Cathode ray oscilloscope (CRO)

Cathode ray oscilloscope

CRO is an electronic device which is capable of giving a visual indication of a signal wave form. CRO consists of the following main constituents

1. Cathode Ray Tube (CRT)
2. Time Base circuits
3. Power supply
4. Deflection voltage amplifier

1. Cathode Ray Tube

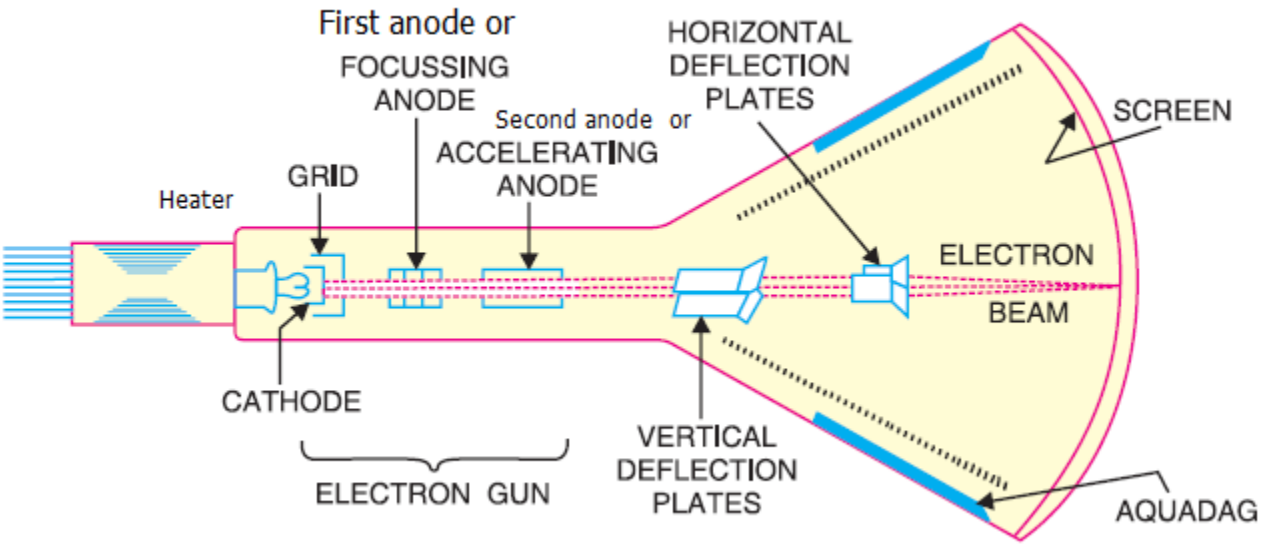
It is a heart of CRO. It converts a varying voltage in to a visible wave form it has four basic parts

i) Electron gun
ii) Deflecting plate or deflection system
iii) Florescent screen
iv) Glass envelops

i) Electron Gun

The function of the electron gun is to produce, accelerate and focus the electron beam to give a fine spot on the florescent screen. It is also consisting of following parts

- Thermionic cathode for emission of electron
- Control grid for varying the electron current density
- Accelerating electrode for attracting the electron
- Focusing electrode or first anode for focusing the electron beam in to a fine spot
- Second or final anode to provide further acceleration and focusing.



The construction of electron gun shown a figure. The electrons are produced by an indirectly heated cathode of cylindrical shape. Surrounding it is the control grid which has a small aperture in the center of end surface. It is given a negative potential with respect cathode. Control grid is the accelerating electrode having one or more apertures it is given high positive potential and the apertures eliminate electrons which diverged from the beam.

Further a narrow electron beam travels the accelerating electrode, it has a tendency to spread because of mutual repulsion between electrons. Hence a focusing electrode is placed next to the accelerating electrode. The positive voltage applied on this focusing electrode (or first anode) focuses the beam of electrons. The final anode (or second anode) which is given a very high positive potential of the order of 2000V or more, accelerates the electron beam. The first and second anode together necessary focusing to the electron beam so that it produces a high intensity light spot on the screen.

ii) Deflection system or Deflection plates

The deflection of the electron beam is accomplished by two sets of deflecting plates placed within the tube beyond the accelerating anode as shown in figure. One set is the vertical deflection plates and the other set is the horizontal deflection plates.

