor key while in the cursors menu.*

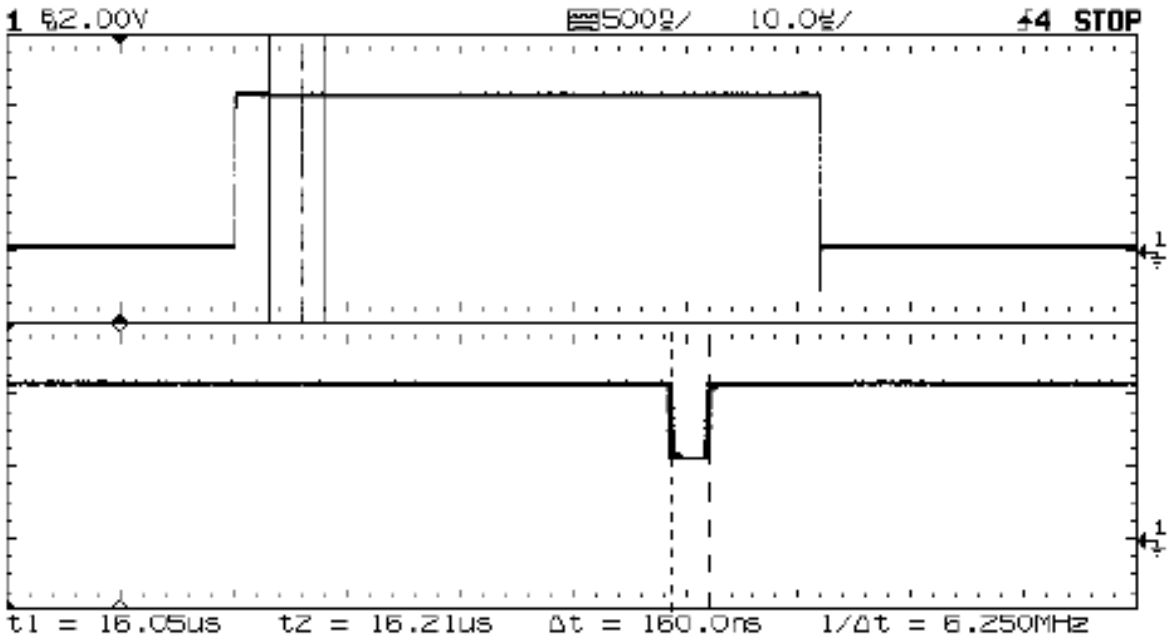
Cursor measurements are not bound to the edge of the screen. If you set a cursor, then pan and zoom the waveform until that cursor is off the screen, when you set the other cursor, the measurement will still be accurate.



