Experiment No.10

The Cathode Ray Tube C.R.T

Object

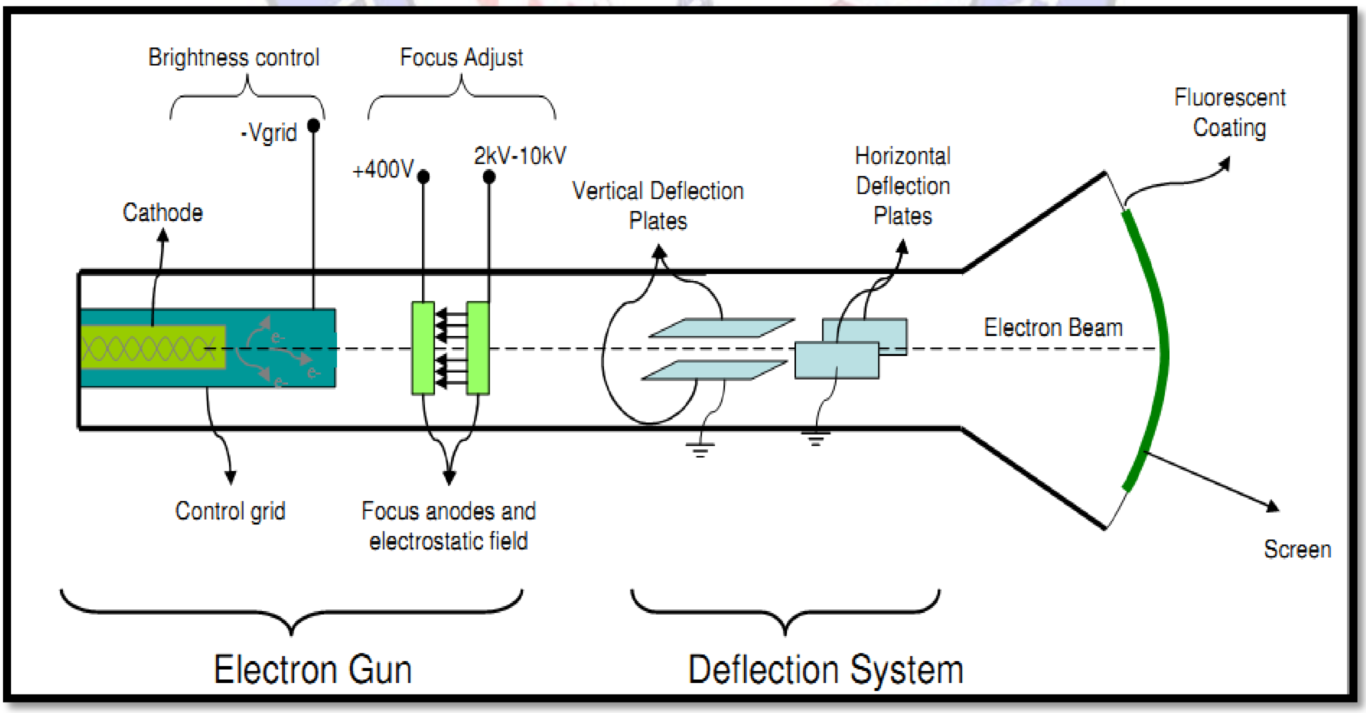
To be familiar with the Cathode Ray Tube.

Theory

This tube is commonly used to obtain a visual display of electronic information in oscilloscopes, radar systems, television receivers, and computer monitors.

The CRT is a vacuum tube in which a beam of electrons is accelerated and deflected under the influence of electric or magnetic fields. The electron beam is produced by an assembly called an electron gun located in the neck of the tube.