The vertical deflection plates are mounted horizontally in the tube. By applying proper potential to these plates, the electron beam can move up and down vertically on the florescent screen.

The horizontal deflection plates are mounted in the vertical plain. By applying potential on these plate, the electron beam can move right and left horizontally on the screen.

iii) Florescent Screen

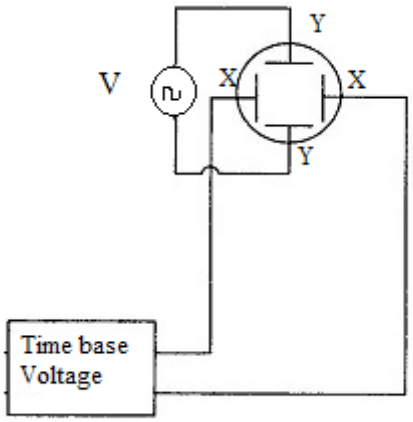
The screen is the inside face of the tube and is coated with some florescent material such as zinc Ortho silicate, zinc oxide, etc. when high velocity electron beam strikes the screen, a spot of light produced at the point of impact. The colour of the spot depends upon the nature of florescent material. If zinc Ortho silicate is used as the florescent material, green light spot is produced.

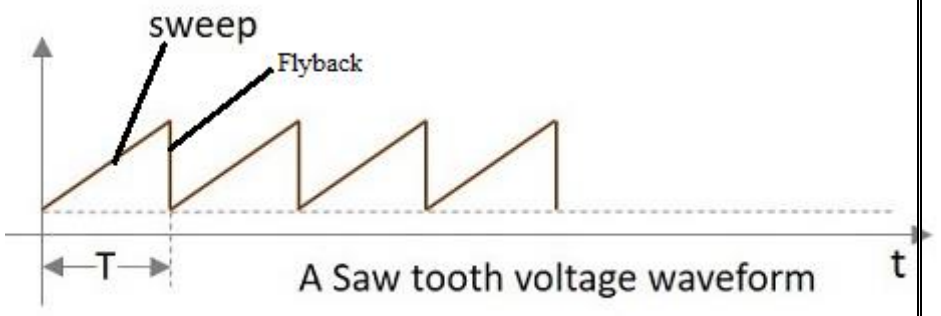
iv) Glass envelop

It is conical highly evacuated glass and supports the various electrodes. The inner valves of CRT between neck and screen are usually coated with a conducting material called **aquadog**. These coating is electrically connected to the accelerating anode so that electrons which accidently strict the walls return to the anode.

1. **Time Based Circuit**

A time base is a circuit which generate a saw-tooth wave form it causes the spot to move in a horizontal or vertical direction linearly with time. The time base voltage is applied to the x- plates of CRO. Due to this voltage, the spot sweeps linearly across the screen from left to right and then flies back quickly to the starting position for the next sweep appears as stationary line on the screen due to persistence of vision. when vertical motion of the spot produced by A.C voltage (Y –plates) is superimposed on the horizontal sweep (produced by X-plates) the actual wave form of A.C is traced on the screen





