54600A

Oscilloscope Operating Instructions

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54600A Oscilloscope Operating Instructions

This pamphlet is intended to give you (the student) an overview on the use of the 54600A Oscilloscope. This pamphlet will instruct you on how to setup the oscilloscope to view and measure various waveforms and signals.

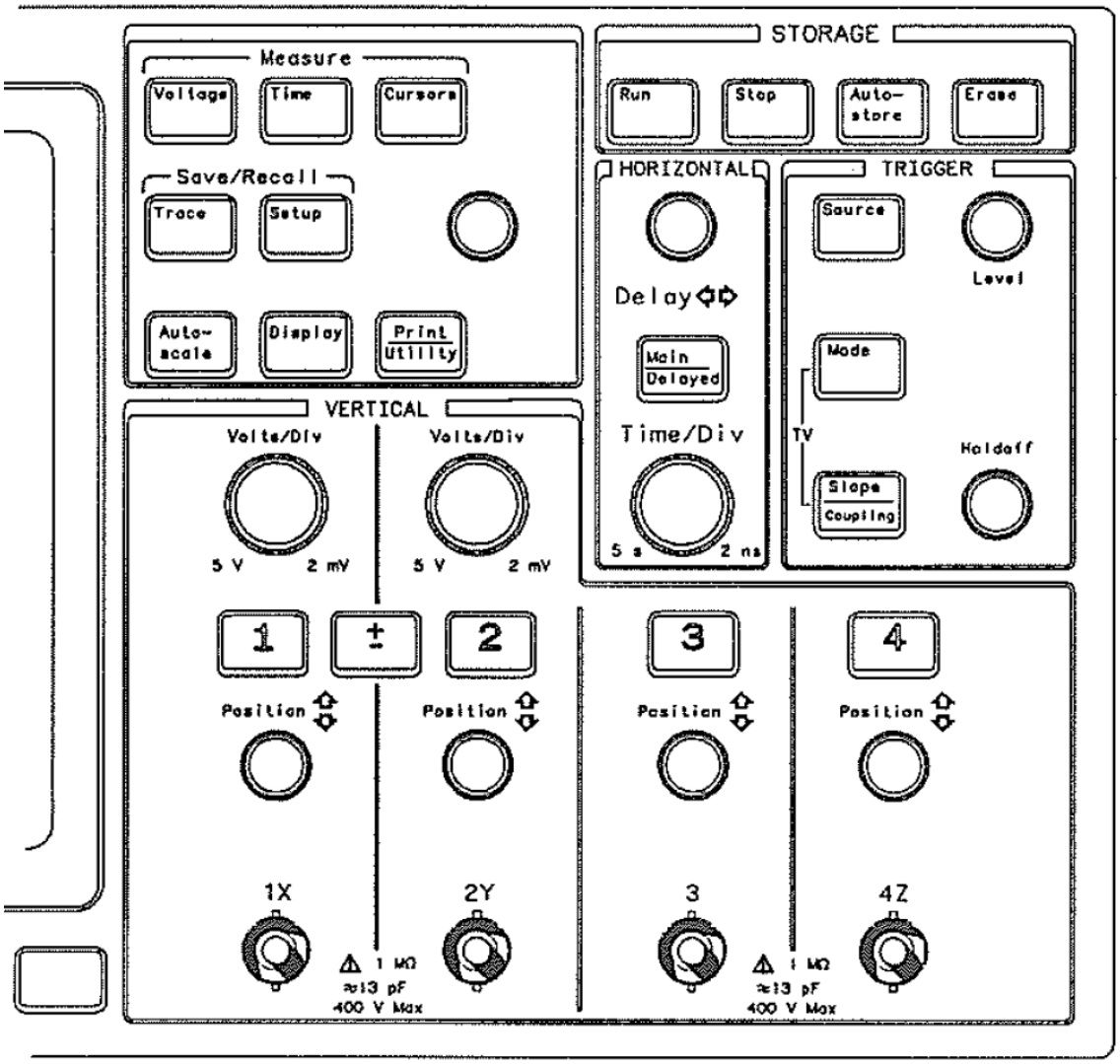
Please visit the Agilent website http://www.home.agilent.com/agilent/home to view the complete user manual for more information.

Throughout this manual, the front-panel keys are denoted by **[ ]** around the name of the key, and softkeys are denoted by **( )**. For example, **[Source]** is the grey front-panel key labeled Source under the trigger portion of the front panel, and **(Line)** is a softkey. The word **(Line)** appears at the bottom of the display directly above its corresponding softkey.

Front Panel Controls

Before using the oscilloscope, familiarize yourself with the front panel controls.

The front panel has knobs, **[ ]** gray keys, and **[ ]** white keys. Knobs are used most often to make adjustments. The grey keys bring up **( )** softkey menus on the display that allow you access to many of the oscilloscope features. The white keys are instant action keys and menus are not associated with them.



Oscilloscope at a Glance

Display a signal automatically

1. Connect a signal to the oscilloscope.
2. Press **[Autoscale]**.
   When you press the **[Autoscale]** key, the oscilloscope changes the front-panel setup to display the signal.

   NOTE: However, if you pressed the Autoscale key unintentionally, you can use the Undo Autoscale feature. To use this feature, perform the following step.

   1. Press **[Setup]**. Next, press the
   2. **(Undo Autoscale)** softkey.

   The oscilloscope returns to the configuration in effect before you pressed the Autoscale key.

Vertical window

1. Center the signal on the display with the Position knob.
   The Position knob moves the signal vertically, and it 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 on the right side of the display moves in conjunction 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 **[1]**. A softkey menu appears on the display, and the channel turns on (or remains on if it was already turned on).
    - Toggle each of the softkeys and notice which keys cause the status line to change.

      Note: Channels 1 and 2 have a vernier softkey that allows the Volt/Div knob to change the vertical step size in smaller increments. These smaller increments are calibrated, which results in accurate measurements even with the vernier turned on.

    - To turn the channel off, either press **[1]** a second time or press the left-most softkey.

Horizontal time base

1. Turn the **Time/Div** knob and notice the change it makes to the status line.

   NOTE: The Time/Div knob changes the sweep speed from 1 ns to 5 s in a 1-2-5 step sequence, and the value is displayed in the status line.

2. Change the horizontal setup and notice that each change affects the status line differently.
   - Press **[Main/Delayed]**.
     A softkey menu appears on the display with six softkey choices.
   - Toggle each of the softkeys and notice which keys cause the status line to change.

     NOTE: There is also a horizontal vernier softkey that allows the Time/Div knob to change the sweep speed in smaller increments. These smaller increments are calibrated, which results in accurate measurements even with the vernier turned on.

   - Turn the **Delay** knob and notice that its value is displayed in the status line.

