# DSO1002A

# Oscilloscope Operating Instructions

Created by Tom Labarr

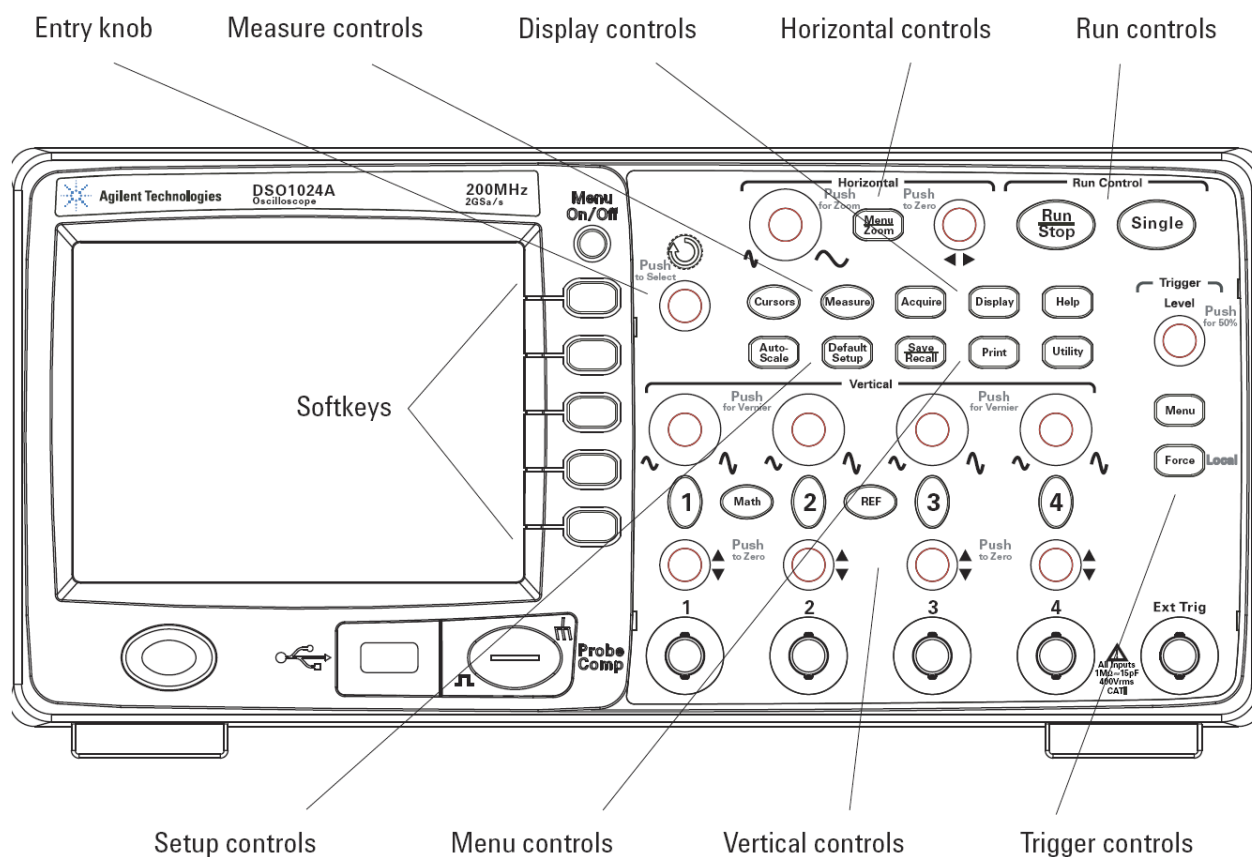# DSO1002A Oscilloscope Operating Instructions

**This pamphlet is intended to give you (the student) an overview on the use of the DSO1002A 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.**

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# Front Panel Controls

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

The front panel has knobs, keys, and softkeys. Knobs are used most often to make adjustments. Keys are used for run controls and to change other oscilloscope settings via menus and softkeys.
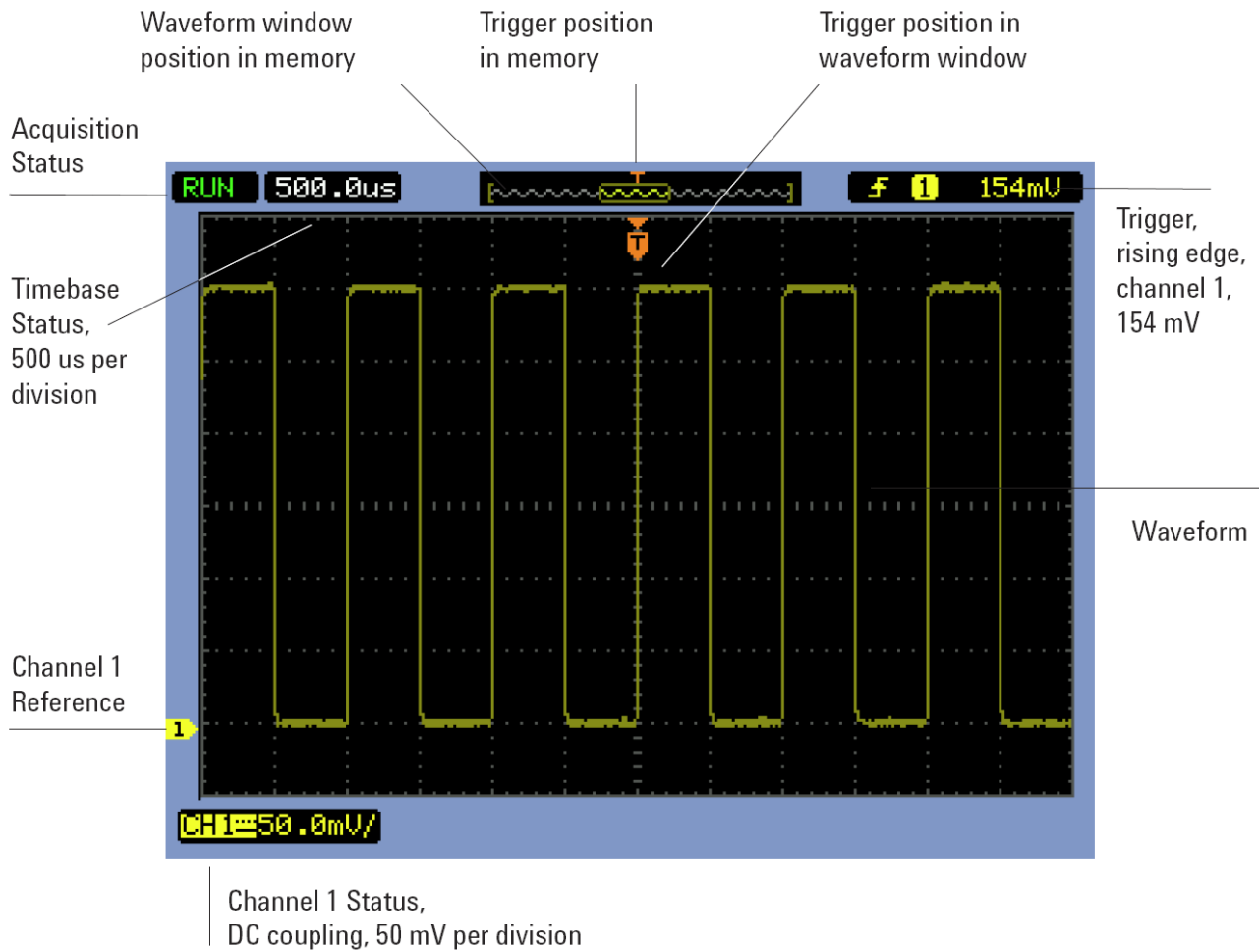


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| | |
|---|---|
| ***Measure controls*** | **[Measure]** and **[Cursors]** front panel keys. |
| ***Waveform controls*** | **[Acquire]** and **[Display]** front panel keys. |
| ***Menu controls*** | **[Save/Recall]** and **[Utility]** front panel keys. |
| ***Vertical controls*** | ↻**Vertical position** knobs, ↻**Vertical scale** knobs, channel (**[1]**, **[2]**) **[Math]**, and **[REF]** front panel keys. |
| ***Horizontal controls*** | ↻**Position** knob, **[Menu/Zoom]** front panel key, and scale knob. |
| ***Trigger controls*** | Trigger **[Level]** knob, **[Menu]**, and **[Force]** front panel keys. |
| ***Run controls*** | **[Run/Stop]** and **[Single]** front panel keys. |
| ***Setup controls*** | **[Auto-Scale]** and **[Default Setup]** front panel keys. |
| ***Softkeys*** | Five gray keys from top to bottom on the right-hand side of the screen, which select the adjacent menu items in the currently displayed menu. |
| ↻ ***entry knob*** | For the adjustment defined controls. |

# Softkey Menus
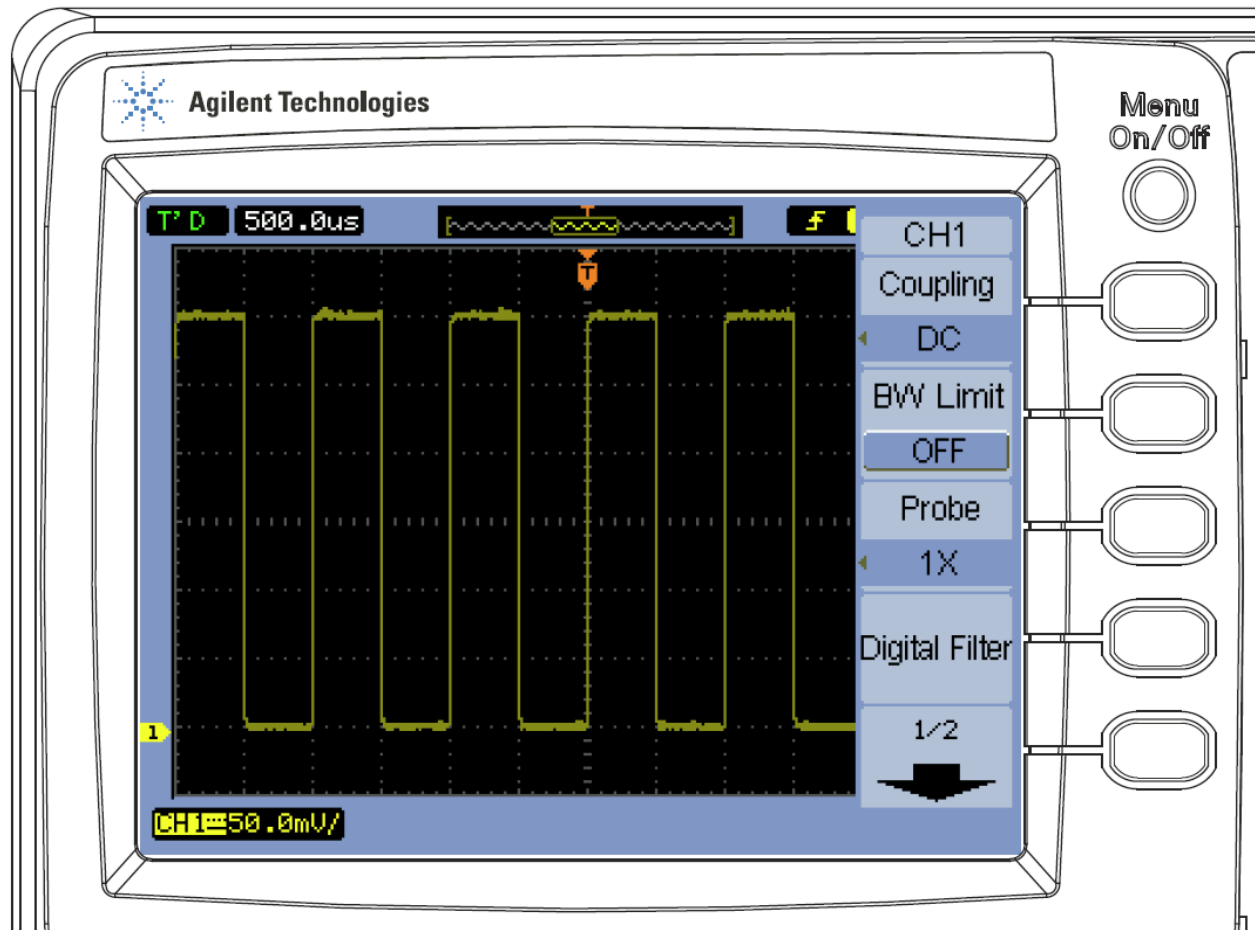


Channel – **CH1** or **CH2**
Coupling – **AC** or **DC**
BW Limit – **ON** or **OFF**
Probe – **1X** or **10X** or **100X**
Digital Filter **LPF** or **HPF** or **BPF** or **BRF**
1/2 – **Page Access**

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# Oscilloscope display

Waveform window
position in memory

Trigger position
in memory

Trigger position in
waveform window

Acquisition
Status

`RUN` `500.0us` `F 1 154mV`

Trigger,
rising edge,
channel 1,
154 mV

Timebase
Status,
500 us per
division

Waveform

Channel 1
Reference

`CH1 50.0mV/`

Channel 1 Status,
DC coupling, 50 mV per division

# Run Control keys

There are two front panel keys for starting and stopping the oscilloscope's acquisition system: **[Run/Stop]** and **[Single]**.
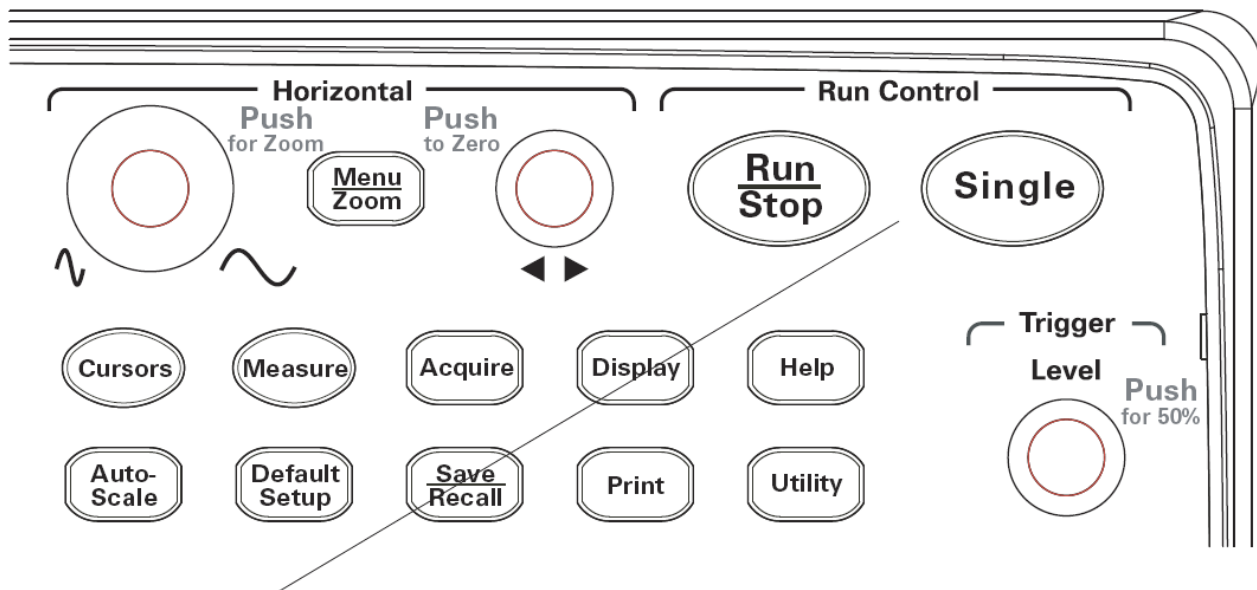


Run Control Keys

- When the **[Run/Stop]** key is *green*, the oscilloscope is acquiring data. To stop acquiring data, press **[Run/Stop]**. When stopped, the last acquired waveform is displayed.
- When the **[Run/Stop]** key is *red*, data acquisition is stopped. To start acquiring data, press **[Run/Stop]**.
- To capture and display a single acquisition (whether the oscilloscope is running or stopped), press **[Single]**. After capturing and displaying a single acquisition, the **[Run/Stop]** key is *red*.

