UNIT 5 PRINCIPLES OF CRT

Force of charged particle in electric and magnetic field

Electric and magnetic forces both affect the trajectory of charged particles, but in qualitatively different ways.

- The force on a charged particle due to an electric field is directed parallel to the electric field vector in the case of a positive charge, and anti-parallel in the case of a negative charge. It does not depend on the velocity of the particle.
- In contrast, the magnetic force on a charge particle is orthogonal to the magnetic field vector, and depends on the velocity of the particle. The right hand rule can be used to determine the direction of the force.
- An electric field may do work on a charged particle, while a magnetic field does no work.
- The Lorentz_force is the combination of the electric and magnetic force, which are often considered together for practical applications.
- Electric field lines are generated on positive charges and terminate on negative ones. The field lines of an isolated charge are directly radially outward. The electric field is tangent to these lines.
- Magnetic_field_lines, in the case of a magnet, are generated at the north pole and terminate on a south pole. Magnetic poles do not exist in isolation. Like in the case of electric field lines, the magnetic field is tangent to the field lines. Charged particles will spiral around these field lines.

Motion of Charged Particles in a Uniform Electric Field

- When a particle of charge q and mass m is placed in an electric field **E**, the electric force exerted on the charge is q**E**. If this is the only force exerted on the particle, it must be the net force and so must cause the particle to accelerate. In this case, Newton's second law applied to the particle gives

$$F = qE = ma$$

The acceleration of the particle is therefore

$$a = \frac{qE}{m}$$

E is uniform (that is, constant in magnitude and direction), then the acceleration is constant. If the particle has a positive charge, then its acceleration is in the direction of the electric field. If the particle has a negative charge, then its acceleration is in the direction opposite the electric field.

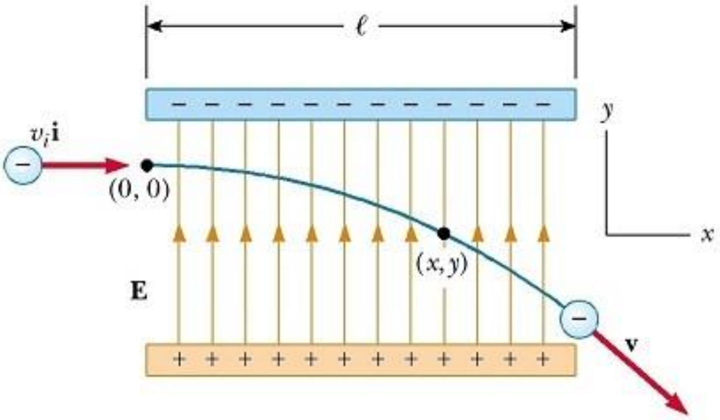


Figure An electron is projected horizontally into a uniform electric field produced by two charged plates. The electron undergoes a downward acceleration (opposite **E**), and its motion is parabolic while it is between the plates.

The electric field in the region between two oppositely charged flat metallic plates is approximately uniform from above figure. Suppose an electron of charge - e is projected horizontally into this field with an initial velocity v_ii. Because the electric field **E** in Figure 23.25 is in the positive y direction, the acceleration of the electron is in the negative y direction. That is,

$$A = \pi r^2$$

$$q = -\frac{eE}{m} j$$

Because the acceleration is constant, we can apply the equations of kinematics in two dimensions with $v_{xi} = v_i$ and $v_{yi} = 0$. After the electron has been in the electric field for a time t, the components of its velocity

$$v_{x=}v_i = constant$$

$$v_y = a_y t = -\frac{eE}{m} t$$

Its coordinates after a time t in the field are

$x = v_i$t

$$y = \frac{1}{2} a_y t^2 = -\frac{1}{2} \frac{eE}{m} t^2$$

Substituting the value $t = x/v_i$ from Equation 23.11 into Equation , we see that y is proportional to x^2. Hence, the trajectory is a parabola. After the electron leaves the field, it continues to move in a straight line in the direction of v in Figure 23.25, obeying Newton's first law, with a speed $v = v_i$. Note that we have neglected the gravitational force acting on the electron. This is a good approximation when we are dealing with atomic particles. For an electric field of 10^4 N/C, the ratio of the magnitude of the electric force eE to the magnitude of the gravitational force mg is of the order of 10^{14} for an electron and of the order of 10^{11} for a proton.