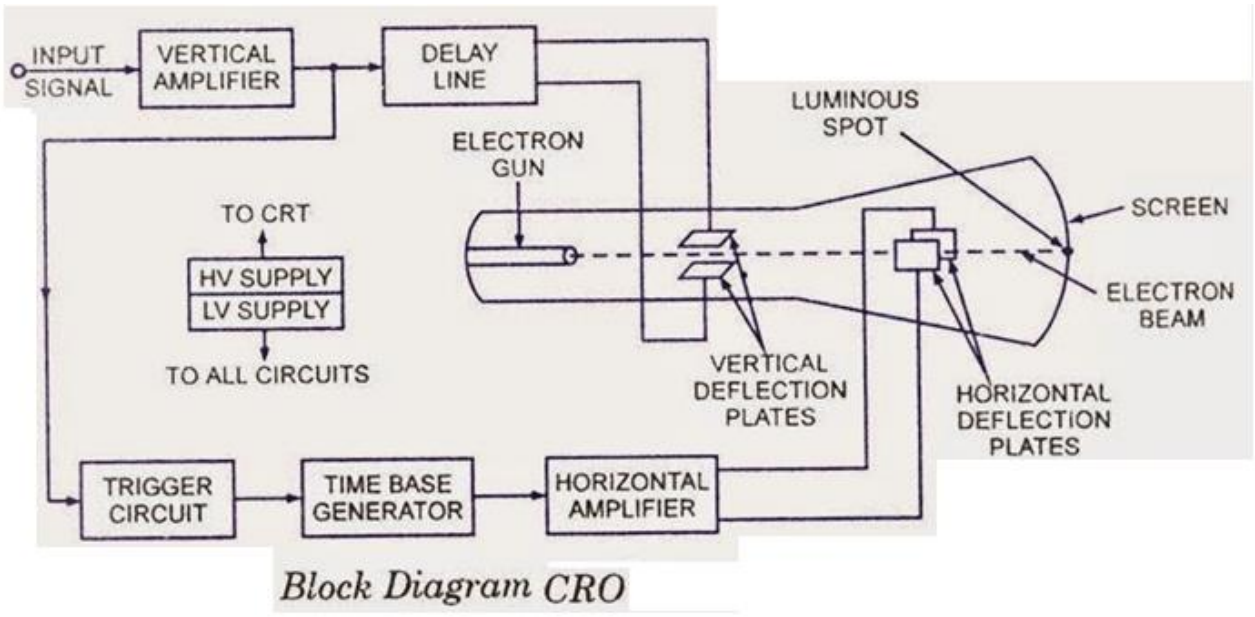
2. **Power Supply**

The power supply unit provides high voltages required by CRT to generate and to accelerate the electron beam. The CRT requires high voltages the order of a few 1000 volts and low power supply unit required to all circuits.

3. **Deflection Voltage Amplifies**

Horizontal and vertical amplifiers are used in a CRO between the applied voltage and X, Y-plates. These amplifiers are well designed to transmit all necessary harmonic components of the highest frequency used without change in phase angles.

Block diagram of CRO



Block Diagram CRO

The block diagram of CRO shown in the figure. It consists of CRT, Power Supply Circuit, and Time base circuit, vertical and horizontal amplifiers

The signal to be examined is fed to the input of the vertical amplifier. After amplification, it is fed to the vertical deflection plates (Y-plates). Simultaneously a saw tooth wave is applied from a time base circuit to the X-plates through a Horizontal amplifier. The time base circuit is connected to an external synchronizing circuit. A power supply is included in the circuit as source of DC voltage for the CRT and also for the amplifiers and sweep circuits.

As the voltage at the X-plates rises linearly with time, the moment of the spot along X-axis is proportional to the time. The resultant pattern on the screen is flat a magnitude of input signal vs the time.

Front Panel Controls of CRO

The proper functioning of CRO, various controls are provided on the phase of CRO

i) Intensity control

The knob of intensity control regulates the bias on the control grid and affects the electron beam intensity. If the negative bias on the grid is increased, the intensity if electron beam is decreased, thus reducing the brightness of the spot.

ii) **Focus Control**

The knob of focus control regulates the positive potential on the focusing anode. If the positive potential on this anode is increased, the electron beam becomes quite narrow and the spot on the screen is a pin-point.

iii) **Horizontal position Control**

The knob of Horizontal position control regulates the amplitude of DC potential which is applied to the Horizontal deflection plates, in addition to the usual saw tooth wave. By adjusting this control the spot can be moved to right or left as required.

iv) Vertical Position Control

The knob of vertical position control regulates the amplitude of DC potential which is applied to the vertical deflection plates in addition to the signal. By adjusting this control, the image can be moved up or down as required.

Applications of CRO

1. Measurement of direct and alternative voltage

a) **Measurement of direct voltage**

Deflection on the CRO screen is directly proportional to the voltage applied to the deflection plates. Therefore, if the screen is first calibrated known voltage that is the deflection sensitivity is determined and direct voltage can be measured by applying it between a pair of deflecting plates. Then the amount of deflection so produced when multiplied by the deflection sensitivity, gives the value of direct voltage.

b) **Measurement of alternative voltage**

To measure the alternating voltage sinusoidal wave form, it is applied across the Y-plates and study the picture of voltage wave form is obtained on the screen by synchronization of time base circuit. The vertical displacement of the spot is proportional to the peak value of the voltage. Knowing the deflection sensitivity, peak value of the applied voltage can be calculated.