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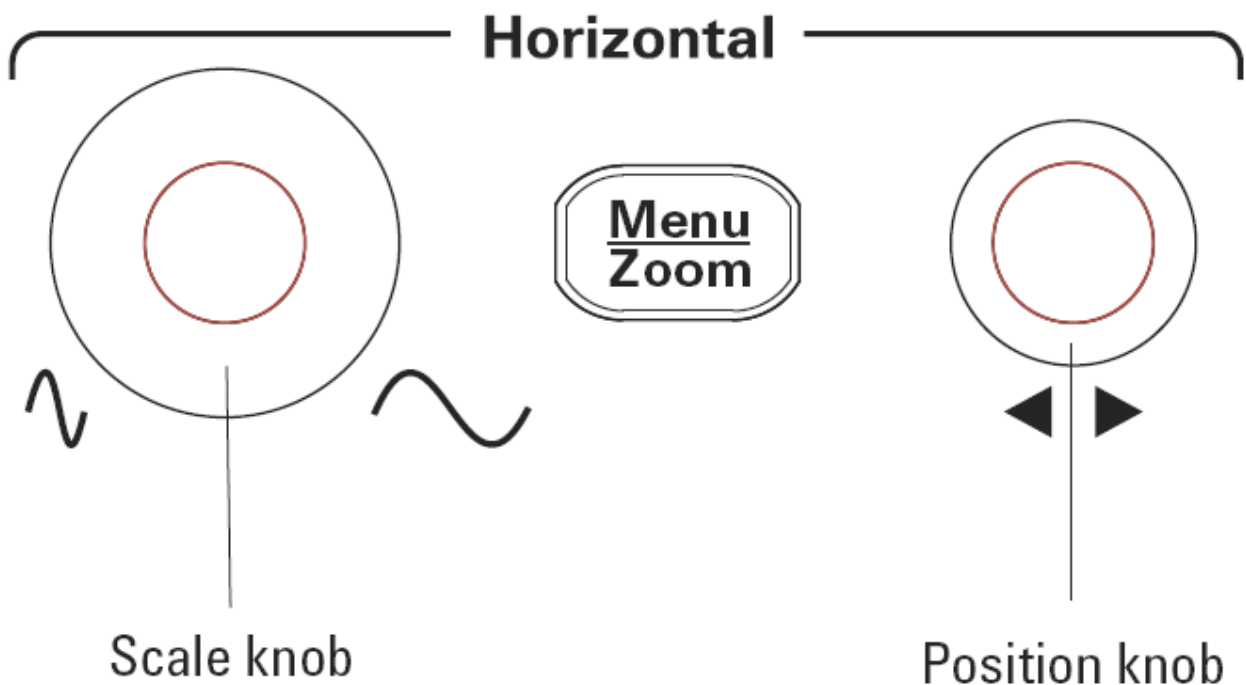
# Access built-in help
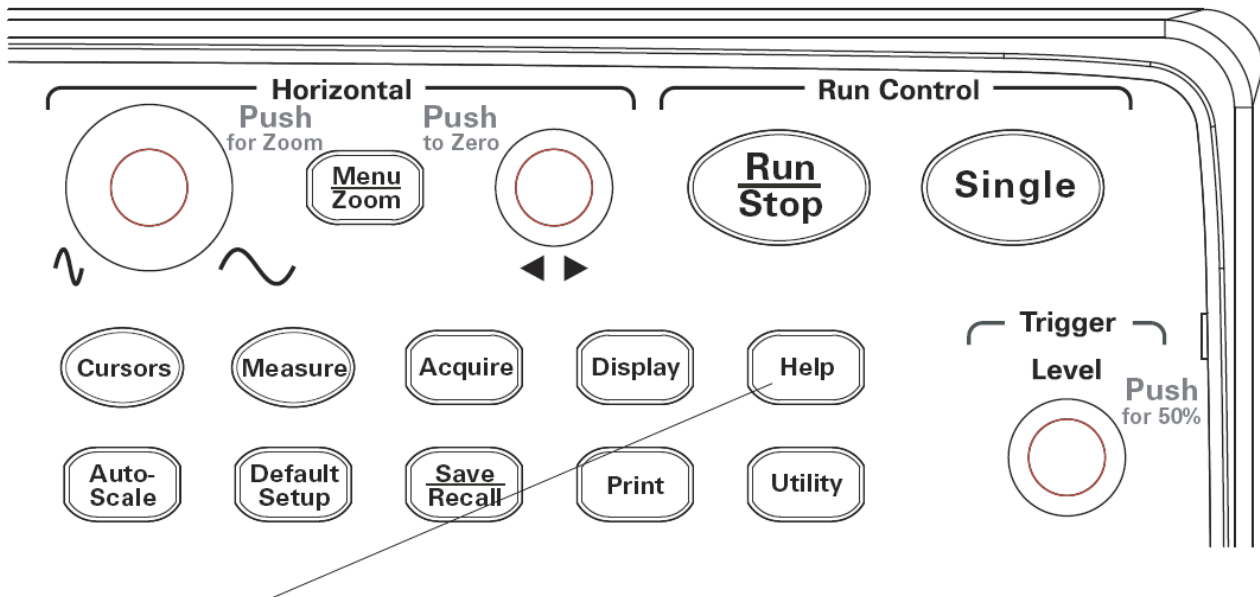


[Help] Key

The oscilloscope has built-in quick help information.
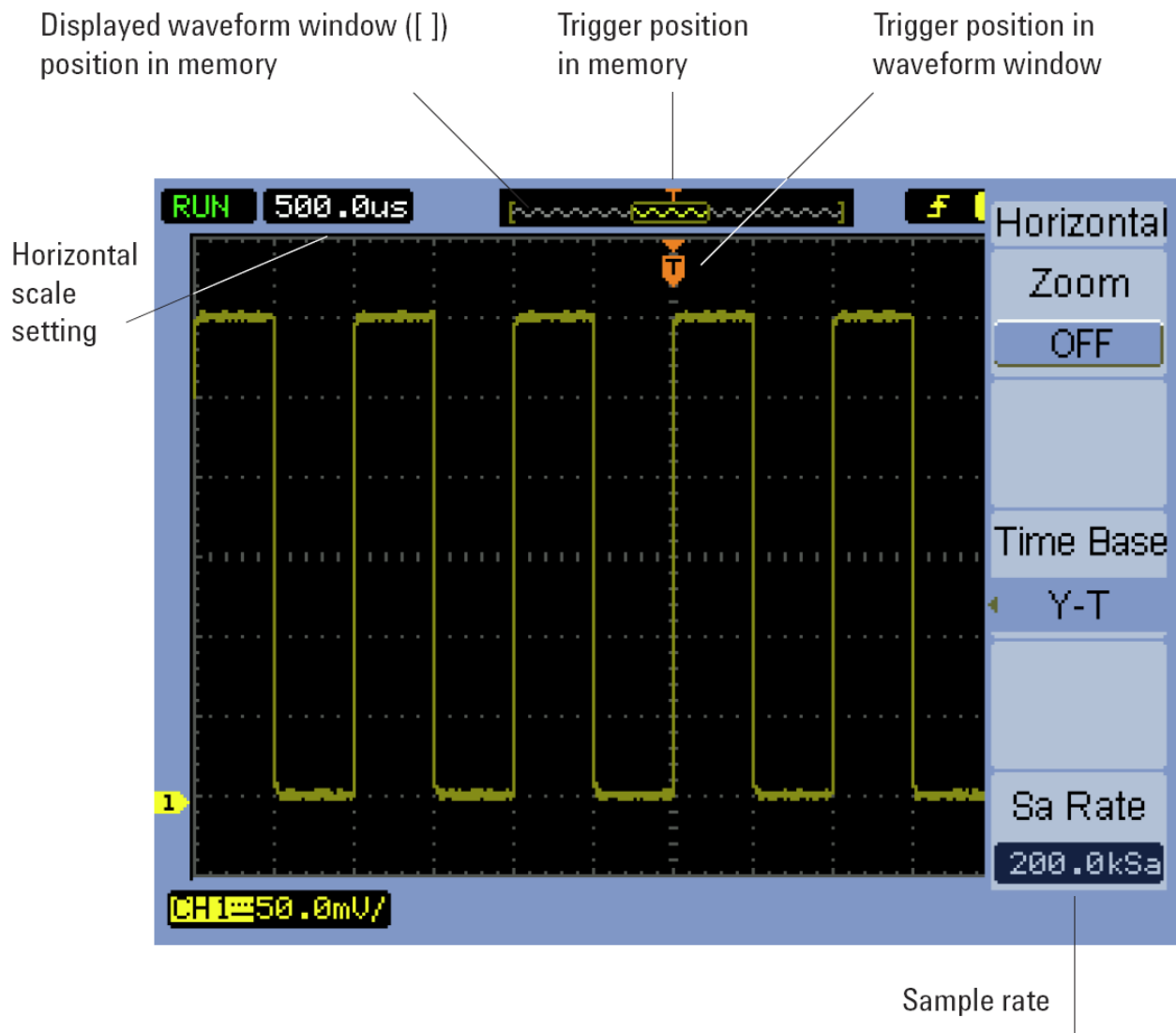To access the built-in help:

**1.** Press the **[Help]** front panel key.

**2.** Press the front panel key, softkey, or pushable ↻knob on which you would like quick help information.

# Horizontal Controls

The horizontal controls consist of:
- The ↻**horizontal scale** knob — changes the oscilloscope's time per division setting using the center of the screen as a reference.
- The ↻**horizontal position** knob — changes the position of the trigger point relative to the center of the screen.
- The **[Menu/Zoom]** key — displays the Horizontal menu which lets you display the zoomed (delayed) time base, change the time base mode, and display the sample rate.



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Displayed waveform window ([ ]) position in memory

Trigger position in memory

Trigger position in waveform window

Horizontal scale setting

Sample rate

- Turn the ↻**horizontal scale** knob to change the horizontal time per division (time/div) setting.
- Push the ↻**horizontal scale** knob to toggle between the zoomed time base and the normal time base display
- Turn the ↻**horizontal position** knob to change the position of the trigger point relative to the center of the screen.
- The ↻ **horizontal position** knob adjusts the horizontal position of all channels, math functions, and reference waveforms.

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# Display zoomed time base

The zoomed time base (also known as delayed sweep time base), magnifies a portion of the original waveform display (now on the top half of the screen) and displays it in a zoomed time base on the bottom half of the screen.

1. To toggle the zoomed time base "ON" or "OFF", either push the ↻**horizontal scale** knob or press **[Menu/Zoom]** key followed by the **Zoom** softkey in the Horizontal menu.
2. When the zoomed time base is "ON":
   - The top half of the display shows the original waveform and the portion being magnified.
   - The ↻**horizontal scale** knob changes the magnification (widens or narrows the area of magnification).
   - The ↻**horizontal position** knob moves the area of magnification forward and backward on the original waveform.
   - The bottom half of the display shows the magnified data in the zoomed time base.



Zoomed window

Zoomed window view

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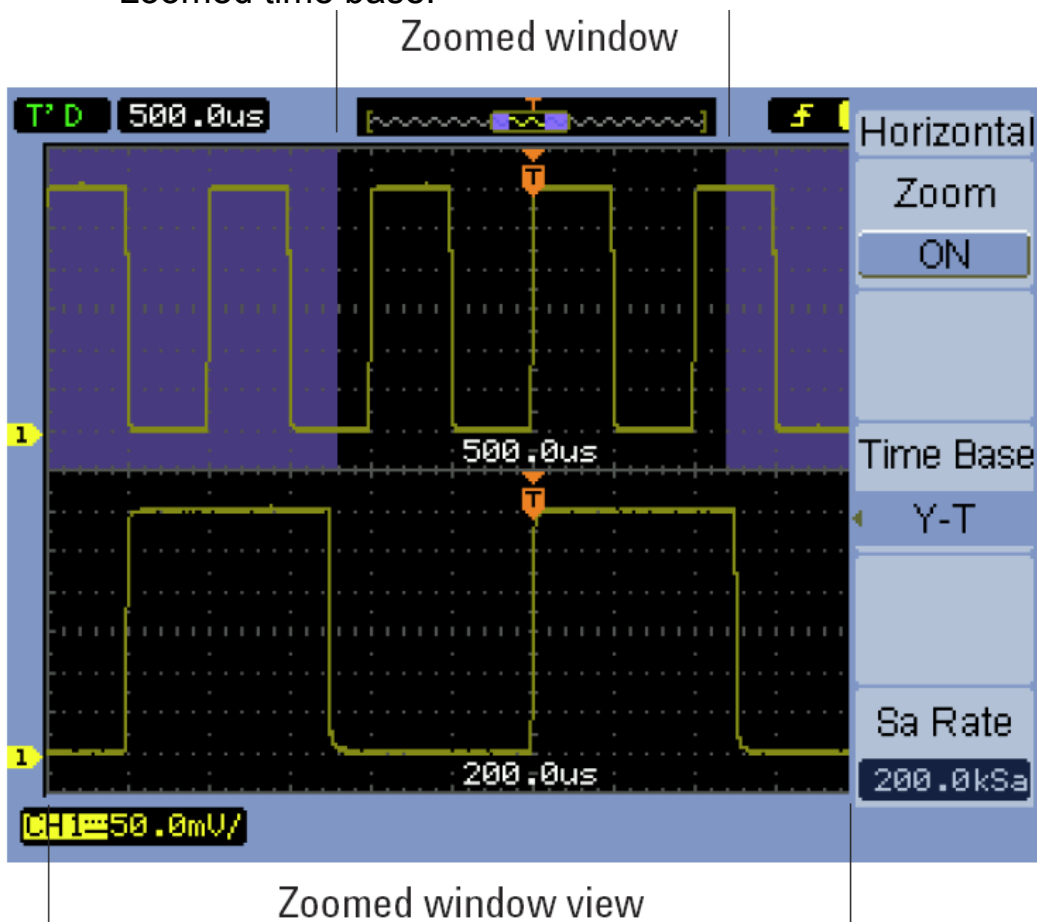
# Vertical Controls

The vertical controls consist of:

- The channel (**[1]** and **[2]**), **[Math]**, and **[REF]** front panel keys — turn waveforms on or off (and display or hide their menus). Note: we have no channel 3 or 4
- The ↻**vertical scale** knobs — change the amplitude per division setting for a waveform, using either ground or the center of the screen as a reference.
- The ↻**vertical position** knobs — change the vertical position of the waveform on the screen.
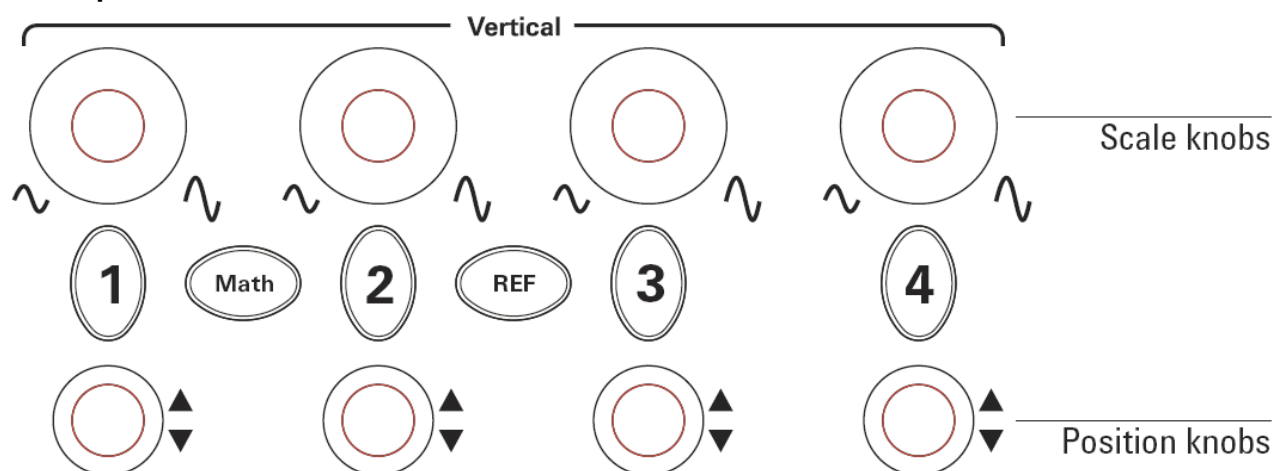


Pressing the channel (**[1] or [2]**, **[Math]**, and **[REF]** front panel keys have the following effect:

- If the waveform is off, the waveform is turned on and its menu is displayed.
- If the waveform is on and its menu is not displayed, its menu will be displayed.
- If the waveform is on and its menu is displayed, the waveform is turned off and its menu goes away.

