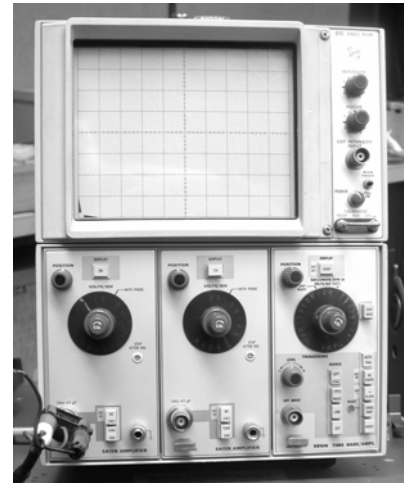


# OSCILLOSCOPE BASICS

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## Overall Design

Oscilloscopes have many uses; one is displaying voltage as a function of time. The heart of the oscilloscope is a device that uses a large potential difference to produce a narrow beam of high-velocity electrons. This beam, when it strikes the screen, makes the screen glow at the point of impact. Before reaching the screen, the beam passes through two sets of parallel plates. The first set of plates is vertical; by creating a potential difference between the two plates, the oscilloscope can create a horizontal electric field that can deflect the electron beam to the left or right. The second set of plates is horizontal and can be used to create a vertical electric field to deflect the beam up and down.



## Horizontal Movement of the Beam

In a typical use, a unit called a Time Base controls the left-to-right motion. It's the right-most module on our scopes. The Time Base creates a steadily-increasing potential difference that causes the beam to move from left to right at a constant rate; this is called "sweeping the beam." When the beam reaches the right end, the Time Base quickly resets the voltage to place the beam at the left end, then sweeps it across the screen again. A large knob lets you control the sweep speed of the beam. This sweep knob is calibrated in seconds per division (SECONDS/DIV). You can set the rate to several different values, such as 1 s/div or 0.1ms/div or 10 $\mu$ s/div, for example. If you choose, say 0.2 s/div, then the beam will take 0.2 seconds to move one division horizontally. Each division is 0.5" (about 12.5 mm) and is subdivided with small ticks every 0.2 divisions. At slow sweep speeds, you can see the luminescent dot produced by the beam move across the screen. The luminescence persists for a while, so at faster sweep speeds you see a continuous line instead of a dot. When displaying a repeating signal, it's important for each sweep to start in the same phase of a cycle so that successive cycles overlap exactly. The Triggering section of the Time Base manages this synchronization. You can use the small knob labeled "LEVEL" to clean up the appearance of the signal.



