How to use an oscilloscope

Each station includes an oscilloscope with two probes. The oscilloscope is an instrument that basically displays the graph of an electrical signal, usually voltage as a function of time. It is generally useful in cases where there is a rapidly changing voltage as a function of time. Using the Oscilloscope, you can determine:

• the magnitude of the voltage and how it is varying with time,
• the frequency of an oscillating signal,
• how much of your signal contains a DC component and an AC component,
• how much noise there is in your signal and how that noise is varying with time, and
• if there is a malfunctioning component in a circuit by observing the response of the circuit when it is subjected to a varying input.

Here is a typical digital oscilloscope:

Typically, the front display will have three sections titled Vertical, Horizontal, and Trigger.
Electronics can be analog or digital. Analog equipment work with continuously varying voltages, whereas digital equipment use binary numbers that represent packets or samples of voltages. An example of an analog equipment is the record player, while its counterpart the CD player is a digital device. Oscilloscopes also come in analog and digital types. An analog oscilloscope works by directly applying the input voltage (i.e. signal to be measured) to an electron beam moving across the oscilloscope screen. The input voltage deflects the beam up and down proportionally, tracing the waveform on the screen. In contrast, a digital oscilloscope samples the waveform and uses an analog-to-digital converter (or ADC) to convert the input voltage (i.e. signal to be measured) into digital information. It then uses this digital information to reconstruct the waveform on the screen. Each has its own advantages. Analog oscilloscopes are useful when it is important to display rapidly varying signals in "real time" (or as they occur). Digital oscilloscopes allow you to capture and view events that may happen only once. They can process the digital waveform data or send the data to a computer for processing. Also, they can store the digital waveform data for later viewing and printing.

The signal to be measured is fed to one of the input connectors, which is usually a coaxial connector called a BNC or N type cable. If the input signal has its own co-axial connector, then a simple co-axial cable is used. Otherwise, a specialized cable called a scope probe, supplied with the oscilloscope, is used.

In its simplest mode, the oscilloscope repeatedly draws a horizontal line called the trace across the middle of the screen from left to right. One of the controls, the timebase control, sets the speed at which the line is drawn, and has units of seconds per division. If the input voltage departs from zero, the trace is deflected either upwards or
downwards. Another control, the *vertical control*, sets the scale of the vertical deflection, and has units of volts per division. The resulting trace is a graph of voltage against time. If the input signal is periodic, then a nearly stable trace can be obtained just by setting the *timebase* to match the frequency of the input signal. For example, if the input signal is a 50 Hz (i.e. 50 cycles per second) sine wave, then its period is 20 ms, so the *timebase* should be adjusted so that the time between successive horizontal sweeps is 20 ms. This operation is called a *continual sweep*. Unfortunately, an oscilloscope's timebase is not perfectly accurate, and the frequency of the input signal is not perfectly stable, so the trace will drift across the screen making measurements difficult.

In order to provide a more stable trace, an oscilloscope has a function called the *trigger*. The *trigger* causes the scope to pause after reaching the right hand side of the screen, and wait for a specified event before returning to the left hand side of the screen and drawing the next trace. Types of trigger or “specified events” include:

1. an *external trigger* or pulse from an external source connected to a dedicated input on the scope.
2. an *edge trigger*, which is an edge-detector that generates a pulse when the input signal crosses a specified threshold voltage in a specified direction.
3. a *video trigger*, which is a circuit that extracts synchronising pulses from video formats such as PAL and NTSC and triggers the timebase on every line, a specified line, every field, or every frame. This circuit is typically found in a waveform monitor device.
4. a *delayed trigger*, which waits a specified time after an edge trigger before starting the sweep. No trigger circuit acts instantaneously, so there is always a certain delay, but a trigger delay circuit extends this delay to a known and adjustable interval.
The effect of the trigger is to resynchronize the timebase to the input signal, preventing horizontal drift of the trace. Trigger circuits allow the display of nonperiodic signals such as single pulses, as well as periodic signals such as sine waves and square waves.

Most oscilloscopes have two or more input channels, allowing them to display more than one input signal on the screen. Many oscilloscopes also allow you to bypass the timebase and feed an external signal into the horizontal amplifier. This is called X-Y mode, and is useful for viewing the phase relationship between two signals, which is commonly used in radio and television engineering. When the two input signals are sinusoids of varying frequency and phase, the resulting trace is called a Lissajous curve.

Some oscilloscopes have cursors, which are lines that can be moved about the screen to measure the time interval between two points, or the difference between two voltages. Usually the oscilloscope has a separate set of vertical controls for each channel, but only one triggering system and timebase. A dual-timebase oscilloscope has two triggering systems so that two signals can be viewed on different time axes. This is also known as a magnification mode. The user traps the desired, complex signal using a suitable trigger setting. Then by turning on the "magnification", "zoom" or "dual timebase" feature, you can move a window to look at details of the complex signal.

Sometimes the event you want to see may only happen occasionally. To catch these sporadic events, some oscilloscopes have a "storage scope" feature that preserves the most recent sweep on the screen. Some digital oscilloscopes can sweep at speeds as slow as once per hour, emulating a strip chart recorder. Most fancy oscilloscopes switch from a sweep to a strip-chart mode right around one sweep every ten seconds. This is because otherwise, the scope looks broken: it is actually collecting data, but the dot or trace cannot be seen on the screen.
**Oscilloscope Etiquette**

- Never fiddle with another person’s scope.
- Always compensate an unknown scope’s probes.
- Never use 1x unless you are absolutely certain of the characteristics of the device being measured.
- Know your (electrical) ground.
- Avoid Autoscale!
- Always ensure that $Z_{\text{in}} >> Z_{\text{out}}$

**Trigger**

The *trigger* triggers the electron beam at a desired voltage level. This level can either be set to the rising portion of the varying input voltage or the falling edge of the input. This feature is very useful for single sweep, and can be delayed:

- Auto
- Normal
- Line
- External

DC or AC coupling

**Vertical Amplification**

- Sets the vertical deflection of the electron beam on the Oscope screen
- Allows you to measure peak-to-peak voltage
- Avoid full screen measurements
- AC or DC coupling

**Horizontal Sweep**

- Sets the beam speed across the Oscope screen in seconds
- Allows measurement of frequency, i.e. inverse of the period, of the input signal
- Allows you to measure towards the middle of the screen

**Some useful stuff:**

1 ms = 1000 Hz = 1 kHz
10 ms = 100 Hz
100 ms = 10 Hz
16.6 ms » 60 Hz