Cursors Measure Pulse Widths other than 50% Points

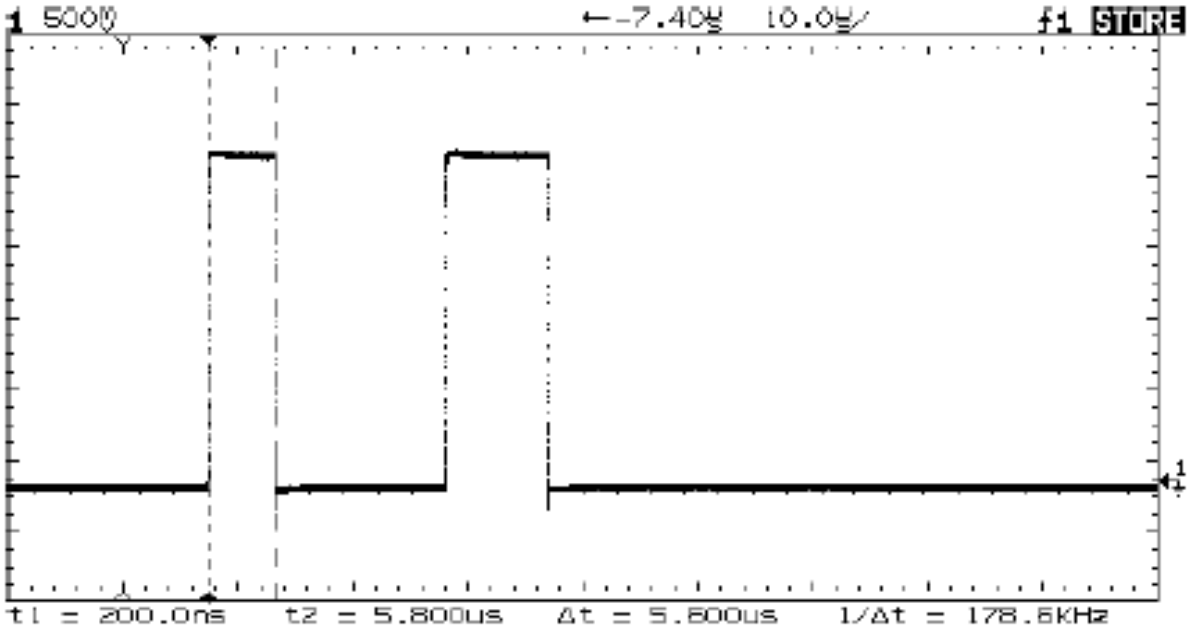


Cursors Measure Frequency of Pulse Ringing



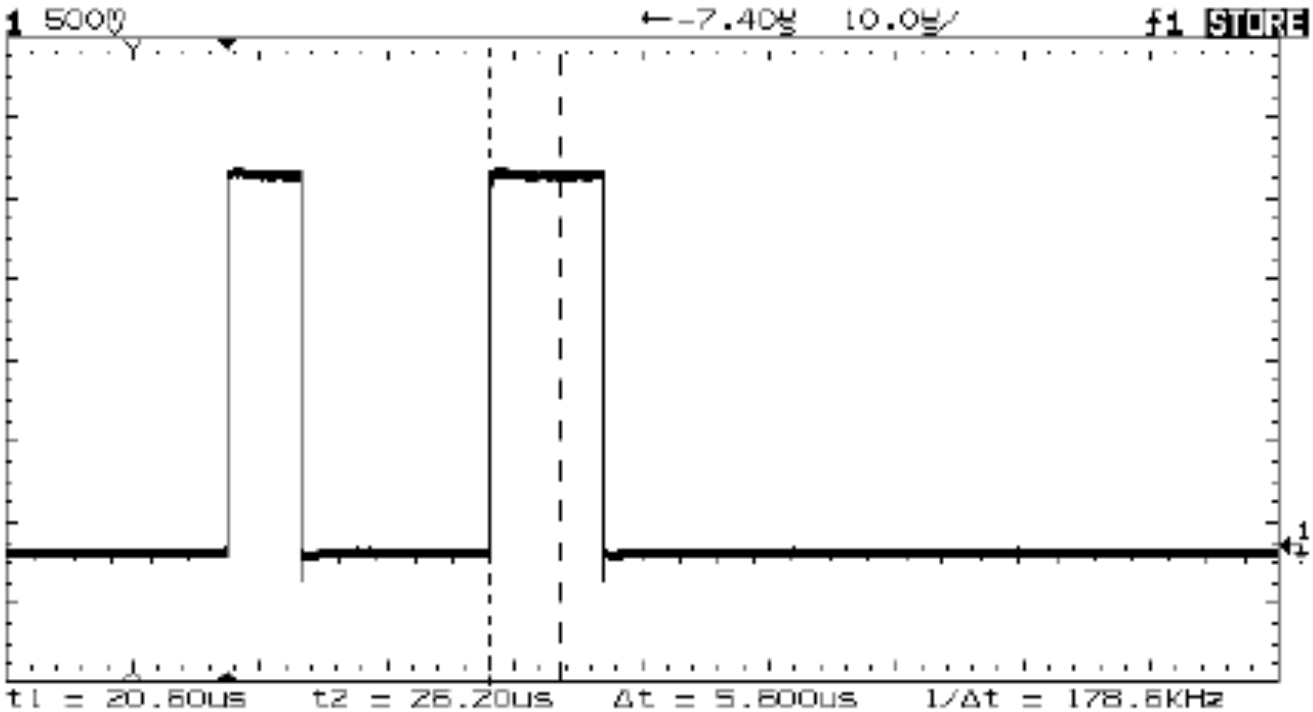
Cursors Track Delayed Sweep

Expand the display with delayed sweep, then characterize the event of interest with the cursors.