TheCathodeRayTube

This tube, illustrated in above figure , 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.

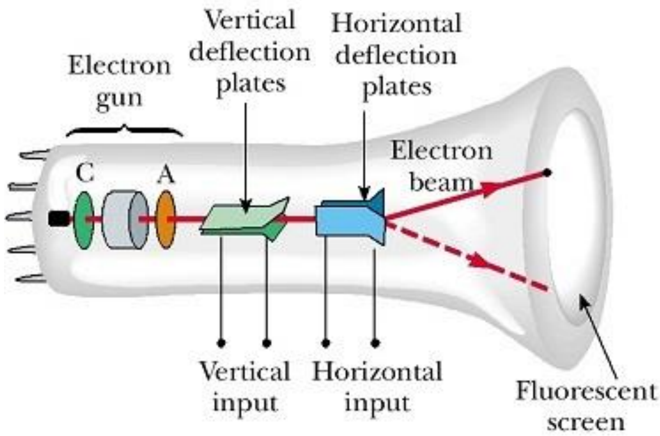


Figure Schematic diagram of a cathode ray tube. Electrons leaving the hot cathode C are accelerated to the anode A. In addition to accelerating electrons, the electron gun is also used to focus the beam of electrons, and the plates deflect the beam.

In an oscilloscope, the electrons are deflected in various directions by two sets of plates placed at right angles to each other in the neck of the tube. (A television **CRT** steers the beam with a magnetic field) An external electric circuit is used to control the amount of charge present on the plates. The placing of positive charge on one horizontal plate and negative charge on the other creates an electric field between the plates and allows the beam to be steered from side to side. The vertical deflection plates act in the same way, except that changing the charge on them deflects the beam vertically.

Oscilloscope features and uses

Oscilloscopes are used to observe the change of an electrical signal over time, such that voltage and time describe a shape which is continuously graphed against a calibrated scale. The observed waveform can be analyzed for such properties as amplitude, frequency, rise time, time interval, distortion and others. Modern digital instruments may calculate and display these properties directly. Originally, calculation of these values required manually measuring the waveform against the scales built into the screen of the instrument.

The oscilloscope can be adjusted so that repetitive signals can be observed as a continuous shape on the screen. A storage oscilloscope allows single events to be captured by the instrument and displayed for a relatively long time, allowing observation of events too fast to be directly perceptible.

Oscilloscopes are used in the sciences, medicine, engineering, and telecommunications industry. General-purpose instruments are used for maintenance of electronic equipment and laboratory work. Special-purpose oscilloscopes may be used for such purposes as analyzing an automotive ignition system or to display the waveform of the heartbeat as an electrocardiogram.

Before the advent of digital electronics, oscilloscopes used cathode ray tubes (CRTs) as their display element (hence were commonly referred to as CROs) and linear amplifiers for signal processing. Storage oscilloscopes used special storage CRTs to maintain a steady display of a single brief signal. CROs were later largely superseded by digital storage oscilloscopes (DSOs) with thin panel displays, fastanalog-to-digital converters and digital signal processors. DSOs without integrated displays (sometimes known as digitisers) are available at lower cost and use a general-purpose digital computer to process and display waveforms.

Types and Models

Cathode-ray oscilloscope (CRO)

The earliest and simplest type of oscilloscope consisted of a cathode ray tube, a vertical amplifier, a timebase, a horizontal amplifier and a power supply. These are now called "analog" scopes to distinguish them from the "digital" scopes that became common in the 1990s and 2000s.