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# Vertical scale

When an input channel waveform is on:

Turn its ↻**vertical scale** knob to change the amplitude per division setting.

- The amplitude/div setting changes in a 1- 2- 5 step sequence from 2 mV/div to 5 V/div (with "1X" probe attenuation).
Either ground or the center of the screen is used as a reference, depending on the "Expand Reference" preference setting. The "center of screen" reference is not available for math function or reference waveforms.

- Push its ↻**vertical scale** knob to toggle between vernier (fine scale) adjustment and normal adjustment.
With vernier adjustment, the amplitude/div setting changes in small steps between the normal (coarse scale) settings.
The **Volts/Div** item in a channel's menu also toggles between vernier and normal adjustment.
Vernier adjustment is not available for math function or reference waveforms.

The amplitude/div setting is displayed in the status bar at the bottom of the screen.

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# Vertical position

Adjusting their vertical position lets you compare waveforms by aligning them above one another or on top of each other.

When an input channel waveform is on:
- Turn the ↻**vertical position** knob to change the vertical position of the waveform on the screen.
  **Notice** that the ground reference symbol on the left side of the display moves with the waveform.
- Push the ↻**vertical position** knob to "zero" the ground reference (move it to the center of the screen).
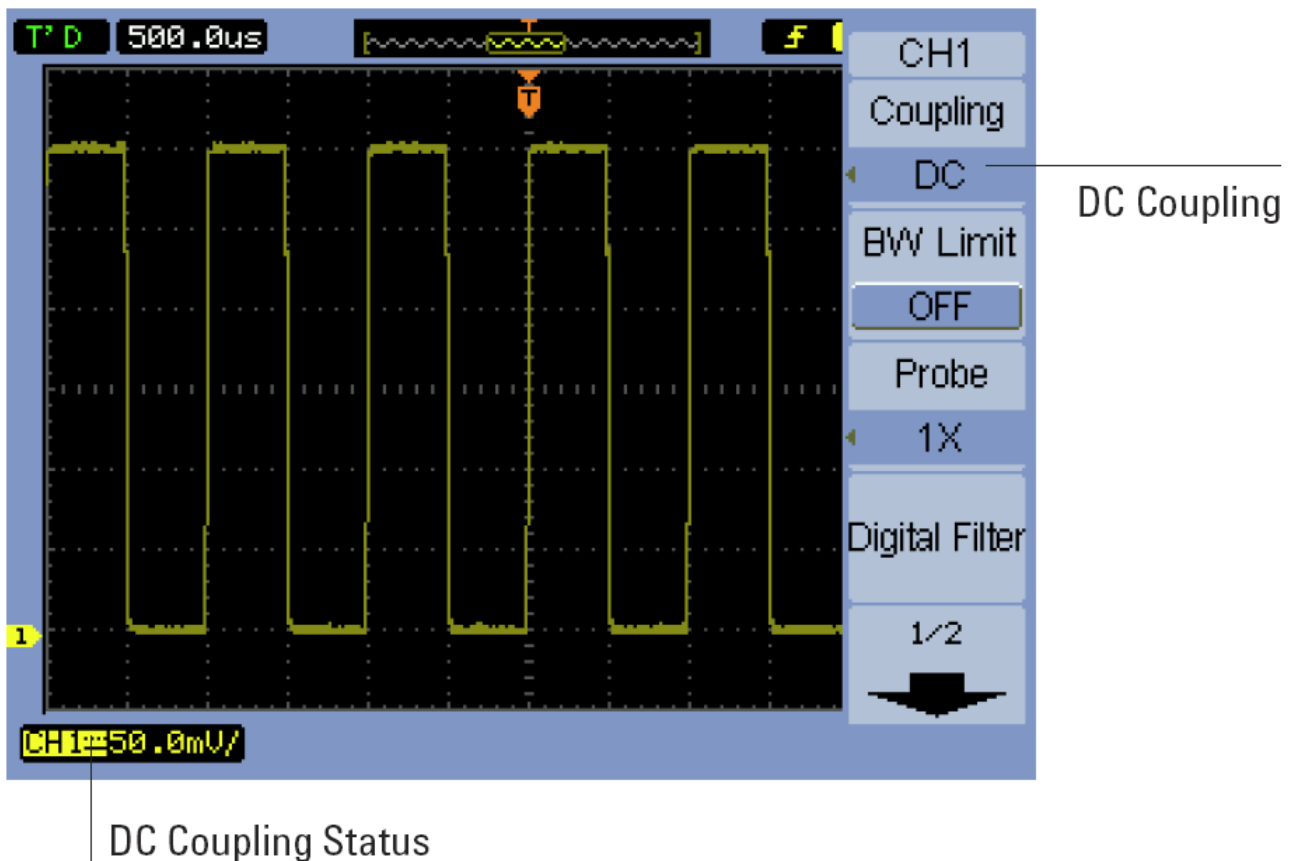
# Specify the channel units

1. If the channel's menu is not currently displayed, press the channel key (**[1] or [2]**).

2. In the Channel menu, press **Unit**.
3. Continue pressing the **Unit** softkey or turn the ↻**entry** knob to select between:

| | |
|---|---|
| **V** | Volts, used with voltage probes. |
| **A** | Amperes, used with current probes. |
| **W** | Watts. |
| **U** | Unknown. |

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# Channel coupling

1. If the channel's menu is not currently displayed, press the channel key (**[1] or [2]**).
2. In the Channel menu, press **Coupling**.
3. Continue pressing the **Coupling** softkey or turn the ↻**entry** knob to select between:

**DC**     Passes both DC and AC components of the input waveform to the oscilloscope.
You can quickly measure the DC component of the waveform by simply noting its distance from the ground symbol.



DC Coupling

DC Coupling Status

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**AC**   Blocks the DC component of the input waveform and passes the AC component.
This lets you use greater sensitivity (amplitude/div settings) to display the AC component of the waveform.
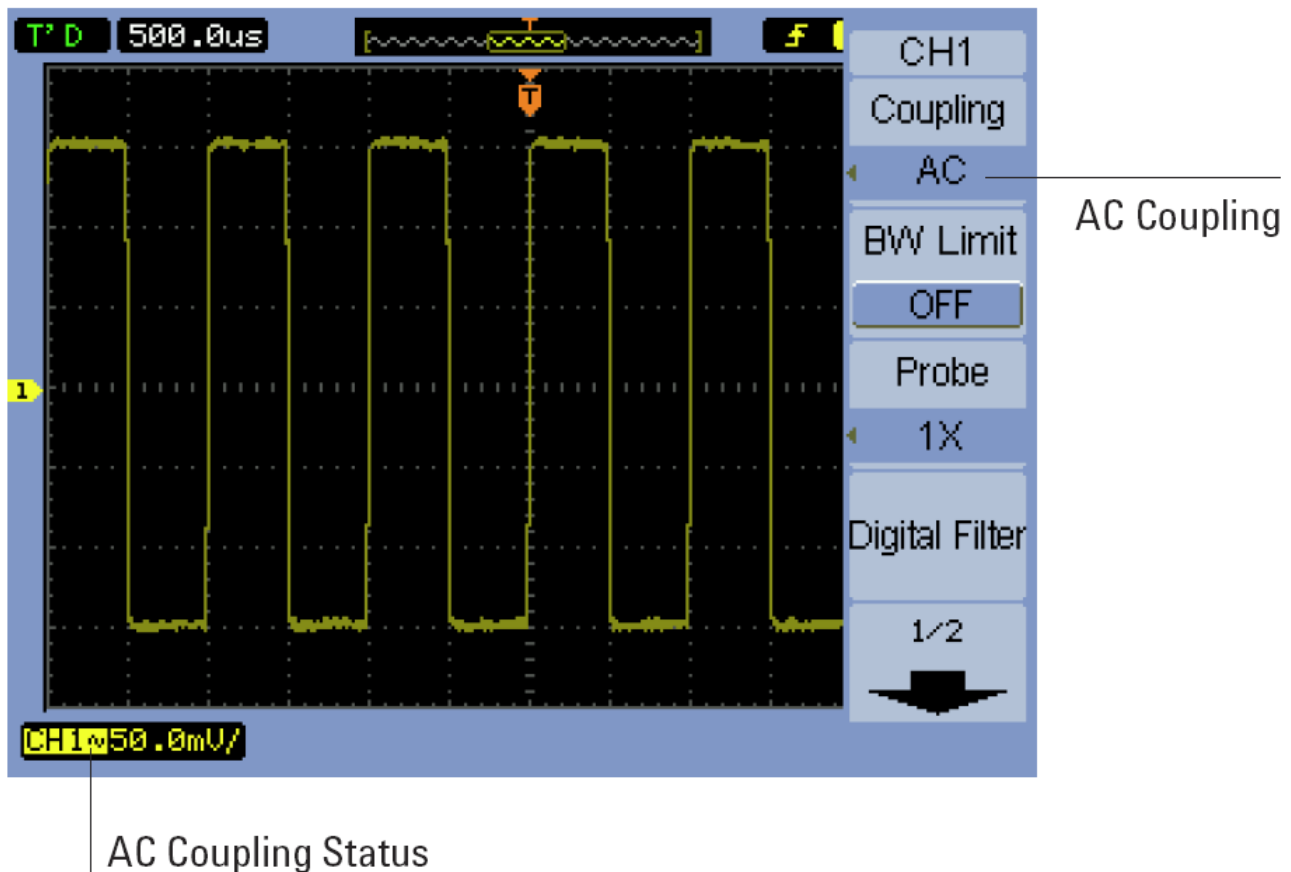


**GND**   The waveform is disconnected from the oscilloscope input.

# Bandwidth limit

When high frequency components of a waveform are not important to its analysis, the bandwidth limit control can be used to reject frequencies above 20 MHz.
If the channel's menu is not currently displayed, press the channel key (**[1] or [2]**).
In the Channel menu, press **BW Limit** to toggle the bandwidth limit setting "ON" and "OFF".



Bandwidth limit OFF



20 MHz Bandwidth
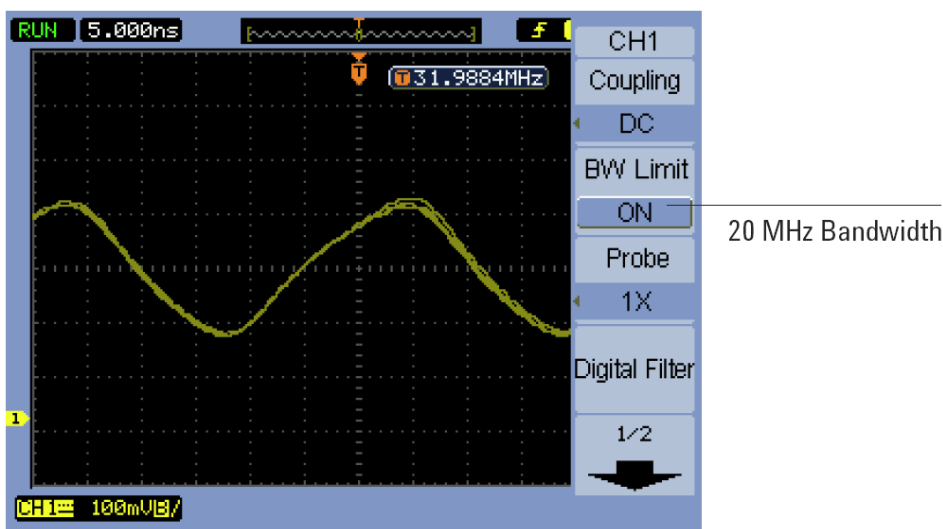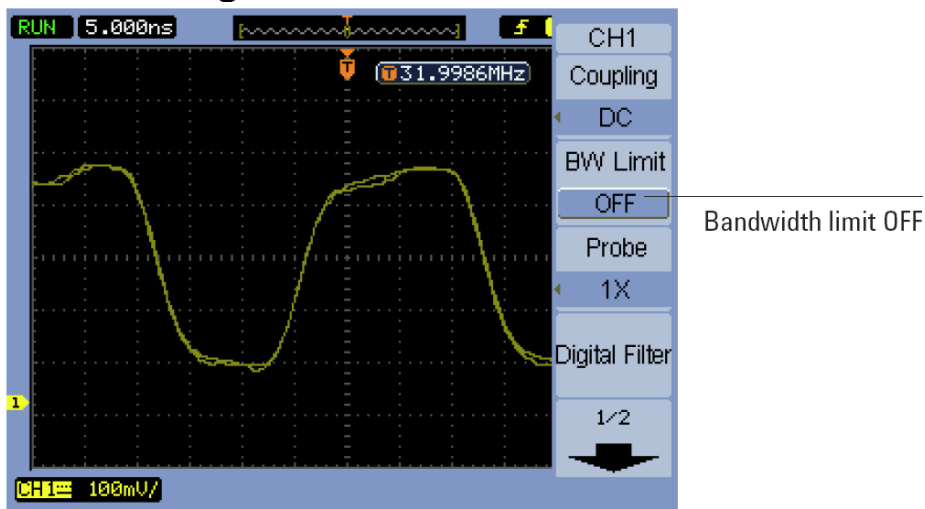
Bandwidth ON Status

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# Probe attenuation

For correct measurements, you must match the oscilloscope's probe attenuation factor settings with the attenuation factors of the probes being used.

The probe attenuation factor setting changes the vertical scaling of the oscilloscope so that the measurement results reflect the actual voltage levels at the probe tip.