     NOTE: The Delay knob moves the main sweep horizontally, and it pauses at 0.00 s, mimicking a mechanical detent. At the top of the graticule is a solid triangle **(▼)** symbol and an open triangle **(▽)** symbol. The ▼ symbol indicates the trigger point and it moves in conjunction 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 pretrigger information or negative time. 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 posttrigger information. The amount of delay range (pretrigger and posttrigger information) available is dependent on the sweep speed selected.

Trigger the oscilloscope

1. Turn the trigger **Level** knob and notice the changes it makes to the display.

   NOTE: As you turn the Level knob or press a trigger menu key, for a short time two things happen on the display. First, the trigger level is displayed in inverse video. If the trigger is dc coupled, it is displayed as a voltage. If the trigger is ac coupled or if LF reject was selected, it is displayed as a percentage of the trigger range. Second, if the trigger source is turned on, a line is displayed showing the location of the trigger level (as long as ac coupling or low frequency reject are not selected).

2. Change the trigger setup and notice that each change affects the status line differently.
   - Press **[Source].**
     A softkey menu appears on the display showing the trigger source choices.
     Trigger Sources: **(1)**, **(2)**, **(Ext)** & **(Line)**.
   - Press **[Mode].**
     A softkey menu appears on the display with five trigger mode choices.
     Trigger Mode: **(Auto Lvl)**, **(Auto)**, **(Normal)** & **(Single)**.
   - Press **[Slope/Coupling]**.
     A softkey menu appears on the display. If you selected Auto level, Auto, Normal, or Single as a trigger mode, six softkey choices are displayed.

Slope/Coupling: **(Slope)**, **(Coupling)**, **(Reject)** & **(Noise Rej)**.

- Toggle each of the softkeys and notice that each key causes the status line to change.

NOTE: When the oscilloscope is triggering properly, the trigger mode portion of the status line is blank.

3. Adjust the **Holdoff** knob and observe how it changes the display. Holdoff keeps the trigger from rearming for an amount of time that you set. Holdoff is often used to stabilize the display of complex waveforms. The Holdoff range is from 200.0 ns to about 13.5 s. When you adjust the Holdoff knob, the current holdoff time is briefly displayed in inverse video near the bottom of the display.

Roll mode

The roll mode continuously moves data across the display from right to left. Roll mode allows you to see dynamic changes on low frequency signals, such as when you adjust a potentiometer. Two frequently used applications of roll mode are transducer monitoring and power supply testing.

1. Press **[Mode]**. Then press the **(Auto Lvl)** or **(Auto)** softkey.
2. Press **[Main/Delayed]**.
3. Press the **(Roll)** softkey.
   The oscilloscope is now untriggered and runs continuously. Also notice that the time reference softkey selection changes to center and right.
4. Press **[Mode]**. Then press the **(Single)** softkey.
   The oscilloscope fills either 1/2 of the display if Center is selected for the time reference, or 9/10 of the display if Right is selected for the time reference, then it searches for a trigger. After a trigger is found, the remainder of the display is filled. Then the oscilloscope stops acquiring data.

   NOTE: You can also make automatic measurements in the roll mode. Notice that the oscilloscope briefly interrupts the moving data while it makes the measurement. The acquisition system does not miss any data during the measurement. The slight shift in the display after the measurement is complete is that of the display catching up to the acquisition system.

Operating the Oscilloscope

You are familiar with the *HORIZONTAL*, *VERTICAL*, and *TRIGGER* groups of the front-panel keys. You should also know how to determine the setup of the oscilloscope by looking at the status line.

NOTE: If you are unfamiliar with this information, I recommend you read "The Oscilloscope at a Glance" again.

This portion of the manual takes you through two new groups of front-panel keys: *STORAGE*, and the group of keys that contains the *Measure*, *Save/Recall*, and Display keys. You will also add to your knowledge of the *HORIZONTAL* keys by using delayed sweep.

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

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

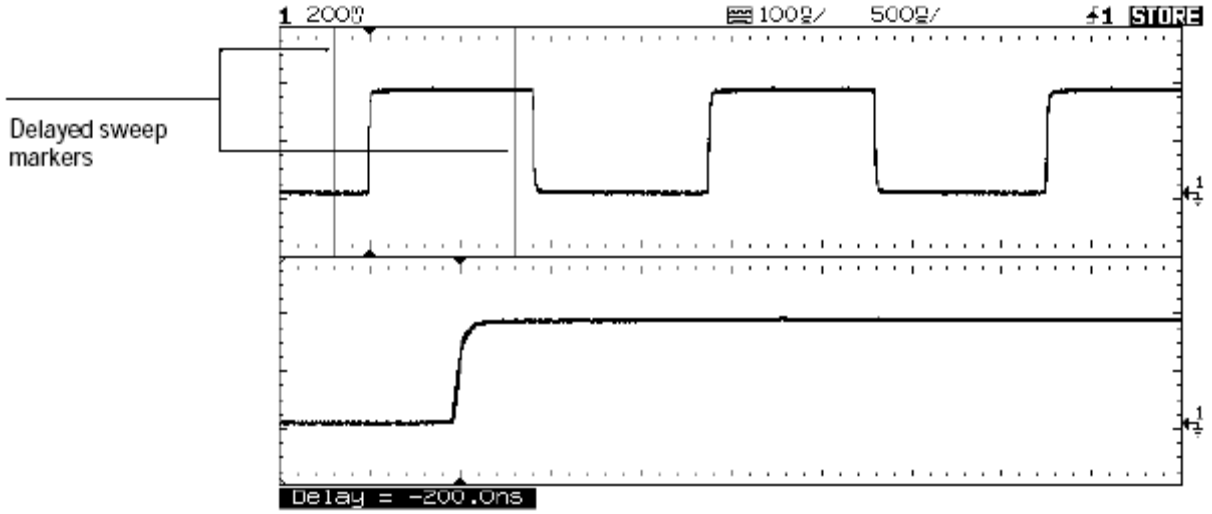
3. Press the **(Delayed)** softkey.
   The screen divides in half. The top half displays the main sweep, and the bottom half displays an expanded portion of the main sweep. This expanded portion of the main sweep is called the delayed sweep. The top half also has two solid vertical lines called markers. 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 for a short time at the bottom of the display.
   - To display the delay value of the delayed time base, either press **[Main/Delayed]** or turn the **Delay** knob.
   - To change the main sweep Time/Div, you must turn off the delayed sweep.

     NOTE: 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.

   - To display the delay time of the delayed sweep, either press **[Main/Delayed]** or turn the delay knob. The delay value is displayed near the bottom of the display.
4. Set the time reference **(Time Ref)** to either left *Lft* or center *Cntr*.