Thus, CRO acts as an ideal volt meter due to its high input impedance.

2. **Measurement of AC-Frequency**

The frequency of wave form measured in two ways

a) Using Lissajous figures b) Using signal wave form

a) **Using Lissajous figures - Measurement of AC-Frequency**

The unknown frequency can be determined accurately with the help of a CRO

The steps of procedure

i) A known frequency is applied to horizontal input and unknown frequency to the vertical input

ii) The various controls are adjusted

iii) A pattern with loops is obtained

iv) The number of loops cut by the horizontal line gives the frequency on the vertical platesf_v (unknown frequency) and the number of loops cut by the vertical line gives the frequency on the horizontal plates f_H(known frequency). The unknown frequency (f_v) can be measured by using below formula

f_v / f_H = number of loops cut by the horizontal line / number of loops cut by vertical line

b) **Using signal wave form- Measurement of AC-Frequency (or time period (T))**

The signal for which the frequency (f) is to be measured is given to the vertical input. The number of divisions occupied by one complete cycle of the wave form is measured. The number of divisions multiplied by the time base setting in sec is equal to the time period (T) of one cycle. The frequency of the wave form is inverse of the time period (T). i.e

$$f = 1 / T$$

OSCILLOSCOPE AND TYPES OF OSCILLOSCOPES

Oscilloscope is an instrument used to display and analyze the input wave form signal. Generally oscilloscopes are two types. They are

1. Analog oscilloscope
2. Digital oscilloscope

APPLICATIONS (OR) USES

1. Used for testing signal voltage in circuit debugging.
2. Testing in manufacturing.
3. Used for designing.
4. Testing of signal voltage in radio broadcasting equipment
5. Used for research purposes.
6. For checking the faulty components in circuits.
7. Audio and video recording equipment.
8. Used for measuring inductance, capacitance, time intervals between signals, frequency, and time period.
9. Used in the medical field.

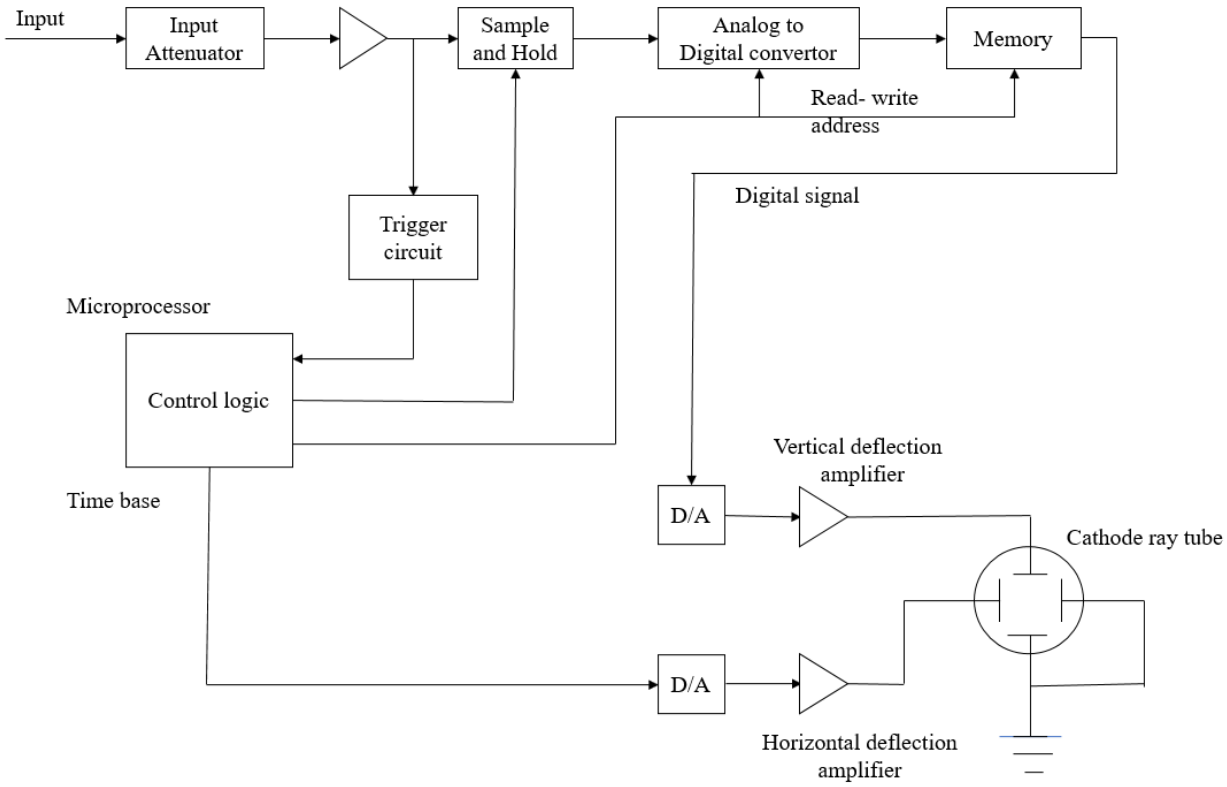
DIGITAL STORAGE OSCILLOSCOPE (DSO)