- If the channel's menu is not currently displayed, press the channel key **[1] or [2]**.

- In the Channel menu, press **Probe**.

- Continue pressing the **Probe** softkey or turn the ↻**entry** knob to select between:

  | | |
  |---|---|
  | **0.001X** | For 1:1000 probes. |
  | **0.01X** | For 1:100 probes. |
  | **0.1X** | For 1:10 probes. |
  | **1X** | For 1:1 probes. |
  | **10X** | For 10:1 probes. |
  | **100X** | For 100:1 probes. |
  | **1000X** | For 1000:1 probes. |

# Volts/Div control sensitivity

When you need to adjust the amplitude/div setting in smaller increments, you can change the sensitivity of the vertical scale control.

1. If the channel's menu is not currently displayed, press the channel key **[1] or [2]**.
2. In the Channel menu, press **Volts/Div** to toggle between:

   **Coarse** The ↻**vertical scale** knob changes the amplitude/div setting in a 1- 2- 5 step sequence from 2 mV/div to 10 V/div (with "1X" probe attenuation).

   **Fine** Also known as vernier, the ↻**vertical scale** knob changes the amplitude/div setting in small steps between the normal (coarse scale) settings.
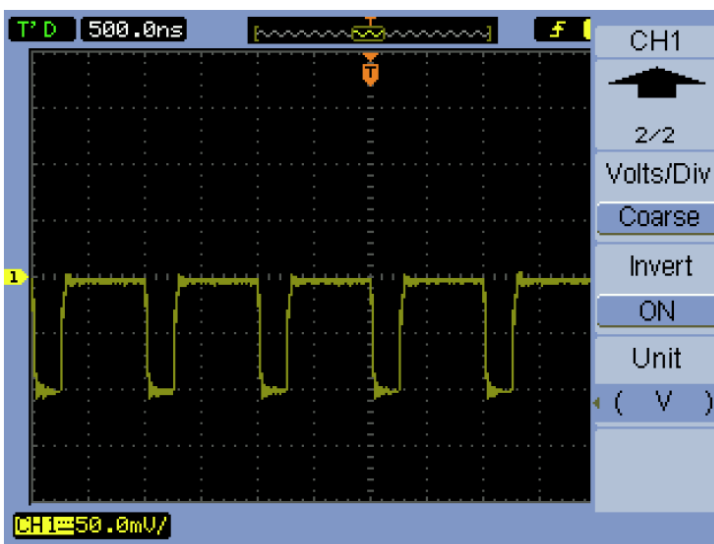
# Invert a waveform

You can invert a waveform with respect to the ground level.

1. If the channel's menu is not currently displayed, press the channel key (**[1] or [2]**).
2. In the Channel menu, press **Invert** to toggle between "**ON**" and "**OFF**".
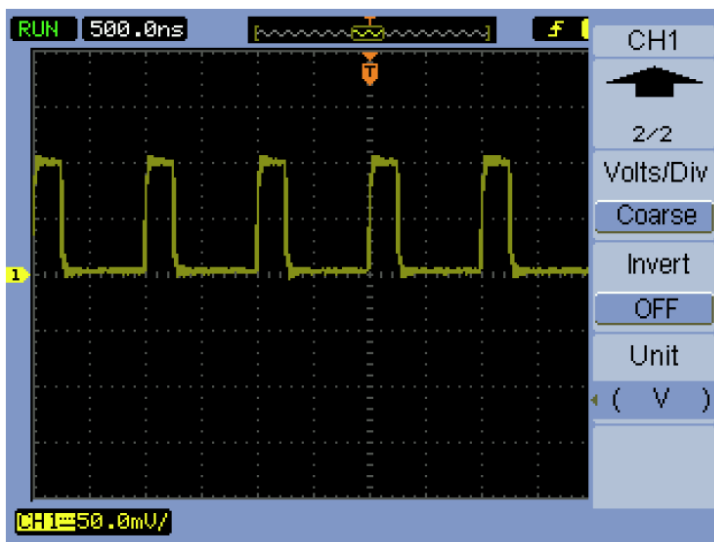


Waveform before inversion



Waveform after inversion

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# Math Function Waveforms

The math functions control allows the selection of the math functions:

- **Add**
- **Subtract**
- **Multiply**
- **FFT** (Fast Fourier Transform)

The mathematical result can be measured using the grid and cursor controls.

The amplitude of the math waveform can be adjusted using a menu item selection in the Math menu and the ↻**entry** knob. The adjustment range is in a 1- 2- 5 step from 0.1% to 1000%.

The math scale setting is shown at the bottom of the display.



Math Scale

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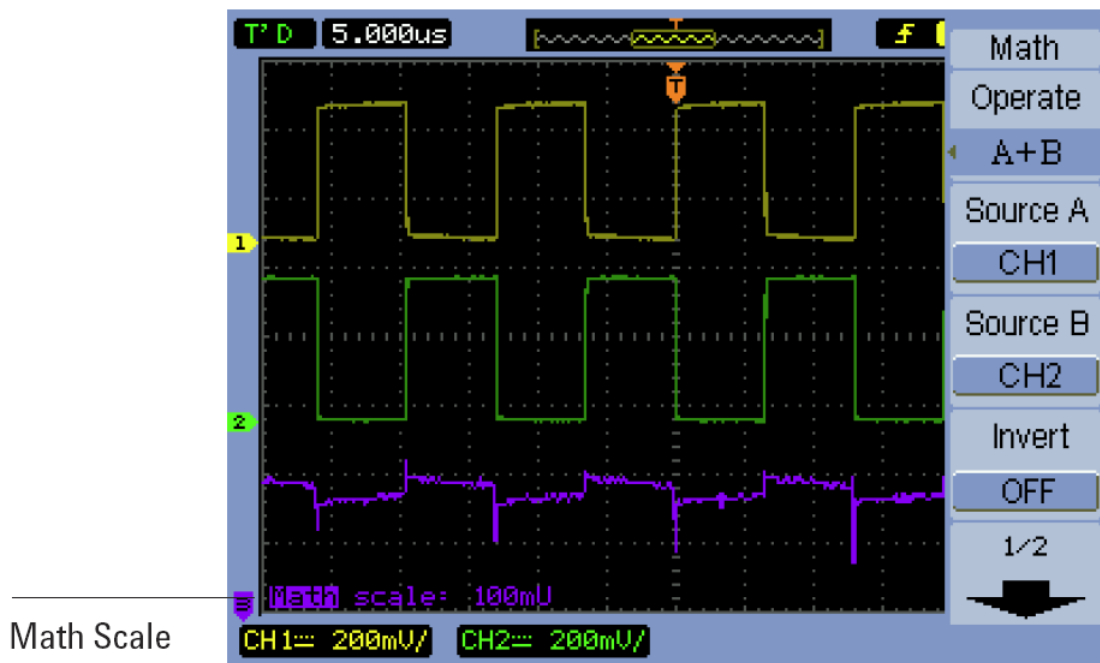
# Add, subtract, or multiply waveforms

1. Press **[Math]**.

**2.** In the Math menu, press the **Operate**.
3. Continue pressing the **Operate** softkey or turn the ↻**entry** knob to select "A + B", "A - B", or "A x B".

4. Press **Source A**, and continue pressing the softkey to select the desired input channel.

5. Press **Source B**, and continue pressing the softkey to select the desired input channel.

**6.** To invert the result of the addition, subtraction, or multiplication (with respect to the reference level), select **Invert** to toggle between "ON" and "OFF".

# Display the frequency domain using FFT

The FFT math function mathematically converts a time-domain waveform into its frequency components. FFT waveforms are useful for finding the harmonic content and distortion in systems, for characterizing noise in DC power supplies, and for analyzing vibration.
To display a waveform's FFT:

1. Press **[Math]**.

2. In the Math menu, press **Operate**.

3. Continue pressing the **Operate** softkey or turn the ↻**entry** knob to select "FFT".

4. In the FFT menu, press **Source**, and continue pressing the softkey to select the desired input channel.

**Note:** The FFT of a waveform that has a DC component or offset can cause incorrect FFT waveform magnitude values. To minimize the DC component, choose AC Coupling on the source waveform.
To reduce random noise and aliasing components (in repetitive or single-shot waveforms), set the oscilloscope acquisition mode to averaging.

5. Press **Window**, and continue pressing the softkey or turn the ↻**entry** knob to select the desired window:
There are four FFT windows. Each window has trade-offs between frequency resolution and amplitude accuracy. What you want to measure and your source waveform characteristics help determine which window to use.

6. Press **Display** to toggle between a "Split" screen display and a "Full Screen" display.

7. Press  and turn the ↻**entry** knob to adjust the vertical position of the FFT waveform.

8. Press  and turn the ↻**entry** knob to adjust the vertical scale of the FFT waveform.

9. Press **Scale** to toggle between "Vrms" and "dBVrms" units.

**Note:** To display FFT waveforms with a large dynamic range, use the dBVrms scale. The dBVrms scale displays component magnitudes using a log scale.

10. Use the horizontal position knob to adjust the frequency per division.
The frequency scale is displayed on the screen. Use this to display the frequencies associated with the peaks in the FFT waveform.

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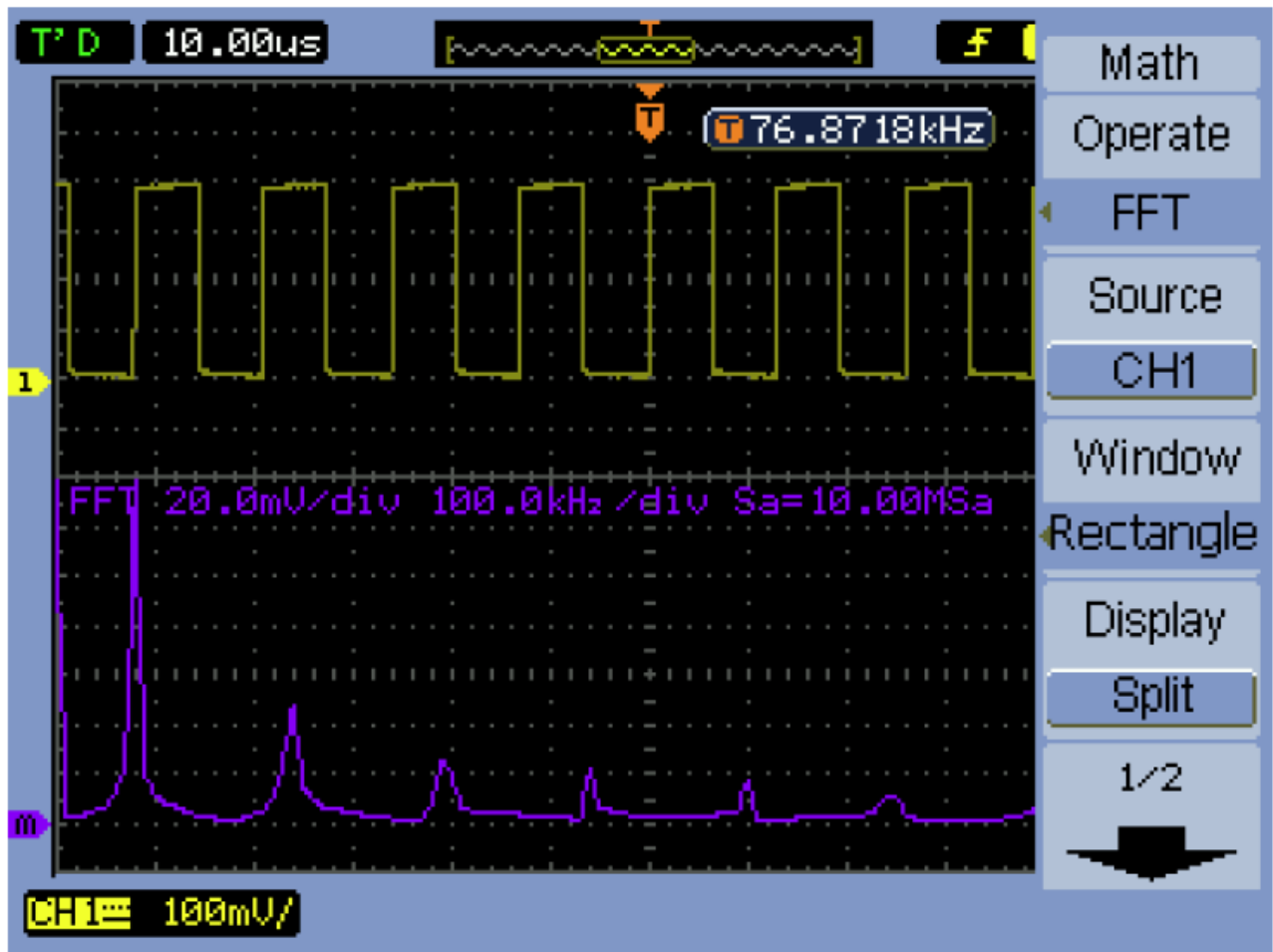
***Note:*** **FFT Resolution**

The FFT resolution is the quotient of the sampling rate and the number of FFT points (fS/N). With a fixed number of FFT points (1024), the lower the sampling rate, the better the resolution.

***Note:*** **Nyquist Frequency & Aliasing in the Frequency Domain**

The Nyquist frequency is the highest frequency that any real-time digitizing oscilloscope can acquire without aliasing. This frequency is half of the sample rate. Frequencies above the Nyquist frequency will be under sampled, which causes aliasing. The Nyquist frequency is also called the folding frequency because aliased frequency components *fold back* from that frequency when viewing the frequency domain.

# Reference Waveforms

You can save a reference waveform to an internal, nonvolatile memory location and then display it on the oscilloscope along with other captured waveforms.

You can also export/import reference waveforms to/from an external USB drive when it is connected to the front panel USB host port.

Reference waveforms are displayed (that is, turned on/off) just like other waveforms.

## Save a reference waveform

1. Before saving a waveform as a reference, set the waveform's scale and position as desired.
   These settings will become the reference waveform's defaults.

2. Press **[REF]**.

3. In the REF menu, press **Source**, and continue pressing the **Source** softkey or turn the ↺**entry** knob to select the waveform you want to save.

4. Press **Location** to choose "Internal".

5. Press **Save**.

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# Export or import reference waveforms

To export or import from external storage (when a USB drive is connected to the front panel USB host port):

1. Press **[REF]**.
2. If exporting a waveform, in the REF menu, press **Source**, and continue pressing the softkey or turn the ↻**entry** knob to select the waveform you want to export.

3. Press **Location** to choose "External".

4. Press **Save** or **Import**.

5. Use the disk manager dialog to navigate to the folder where you want to export the file or to select the file you want to import.

6. In the Save or Import menu:

   - To export the waveform, press **New File**, enter the filename, and press **Save**.
   - To load the selected waveform (.wfm file), press **Import**.

## Return the reference waveform to its default scale

1. Press **[REF]**.

2. In the REF menu, press **Reset**.

*The scale and position of the waveform as originally saved are restored.*

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# Choosing the Acquisition Mode

The oscilloscope can operate in normal, average, or peak detect acquisition modes.

You can choose the oscilloscope's acquisition mode in the Acquire menu (accessed by pressing the **[Acquire]** front panel key).



