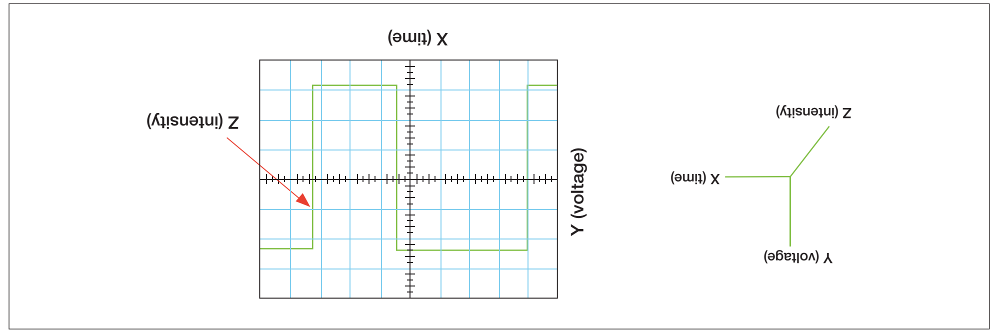
Pocket Guide to Oscilloscopes

Tektronix

Oscilloscope Principles



What is an oscilloscope?

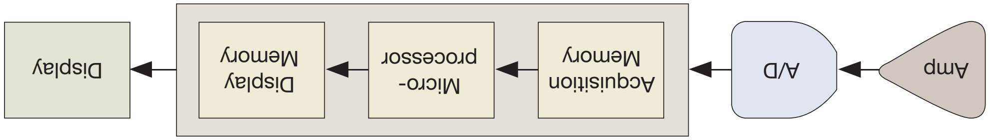
The oscilloscope is a device that draws a graph of an electrical signal.

In most applications, the graph shows how signals change over time: the vertical (Y) axis represents voltage and the horizontal (X) axis represents time. The intensity or brightness of a waveform is sometimes called the Z axis.

Key Oscilloscope Specifications

- **Bandwidth**
  The frequency range of the instrument.
- **Record Length**
  The number of waveform points used to create a record of a signal.
- **Sample Rate**
  How frequently a digital oscilloscope takes a sample of the signal, specified in samples per second (S/s).

How does a digital storage oscilloscope work?



- First, the signal travels through the probe to the vertical **amplifier**.
- Next, an **analog-to-digital converter** (A/D) digitizes the signal by sampling the signal at discrete points in time and converts the signal's voltage at these points into digital values called sample points.
- The sample points from the A/D are stored in **acquisition memory** as waveform points. Together, the waveform points comprise one waveform record.
- The number of waveform points used to create a waveform is called the record length.
- The trigger determines the start and stop points of the record.
- The signal path includes a **microprocessor** which measures the signal and formats it for display.
- The signal then passes through the **display memory** and is displayed on the oscilloscope **screen**.

Learn More...

For everything you should know about the basics of oscilloscopes and probes, check out:

- XYZs of Oscilloscopes
- ABCs of Probes

View these primers and more at:

www.tektronix.com/fundamentals

Basic and Bench Oscilloscopes from Tektronix

TDS1000B and TDS2000B Series

- 40 MHz to 200 MHz
- 2 or 4 analog channels
- Lifetime Warranty*

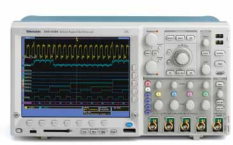
* Limitations apply. For terms and conditions, visit: www.tektronix.com/lifetimewarranty

TPS2000 Series

- 100 MHz to 200 MHz
- 2 or 4 isolated analog channels
- Battery operation
- Power analysis

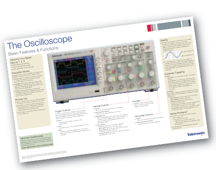
TDS3000C Series

- 100 MHz to 500 MHz
- 2 or 4 analog channels
- Optional battery operation



MSO/DPO Series

- 100 MHz to 1 GHz
- 2 or 4 analog channels
- Up to 16 digital channels
- Serial data triggering and analysis
- Power analysis



For more educational materials visit:
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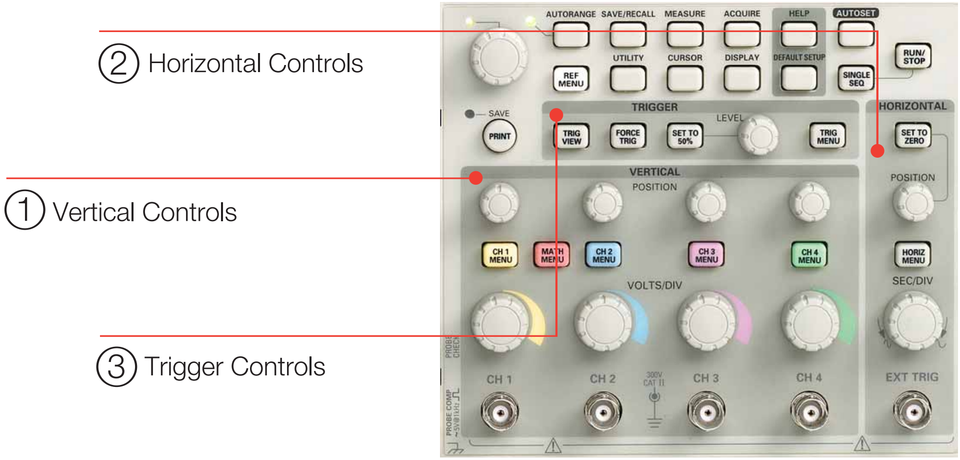
Oscilloscope Front Panel

3 Main Sections:



1. Vertical Controls

Position and Volts-Per-Division (Volts/Div)

- The vertical position control allows you to move the waveform up and down on the display.
- The volts-per-division (volts/div) setting varies the size of the waveform on the screen. The volts/div setting is a scale factor. If the volts/div setting is 5 volts, then each vertical division represents 5 volts and an entire screen of 8 divisions can display 40 volts from top to bottom.

