CATHODE RAY OSCILLOSCOPE (CRO)

4.1. Introduction

The cathode ray oscilloscope is an extremely useful and versatile laboratory equipment which allows the viewing of waveform and amplitude of electrical signals as a function of time. It is used to study wave shapes as well as measure almost all quantities that involve amplitude and waveform such as voltage, current, power and frequency

The more expensive CRO models can measure signals at frequencies up to 500 MHz and the cheaper models can measure signals up to 20 MHz. Perhaps the most significant feature of the CRO is its high input impedance, typically 1 MΩ, which means its loading effect is negligible. The drawbacks associated with its use are its fragile nature (built around a cathode ray tube) and its high cost.

The applications of oscilloscopes have been enhanced on account of many recent developments. Oscilloscopes are used by almost every professional from a TV repair technician to physicists and even medical doctors. Some applications of the CRO include;

1. Display of signal waveforms.
2. Measurement of voltage and power.
3. Measurement of frequency, period and phase

angle of alternating quanties.

4. Comparing frequencies of two quanties.
5. Power and power factor measurement.
6. Comparing of two waveforms.
7. Testing of TV, RADARs and other equipment.
8. Creation of images in TV receivers
9. Visual indication of targets on a RADAR system.
10. Caliberation of instruments

4.2. Parts of a General Purpose CRO

The CRO is relatively complicated, consisting of a number of subunits. The block diagram of a general purpose oscilloscope is shown in fig 4.1.

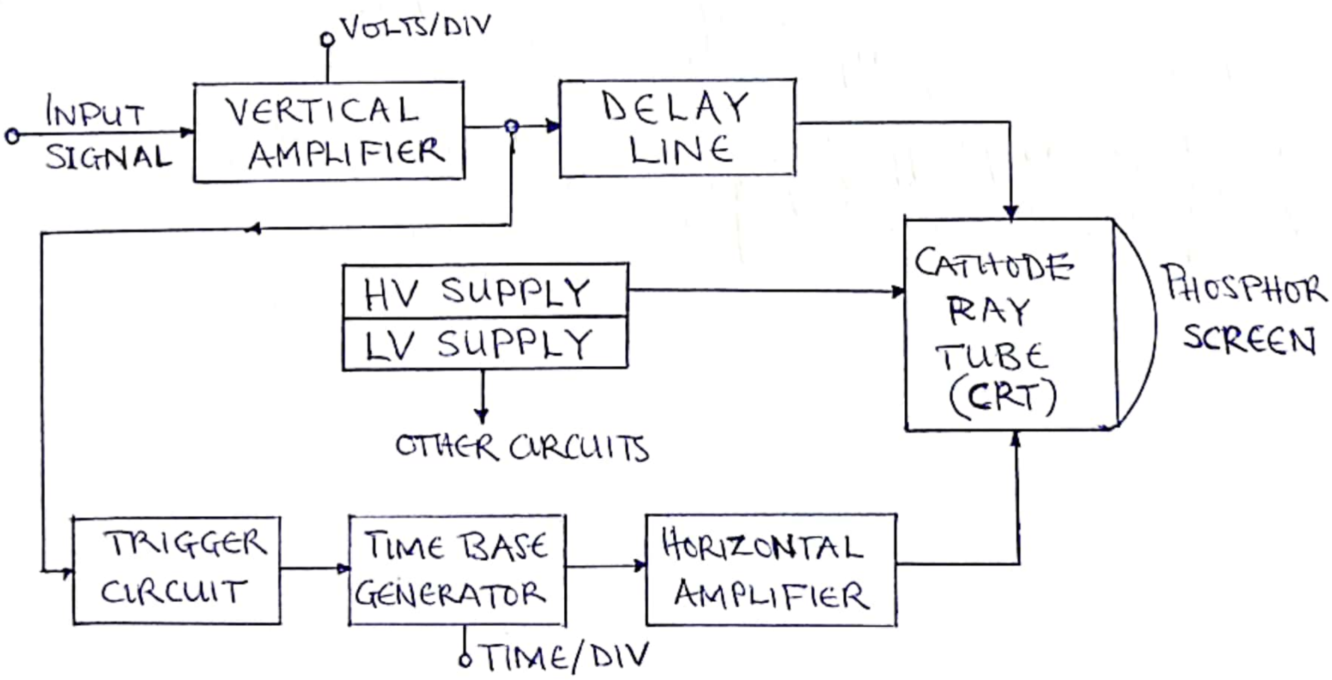

Fig 4.1. Block diagram of general purpose CRT

The modern tim-based CRO consists of the following main parts;

1. Cathode ray tube (CRT) — Display unit.
2. Power supplies and associated circuitry.
3. Vertical amplifier.
4. Time base (sweep) generator.
5. Horizontal amplifier.
6. Delay line.
7. Deflection plates (vertical and horizontal).
8. Trigger or time synchronizing circuit.
9. Electron gun.
10. Phosphor screen.