Acquire Key
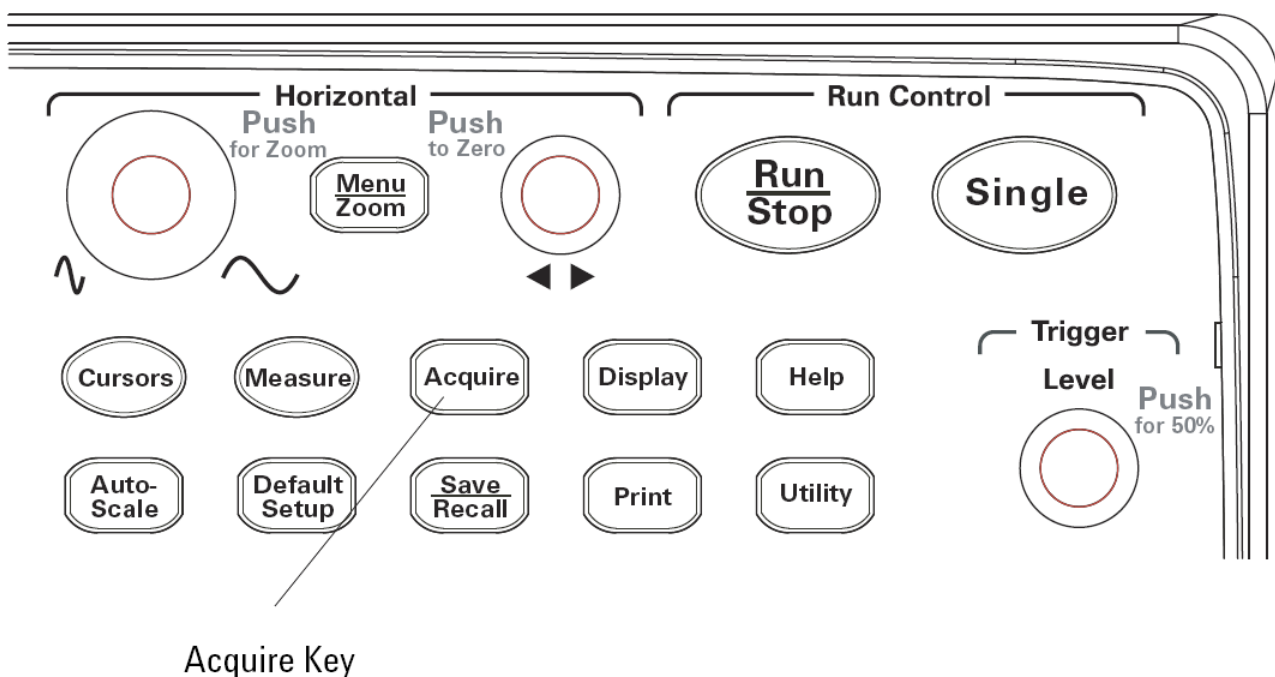
# Select the Normal acquisition mode

In the Normal acquisition mode, acquisitions are made and displayed one after the other.

To select the Normal acquisition mode:

1. Press **[Acquire]**.
2. In the Acquire menu, press **Acquisition**.
3. Continue pressing the **Acquisition** softkey or turn the ↻**entry** knob to select "Normal".

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# Select the Average acquisition mode

In the Average acquisition mode, acquisitions are made, and the running average over the specified number of acquisitions is displayed.

Use the Average acquisition mode to remove random noise from the waveform and to improve measurement accuracy.



Noisy Waveform Without Averaging
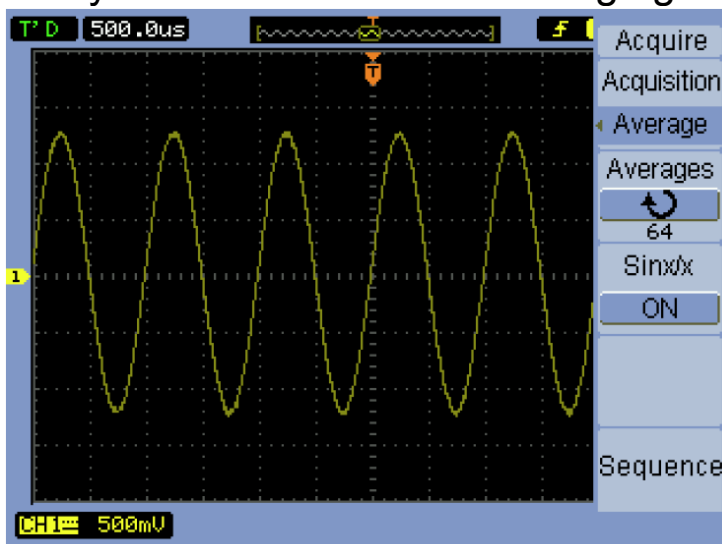


Noisy Waveform With Averaging

The Average acquisition mode decreases the screen refresh rate.

To select the Average acquisition mode:

1. Press **[Acquire]**.

2. In the Acquire menu, press **Acquisition**.

3. Continue pressing the **Acquisition** softkey or turn the ↻**entry** knob to select "Average".

4. Press **Averages** and turn the ↻**entry** knob to select the desired number (2, 4, 8, 16, 32, 64, 128, or 256).

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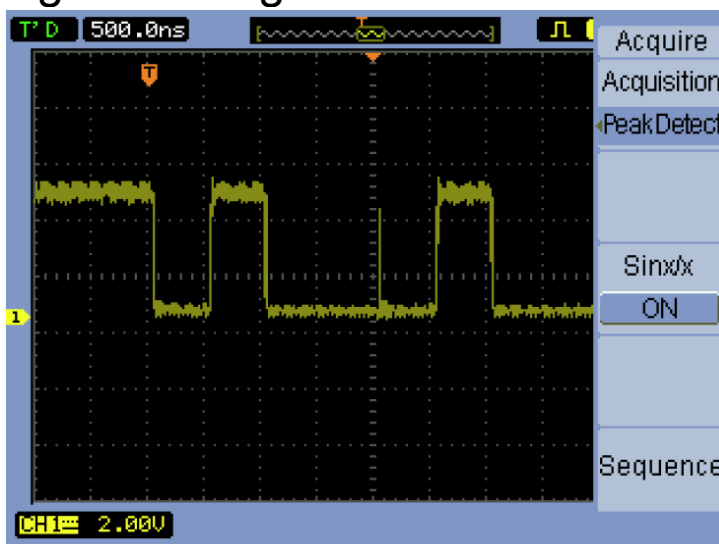
# Select the Peak Detect acquisition mode

In Normal or Average acquisition modes, at longer horizontal time/div settings, the oscilloscope's analog- to- digital converter samples at a rate that yields more samples than can be stored in a limited amount of oscilloscope memory. Consequently, samples are thrown away (decimated), and you can miss narrow excursions on a signal.

In the Peak Detect acquisition mode, acquisitions are made at the fastest sample rate, and the minimum and maximum values for the period associated with the actual sample rate are stored. This way, you can capture narrow excursions on a signal at longer horizontal time/div settings.



Because minimum and maximum values for a sample period are stored, you can use the Peak Detect acquisition mode to avoid waveform aliasing.
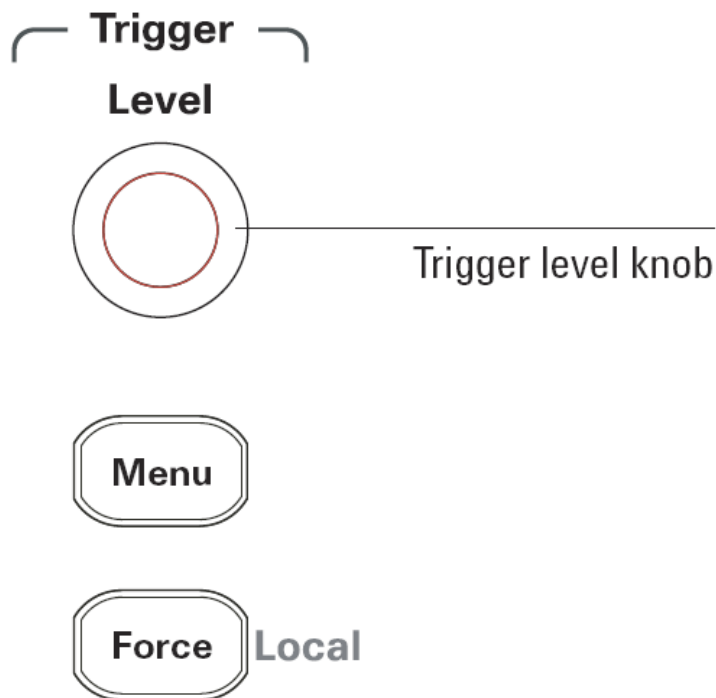
Peak Detect Waveform

To select the Peak Detect acquisition mode:
Press **[Acquire]**.
In the Acquire menu, press **Acquisition**.
Continue pressing the **Acquisition** softkey or turn the ↻**entry** knob to select "Peak Detect".

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# Adjusting the Trigger Level

**Trigger**
**Level**

Trigger level knob

Menu

Force Local

## Adjust the trigger level

- Turn the ↻**trigger level** knob.

  Two things happen:

  1. The trigger level value is displayed at the lower left-hand corner of the screen.

  2. A line is displayed showing the location of the trigger level with respect to the waveform (except when using AC coupling or LF reject coupling modes).

- Push the ↻**trigger level** knob to set the level at 50% of the signal's vertical amplitude.

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**Force a trigger**

Make an acquisition even if no valid trigger has been found:

1. Press **[Force]**.

Forcing a trigger is useful when you want to display the DC voltage of a level signal.

The **[Force]** key has no effect if the acquisition is already stopped.

# Choosing the Trigger Mode

The following trigger modes are available:

**Edge**        Can be used with analog and digital circuits. An edge trigger occurs when the trigger input passes through a specified voltage level with the specified slope.

**Pulse**       Is used to find pulses with certain widths.

**Video**       Is used to trigger on fields or lines for standard video waveforms.

**Pattern**     Is used to trigger on patterns from all input channels.

**Alternate**   Is used to trigger on non- synchronized signals.

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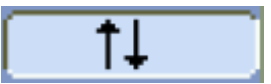
## Set up edge triggers

1. Press **[Menu]**.

2. In the Trigger menu, press **Mode**.

3. Continue pressing the **Mode** softkey or turn the ↻**entry** knob to select "Edge".

4. Then, either push the ↻**entry** knob or press **Mode** again.

5. Press **Source** and continue pressing the softkey or turn the ↻**entry** knob to select the waveform to trigger on:

    **CH1 – CH2** The oscilloscope input channel.

    **EXT** The external trigger input.

    **EXT/5** The (5:1) attenuated external trigger input.

    **AC Line** The AC power line.

6. Press **Slope** and continue pressing the softkey or turn the ↻**entry** knob to select the edge to trigger on:

Rising edge.

Falling edge.

Both rising and falling edges.

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## Set up pulse width triggers

A pulse width trigger occurs when a pulse that matches the pulse definition is found in a waveform.

The width setting can be adjusted from 20 ns to 10 s.

1. Press **[Menu]**.

2. In the Trigger menu, press **Mode**.

3. Continue pressing the **Mode** softkey or turn the ↻**entry** knob to select "Pulse".

4. Then, either push the ↻**entry** knob or press **Mode** again.

5. Press **Source** and continue pressing the softkey or turn the ↻**entry** knob to select the waveform to trigger on:

   **CH1 – CH2** The oscilloscope input channel.
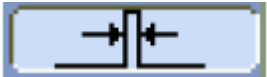   **EXT** The external trigger input.
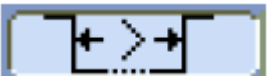   **EXT/5** The (5:1) attenuated external trigger input.

6. Press **When** and continue pressing the softkey or turn the ↻**entry** knob to select the type of pulse to trigger on:
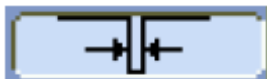
   Positive pulse greater than the width setting.

   Positive pulse less than the width setting.

   Negative pulse greater than the width setting.

   Negative pulse less than the width setting.

7. Press **Setting** and turn the ↻**entry** knob to adjust the width setting.

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**Trigger coupling**

Trigger coupling is used to filter low frequency signal components or DC offsets from the trigger path when they interfere with achieving stable triggers.

Set the trigger coupling:

1. Press **[Menu]**.

2. In the Trigger menu, press **Set Up**.

3. In the Set Up menu, press **Coupling**.

4. Continue pressing the the **Coupling** softkey or turn the ↻**entry** knob to select one of these trigger coupling settings:

   **DC** Sets the trigger coupling to DC.

   **AC** Sets the trigger coupling to AC — use for waveforms greater than 50 Hz.

   **LF Reject** Sets the trigger coupling to low frequency reject (10 kHz cutoff).

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## Trigger high-frequency reject coupling

Trigger high- frequency reject coupling (100 kHz cutoff) is used to filter high frequency signal components from the trigger path when they interfere with achieving stable triggers.

Set the trigger high- frequency reject coupling:

1. Press **[Menu]**.

2. In the Trigger menu, press **Set Up**.

3. In the Set Up menu, press **HF Reject** to toggle between "ON" and "OFF".

## Trigger sensitivity

Trigger sensitivity specifies the vertical change that must occur in order for a trigger to be recognized. In the 1000 Series oscilloscopes, you can adjust the trigger sensitivity.

Change the trigger sensitivity:

Press **[Menu]**.
In the Trigger menu, press **Set Up**.

In the Set Up menu, press **Sensitivity** and turn the ↻entry knob to adjust the sensitivity setting.

**NOTE:** The trigger sensitivity can be adjusted from 0.1 div to 1 div.

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## Specify a trigger holdoff

Trigger holdoff can be used to stabilize a waveform. The holdoff time is the oscilloscope's waiting period before starting a new trigger. The oscilloscope will not trigger until the holdoff time has expired.
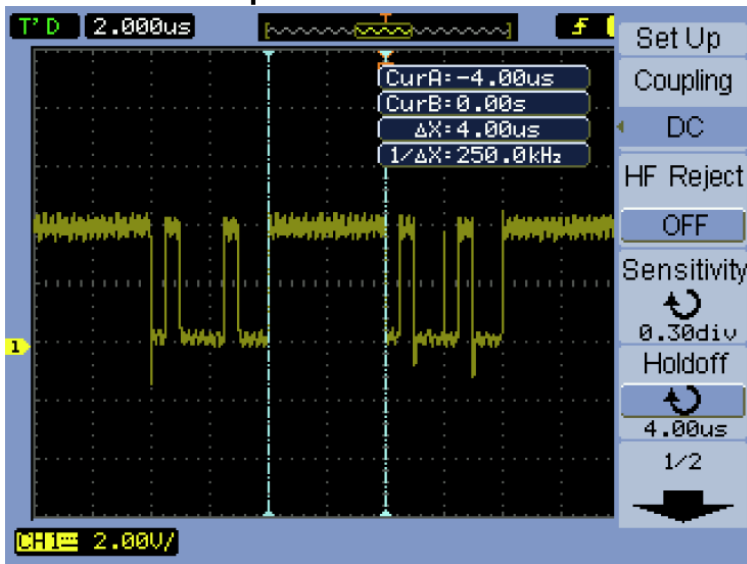
To specify a trigger holdoff:

1. Press **[Menu]**.

2. In the Trigger menu, press **Set Up**.

3. In the Set Up menu, press **Holdoff** and turn the ↻**entry** knob to adjust the holdoff setting.

### Reset the trigger holdoff

1. In the Set Up menu, select the **Holdoff Reset** menu item to return the trigger holdoff setting to the 100 ns minimum value.