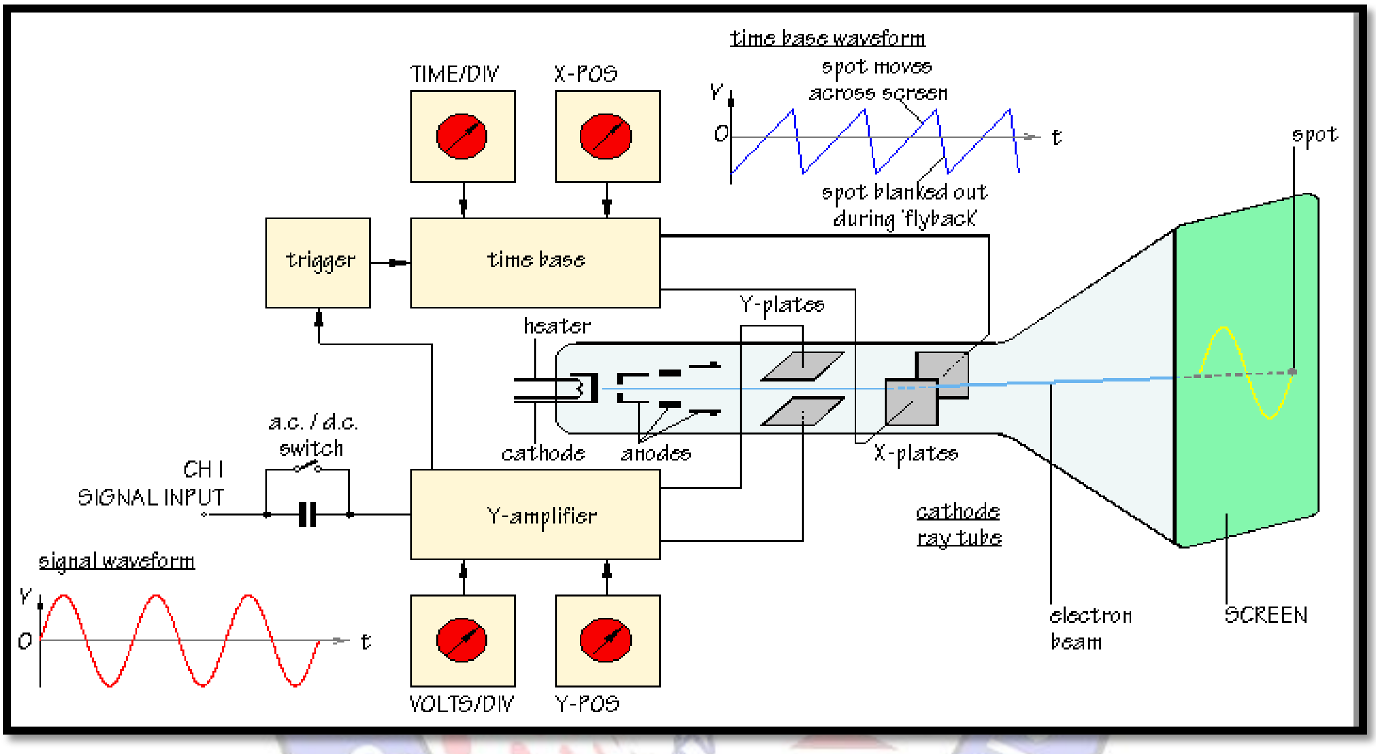
These electrons, if left undisturbed, travel in a straight-line path until they strike the front of the CRT, the "screen,'' which is coated with a material that emits visible light when bombarded with electrons.



The CRT is composed of two main parts,

1.Electron Gun

2.Deflection System



Electron Gun

- Electron gun provides a sharply focused electron beam directed toward the fluorescent-coated screen.
- The thermally heated cathode emits electrons in many directions. The control grid provides an axial direction for the electron beam and controls the number and speed of electrons in the beam.
- The momentum of the electrons determines the intensity, or brightness, of the light emitted from the fluorescent coating due to the electron bombardment. Because electrons are negatively charged, a repulsion force is created by applying a negative voltage to the control grid, to adjust their number and speed.
- A more negative voltage results in less number of electrons in the beam and hence decreased brightness of the beam spot. Since the electron beam

consists of many electrons, the beam tends to diverge. This is because the similar (negative) charges on the electrons repulse each other. To compensate for such repulsion forces, an adjustable electrostatic field is created between two cylindrical anodes, called the focusing anodes. The variable positive voltage on the second anode cylinder is therefore used to adjust the focus or sharpness of the bright spot.

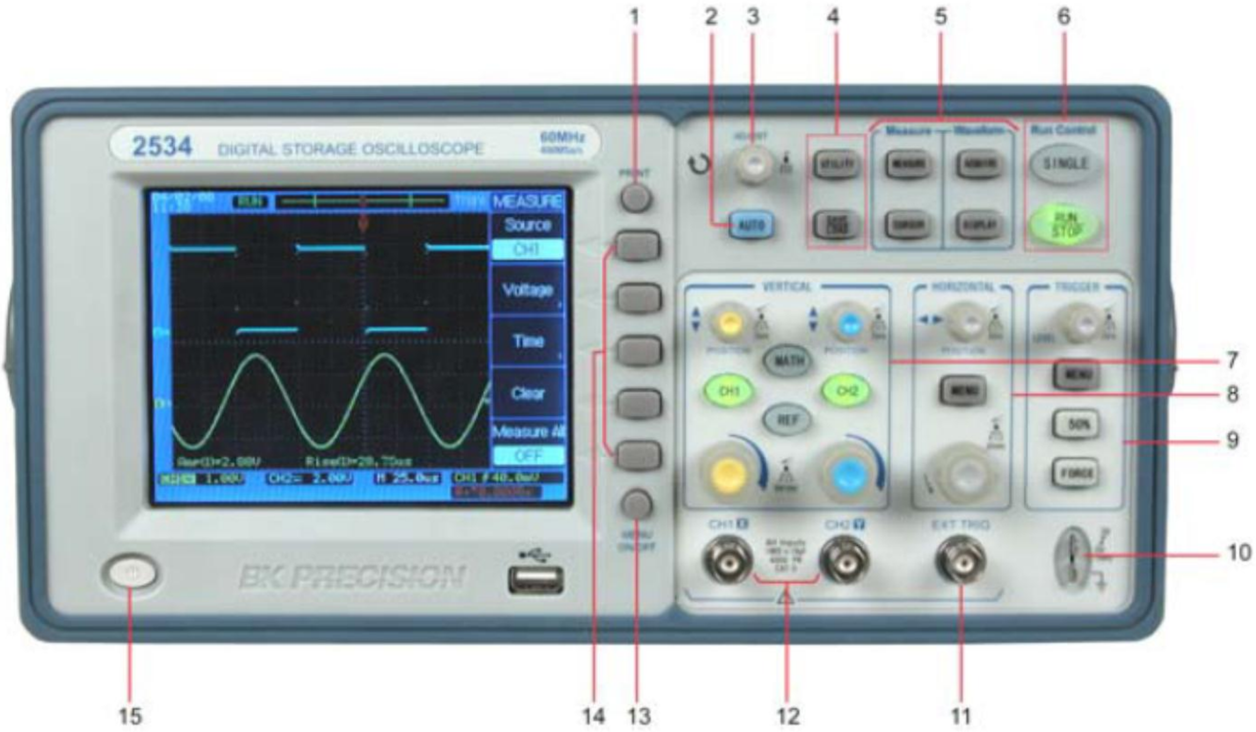
The Deflection System

- The deflection system consists of two pairs of parallel plates, referred to as the vertical and horizontal deflection plates. One of the plates in each set is permanently connected to the ground (zero volt), whereas the other plate of each set is connected to input signals or triggering signal of the CRO.