Analog scopes do not necessarily include a calibrated reference grid for size measurement of waves, and they may not display waves in the traditional sense of a line segment sweeping from left to right. Instead, they could be used for signal analysis by feeding a reference signal into one axis and the signal to measure into the other axis. For an oscillating reference and measurement signal, this results in a complex looping pattern referred to as a Lissajous curve. The shape of the curve can be interpreted to identify properties of the measurement signal in relation to the reference signal, and is useful across a wide range of oscillation frequencies.

Dual-beam oscilloscope

The dual-beam analog oscilloscope can display two signals simultaneously. A special dual-beam CRTgenerates and deflects two separate beams. Although multi-trace analog oscilloscopes can simulate a dual-beam display with chop and alternate sweeps, those features do not provide simultaneous displays. (Real time digital oscilloscopes offer the same benefits of a dual-beam oscilloscope, but they do not require a dual-beam display.) The disadvantages of the dual trace oscilloscope are that it cannot switch quickly between the traces and it cannot capture two fast transient events. In order to avoid this problems a dual beam oscilloscope is used.

Analog storage oscilloscope

Trace storage is an extra feature available on some analog scopes; they used direct-view storage CRTs. Storage allows the trace pattern that normally decays in a fraction of a second to remain on the screen for several minutes or longer. An electrical circuit can then be deliberately activated to store and erase the trace on the screen.

Digital oscilloscopes

While analog devices make use of continually varying voltages, digital devices employ binary numbers which correspond to samples of the voltage. In the case of digital oscilloscopes, an analog-to-digital converter (ADC) is used to change the measured voltages into digital information..

The digital storage oscilloscope, or DSO for short, is now the preferred type for most industrial applications, although simple analog CROs are still used by hobbyists. It replaces the electrostatic storage method used in analog storage scopes with digital memory, which can store data as long as required without degradation and with uniform brightness. It also allows complex processing of the signal by high-speed digital signal processing circuits.

A standard DSO is limited to capturing signals with a bandwidth of less than half the sampling rate of the ADC (called the Nyquist limit). There is a variation of the DSO called the digital sampling oscilloscopethat can exceed this limit for certain types of signal, such as high-speed communications signals, where the waveform consists of repeating pulses. This type of DSO deliberately samples at a much lower frequency than the Nyquist limit and then uses signal processing to reconstruct a composite view of a typical pulse. A similar technique, with analog rather than digital samples, was used before the digital era in analog sampling oscilloscopes.

A digital phosphor oscilloscope (DPO) uses color information to convey information about a signal. It may, for example, display infrequent signal data in blue to make it stand out. In a conventional analog scope, such a rare trace may not be visible.

Mixed-signal oscilloscopes

A mixed-signal oscilloscope (or MSO) has two kinds of inputs, a small number of analog channels (typically two or four), and a larger number of digital channels(typically sixteen). It provides the ability to accurately time-correlate analog and digital channels, thus offering a distinct advantage over a separate oscilloscope and logic analyser. Typically, digital channels may be grouped and displayed as a bus with each bus value displayed at the bottom of the display in hex or binary. On most MSOs, the trigger can be set across both analog and digital channels.

Mixed-domain oscilloscopes

In a mixed-domain oscilloscope (MDO) you have an additional RF input port that goes into a spectrum analyzer part. It links those traditionally separate instruments, so that you can e.g. time correlate events in the time domain (like a specific serial data package) with events happening in the frequency domain (like RF transmissions).

Handheld oscilloscopes

Handheld oscilloscopes are useful for many test and field service applications. Today, a hand held oscilloscope is usually a digital sampling oscilloscope, using a liquid crystal display.

Many hand-held and bench oscilloscopes have the ground reference voltage common to all input channels. If more than one measurement channel is used at the same time, all the input signals must have the same voltage reference, and the shared default reference is the "earth". If there is no differential preamplifier or external signal isolator, this traditional desktop oscilloscope is not suitable for floating measurements. (Occasionally an oscilloscope user will break the ground pin in the power supply cord of a bench-top oscilloscope in an attempt to isolate the signal common from the earth ground. This practice is unreliable since the entire stray capacitance of the instrument cabinet will be connected into the circuit. Since it is also a hazard to break a safety ground connection, instruction manuals strongly advise against this practice.Some models of oscilloscope have isolated inputs, where the signal reference level terminals are not connected together. Each input channel can be used to make a "floating" measurement with an independent signal reference level. Measurements can be made without tying one side of the oscilloscope input to the circuit signal common or ground reference.