## External Trigger Input

You can trigger on external inputs by selecting "EXT" or "EXT/5" (5:1 attenuated) as the trigger source in all trigger modes except Alternate.

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# Automatic Measurements

## Displaying Automatic Measurements

You can use the **[Measure]** key to display automatic measurements. The oscilloscope has 22 automatic measurements and a hardware frequency counter.
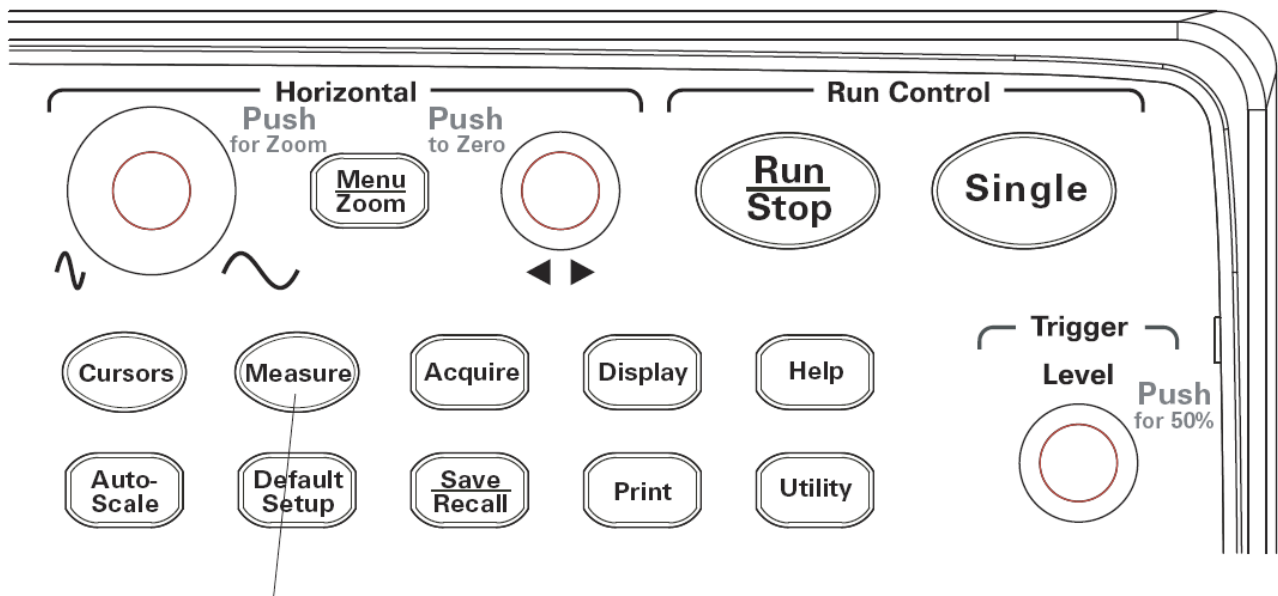


[Measure] Key

## Display an automatic measurement

1. Press **[Measure]**.

2. In the Measure menu, press **Source** to select the input channel on which to make the automatic measurement.

3. Press **Voltage** (for voltage measurements) or **Time** (for time measurements) and turn the ↻entry knob to select the desired measurement.

4. Then, either push the ↻**entry** knob or press **Voltage** or **Time** again to add the measurement to the bottom of the display.

**NOTE:** If the measurement result is displayed as "*****", the measurement cannot be performed with the current oscilloscope settings.

**NOTE:** A maximum of three measurements can be displayed at the bottom of the display. When three measurements are displayed and you add a new one, the measurements shift to the left, pushing the first measurement result off screen.

## Clear automatic measurements from the display

1. Press **[Measure]**.

2. In the Measure menu, press **Clear** to clear all automatic measurements from the display.

## Display or hide all automatic measurements

1. Press **[Measure]**.

2. In the Measure menu, press **Display All** to toggle the display of all automatic measurements "ON" or "OFF".

## Select channels for delay/phase measurements

1. Press **[Measure]**.

2. In the Measure menu, press **Delay/Phase**.

3. In the Delay/Phase menu, press **DelayA**, **DelayB**, **PhaseA**, or **PhaseB** to select the input channel for the respective measurement.

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# Voltage Measurements

There are 10 automatic voltage measurements:
- Vmax (Maximum Voltage)
- Vmin (Minimum Voltage)
- Vpp (Peak- to- Peak Voltage)
- Vtop (Top Voltage)
- Vbase (Base Voltage)
- Vamp (Amplitude Voltage = Vtop - Vbase)
- Vavg (Average Voltage)
- Vrms (Root-Mean- Square Voltage)
- Overshoot
- Preshoot
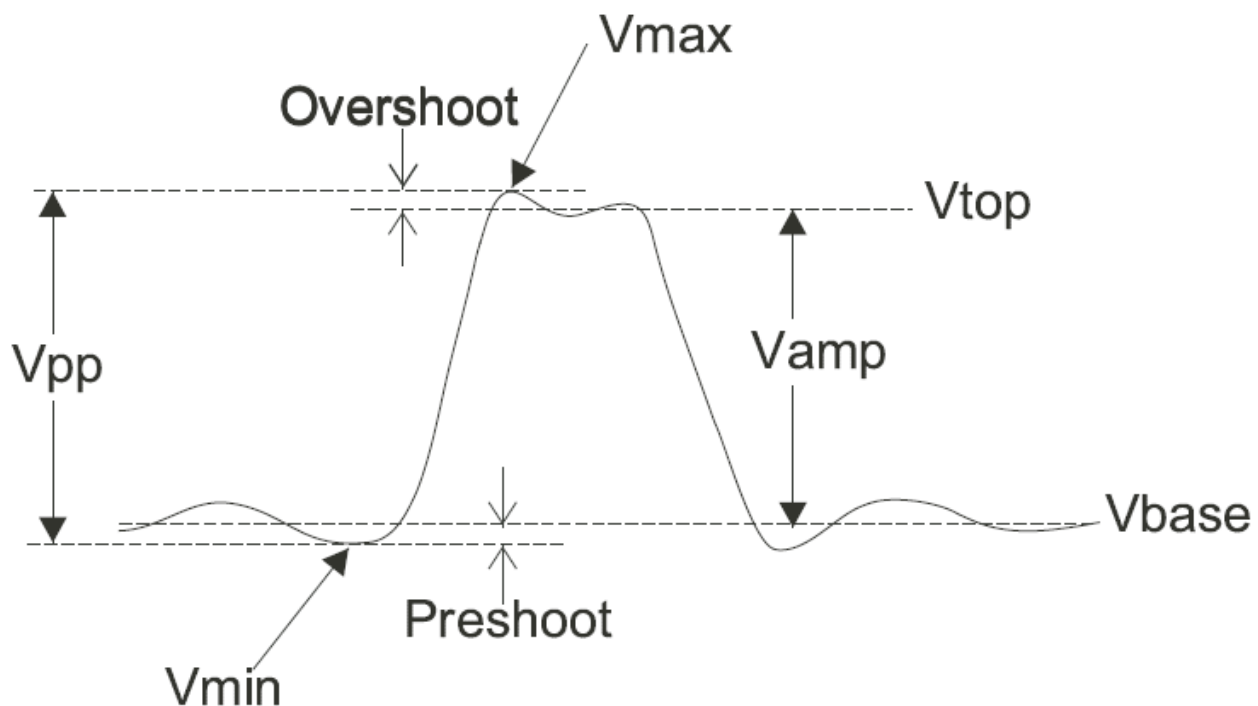


I          Voltage Measurement Points

## Vmax (Maximum Voltage)

The maximum amplitude. The most positive peak voltage measured over the entire waveform.

### Vmin (Minimum Voltage)
The minimum amplitude. The most negative peak voltage measured over the entire waveform.

### Vpp (Peak-to-Peak Voltage)
Peak- to- peak voltage.

### Vtop (Top Voltage)
Voltage of the waveform's flat top, useful for square and pulse waveforms.

### Vbase (Base Voltage)
Voltage of the waveform's flat base, useful for square and pulse waveforms.

### Vamp (Amplitude Voltage = Vtop - Vbase)
Voltage between Vtop and Vbase of a waveform.

### Vavg (Average Voltage)
The arithmetic mean over the entire waveform.

### Vrms (Root-Mean-Square Voltage)
The true root-mean- square voltage over the entire waveform.

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$$RMS = \sqrt{\frac{\displaystyle\sum_{i=1}^{n} x_i^2}{n}}$$

Where:
*xi* = value at *i*th point.
*n* = number of points.

**Overshoot**
Defined as (Vmax-Vtop)/Vamp, useful for square and pulse waveforms.

**Preshoot**
Defined as (Vmin- Vbase)/Vamp, useful for square and pulse waveforms.

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# Time Measurements

There are 12 automatic time measurements plus the hardware frequency counter:
- Period
- Frequency
- Rise Time
- Fall Time
- + Pulse Width
- - Pulse Width
- + Duty Cycle
- - Duty Cycle
- Delay A-B, rising edges
- Delay A- B, falling edges. Phase A- B, rising edges
- Phase A- B, falling edges

## Period
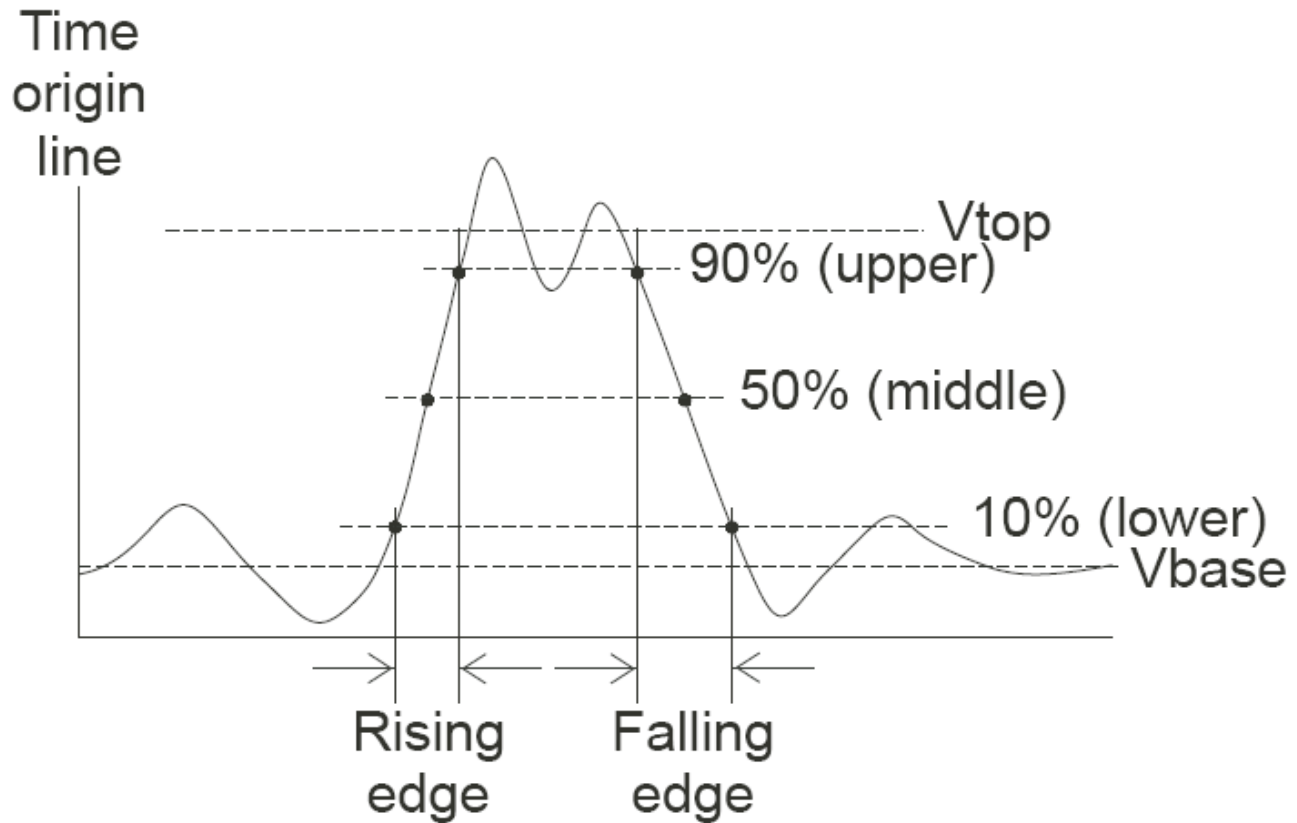Measures the period of a waveform.



Period and Frequency Measurements
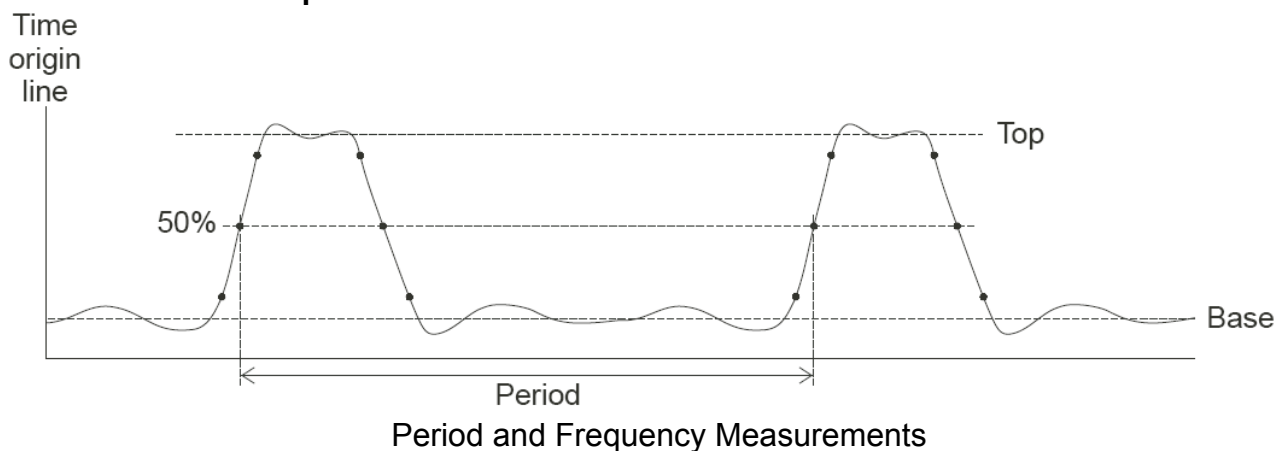
## Frequency
Measures the frequency of a waveform.

## Rise Time

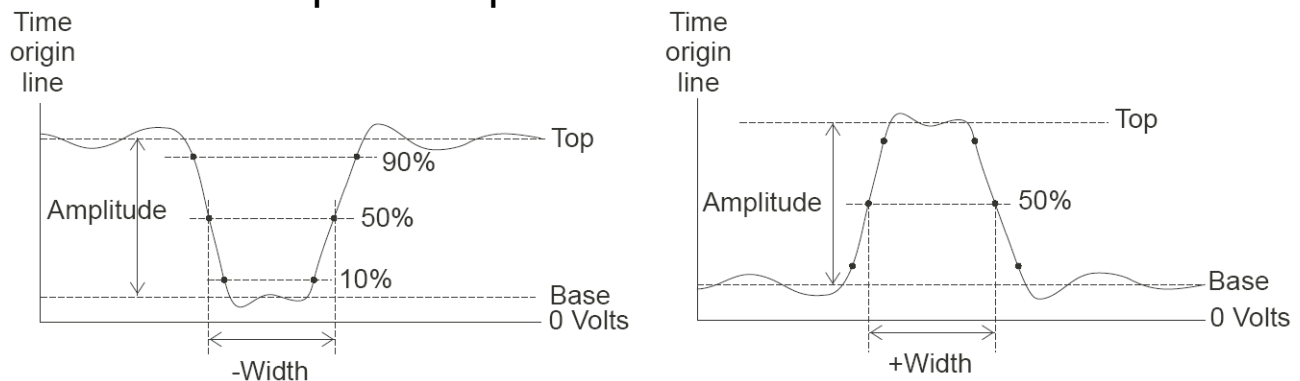Measures the rise time of a waveform.