Moving Cursors Together

Pressing the time cursor softkey until both time cursors are highlighted allows you to move them together when rotating the ↻**Entry** knob.



Checking Pulse Width Variations

Move the cursors together to check for pulse width variations in a pulse train.

Frequency measurements automatically

1. Connect a signal to the oscilloscope and obtain a stable display.
2. Press **[Time]**. The first softkey menu appears with frequency, period, and duty cycle measurement choices.
3. Toggle the **(Source)** softkey to select analog channels (**A1** or **A2**) for the frequency measurement. you can also select any of the digital channels that are displayed for the frequency measurement.
4. Press the **(Freq)** softkey. The oscilloscope automatically measures the frequency and displays the result on the lower line of the display. The number in parentheses after the word **Freq** shows the channel number (**A1**) used for the measurement.
    - To find the **Show Meas** softkey, press the **(Next Menu)** softkey key.
      When the **(Show Meas)** softkey is turned on, cursors are displayed on the waveform, and show measurement points for the measurement result displayed on the right-most part of the status line. If you select more than one measurement, you can show a previous measurement by reselecting the measurement.

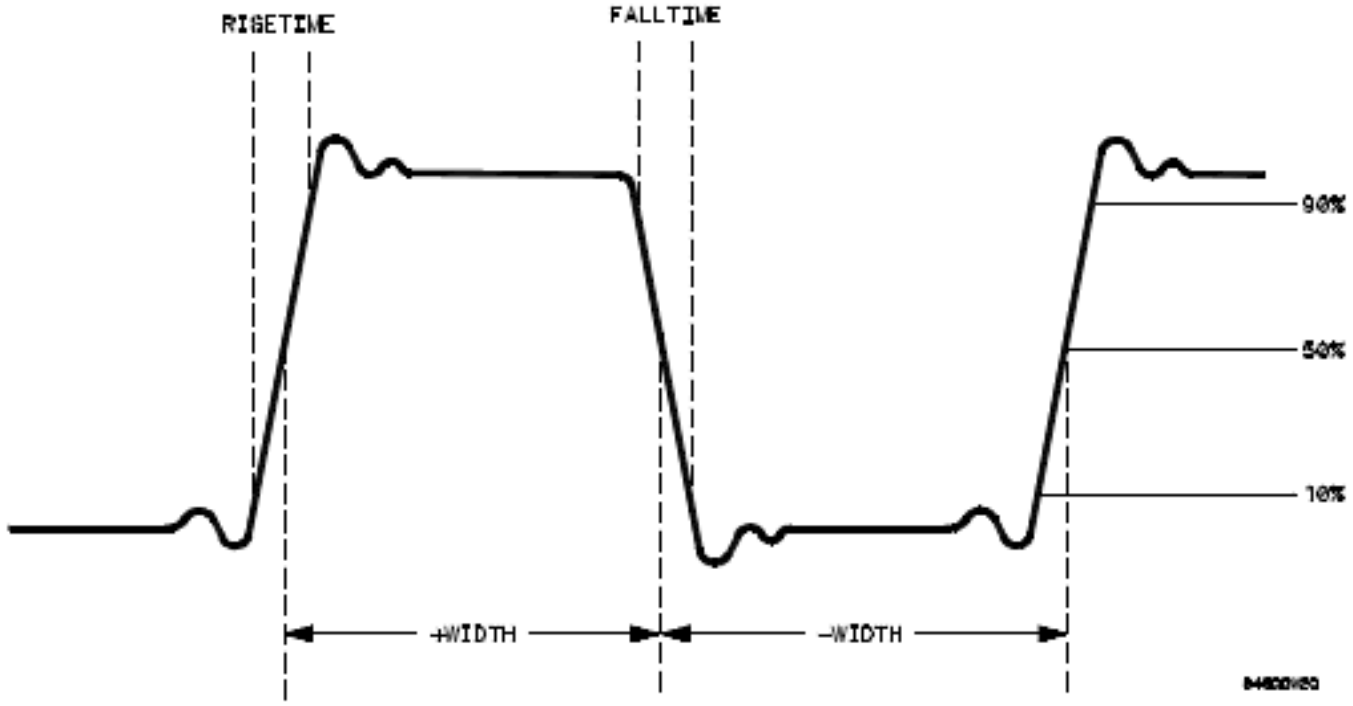
NOTE: The oscilloscope makes automatic measurements on the first displayed event.