Input Coupling

Determines which part of the signal presented to the oscillscope's input is displayed on the screen.

- DC coupling shows all of an input signal.
- AC coupling blocks the DC component of a signal so that you see the waveform centered around zero volts.
- Ground coupling disconnects the input signal from the vertical system, which lets you see where zero volts is located on the screen.

2. Horizontal Controls

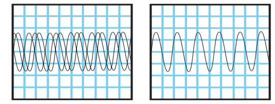
Position and Seconds-Per-Division (Sec/Div)

- The horizontal position control allows you to move the waveform left and right on the display.
- The seconds-per-division (sec/div) setting varies the rate at which the waveform is drawn across the screen (also known as the time base setting or sweep speed). The sec/div setting is a scale factor. If the setting is 1 ms, then each horizontal division represents 1 ms and the entire screen of 10 divisions represents 10 ms.

3. Trigger Controls

Trigger controls allow you to capture single-shot waveforms and stabilize repetitive waveforms.

Imagine the jumble on the screen that would result if each time the trace is drawn across the screen, the drawing begins at a different part of the waveform. The trigger ensures the same part of the waveform is drawn each time, making repetitive waveforms appear static.



Untriggered Display   Triggered Display

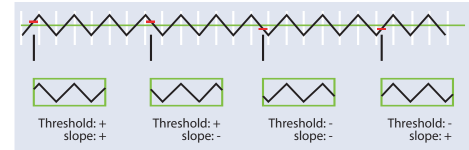
The trigger circuit acts as a comparator. When the signal matches the trigger setting, the oscilloscope generates a trigger and captures a signal. Edge triggering is used most often; it captures the signal on a rising or falling edge.

Trigger level and slope

- The slope control determines whether the trigger point is on the rising edge (positive slope) or the falling edge (negative slope) of a signal.
- The level control determines where on the edge the trigger point occurs.

Source

- Determines which signal is compared to the trigger settings.



Modes

Determines whether or not the oscilloscope draws a waveform based on a signal condition.

- Normal mode - the oscilloscope only sweeps if the input signal reaches the set trigger point; otherwise the screen is frozen on the last acquired waveform.
- Auto mode - the oscilloscope sweeps, even without a trigger. If no signal is present, a timer in the oscilloscope triggers the sweep. This ensures that the display will not disappear if the signal does not cause a trigger.
- Single sequence mode - After the oscilloscope detects a trigger, the oscilloscope acquires and displays one triggered screen of a signal and then stops.

Coupling

Similar to vertical coupling. High frequency, low frequency, and noise rejection trigger coupling are useful for eliminating noise from the trigger signal to prevent false triggering.

Tips for Capturing your Signal

1. Return the oscilloscope to a known state.
   Press the Default Setup button.
2. Connect the appropriate probe to the oscilloscope.
   - Check that the oscilloscope and probe bandwidths match.
   - Check probe compensation.
3. Connect your probe to the circuit signal.

When using an oscilloscope, you need to adjust three basic settings to accommodate an incoming signal:
- The vertical scale (volts/div).
- The time base / horizontal scale (sec/div).
- The trigger level, slope, source, mode, and type.

If you do not see a signal, check the following:

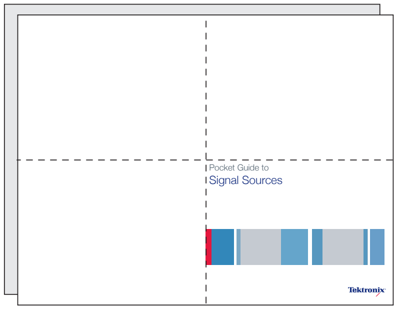
- Is the channel on?
- Is the waveform off screen?
  - Adjust the vertical position and scale.
  - Adjust vertical coupling if signal has large DC component.

If your waveform is indistinguishable, adjust the horizontal scale.

If you can not get a stable trace, check the following:

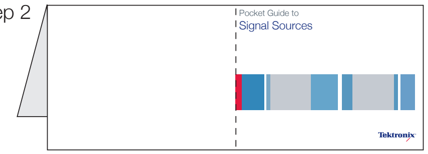
- Trigger level and source.
- For waveforms with events far apart in time, use normal mode.
- For single shot events, use single sequence mode.
- When using two or more traces, one trace may be stable while the others keep racing across the display. The frequencies of the waveforms are different.
  - Change trigger source to characterize each signal individually.
  - Or, use single sequence mode.

step 1



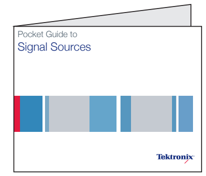
1. Print the four-panel guide on both sides of a single sheet of paper

step 2



2. Fold the guide in half with a horizontal fold

step 3



3. Fold the guide in half with a vertical fold