PC-based oscilloscopes

A new type of oscilloscope is emerging that consists of a specialized signal acquisition board (which can be an external USB or parallel port device, or an internal add-on PCI or ISA card). The user interface and signal processing software runs on the user's computer, rather than on an embedded computer as in the case of a conventional DSO.

CRO

The ***cathode ray oscilloscope*** is an extremely useful and versatile laboratory instrument used for studying wave shapes of alternating currents and voltages as well as for measurement of voltage, current, power and frequency, in fact, almost any quantity that involves amplitude and waveform. It allows the user to see the amplitude of electrical signals as a function of time on the screen. It is widely used for trouble shooting radio and TV receivers as well as laboratory work involving research and” design. It can also be employed for studying the wave shape of a signal with respect to amplitude distortion and deviation from the normal. In true sense the cathode ray oscilloscope has been one of the most important tools in the design and development of modern electronic circuits.

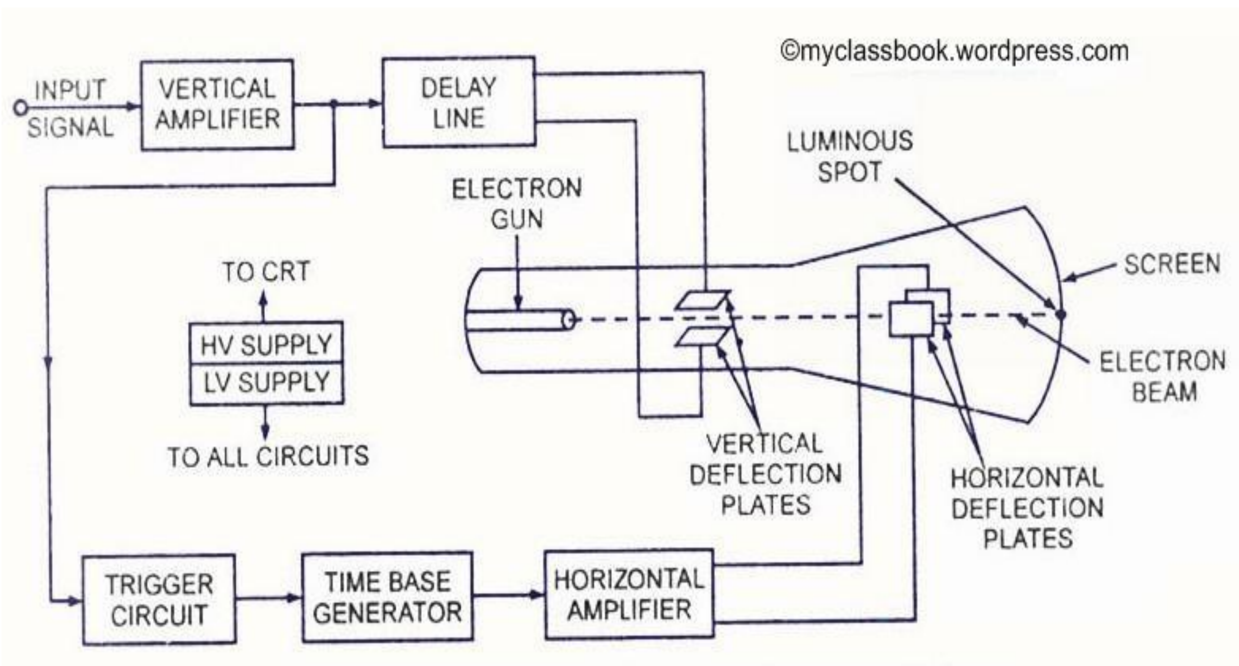


Fig 1 block diagram of CRO

> The instrument employs a **cathode ray tube** (CRT), which is the heart of the oscilloscope. It generates the electron beam, accelerates the beam to a high velocity, deflects the beam to create the image, and contains a phosphor screen where the electron beam eventually becomes visible.