A CATHODE RAY OSCILLOSCOPE

A Cathode Ray Oscilloscope, abbreviated as CRO and referred to as oscilloscope, in short, is now a basic, important and versatile instrument in every electronics and electrical engineering laboratory. In the previous experiment, you got opportunities to measure voltages of a dc-source and an ac-source using a voltmeter and a multimeter. If you study time variation of these voltages, you will observe that the dc voltage remains constant with time (the curve is a straight line parallel to the x-axis in a voltage versus time graph), whereas ac voltage varies sinusoidally with time. While an ac-voltmeter or multimeter can give us information about the magnitudes of the voltages, details on the nature of waveform (of an ac or dc signal) remain hidden. To display a signal or a waveform of any type, we have to use an oscilloscope. This characteristic of CRO makes it a vital tool in medical diagnostics and care.

Fig.1 shows one of the commonly available oscilloscopes. A CRO is essentially an assembly of a cathode ray tube (CRT) and specific electronic circuits. The CRT is the major component of the CRO. It produces a sharply focused high-speed electron beam, which can be moved on the screen using appropriate voltages for deflection. The front panel consists of the CRT screen and various control knobs, which are used for different purposes. The functions of these control knobs are discussed in this section.



Front panel

1. **PRINT key**
   Press this key to print the current display to a USB mass storage device.
2. **AUTO key**
   When you press the AUTO key, the oscilloscope will quickly determine which channels are active and automatically scale the display to show the signals on these channels.
3. **Entry knob↻**
   The Entry knob is used to select items from menus and input values. Its function changes when a different menu is displayed. The curved arrow symbol ↻ to the left of the Entry knob lights up when the Entry knob is active and can be used to select a value.
4. **Utility and Save/Load Menu**
   UTILITY
   Access the system utility functions, such as Language Setup, I/O Setup, and Print Setup etc.
   SAVE/LOAD
   You can save your current setup and waveform data to the oscilloscope's internal memory or to a USB mass storage device and retrieve the setup or waveform later.
5. **Measure and Waveform Menu**
   MEASURE
   Perform automated measurements of waveform parameters.
   ACQUIRE
   The ACQUIRE menu lets you set the oscilloscope to acquire waveforms in Normal, Peak Detect, or Average mode and lets you select Real Time or Equivalent sampling.
   CURSOR
   Press the CURSOR key to activate the cursors for making custom voltage or time measurements on scope signals.
   DISPLAY
   You can change the appearance of waveforms and the display screen, select the color schemes, and adjust the contrast, etc.
6. **RUN control keys**
   The RUN/STOP key will be green when the oscilloscope is waiting for a trigger event. When the trigger mode is set to Normal, the display will not update until a trigger event occurs. If the trigger mode is set to Auto, the oscilloscope looks for a trigger; if no trigger is found, it will be triggered automatically and the input signals will be displayed.

Press the **RUN/STOP** key again to stop acquiring data. The **RUN/STOP** key will be red. Now you may examine the acquired waveform by panning and zooming.

Press the **SINGLE** key to acquire a single waveform trace. The key will remain orange until the oscilloscope is triggered. After the trigger event, the waveform is displayed and triggering is disabled until re-armed by pressing the **SINGLE** key again.

7. **Vertical controls**

   You can use the vertical position control knob to move the waveforms up or down on the display. There is one vertical position control knob for each channel.
   You can press the channel key **CH1** or **CH2** to switch the channel on or off or access the associated channel menu via the softkeys. There is one channel on/off key for each channel.
   You can press the **MATH** key to access the FFT (Fast Fourier Transform), multiply, subtract, and add functions.
   You can press the **REF** key to save or load a reference waveform from the internal memory or an external USB mass storage device.
   You can use the vertical scale control knob to change the vertical scale of a waveform. The waveform display will contract or expand relative to the ground reference level. There is one vertical scale control knob for each channel.

8. **Horizontal controls**

   When the oscilloscope is in run mode, the horizontal position control knob lets you set the acquisition window relative to the trigger point. When acquisition is stopped, you can turn this knob to pan through the stored waveform data horizontally. This lets you see the captured waveform before or after the trigger.
   Press the horizontal **MENU** key to access the menu where you can activate a delayed sweep or select X-Y or Roll modes.
   Turn the horizontal sweep rate control knob to adjust the sweep speed. This changes the time base on the display. When adjusted after the waveform has been acquired and the oscilloscope is stopped, this has the effect of stretching or compressing the waveform horizontally.

9. **Trigger controls**

   These controls are used to control how the oscilloscope triggers to capture waveforms.

10. **Probe compensation terminals**

    Use these two probe compensation terminals to match each probe's characteristics to the oscilloscope channel to which it is connected.