The cathode ray tube (CRT) is the heart of the CRO It generates, accelerates and deflects an electron beam to create a visible image on a phosphore screen. The power supply provides the necessary voltages and signals for the CRT to function. Low voltage is required by the electron gun to produce the electron beam, high voltage of a few thousand volts is needed to accelerate the electron beam and medium voltage of a few hundred votes is required by other control circuits of the CRO.

4.3. Cathode Ray Tube (CRT)

The cathode ray tube (CRT) is the heart of the Cathode ray oscilloscope (CRO). The other parts of the CRO simply work to make the CRT function properly. The CRT consist of mainly three parts;

1. Electron gun assembly.
2. Deflection plate assembly.
3. Flourescent (phosphor) screen.

The main parts of the CRT are Illustrated in fig. 4.2

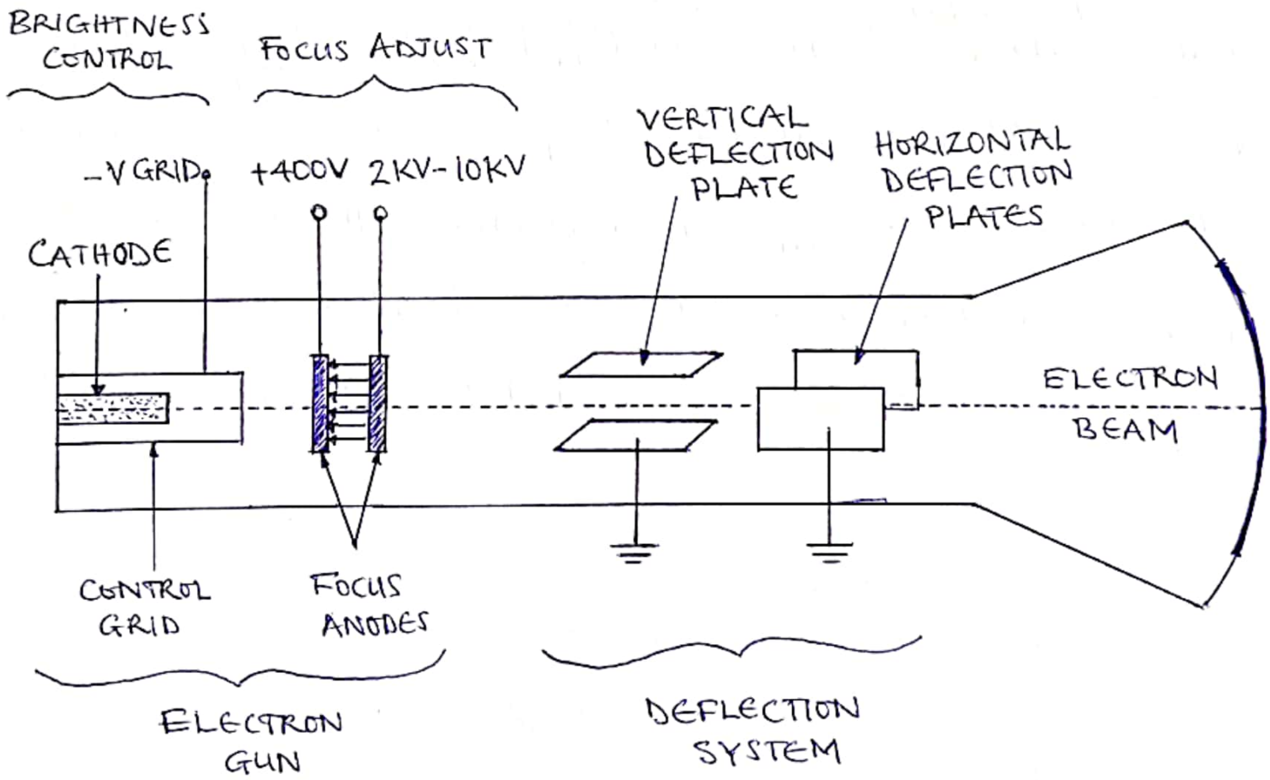

Fig 4.2 Illustration of CRT.