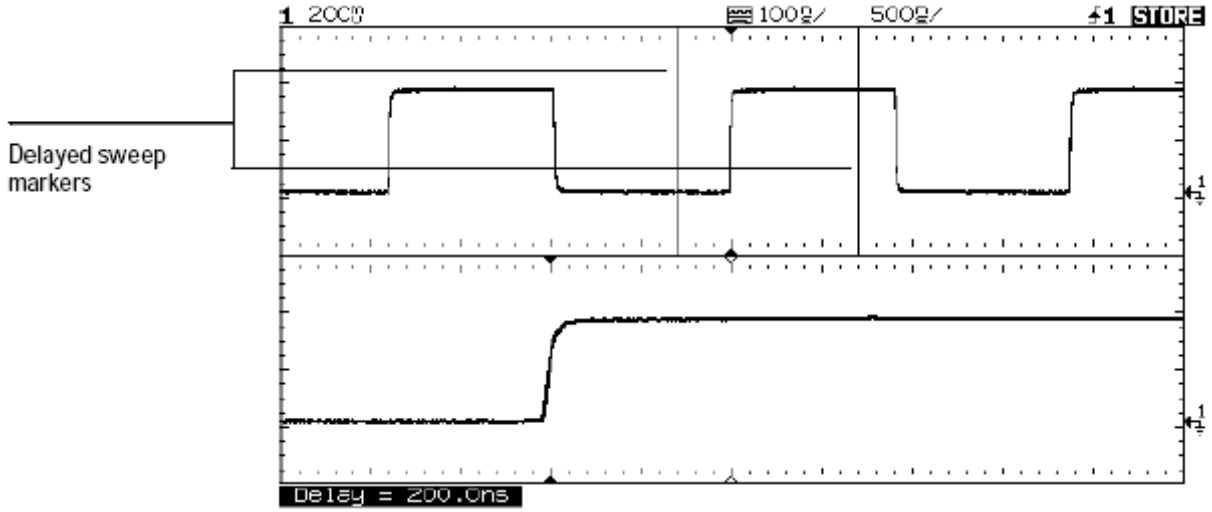
The figure below shows the time reference set to left.

e operation is like the delayed sweep of an analog oscilloscope, where the delay time defines the start of the delayed sweep.



Time reference set to left

figure below shows the time reference set to center. Notice that the markers expand around the area of interest. You can place the markers over the area of interest with the delay knob, then expand the delayed sweep with the time base knob to increase the resolution.



Time reference set to center

Storage oscilloscope operation

There are four front-panel storage keys. They are white instant action keys that change the operating mode of the oscilloscope. The following steps demonstrate how to use these storage keys.

1. Connect a signal to the oscilloscope and obtain a stable display.
2. Press **[Autostore]**.

   NOTE: Notice that *STORE* replaces *RUN* in the status line. For easy viewing, the stored waveform is displayed in half bright and the most recent trace is displayed in full bright. Autostore is useful in a number of applications.

   - Displaying the worst-case extremes of varying waveforms
   - Capturing and storing a waveform
   - Measuring noise and jitter
   - Capturing events that occur infrequently

3. Using the position knob in the Vertical section of the front panel, move the trace up and down about one division.

   NOTE: Notice that the last acquired waveform is in full bright and the previously acquired waveforms are displayed in half bright.

   - To characterize the waveforms, use the cursors. See "To make cursor measurements".
   - To clear the display, press **[Erase]**.

- To exit the **[Autostore]** mode, press either **[Run]** or **[Autostore]**.

NOTE:

[*Run*] – The oscilloscope acquires data and displays the most recent trace.
[*Stop*] – The display is frozen.
[*Autostore*] – The oscilloscope acquires data, displaying the most recent trace in full bright and previously acquired waveforms in half bright.
[*Erase*] – Clears the display.

Capture a single event

To capture a single event, you need some knowledge of the signal in order to set up the trigger level and slope. For example, if the event is derived from TTL logic, a trigger level of 2 volts should work on a rising edge. The following steps show you how to use the oscilloscope to capture a single event.

1. Connect a signal to the oscilloscope.
2. Set up the trigger.
    - Press **[Source]**. Select a trigger source with the softkeys.
    - Press **[Slope/Coupling]**. Select a trigger slope with the softkeys.
    - Turn the **Level** knob to a point where you think the trigger should work.
3. Press **[Mode]**, then press the Single softkey.
4. Press **[Erase]** to clear previous measurements from the display.

5. Press **[Run]**.

NOTE: Pressing the **[Run]** key arms the trigger circuit. When the trigger conditions are met, data appears on the display representing the data points that the oscilloscope obtained with one acquisition. Pressing the **[Run]** key again rearms the trigger circuit and erases the display.

6. If you need to compare several single-shot events, press **[Autostore]**.

Like the **[Run]** key, the **[Autostore]** key also arms the trigger circuit. When the trigger conditions are met, the oscilloscope triggers. Pressing the **[Autostore]** key again rearms the trigger circuit without erasing the display. All the data points are retained on the display in half bright with each trigger allowing you to easily compare a series of single-shot events.

After acquiring a single-shot event, pressing a **[ ]** front-panel key, **( )** softkey, or changing a knob can erase the event from the display. If you press the **[Stop]** key, the oscilloscope will recover the event and restore the oscilloscope settings.

- To clear the display, press **[Erase]**.
- To exit the Autostore mode, press either **[Run]** or Autostore . Notice that ***RUN*** replaces ***STORE*** in the status line, indicating that the oscilloscope has exited the Autostore mode.

Capture glitches or narrow pulses

A glitch is a rapid change in the waveform that is usually narrow as compared to the waveform. This oscilloscope has two modes of operation that you can use for glitch capture: peak detect and Autostore.

1. Connect a signal to the oscilloscope and obtain a stable display.
2. Find the glitch.
   Use peak detect for narrow pulses or glitches that require sweep speeds slower than 50 ms/div.
   - To select peak detect, press Display . Next, press the(Peak Det) softkey.

NOTE: Peak detect operates at sweep speeds from 5s/div to 50 ms/div. When operating, the initials ***Pk*** are displayed in the status line in inverse video. At sweep speeds faster than 50 ms/div, the ***Pk*** initials are displayed in normal video, which indicates that peak detect is not operating.

Use Autostore for the following cases: waveforms that are changing, waveforms that you want to view and compare with stored waveforms, and narrow pulses or glitches that occur infrequently but require the use of sweep speeds outside the range of peak detect.

- Press **[Autostore]**.

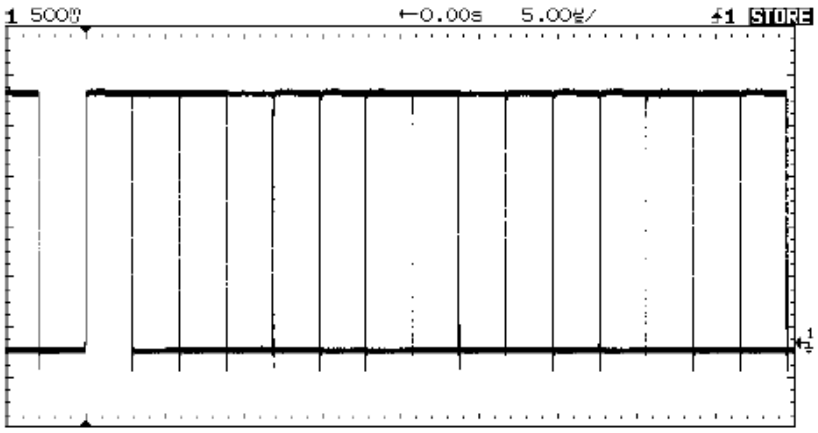
You can use peak detect and Autostore together. Peak detect captures the glitch, while Autostore retains the glitch on the display in half bright video.