Time measurements automatically

1. Connect a signal to the oscilloscope and obtain a stable display.

When the signal has a well-defined top and bottom, the rise time and fall time measurements are made at the 10% and 90% levels. If the oscilloscope cannot find a well-defined top or bottom, the maximum and minimum levels are used to calculate the 10% and 90% points from. These levels are shown in the section on making voltage measurements automatically.

The following figure shows a pulse with some time measurement points.



Pulse with Time Measurement Points

2. Press **[Time]**.

   The first softkey menu appears with frequency, period, and duty cycle measurement choices.
   (Source) selects channel **A1** or **A2** for the time measurement.
   (Time Measurements) include frequency, period, and duty cycle. These measurements are made at the 50% levels.
   (Clear Meas) *clear measurement* erases the measurement results and removes the cursors from the display.
   (Next Menu) displays the next softkey menu with additional time measurement choices.

3. Press the **(Next Menu)** softkey.

   Another menu appears with positive and negative pulse width, and rise time and fall time measurement choices.
   (Show Meas) *show measurement* places the horizontal and vertical cursors to show where the measurement was taken.
   (Time Measurements) include positive width, negative width, rise time, and fall time. Pulse width measurements are made at the 50% levels.
   Rise time and fall time measurements are made at the 10% to 90% levels, and *apply only to the analog channels (not the digital channels)*.
   (Previous Menu) Returns to the previous softkey menu.

4. Press the **(Rise Time)** softkey.

The oscilloscope automatically measures the rise time of the signal and displays the result on the display.

NOTE: The oscilloscope makes automatic measurements on the first displayed event.

5. To measure the fall time, press the **(Fall Time)** softkey.

NOTE: Rise-time and fall-time measurements do not work on digital channels.