Rise Time and Fall Time Measurements

## Fall Time
Measures the fall time of a waveform.

## Positive Pulse Width
Measures the positive pulse width of a waveform.



Positive Pulse Width and Negative Pulse Width Measurements

## Negative Pulse Width

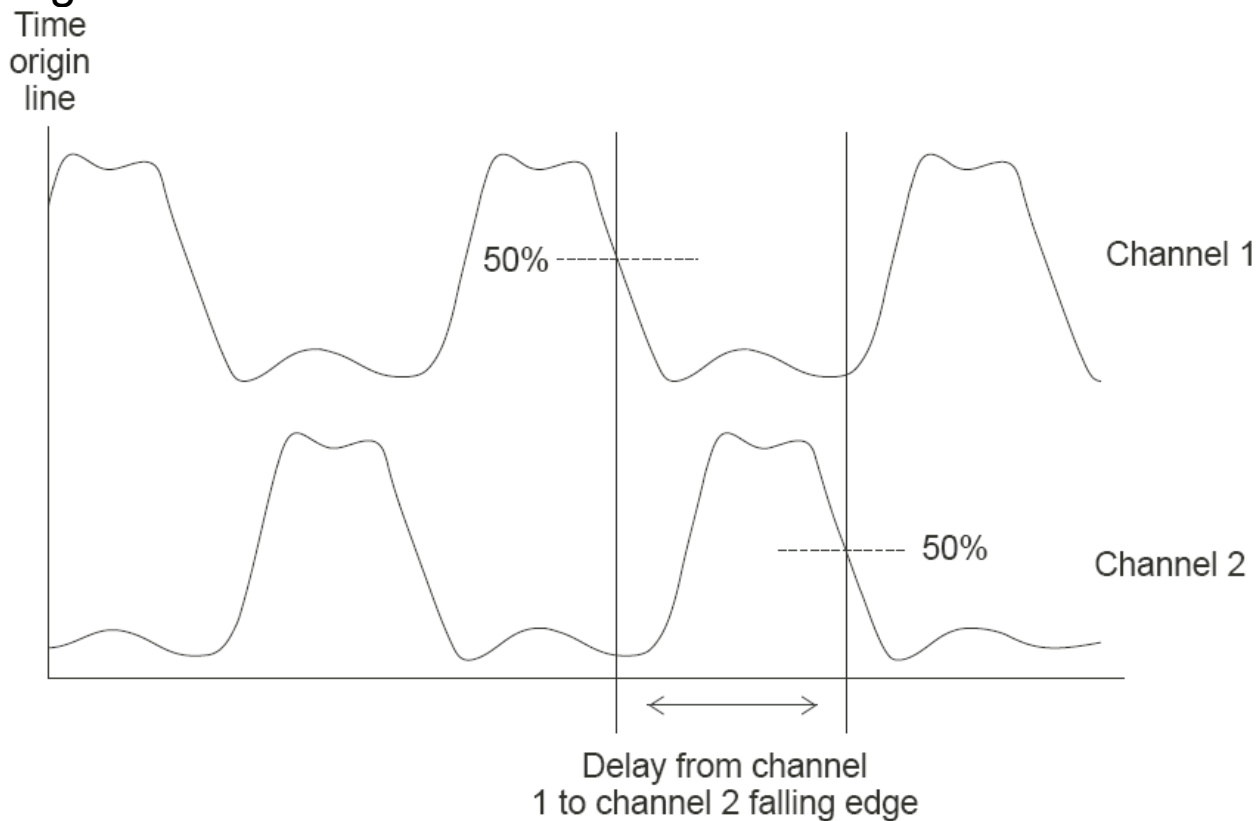Measures the negative pulse width of a waveform.

## Positive Duty Cycle
Measures the positive duty cycle of a waveform.

## Negative Duty Cycle
Measures the negative duty cycle of a waveform.

## Delay Between Rising Edges
Measures the delay between two waveforms using the rising edges.



Delay from channel
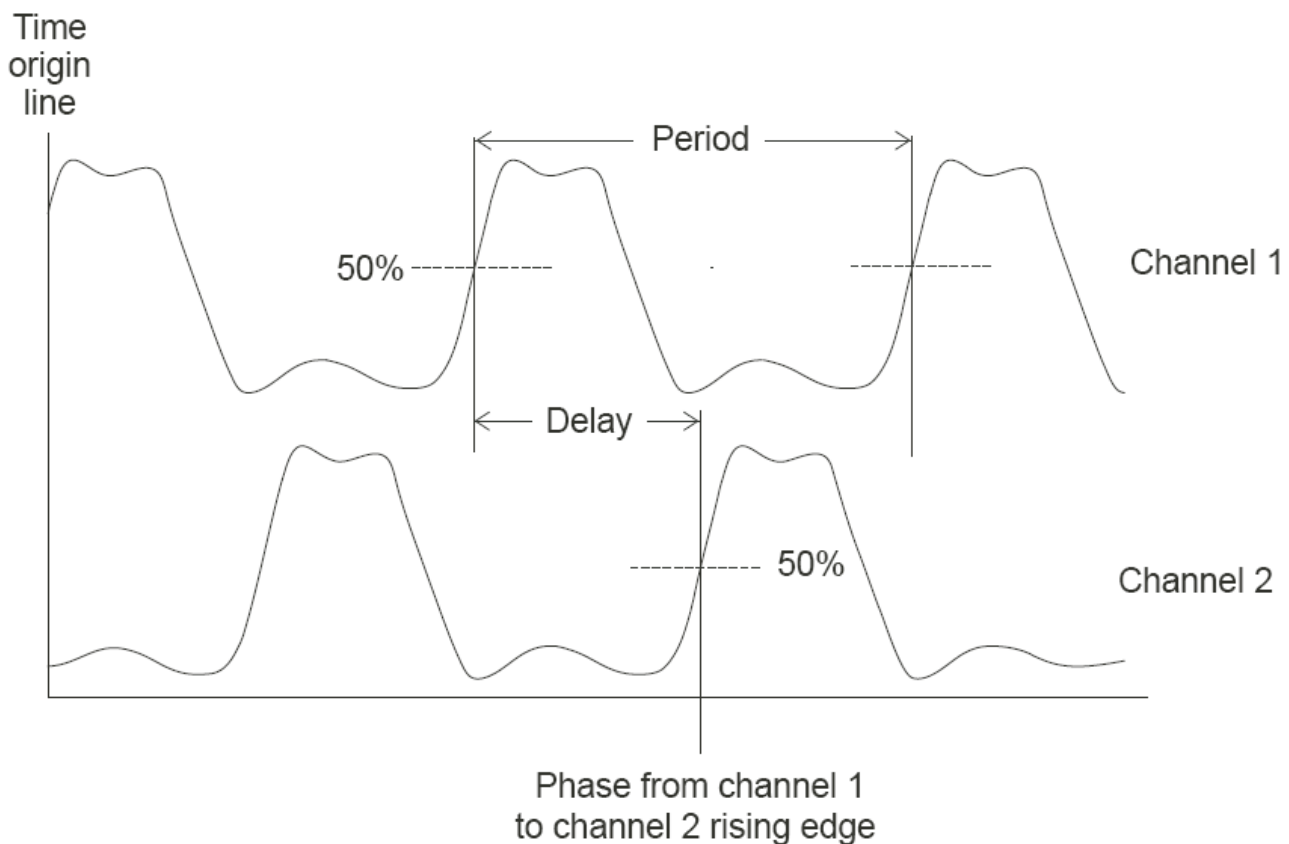1 to channel 2 falling edge

## Delay Between Falling Edges
Measures the delay between two waveforms using the falling edges.

## Phase Between Rising Edges

Measures the phase between two waveforms using the rising edges.
Phase is the calculated phase shift from source 1 to source 2, expressed in degrees. Negative phase shift values indicate that the rising edge of source 1 occurred after the rising edge of source 2.

$$Phase = \frac{Delay}{Source\ 1\ Period} \times 360°$$

Time origin line

Period

50% - - - - - - - - - - - - - - - - - - - - - Channel 1

← Delay →

- - - - - - - - 50%

Channel 2

Phase from channel 1
to channel 2 rising edge

## Phase Between Falling Edges

Measures the phase between two waveforms using the falling edges.

# Counter (Frequency)

The counter operates on the currently selected trigger source and can measure frequencies from 5 Hz to the bandwidth of the oscilloscope.

The counter uses the trigger comparator to count the number of cycles within a period of time (known as the gate time), so the trigger level must be set correctly.

**NOTE:** The frequency counter is not available in the Alternate trigger mode.

Turn the hardware frequency counter on or off:

1. Press **[Measure]**.

2. In the Measure menu, press **Counter** to toggle the frequency counter display "ON" or "OFF".

# Cursor Measurements

Created by Tom Labarr

You can use the **[Cursors]** front panel key to select between these cursor measurement modes:

**Manual**  Gives you manually adjustable, parallel cursors for measuring time or amplitude between cursors.

**Track**  Gives you one or two manually adjustable, cross-hair cursors that track the points of a waveform, measuring time and amplitude.

**Auto**  Gives you automatically adjusted cursors for the most recently displayed voltage or time measurement.

**OFF**  Cursors are tuned off.
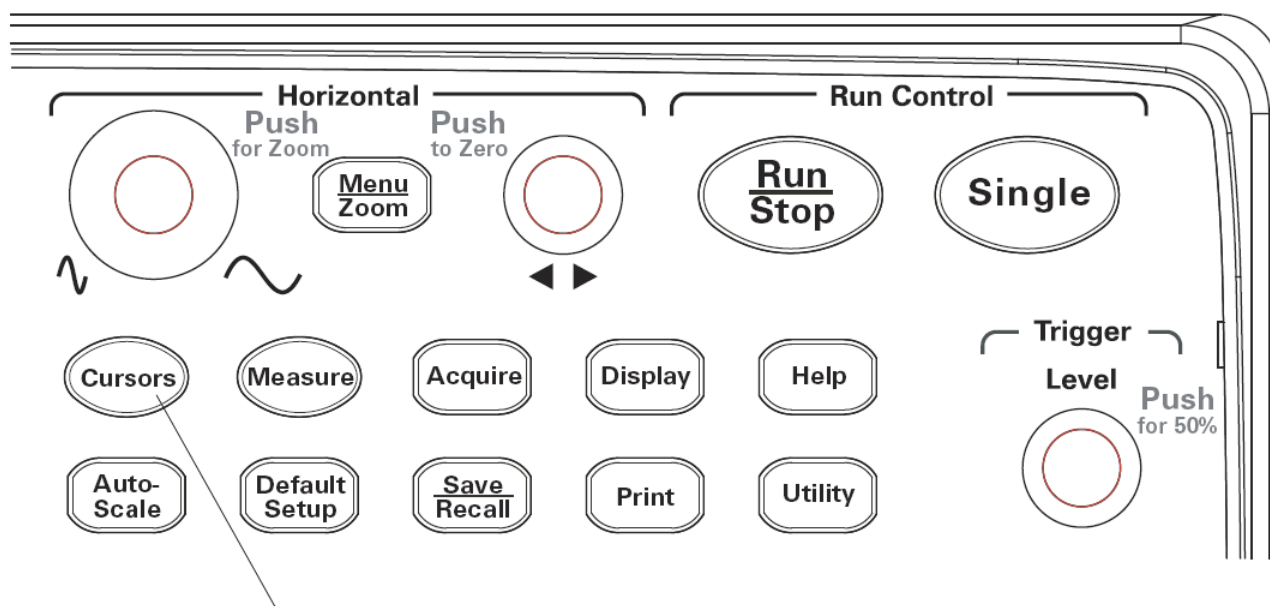


[Cursors] Key

## Manually adjustable cursors

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1. Press **[Cursors]**.
2. In the Cursors menu, press **Mode**.
3. Continue pressing the **Mode** softkey or turn the ↻**entry** knob to select "Manual".
4. Press **Type** to toggle between:
   **Time** To use cursors to measure time parameters.
   **Amplitude** To use cursors to measure amplitude parameters.
5. Press **Source**, and continue pressing the softkey or turn the ↻**entry** knob to select the channel or math waveform on which to make the measurement.
6. To adjust the cursors:
   - Press **CurA** and turn the ↻**entry** knob to adjust the "A" cursor.
   - Press **CurB** and turn the ↻**entry** knob to adjust the "B" cursor.
   - Press **CurA** and **CurB** and turn the ↻**entry** knob to adjust both cursors at the same time.

The cursor values displayed are:
- CurA.
- CurB.
- $\triangle$X or $\triangle$Y — difference between CurA and CurB values.
- 1/$\triangle$X — when measuring time parameters, shows the frequency associated with the time period.

## Tracking cross-hair cursors

You can set up one or two manually adjustable, tracking cross- hair cursors to make amplitude (vertical) and time (horizontal) measurements at different points of a selected channel's waveform.

Press **[Cursors]**.

In the Cursors menu, press **Mode**.

Continue pressing the **Mode** softkey or turn the ↻**entry** knob to select "Track".

Press **Cursor A**, and continue pressing the softkey or turn the ↻**entry** knob to select the channel on which to make the measurement (or "None" to turn off the cursor).

Press **Cursor B**, and continue pressing the softkey or turn the ↻**entry** knob to select the channel on which to make the measurement (or "None" to turn off the cursor).

To adjust the cursors:
- Press **CurA** and turn the ↻**entry** knob to adjust the "A" cursor.
- Press **CurB** and turn the ↻**entry** knob to adjust the "B" cursor.

The A cursor values displayed are:
- >X
- >Y.

The B cursor values displayed are:
- B- >X.
- B- >Y

If both A and B cursors are used, these values are also displayed:
- X — difference between CurA and CurB time values.

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- 1/$\Delta$X — shows the frequency associated with the time value difference.
- Y — difference between CurA and CurB amplitude values.

## Display cursors for automatic measurements

1. Press **[Cursors]**.

2. In the Cursors menu, press **Mode**.

3. Continue pressing the **Mode** softkey or turn the entry knob to select "Auto".

In the "Auto" cursors mode:
- Cursors appear for the most recently displayed automatic measurement
(see "To display an automatic measurement" on page 98).
- No cursors are displayed if there are no automatic measurements.

# Saving, Recalling, and Printing Data

Created by Tom Labarr

The oscilloscope has internal, nonvolatile memory locations for saving and recalling waveforms and setups.