3. Characterize the glitch with delayed sweep.
   Peak detect functions in the main sweep only, not in the delayed sweep. To characterize the glitch with delayed sweep follow these steps.
   - Press **[Main/Delayed]**. Next press the **(Delayed)** softkey.
   - To obtain a better resolution of the glitch, expand the time base.
   - To set the expanded portion of the main sweep over the glitch, use the **Delay** knob.
   - To characterize the glitch, use the cursors or the automatic measurement capabilities of the oscilloscope.

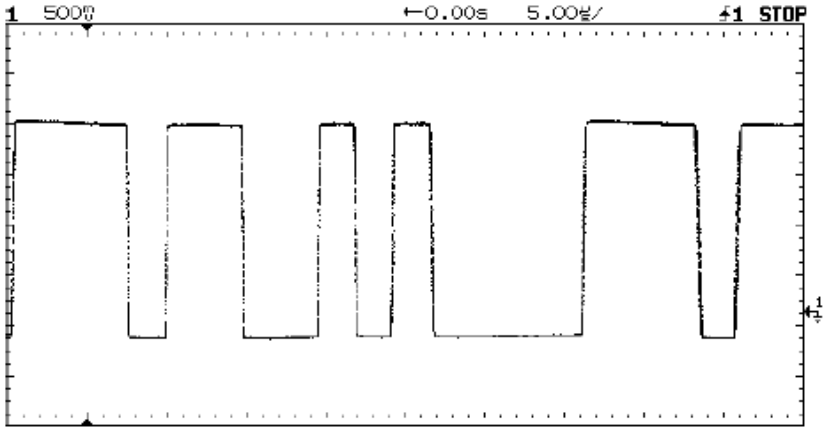
Trigger on a complex waveform

The difficulty in viewing a complex waveform is triggering on the signal.
The simplest trigger method is to trigger the oscilloscope on a sync pulse that is associated with the waveform. If there is no sync pulse, use the following procedure to trigger on a periodic complex waveform.

1. Connect a signal to the oscilloscope.
2. Set the trigger level to the middle of the waveform.
3. Adjust the **Holdoff** knob to synchronize the trigger of the oscilloscope with the complex waveform.



Stable trigger, but the waveform is not synchronized with the trigger



Holdoff synchronizes the waveform with the trigger

Automatic frequency measurements

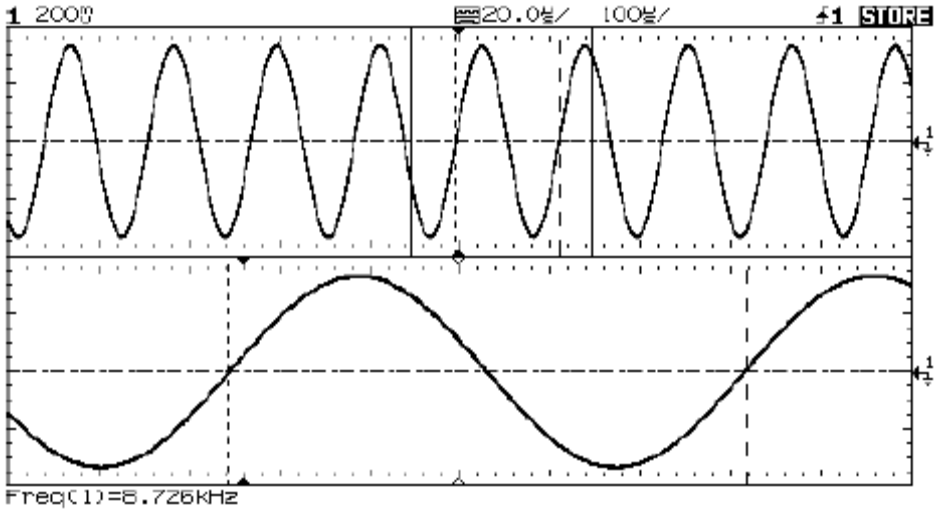
The automatic measurement capability of the oscilloscope makes frequency measurements easy, as the following steps demonstrate.

1. Connect a signal to the oscilloscope and obtain a stable display.
2. Press **[Time]**.
   A softkey menu appears with six softkey choices.
3. Toggle the **(Source)** softkey to select a channel 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) is the number of the channel that the oscilloscope used for the measurement. The oscilloscope retains in memory and displays the three most current measurement results. If you make a fourth measurement, the left-most result is dropped.

NOTE: If the Show **(Meas)** softkey is turned on, cursors are displayed on the waveform that show the measurement points for the right-most measurement result. If you select more than one measurement, you can show a previous measurement by reselecting the measurement.

- To find the Show **(Meas)** softkey, press the **(Next Menu)** softkey.

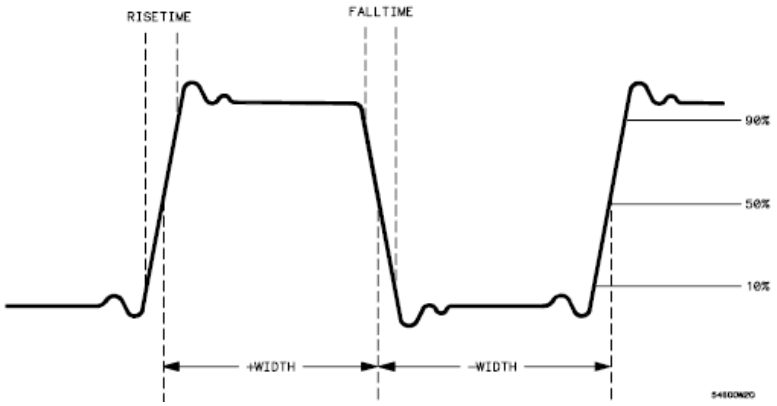
The oscilloscope makes automatic measurements on the first displayed event. The below figure shows how to use delayed sweep to isolate an event for a frequency measurement. If the measurement is not possible in the delayed time base mode, then the main time base is used. If the waveform is clipped, it may not be possible to make the measurement.