11. **External trigger input**

    This is the external trigger input BNC connector.

12. **Channel input BNC**

    This is the channel's input BNC connector. Connect the oscilloscope probe or BNC cable to the BNC Connector.

13. **MENU On/Off key**

    Press this key to toggle the menu display on and off.

14. **Softkeys**

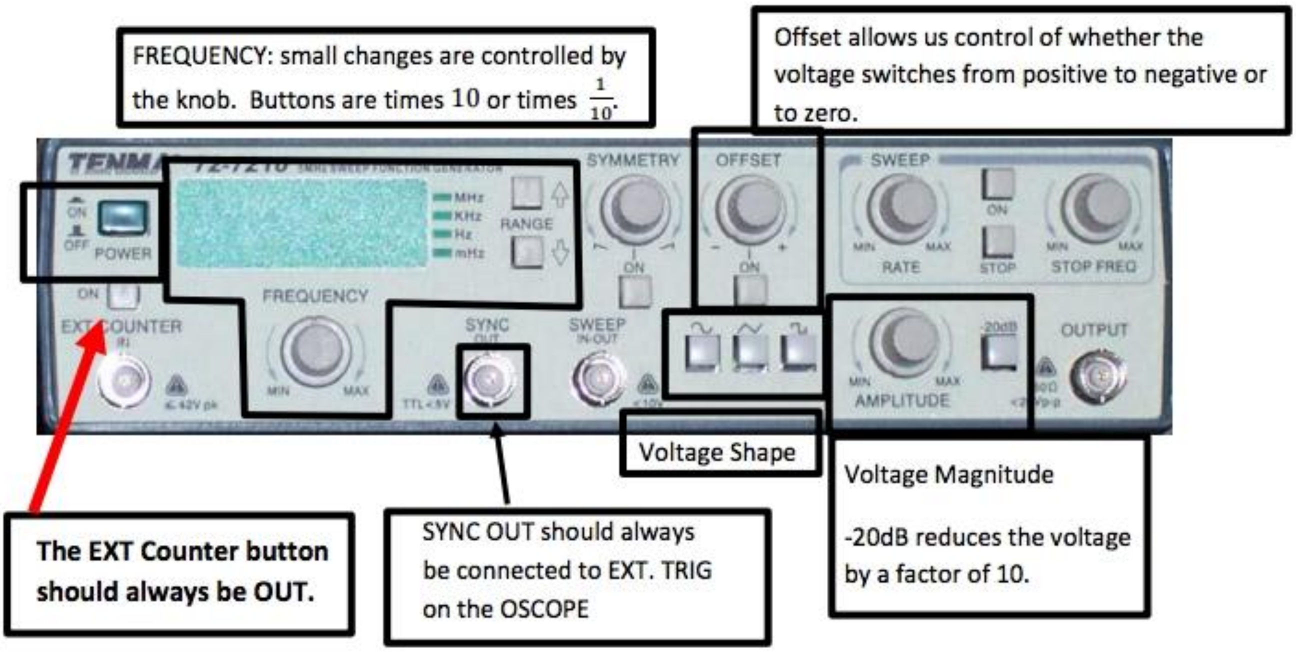
    Five menu softkeys are used to select the control and parameter setting functions. Each softkey has a label along the right side of the screen.

15. **Power switch**

    Press once to turn power on, press again to turn power off.

16. **LCD display**

    The 320*240 matrix (5.7 inch) LCD displays captured waveforms, setup information, measurement results, and softkeys for setting up parameters.



Function Generator

A function generator shown in figure above is usually a piece of electronic test equipment or software used to generate different types of electrical waveforms over a wide range of frequencies. Some of the most common waveforms produced by the function generator are the sine wave, square wave, triangular wave and sawtooth shapes. These waveforms can be either repetitive or single-shot (which requires an internal or external trigger source).[1] Integrated circuits used to generate waveforms may also be described as function generator ICs.

In addition to producing sine waves, function generators may typically produce other repetitive waveforms including sawtooth and triangular waveforms, square waves, and pulses. Another feature included on many function generators is the ability to add a DC offset.

Although function generators cover both audio and RF frequencies, they are usually not suitable for applications that need low distortion or stable frequency signals. When those traits are required, other signal generators would be more appropriate.

Some function generators can be phase-locked to an external signal source (which may be a frequency reference) or another function generator.[2]