## Vertical Movement of the Beam

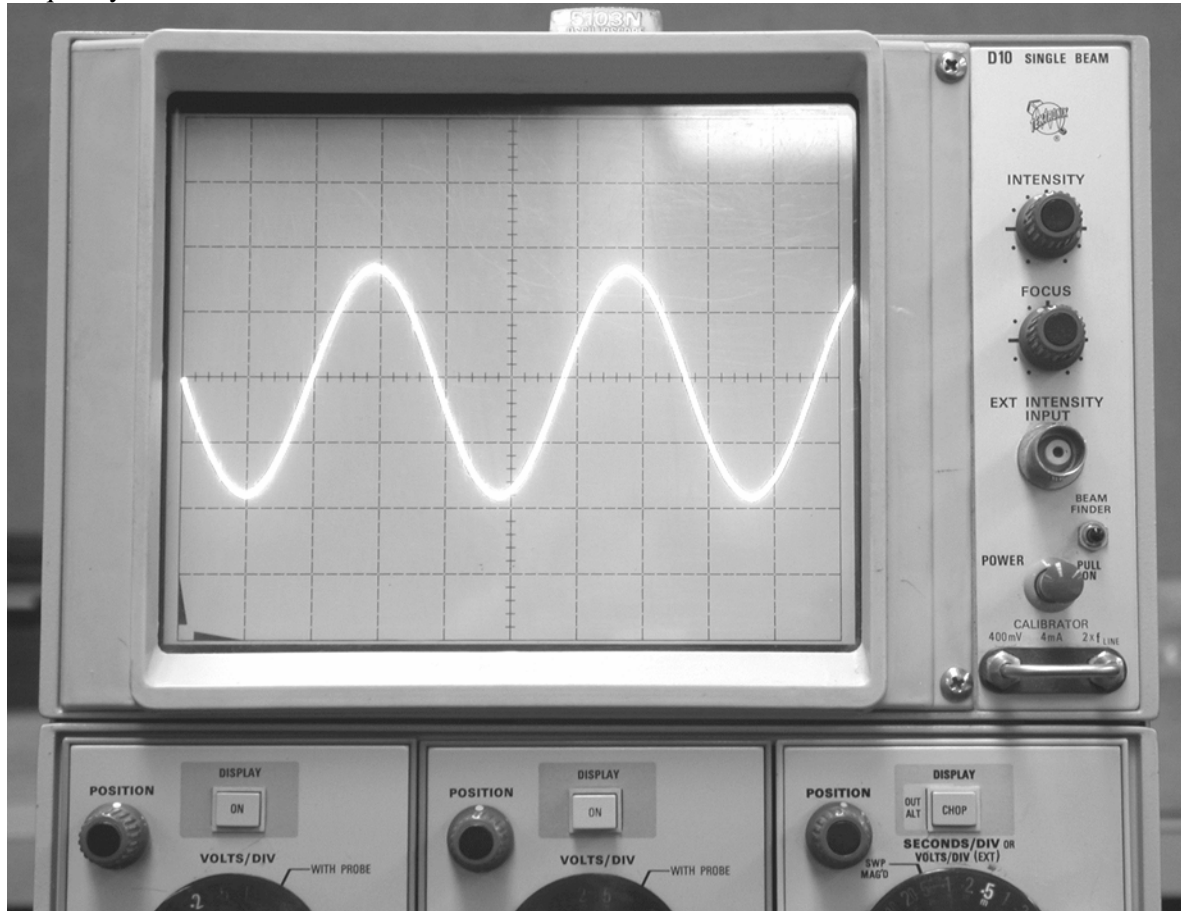
The vertical motion typically is controlled by an amplifier unit that supplies a vertical displacement based on an external voltage. It has a large knob calibrated in volts per division (VOLTS/DIV). For example, if you have the knob set to 1 V/div and you connect the leads to the two ends of a 1.5-V battery, the beam will be deflected 1.5 divisions upward (or downward, depending on which lead you connect to the positive battery terminal). By changing the V/div setting, you can accommodate the oscilloscope to a range of voltages.



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## Measuring Periods and Frequency

If you connect to, say, a function generator producing a 10 Hz sine wave voltage, the dot will move up and down with a frequency of 10 Hz and a period of 0.10 seconds. If you set the time base to 0.1 sec/div, then the beam will move one division horizontally each complete oscillation, tracing out a sine wave on the screen. In general, you can use the oscilloscope to read the period of a periodic signal directly by noticing how many horizontal divisions it takes from one maximum to the next, then multiplying the number of divisions by the sec/div setting to get the period in seconds. Take the inverse to get the frequency.



For example, the picture above shows about 3.9 divisions horizontally peak to peak, and the time setting is 0.5 ms/div. Hence the period is  $3.9 \text{ div} \times 0.5 \text{ ms/div} = 1.95 \text{ ms}$ , and the frequency is the inverse, or about 513 Hz.

## Connectors

The oscilloscope uses something called a BNC connector for connecting leads to the oscilloscope. A common arrangement is to use a co-axial cable (two shielded conductors) with a BNC connector at one end and a dual banana plug at the other end. The banana plug on the tabbed side of the plug is grounded. You can connect the BNC-end to the oscilloscope and a regular single banana-plug cable to each plug at the other end, thus getting two leads connected to the oscilloscope. Or you can connect the dual plug directly to two locations if they have the correct connectors with the correct spacing. The oscilloscope measures the voltage difference between the two banana plugs (or their extensions).