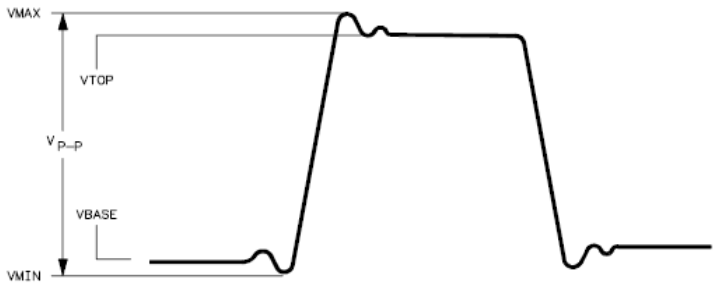
Delayed time base isolates an event for a frequency measurement

Automatic time measurements

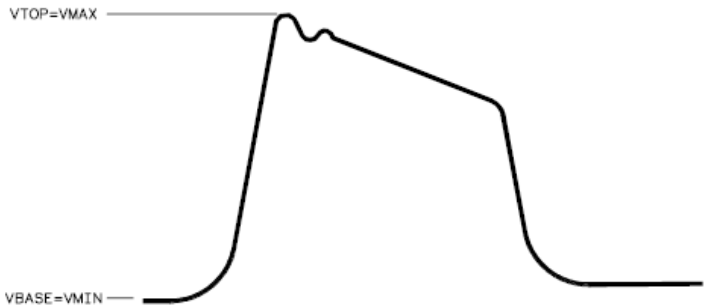
You can measure the following time parameters with the oscilloscope: frequency, period, duty cycle, width, rise time, and fall time. The following exercise guides you through the Time keys by making a rise time measurement. The below figure shows a pulse with some of the time measurement points.



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. These levels are shown on below.

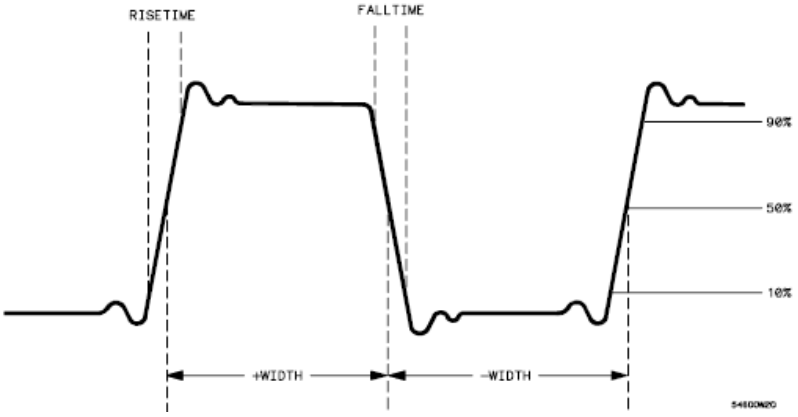


Pulse where the top and bottom are well-defined



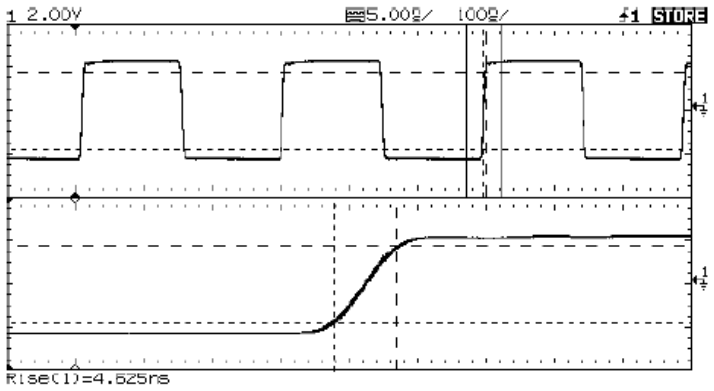
Pulse where the top and bottom are not well-defined

2. Press **[Time]**.
   A softkey menu appears with six softkey choices. Three of the softkeys are time measurement functions.
   (Source) Selects a channel for the time measurement.
   (Time Measurements) Three time measurement choices are available: **(Freq)** frequency, **(Period)**, and **(Duty Cy)** 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) Replaces the softkey menu with six additional softkey choices.

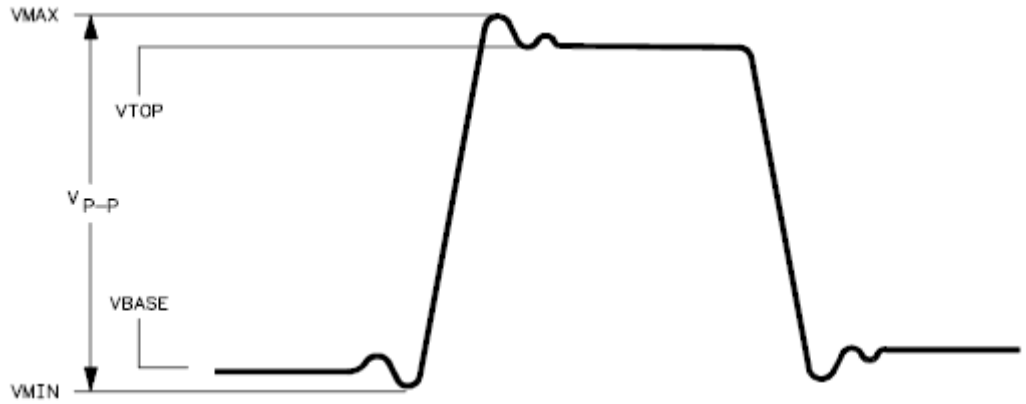
3. Press the **(Next Menu)** softkey.
   Another time measurement softkey menu appears with six additional choices.
   Four of the softkeys are time measurement functions.
   (Show Meas), show measurement, displays the horizontal and vertical cursors where the measurement was taken.
   (Time Measurements) Four additional time measurement choices are available; **(+Width)**, Pulse Width **(-Width)**, **(Rise Time)**, and **(Fall Time)**.
   Width measurements are made at the 50% levels, whereas rise time and fall time measurements are made at the 10% to 90% levels.
   (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.
   The oscilloscope makes automatic measurements on the first displayed event. The figure below shows how to use delayed sweep to isolate an edge for a rise time measurement.



Delayed sweep isolates a leading edge for a rise time measurement

Automatic voltage measurements

You can measure the following voltage parameters automatically with the oscilloscope: ***peak-to-peak***, ***average***, ***rms***, ***maximum***, ***minimum***, ***top***, and ***base***.
The following exercise guides you through the Voltage keys by making an rms voltage measurement.The figures below show pulses with some of the voltage measurement points.