Definition:

A digital storage oscilloscope (DSO) is an instrument that stores and analyzes the input signal digitally (0 or 1). The digital storage oscilloscope digitalizes and stores the input signal.

The block diagram of DSO is shown in the figure. It consists of the following main parts.

1. Input attenuator
2. Vertical amplifier
3. Sample and Hold
4. ADC (Analog to Digital converter)
5. Memory
6. Control logic
7. Trigger circuit
8. DAC (Digital to Analog Converter)
9. Deflection plates
10. CRT (Cathode ray tube)



The attenuator and amplifier allow adjustment of the magnitude of the input signal to an appropriate level. The attenuator circuit offers high resistance and low capacitance, it is very important for the measurement of high-frequency quantities. later this signal will be fed to the sample and hold circuit. Control logic controls the sample and hold circuit.

The sampled signal is then passed through an analog to digital converter (ADC). This analog to digital converter (ADC) will the analog signal into the digital signal. The digitalized signal is stored in the memory as a data set. The data set is processed by the microprocessor and then sent to display. And this digital signal enters into the digital to analog converter (DAC). The digital to analog converted signal is amplified and given to vertical deflection plates of cathode ray tube (CRT).

Control logic (Microprocessor) is logic or software that allows a user to configure how signals are captured and displayed. The time base circuit is producing the digital signal and enters into a digital to analog converter (DAC). The digital signal converted into analog is amplified (by using a horizontal deflection amplifier) and given to horizontal deflection plates of the cathode ray tube (CRT). The time base circuit is controlling the horizontal axis on the display.

The user can set one or more trigger points to adjust the time base to capture sporadic or hold periodic signals like sine waves, steady in the display. Digital values are displayed on a cathode ray tube (CRT).

ADVANTAGES

1. Infinite storage time
2. Easy to operate.
3. Portable.
4. High speed.
5. Highest bandwidth.
6. Cursor measurement is possible.
7. It is capable of displaying an X-Y plot, P-V diagram, and B-H curve.
8. Pre-triggering features allow the display of the waveform, before the trigger pulse.
9. Long term display of a transient quantity.
10. Easy to produce a hard copy of the display
11. Computation and signal processing can be done within the DSO
12. Easy transfer of data to a computer
13. Cursor measurement is possible.
14. Simple user interface.

DISADVANTAGE

1. Signal changes that occur between sampling instant (fast transient) are not detected.
2. Complex.
3. Expensive.

APPLICATIONS (OR) USES

1. Used for testing signal voltage in circuit debugging.
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3. Used for designing.
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5. Used to research purpose.
6. For checking the faulty components in circuits.
7. Audio and video recording equipment.
8. Used for measuring inductance, capacitance, time intervals between signals, frequency and time period.
9. Used in the medical field.