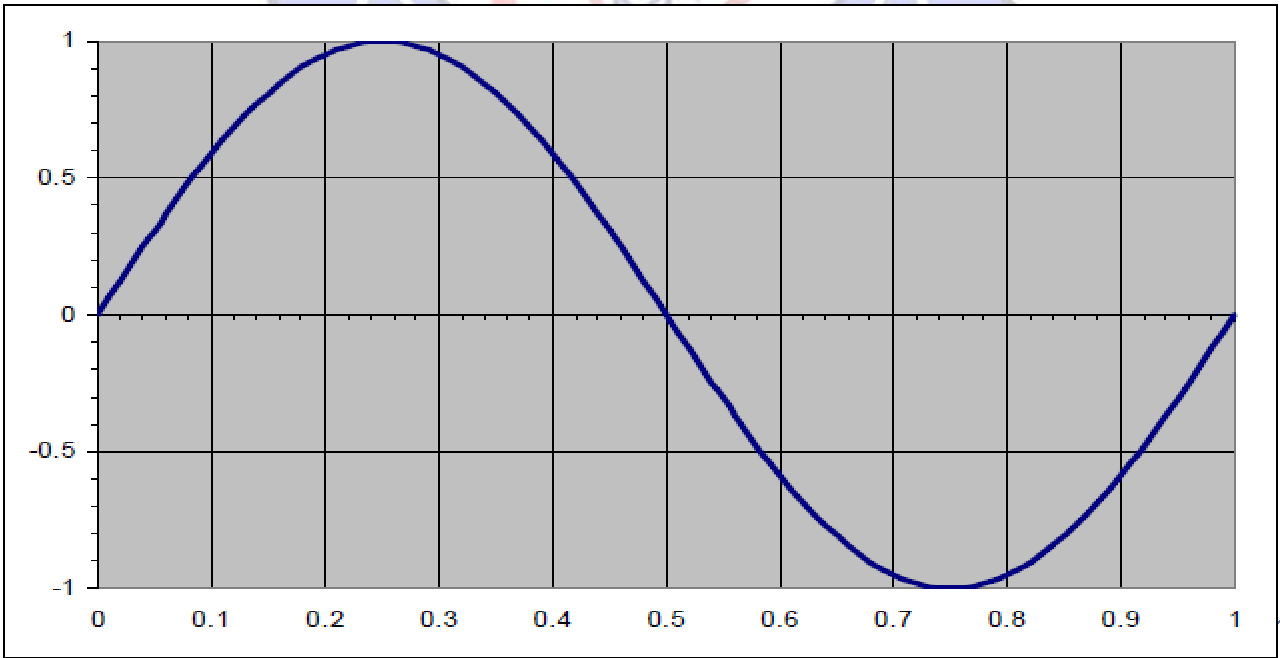
Function generators are used in the development, test and repair of electronic equipment. For example, they may be used as a signal source to test amplifiers or to introduce an error signal into a control loop. Function generators are primarily used for working with analog circuits, related pulse generators are primarily used for working with digital circuits.

The Oscilloscope can be operated in the following modes:

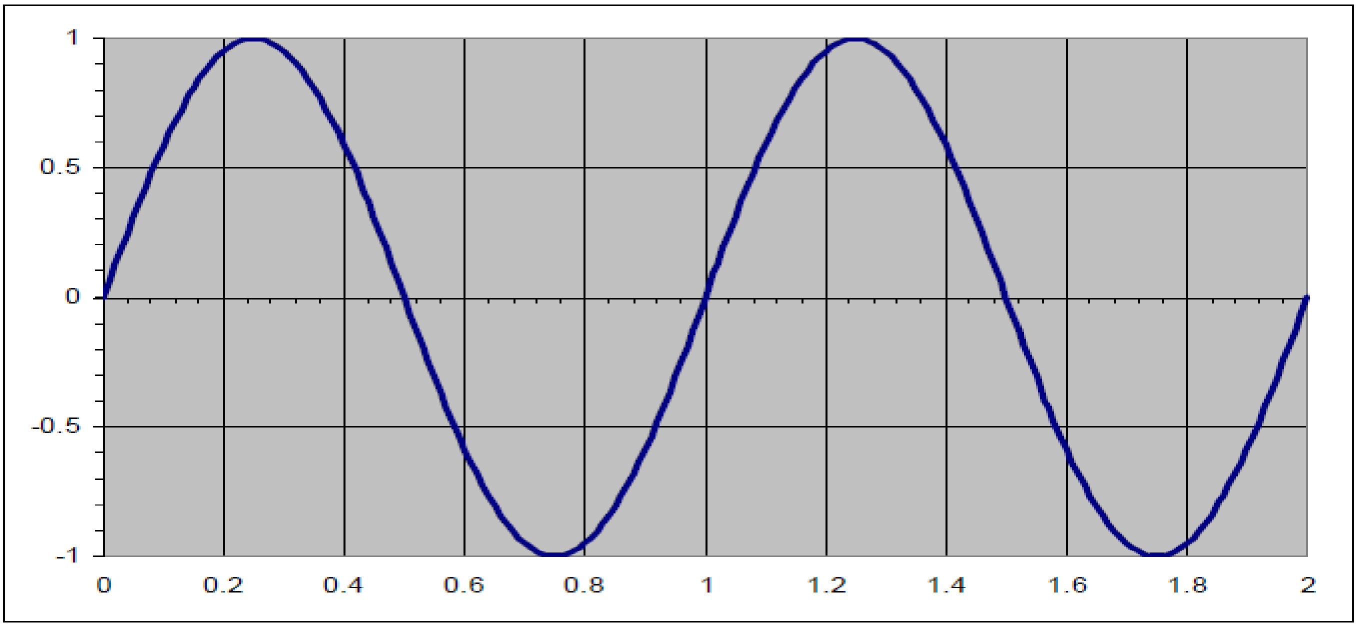
There are several controls on the scope. They include: the vertical grid (or scale) control (Volts/Div), vertical position control, the horizontal scale control (time base), intensity control, Trigger Level, Trigger Source, etc. There are vertical controls for each Y Input supported by the scope.

- Time Base Mode

(Assume that Volts/Div is set to 500 millivolts/division = .5 volts/division.) The time base controls how the horizontal (X-axis) is read. In the following figure, a sine wave with frequency 1 Hz is displayed. In this case, the frequency is 1 Hz and its period are 1 complete cycle in 1 second (recall Hz = cycles per second). Since the time base is set to 0.1 seconds (or 100 milliseconds/division) and there are 10 divisions on the horizontal axis, a second of time spans the full X-axis and, therefore, a full cycle will be displayed.