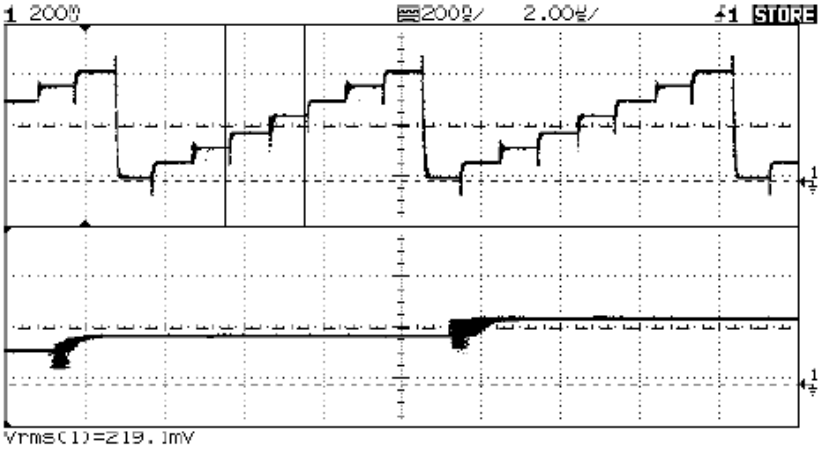


Pulse where the top and bottom are well-defined

Pulse where the top and bottom are not well-defined

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

2. Press **[Voltage]**.
   A softkey menu appears with six softkey choices. Three of the softkeys are voltage measurement functions.
   (Source) Selects a channel for the voltage measurement.
   (Voltage Measurements) Three voltage measurement choices are available: **(Vp-p)**, **(Vavg)**, and **(Vrms)**. The 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) Replaces the softkey menu with six additional softkey choices.
3. Press the **(Vrms)** softkey.
   The oscilloscope automatically measures the *rms voltage* and displays the result on the display.
   The oscilloscope makes automatic measurements on the first pulse or period in the display. Below figure shows how to use delayed sweep to isolate a pulse for an rms measurement.



Delayed sweep isolates an area of interest for an rms voltage measurement

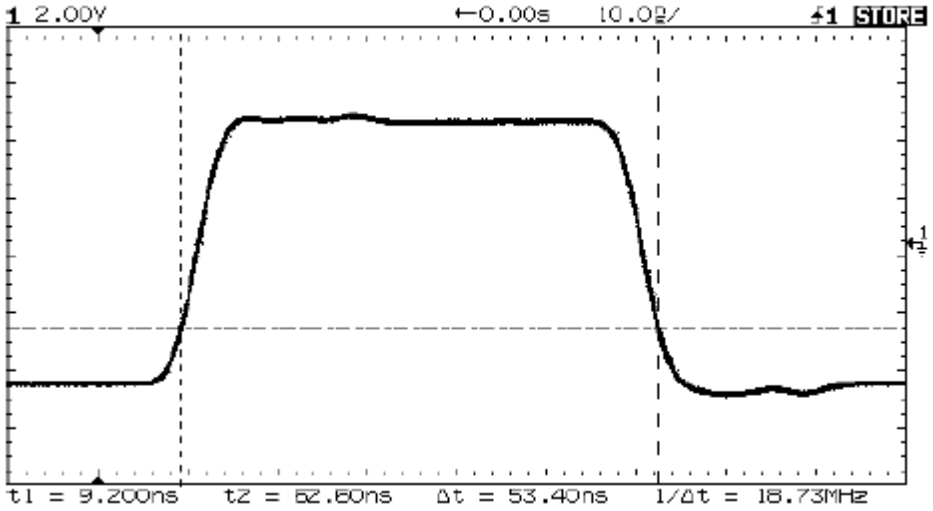
4. Press the **(Next Menu)** softkey.
   Another voltage measurement softkey menu appears with six additional choices. Four of the softkeys are voltage measurement functions.
   (Show Meas) show measurement displays the horizontal and vertical cursors that show where the measurement was taken on the signal.
   (Voltage Measurements) Four additional voltage measurement choices are available: **(Vmax)**, **(Vmin)**, **(Vtop)**, **(Vbase)**.
   (Previous Menu) Returns to the previous softkey menu.

Cursor measurements

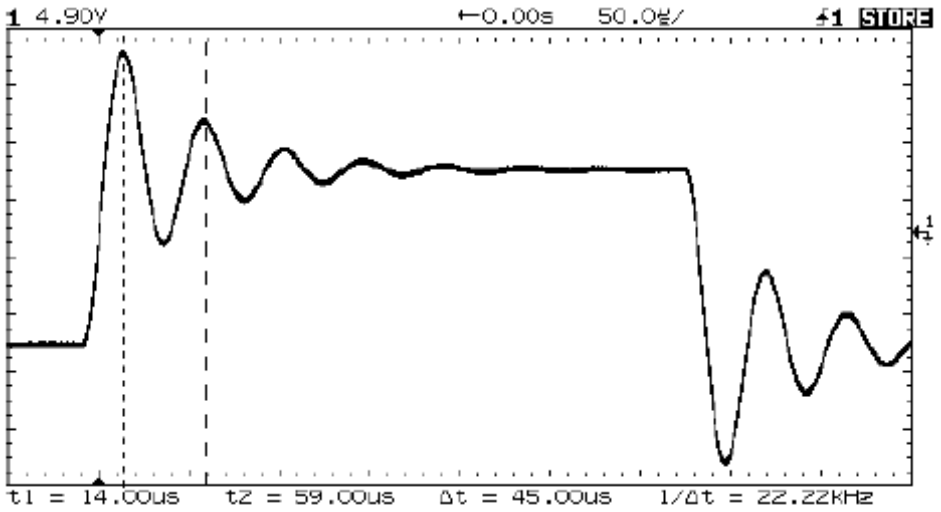
The following steps guide you through the front-panel Cursors key. You can use the cursors to make custom voltage or time measurements on the signal.
Examples of custom measurements include rise time measurements from reference levels other than 10-90%, frequency and width measurements from levels other than 50%, channel-to-channel delay measurements, and voltage measurements. See below figures for examples of custom measurements.

1. Connect a signal to the oscilloscope and obtain a stable display.
2. Press **[Cursors]**.
   A softkey menu appears with six softkey choices. Four of the softkeys are cursor functions.
   (Source) Selects a channel for the voltage cursor measurements.
   (Active Cursor) There are four cursor choices: **(V1)**, and **(V2)** are voltage cursors, while **(t1)**, and **(t2)** are time cursors. Use the knob below the [Cursors] key to move the cursors. When you press the (V1) and **(V2)** softkeys simultaneously or the **(t1)** and **(t2)** softkeys simultaneously, the cursors move together.
   (Clear Cursors) Erases the cursor readings and removes the cursors from the display.