The oscilloscope also has rectangular USB host ports on its front and back panel to which you can connect a USB drive (for saving and recalling data).
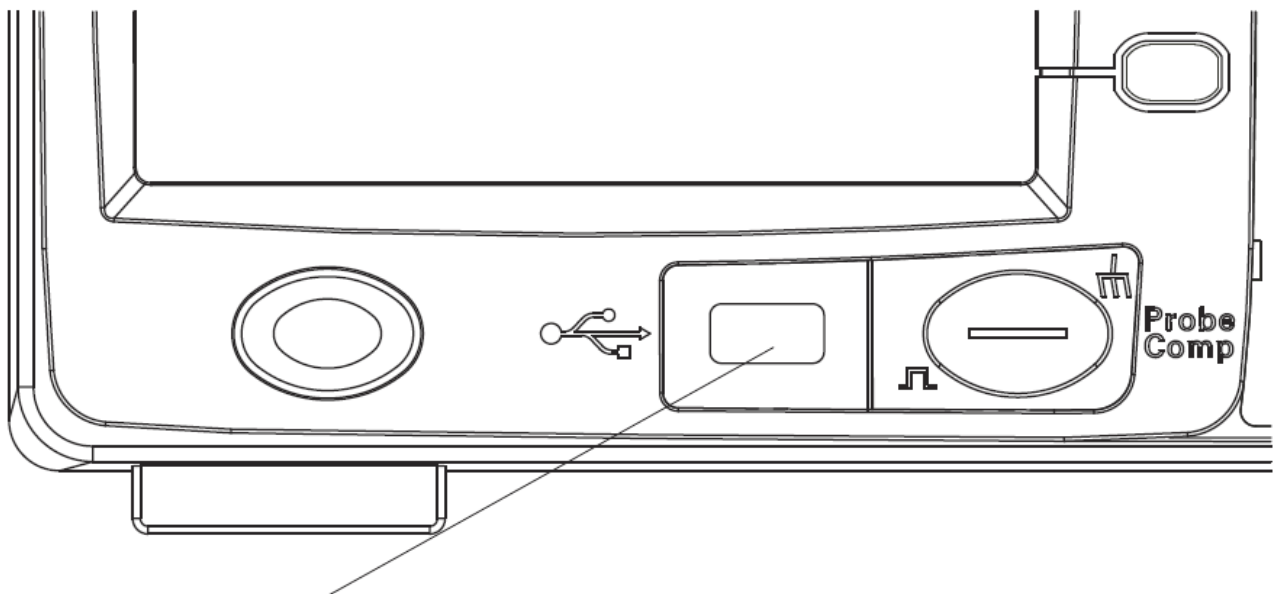


USB Host Port on Front Panel

# Saving and Recalling Data

Created by Tom Labarr

With the oscilloscope's **[Save/Recall]** key, you can save and recall oscilloscope waveforms and setups, and you can save oscilloscope display screens and data.
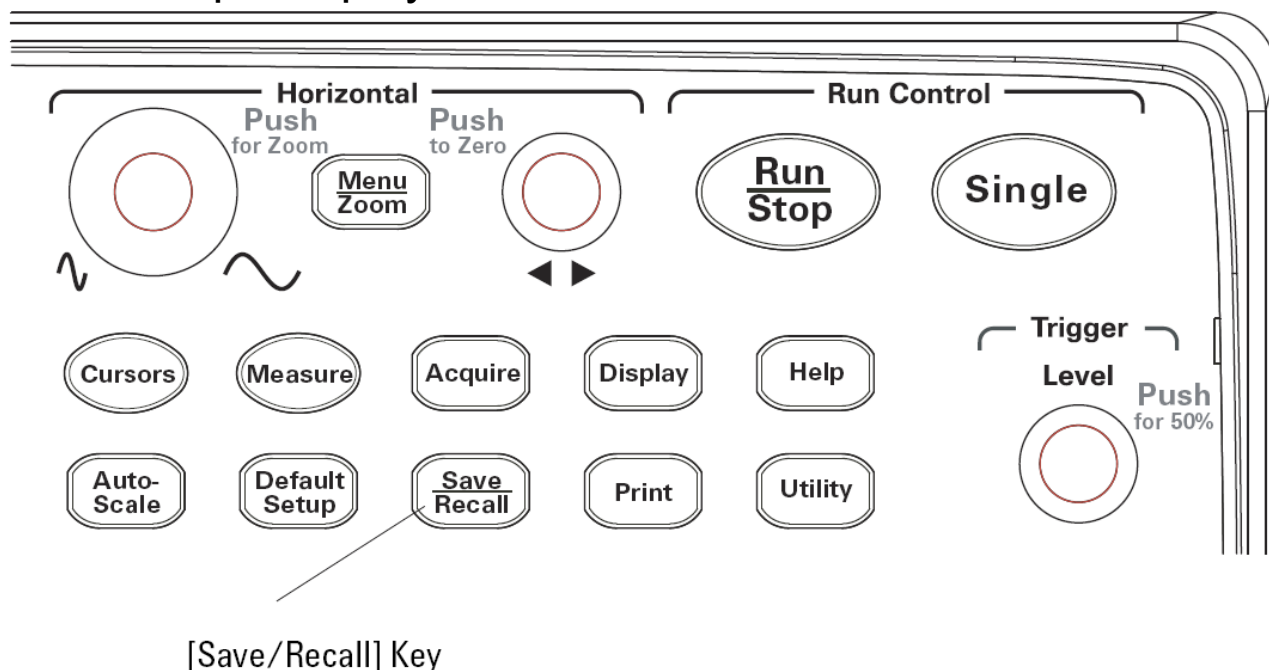


[Save/Recall] Key

**NOTE:** After saving or recalling data from an external USB drive, allow at least five seconds for the data transfer to complete before turning off the oscilloscope.

# Save and recall waveforms

You can save/recall oscilloscope waveforms and setups to/from 10 internal, nonvolatile memory locations in the oscilloscope.

You can also save/recall waveforms and setups to an external USB drive when it is connected to a rectangular USB host port.

1. Press **[Save/Recall]**.
2. In the Storage menu, press **Storage**.
3. Continue pressing the **Storage** softkey or turn the ↻**entry** knob to select "Waveform".
   To *save* to or *recall* from internal storage:
   a. Press **Internal**.
   b. In the Internal menu, press **Location**.
   c. Continue pressing the **Location** softkey or turn the ↻**entry** knob to select the desired internal storage location.
   The "(N)" suffix shows that nothing has been saved to the location.
   The "(S)" suffix shows waveforms have been previously saved to the location.
   d. Press **Save** or **Recall**.
   To *save* to or *recall* from external storage (when a USB drive is connected to the front panel USB host port):
   a. Press **External**.
   b. Use the disk manager dialog to navigate to the folder where you want to save the file or to select the file you want to.
   c. In the External menu:
   To *save* the waveform, press **New File**, enter the filename, and press **Save**.
   To *load* the selected waveform (.wfm file), press **Recall**.

## Save and recall oscilloscope setups

You can save/recall oscilloscope setups to/from 10 internal, nonvolatile memory locations in the oscilloscope.

You can also save/recall setups to an external USB drive when it is connected to the front panel USB host port.

1. Press **[Save/Recall]**.
2. In the Storage menu, press **Storage**.
3. Continue pressing the **Storage** softkey or turn the ↻**entry** knob to select "Setups".
   To *save* to or *recall* from internal storage:
   a. Press **Internal**.
   b. In the Internal menu, press **Location**.

   c. Continue pressing the **Location** softkey or turn the ↻**entry** knob to select the desired internal storage location.
   The "(N)" suffix shows that nothing has been saved to the location.
   The "(S)" suffix shows waveforms have been previously saved to the location.
   d. Press **Save** or **Recall**.
   To *save* to or *recall* from external storage (when a USB drive is connected to the front panel USB host port):
   a. Press **External**.
   b. Use the disk manager dialog to navigate to the folder where you want to save the file or to select the file you want to load.
   a. In the External menu:
   To *save* the setup, press **New File**, enter the filename and press **Save**.
   To *recall* the selected setup (.stp file), press **Recall**.

# Save screens to BMP or PNG format files

1. Press **[Save/Recall]**.

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2. In the Storage menu, press **Storage**.
3. Continue pressing the **Storage** softkey or turn the ↻**entry** knob to select one of:
    **8-Bitmap** 8- bit BMP format.
    **24-Bitmap** 24- bit BMP format.
    **PNG** Portable Network Graphics format.
1. To specify whether oscilloscope parameters be saved along with the screen, press **Para Save** to toggle between on and off.
2. Press **External**.
3. Use the disk manager dialog to navigate to the folder where you want to save the file
4. In the External menu, press **New File**, enter the filename and press **Save**.

# Save data to CSV format files

You can save captured data (in CSV, comma- separated value format) to an external USB drive when it is connected to the front panel USB host port.
1. Press **[Save/Recall]**.
2. In the Storage menu, press **[Storage]**.
3. Continue pressing the **Storage** softkey or turn the ↻**entry** knob to select "CSV".
4. To specify the amount of data to be saved, press **Data Depth** to toggle between "Displayed" and "Maximum".
5. To specify whether oscilloscope parameters be saved along with the data, press **Para Save** to toggle between "ON" and "OFF".
6. Press **External**.
7. Use the disk manager dialog to navigate to the folder where you want to save the file).
8. In the External menu, press **New File**, enter the filename and press **Save**.

# Disk Manager

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When a USB drive is connected to the front panel USB host port, you can use the Disk Manager to select and name files and folders.

To access the Disk Mana. menu:
1. Press **[Save/Recall]**.
2. In the Storage menu, press **Disk Mana**.

The Disk Manager screen appears. It looks similar to:
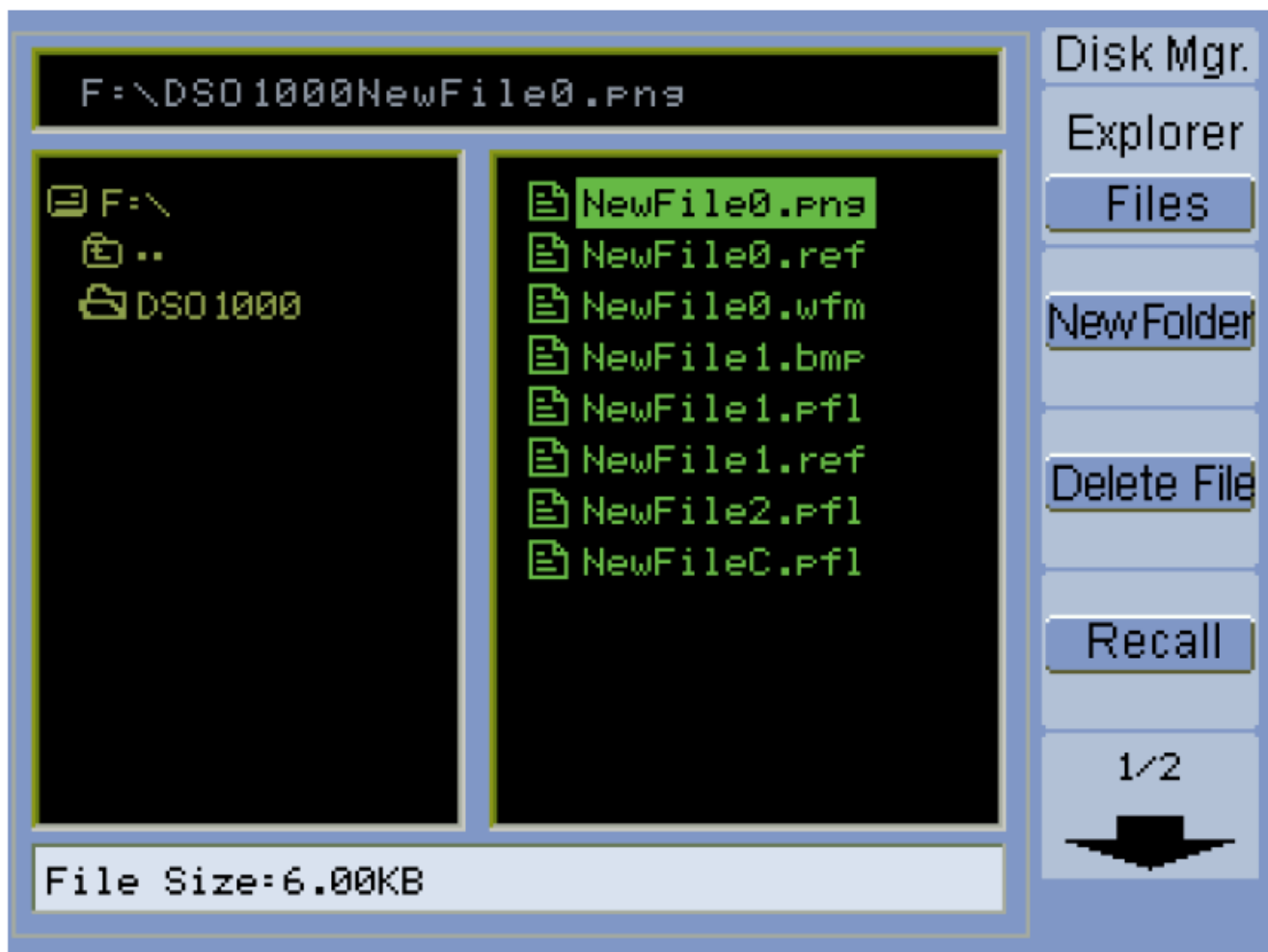


# Switch between files, path, and directory panes

1. In the Disk Mana. menu (**[Save/Recall] > Disk Mana.**), press **Explorer** to switch between:
In each of these panes, the ↻**entry** knob is used to select items.

## Navigate the directory hierarchy

In the directory pane:
- Turn the ↻**entry** knob to select folders.
- Push the ↻**entry** knob to navigate into the selected folder.

## Create new folders

1. In the Disk Mana. menu (**[Save/Recall] > Disk Mana.**), press **New Folder**.
2. Use the folder/file naming dialog to enter the folder name. See.
3. In the New Folder menu, press **Save**.

**Files** Places the cursor in the files pane.

**Path** Places the cursor in the path pane.

**Directories** Places the cursor in the directories pane.

## Edit folder/file names

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In the folder/file name edit dialog:

- Select the ⬆ ⬇ menu item to move the cursor between fields in the dialog.
- Turn the ↻**entry** knob to select:
  - A character in the filename (when the cursor is in the name field).
  - A key (when the cursor is in the keypad field).
- When the cursor is in the keypad field, push the ↻**entry** knob to:
  - Choose an alphanumeric character for the name (and move to the next name character).
  - On "Aa", change from upper to lower case characters on the keypad.
  - On "En", change from single- byte to multi- byte character entry fields.
- Select the ✕ menu item to delete a character from the name.

## Delete folders

In the directory pane:

1. Turn the ↻**entry** knob to select folders.
2. Press **Del Folder** to delete the selected folder.
3. Press **Ok** to confirm the deletion.

## Rename folders

In the directory pane:

1. Turn the ↻**entry** knob to select the folder.
2. Press **Rename**.
3. Use the folder/file naming dialog to edit the folder name.
4. In the Rename menu, press **Ok**.

## Delete files

In the files pane:

1. Turn the ↻**entry** knob to select the file.
2. Press **Delete File** to delete the selected file.
3. Press **Ok** to confirm the deletion.

## Recall files

In the files pane:

1. Turn the ↻**entry** knob to select the file.
2. Press **Recall** to load the selected file.

## Rename files

In the files pane:

1. Turn the ↻**entry** knob to select the file.
2. Press **Rename**.

Use the folder/file naming dialog to edit the file name.

1. In the Rename menu, press **Ok**.

## Display disk information

1. In the Disk Mana. menu (**[Save/Recall] > Disk Mana.**), press **Disk info**.

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