Electron Gun Assembly

The electron gun is made up of an indirectly heated cathode, a control grid surrounding the cathode, a focusing anode and an accelerating anode. The main function of the electron gun assembly is to produce high speed electron beam which is focused on the phosphor screen. The cathode is made up of a material which emits plenty of electrons when heated. The intensity of electron beam is controlled by the control grid.

The typical values of current and voltage required by an indirectly heated cathode are 600 mA at 6.3V (AC or DC). The control grid which is maintained at a negative potential wrt the cathod controls the electron emission and thus the brightness of the spot on the screen.

The function of focusing and accelerating anodes is to consentrate and accelerate the electron beam on the screen. The accelerating anode is connected to a high voltage of about 1,500V while the focusing anode is connected to a voltage of 500V (variable).

Deflection Plate Assembly

The deflection plate assembly consists of two pairs of parallel plates known as vertical and horizontal deflection plates. For each pair of plates while one plate is connected to ground (zer volts) the other plate is connected to CRO input signal.

After the electron beam leaves the electron gun it is made to pass through the two pairs of deflection plates. The horizontal or X-plates (mounted vertically) deflects the beam horizontally or X-direction while the vertical or Y-plates (mounted horizontally) deflects the beam in vertical or Y-direction. These plates deflect the beam based on the voltage applied across them.

For example if a +ve voltage is applied to the upper Y-plate the electron beam would be deflected upwards while the reverse is the case if the positive voltage is applied to the lower plate. A similar deflection to the right or left is observed depending on the polarity of the plates. When a sinusoidal voltage is applied to the Y-plates the beam will be moved up and down depending on the variation of plate potential. If the frequency is more than 300 KHz the display would be a vertical line. If the sinusoidal voltage is applied to the Xplate and frequency of variation is more than 300KHz the deflection would be a horizontal line. If potential is applied simultaneously to both sets of plates then the deflection would be oblique line. The amount of deflection would be proportional to the voltage on each pair of plates.

Flourescent Screen

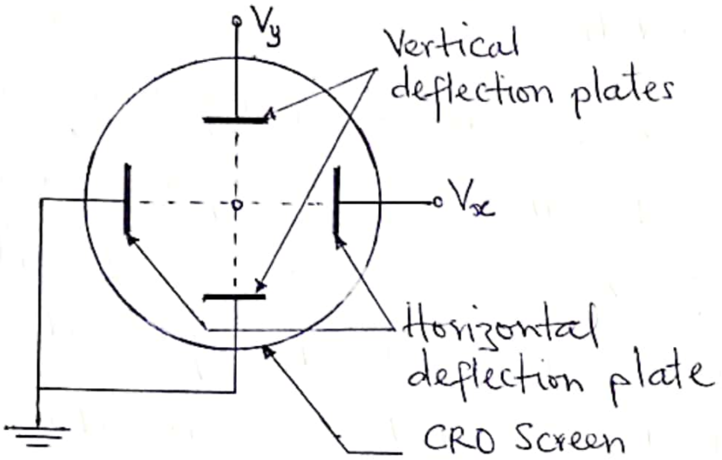

Fig.4.3 Face plate of the CRT

The flourescent screen or face plate, which is the front face of the CRT is shown in Fig4.3. This is the picture screen of the CRT. The screen is flat for CRTs with small display area of 100mm × 100mm or less and is slightly convex for larger screens.

The CRT screen is coated with phosphor, which has the property of emitting light when exposed to radiation. This property is called flourescence characteristic. Also these flourescent materials continue to emit light after radiation has been cut off. This is called the phosphorescence characteristic. The length of time during which phosphorescence occurs is called persistence of phosphor.

When the accelerated electron beam strikes the CRT Screen a spot of light is produced on the screen. The Phosphor absorbs the kinetic energy in the electrons and emits light energy at a lower frequency visible to the eyes. The intensity of the light emitted from the screen known as luminance depends on several factors;

1. The number of electrons striking the screen/sec.
2. The energy with which the electrons strike the screen. The high the energy the brighter the light.
3. The time the beam strikes a particular area.
4. The physical characteristics of the phosphor its-elf.