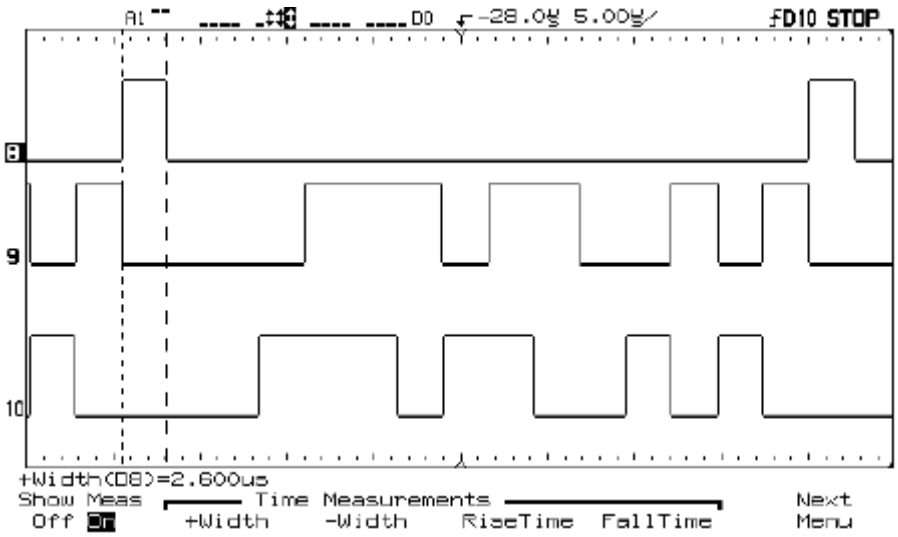
Measure the duty cycle

1. Press **(Next Menu)** until you find the **(Duty Cy)** softkey, and press it.

Measure the pulse widths

1. To measure the positive pulse width, press **(Next Menu)** until you find the **(+Width)** softkey, and press it.

2. To measure the negative pulse width, press **(Next Menu)** until you find the **(-Width)** softkey, and press it.

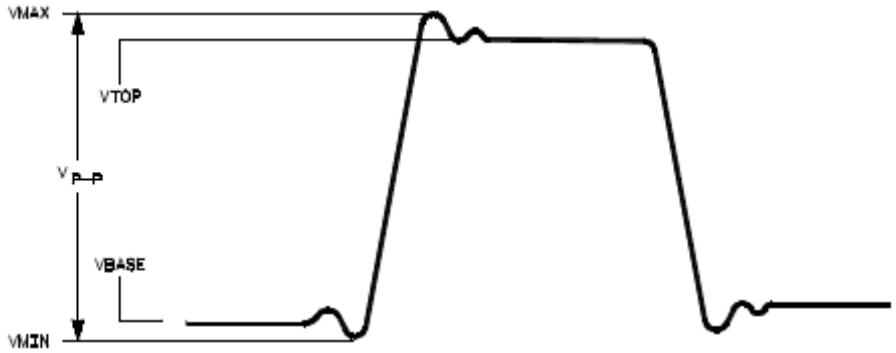


Positive Width Measurement

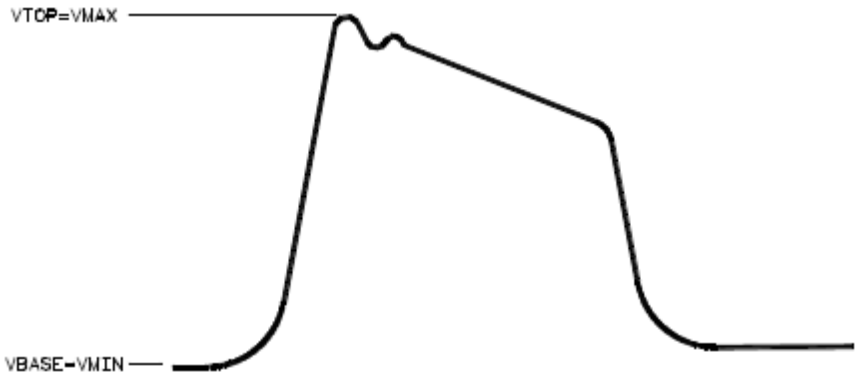
Voltage measurements automatically

You can measure the following voltage parameters automatically with the oscilloscope: peak-to-peak, average, rms, maximum, minimum, top, base, amplitude, overshoot, and preshoot.

The following figures show pulses with some of the voltage measurement points.



Pulse with Well-Defined Top and Bottom



Pulse with Top and Bottom not Well-Defined

NOTE: Voltage measurements do not work on digital channels

1. Connect a signal to the oscilloscope and obtain a stable display.

2. Press **[Voltage]**. A softkey menu appears with voltage measurement choices.
    - **(Source)** selects a channel for the voltage measurement.
    - **(Voltage Measurements)** include peak-to-peak **(Vp-p)**, average **(Vavg)**, and root mean square **(Vrms)**. Measurements are determined by voltage histograms of the signal.
    - **(Clear Meas)** *clear measurement* erases any measurement results from the display, and removes the horizontal and vertical cursors from the display.
    - **(Next Menu)** displays the next softkey menu with additional voltage measurement choices.
3. Press the **(V top)** softkey. The oscilloscope automatically measures the top voltage and displays the result on the screen.

NOTE: The oscilloscope makes automatic measurements on the first displayed event.

4. Press the **Next Menu** softkey. A softkey menu appears with additional voltage measurement choices.
    - **(Show Meas)** *show measurement* displays the horizontal and vertical cursors showing where the measurement was taken.
    - **(Voltage Measurements)** include choices for measuring the maximum (Vmax), minimum (Vmin), top (Vtop), and base (Vbase) voltages.
    - **(Next Menu)** displays the next softkey menu.