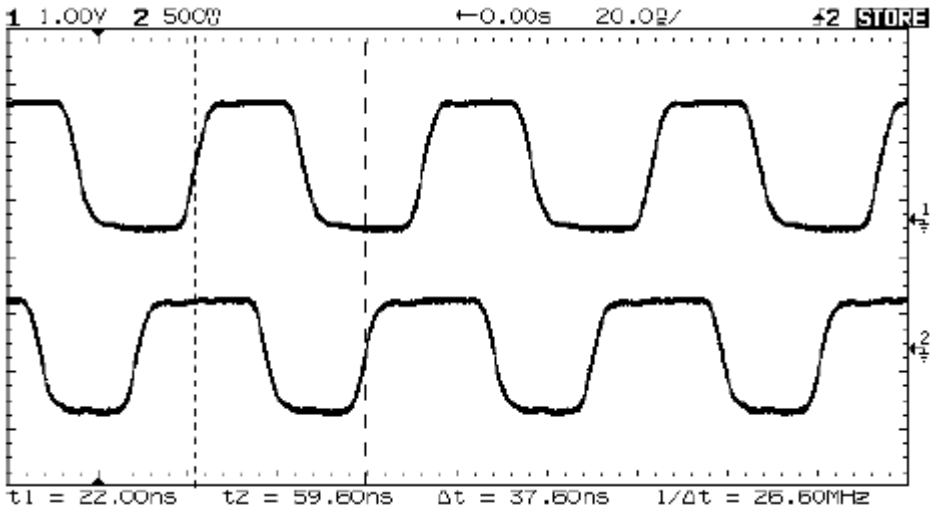
See the below diagrams for examples for cursor use.



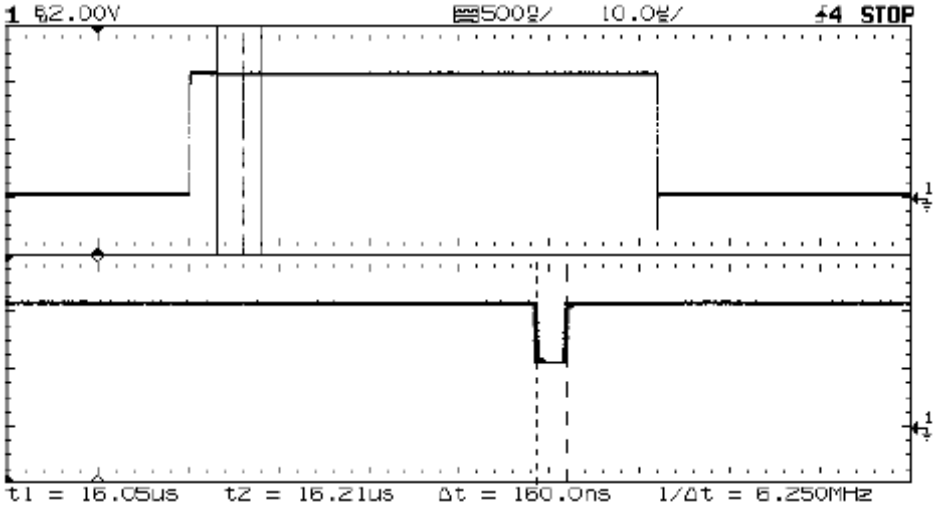
Cursors used to measure pulse width at levels other then the 50% points



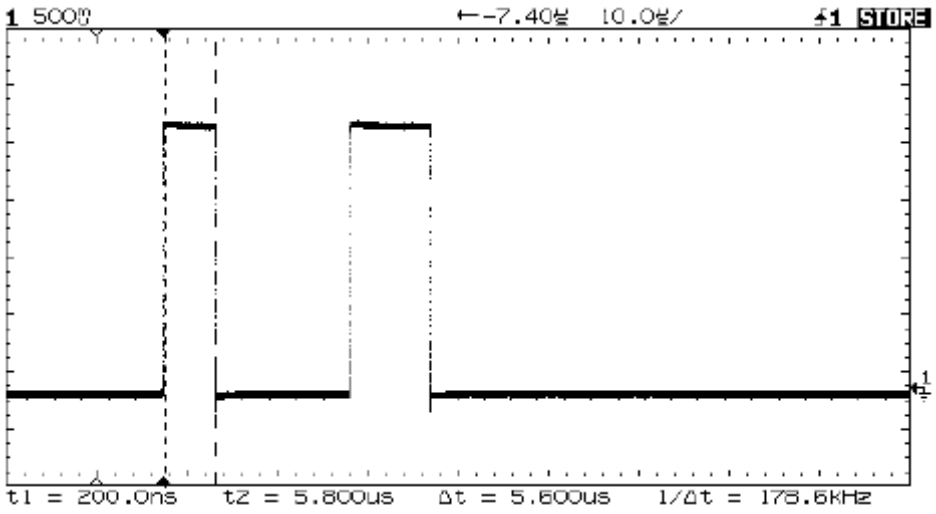
Cursors used to measure the frequency of the ringing on a pulse



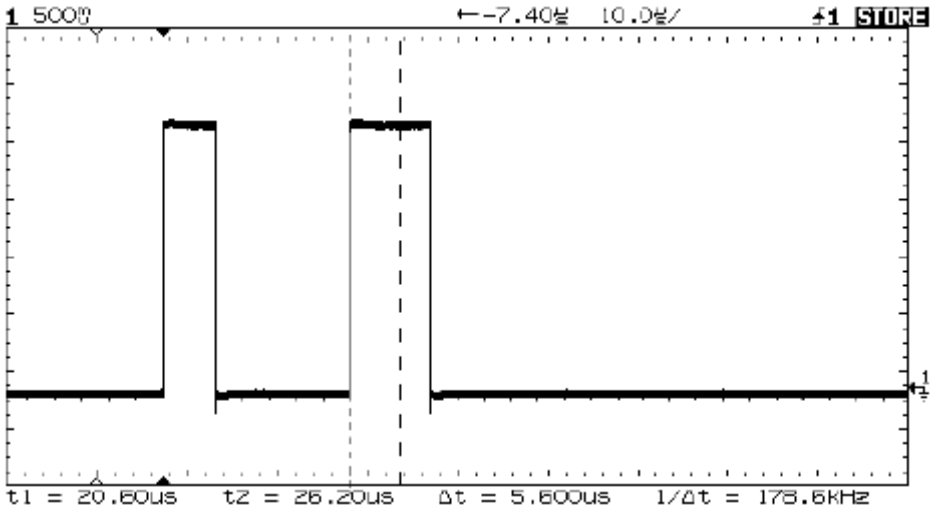
Cursors used to make channel-to-channel delay measurements



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



Pressing **(t1)** and **(t2)** softkeys simultaneously causes the cursors to move together when the cursor knob is adjusted.

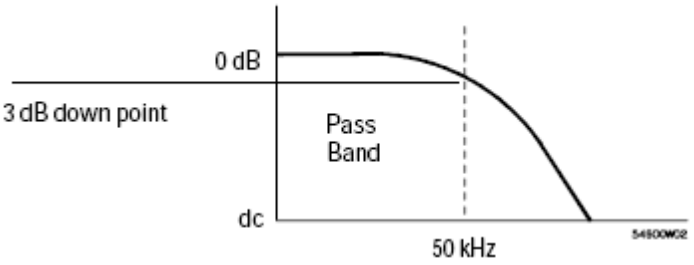


By moving the cursors together, you can check for pulse width variations in a pulse train.