SPECIAL TYPES OF OSCILLOSCOPE

5.1. Introduction

Apart from the general purpose CRO described in the previous section special purpose CRO, having features which extend their capabilities, also exist. Some of the most import special purpose oscilloscopes are;

1. Delayed time-base oscilloscope.
2. Multiple trace oscilloscope.
3. High frequency oscilloscope.
4. Sampling oscilloscope
5. Digital readout oscilloscope.
6. Electromagnetic oscilloscope.
7. Personal computer based oscilloscope.
8. Analog storage oscilloscope.
10. Digital storage oscilloscope.

5.2. Sampling Oscilloscope

The sampling oscilloscope is used to display waveforms of signals with very high frequency, by using the sampling technique. In this technique, samples of the original signal are taken at different times and stored. These different samples are later used to reconstruct the original signal on the CRT display. This is Illustrated in fig.5.1.

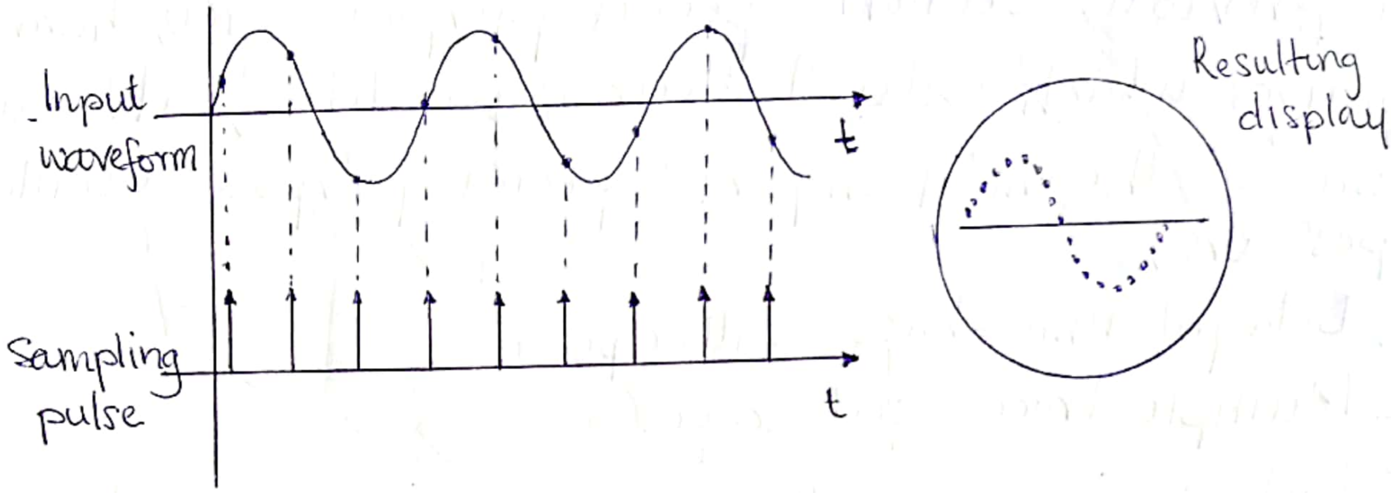

Fig. 5.1. Sampling operation of sampling oscilloscope.

5.3. Oscilloscope Probes.

The input to the oscilloscope is received through a pair of wire referred to as probes. A probe should connect the test circuit to an oscilloscope without loading, altering or test circuit. Typically an oscilloscope probe is 1m shielded cable of capacitance 120pF. Some types of oscilloscope probes are;

1. Direct probes: This is the simplest type of probe which uses a shielded coaxial cable. It is used for low frequency and low impedance circuits.

2. High frequency probes: These are special probes for displaying high frequency signals. These probes are shielded to avoid picking up surrounding signals.

3. Isolation probes: These probes are used to avoid the undesirable circuit loading effects of shielded probes. They make use of a carbon resistor in series with the test leads.

4. Detector probe: These are special probes used in communication equipment such as AM and FM receivers. They operate by separating the low frequency (LF) modulation component from the high frequency (HF) carrier component

5. High impedance or 10:1 probe: These probes operate by increasing the input resistance and reduce the effective input capacitance seen by the test circuit. These are also called passive probes.

6. Active probes: These probes have very high input impedance, with less attenuation compared to passive probes. They are designed to create an efficient method of coupling high frequency, fast rise time, signals to the CRO They are useful for measurement of small signals

7. <u>Current probe:</u> These are special probes which allow oscilloscope to detect and measure currents with frequency from 0 to 50MHz. They can be clamped around a wire carrying current without physical contact.