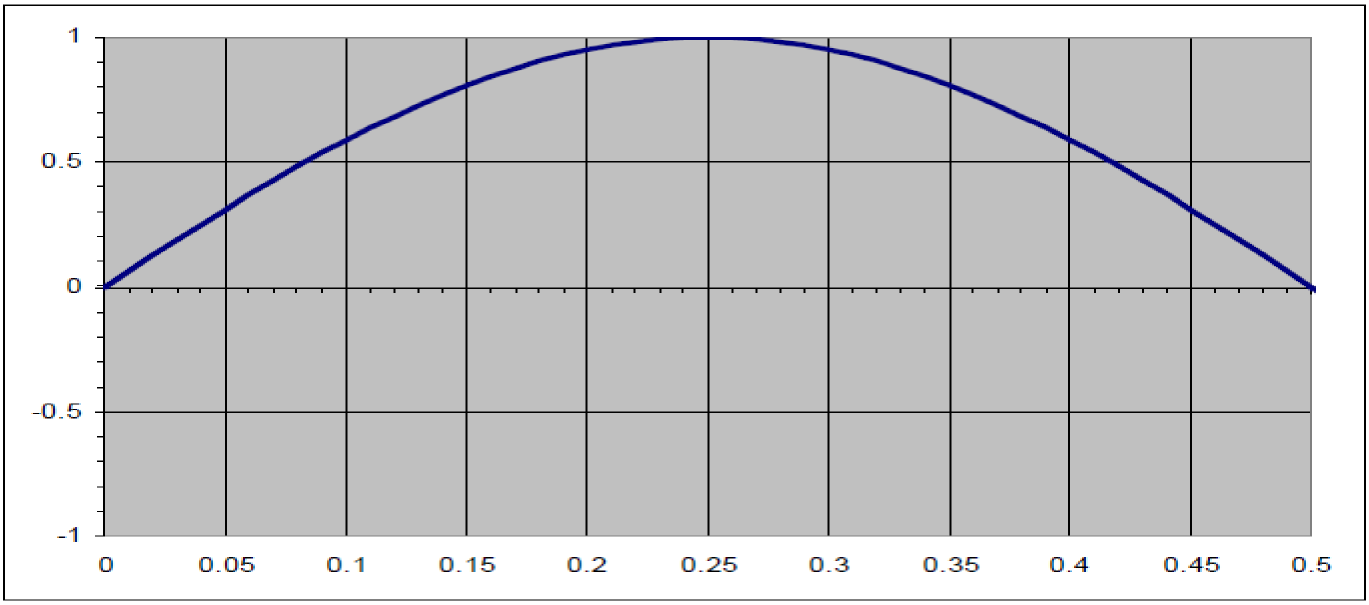


Setting the time base to 200 milliseconds/division X 10 divisions = 2 seconds will yield a display of 2 cycles.

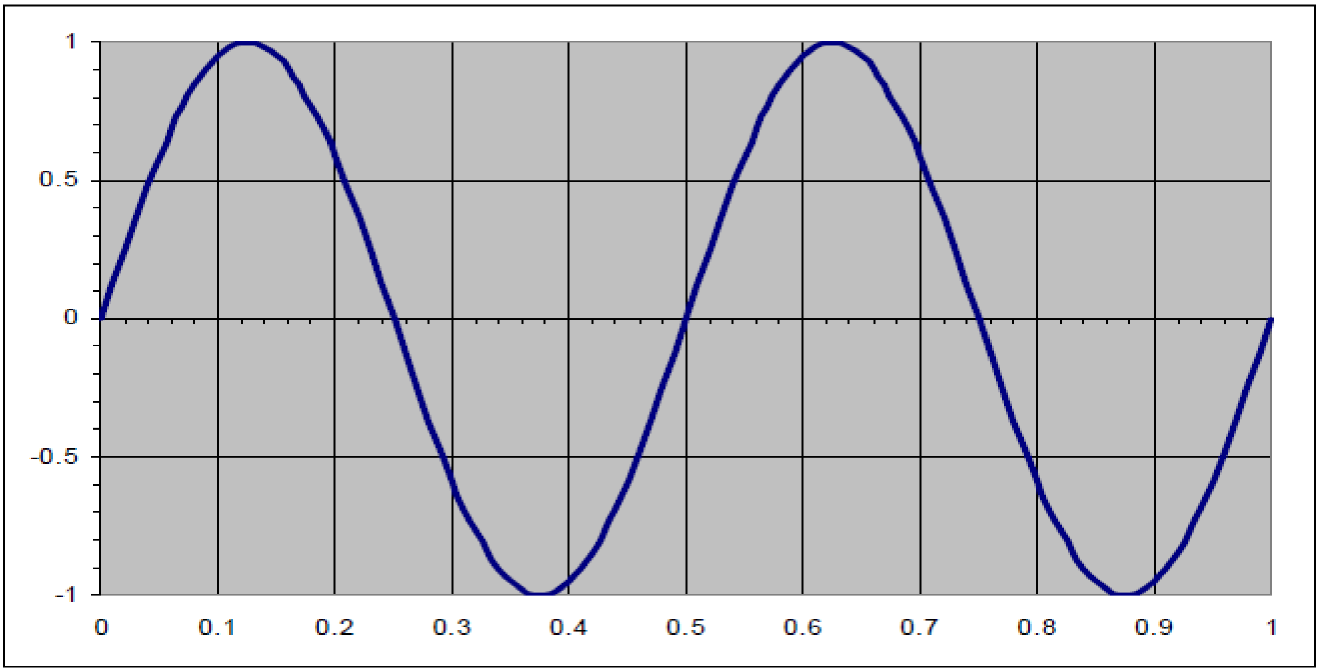


Therefore, increasing the Timebase will display more cycles of a periodic signal.