Reduce the random noise on a signal

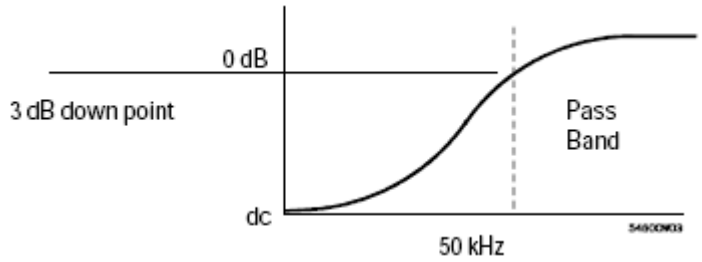
If the signal you are applying to the oscilloscope is noisy, you can set up the oscilloscope to reduce the noise on the waveform. First, you stabilize the displayed waveform by removing the noise from the trigger path. Second, you reduce the noise on the displayed waveform.

1. Connect a signal to the oscilloscope and obtain a stable display.
2. Remove the noise from the trigger path by turning on either high frequency reject or noise reject.
   High frequency reject **(HF Reject)** adds a low pass filter with the 3 dB point at 50 kHz. You use HF reject to remove high frequency noise such as AM or FM broadcast stations from the trigger path.



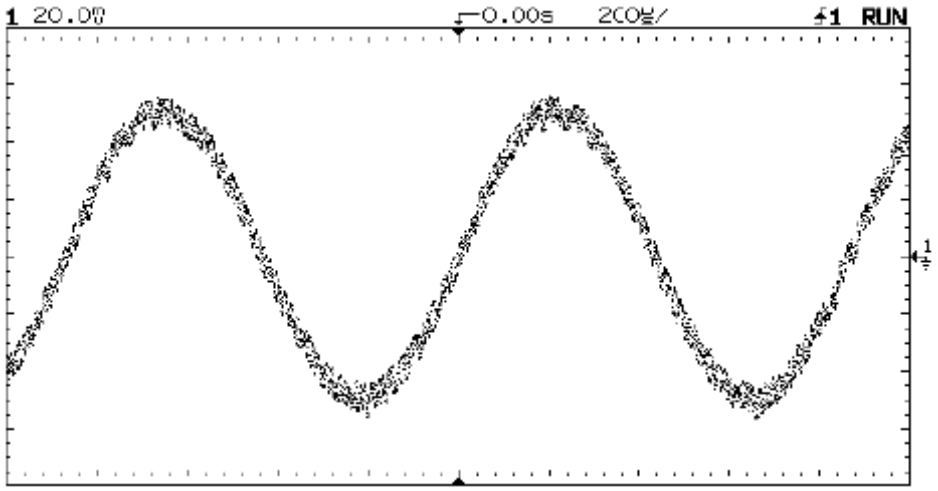
HF reject

Low frequency reject (LF Reject) adds a high pass filter with the 3-dB point at 50 kHz. Use LF reject to remove low frequency signals such as power line noise from the trigger path.



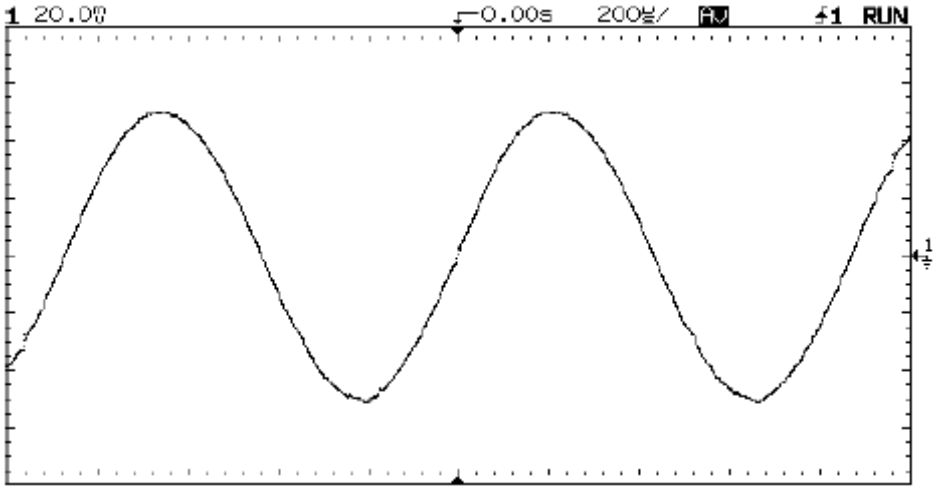
LF reject

Noise reject increases the trigger hysteresis band. By increasing the trigger hysteresis band you reduce the possibility of triggering on noise. However, this also decreases the trigger sensitivity so that a slightly larger signal is required to trigger the oscilloscope.



Random noise on the displayed waveform

3. Use averaging to reduce noise on the displayed waveform.
   To use averaging follow these steps.
   - Press **[Display]**, the press the **(Average)** softkey. Notice that *Av* appears in the status line.
   - Toggle the **(# Average)** softkey to select the number of averages that best eliminates the noise from the displayed waveform.
     The *Av* letters in the status line indicate how much of the averaging process is finished by turning to inverse video as the oscilloscope performs averaging.
     NOTE: The higher the number of averages, the more noise that is removed from the display. However, the higher the number of averages, the slower the displayed waveform responds to waveform changes. You need to choose between how quickly the waveform responds to changes and how much noise there is on the signal.



On this waveform, 256 averages were used to reduce the noise

Save or recall traces

The oscilloscope has two pixel memories for storing waveforms. The following exercise guides you through how to store and recall waveforms from pixel memories.

1. Connect a signal to the oscilloscope and obtain a stable display.
2. Press **[Trace]**.
   A softkey menu appears with five softkey selections. Four of the softkeys are trace memory functions.
   (Trace) Selects memory 1 or memory 2.
   (Trace Mem) Turns on or off the selected memory.
   (Save to) Saves the waveform to the selected memory.

   NOTE: The front-panel setup is saved to a separate memory location.
   (Clear) Erases the selected memory.
   (Recall Setup) Recalls the front-panel setup that was saved with the waveform.
3. Toggle the **(Trace)** softkey to select memory 1 or memory 2
4. Press the **(Save to)** softkey.
   The current display is copied to the selected memory.
5. Turn on the **(Trace Mem)** softkey to view the stored waveform.
   The trace is copied from the selected trace memory and is displayed in half bright video.

Save or recall front-panel setups

There are 16 memories for storing front-panel setups. Saving front-panel setups can save you time in situations where several setups are repeated many times.

1. Press **[Setup]**.
2. To change the selected memory location, press either the left-most softkey or turn the knob closest to the Cursors key.
3. Press the **(Save)** softkey to save a front-panel setup, then press the **(Recall)** softkey to recall a front-panel setup.