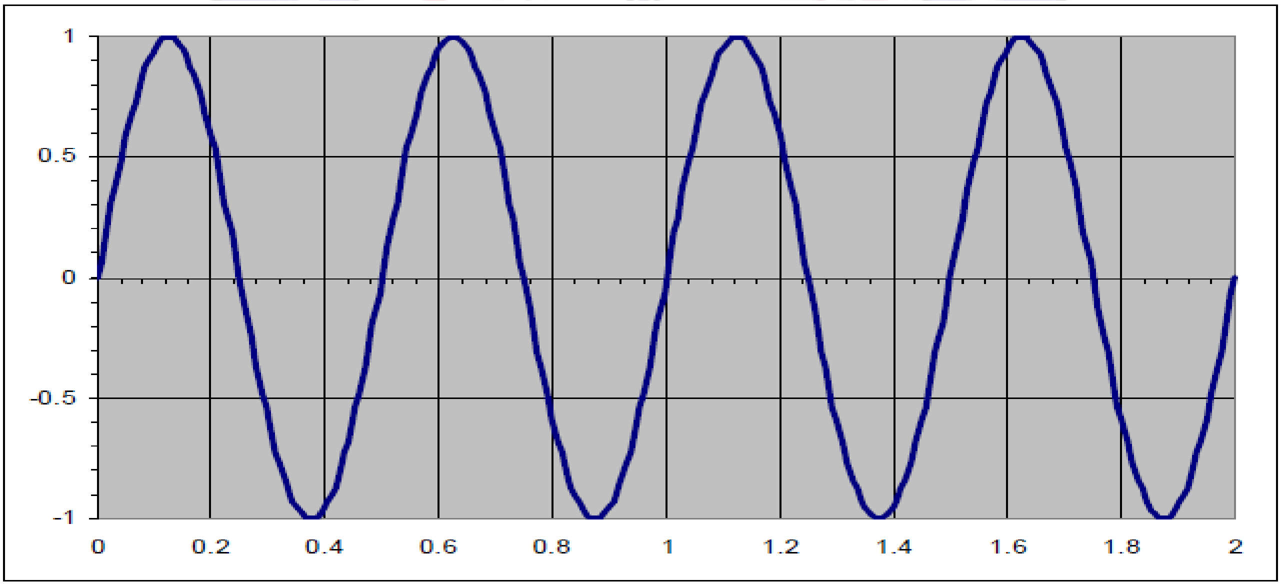
Increasing too much will clutter the display. Conversely, reducing the Timebase, fewer cycles will be displayed. In the following figure, the Timebase is set to 50 milliseconds/division and one half of a cycle is displayed. Reducing is too much may display a useless fragment of a cycle.



Now, what happens when the frequency changes? For a sine wave with frequency of 2 Hz has a period of 0.5 second (or 500 milliseconds). Therefore, with the Timebase set at 100 milliseconds/division, our 10-division scope will display 2 cycles

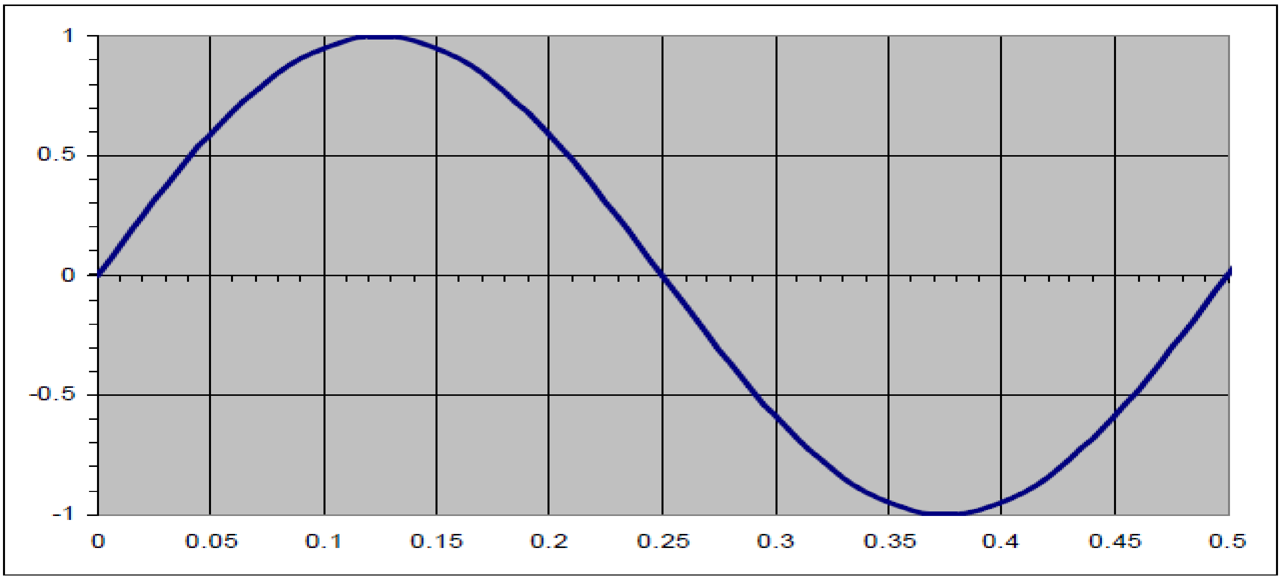


and with a Timebase set at 200 milliseconds/division, 4 cycles will be displayed.



As stated previously, increasing the Timebase further will display more cycles. However, to display one cycle of the 2 Hz sine wave, the Timebase needs to be reduced to 50 milliseconds/division (since the inverse of the frequency 2 Hz =

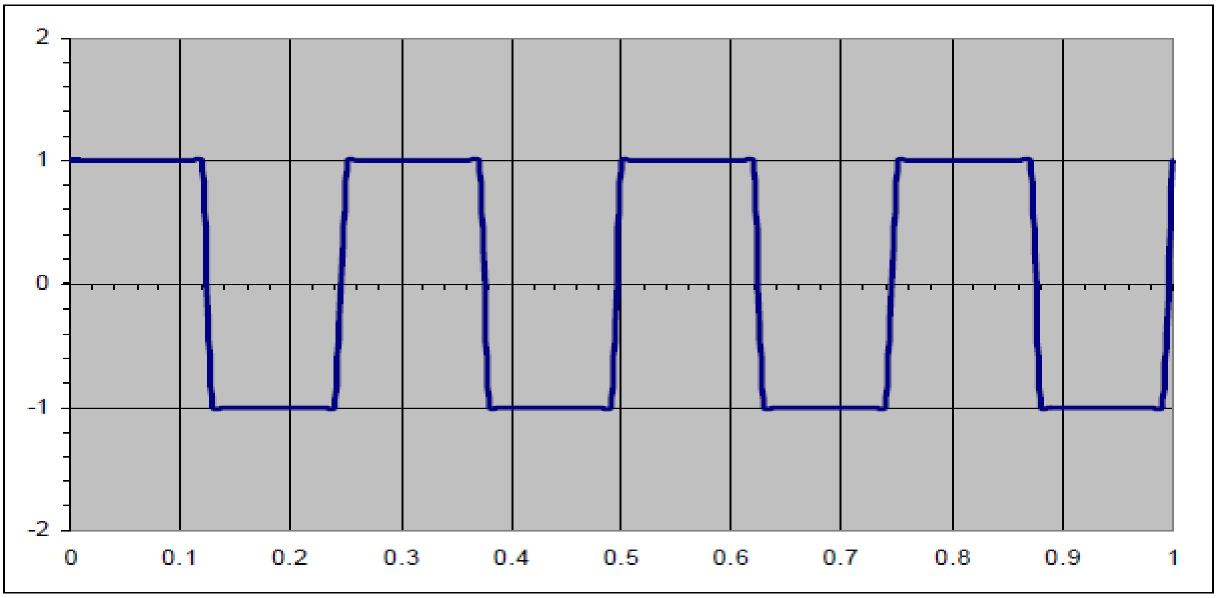
0.5 seconds is the signal's period and since our scope has 10 divisions, we have 50 milliseconds).



Therefore, reducing the Timebase will support higher frequency periodic signals.

The above discussion is true whether the signal is a sine wave, square wave, or other type of periodic signal.

The following figure shows the trace of a square wave with a frequency of 4 Hz.



<u>Therefore, knowing the approximate maximum frequency of the input signal is the guiding factor for choosing an appropriate value for the Timebase. Recall that the inverse of the maximum frequency of a periodic signal will yield the (time)</u>

period of 1 cycle. Therefore, the Timebase should be calculated by taking the period of the signal and dividing it by the number of horizontal X-axis divisions times the desired number of cycles to be displayed.

adjust the Timebase and Volts/Div

When an unknown signal (both in voltage and frequency), one may have to adjust both the Timebase and Volts/Div in a sequential manner until a clear signal is discerned. For example, if the unknown signal races (moves slowly) across the screen, lower (raise) the Timebase until a stationary signal is seen. If the amplitude is low (high), raise (lower) the Volts/Div. This may have to be iteratively performed until an acceptable signal is obtained.

- X-Y mode

Most modern oscilloscopes have several inputs for voltages, and thus can be used to plot one varying voltage versus another. This is especially useful for graphing I-V curves (current versus voltage characteristics) for components such as diodes, as well Lissajous patterns. Lissajous figures are an example of how an oscilloscope can be used to track phase differences between multiple input signals. This is very frequently used in broadcast engineering to plot the left and right stereophonic channels, to ensure that the stereo generator is calibrated properly. Historically, stable Lissajous figures were used to show that two sine waves had a relatively simple frequency relationship, a numerically-small ratio. They also indicated phase difference between two sine waves of the same frequency.

The X-Y mode also lets the oscilloscope serve as a vector monitor to display images or user interfaces. Many early games, such as Tennis for Two, used an oscilloscope as an output device.

Complete loss of signal in an X-Y CRT display means that the beam is stationary, striking a small spot. This risk burning the phosphor if the brightness is too high. Such damage was more common in older scopes as the phosphors previously used burned more easily. Some dedicated X-Y displays reduce beam current greatly, or blank the display entirely, if there are no inputs present.