Cathode Ray Tube (CRT):

CRT Produces a sharply focused beam of electrons, accelerated to a very high velocity. This electron beam travels from electron gun to the screen. The electron gun consists of filament, cathode, control grid, accelerating anodes and focusing anode. While travelling to the screen, electron beams passes between a set of vertical deflecting plates and a set of horizontal deflection plates. Voltages applied to these plates can move the beam in vertical and horizontal plane respectively. The electron beam then strikes the fluorescent material (phosphor) deposited on the screen with sufficient energy to cause the screen to light up in a small spot.

Vertical Amplifier:

The input signal is applied to vertical amplifier. The gain of this amplifier can be controlled by VOLT/DIV knob. Output of this amplifier is applied to the delay line.

Delay Line:

The delay Line retards the arrival of the input waveform at the vertical deflection plates until the trigger and time base circuits start the sweep of the beam. The delay line produces a delay of 0.25 microsecond so that the leading edge of the input waveform can be viewed even though it was used to trigger the sweep.

Trigger (Sync.) Circuit:

A sample of the input waveform is fed to a trigger circuit which produces a trigger pulse at some selected point on the input waveform. This trigger pulse is used to start the time base generator which then starts the horizontal sweep of CRT spot from left hand side of the screen.

Time Base (Sweep) Generator:

This produces a saw – tooth waveform that is used as horizontal deflection voltage of CRT. The rate of rise of positive going part of sawtooth waveform is controlled by TIME/DIV knob. The sawtooth voltage is fed to the horizontal amplifier if the switch is in INTERNAL position. If the switch is in EXT. position, an external horizontal input can be applied to the horizontal amplifier.

Horizontal Amplifier:

This amplifies the saw – tooth voltage. As it includes a phase inverter two outputs are produced. Positive going sawtooth and negative going sawtooth are applied to right – hand and left – hand horizontal deflection plates of CRT.

Blanking Circuit:

The blanking circuit is necessary to eliminate the retrace that would occur when the spot on CRT screen moves from right side to left side" This retrace can cause confusion if it is not eliminate. The blanking voltage is produced by sweep generator. Hence a high negative voltage is applied to the control grid during retrace period or a high positive voltage is applied to cathode in CRT.

When a sawtooth voltage is applied to horizontal plates and an input signal is applied to vertical plates, display of vertical input signal is obtained on the screen as a function of time.

Power Supply:

A high voltage section is used to operate CRT and a low voltage section is used to supply electronic circuit of the oscilloscope.

Dual Beam Oscilloscope

Dual Beam Oscilloscope Another method of studying two voltages simultaneously on the screen is to u special cathode ray tube having two separate electron guns generating two separate beam Each electron beam has its own vertical deflection plates. But the two beams are deflected horizontally by the common set of horizontal plate\ The time base circuit may be same or different. Such an oscilloscope is called Dual Beam Oscilloscope. The oscilloscope has two vertical deflection plates and two separate channels A and B for the two separate input signals. Each channel consists of a preamplifier and an attenuator. A delay line, main vertical amplifier and a set of vertical deflection plates together forms a single channel. There is a single set of horizontal plates and single time base circuit. The sweep generator drives the horizontal amplifier which inturn drives the plates. The horizontal plates sweep both the beams across the screen at the same rate. The sweep generator can be triggered internally by the channel A signal or .channel B signal. Similarly it' can also be triggered from an external signal or line frequency signal. This is possible with the help of trigger selector switch, a front panel control. Such an oscilloscope may have separate timebase circuit for separate channel. This allows different sweep rates for the two channels but increases the size and weight of the oscilloscope.

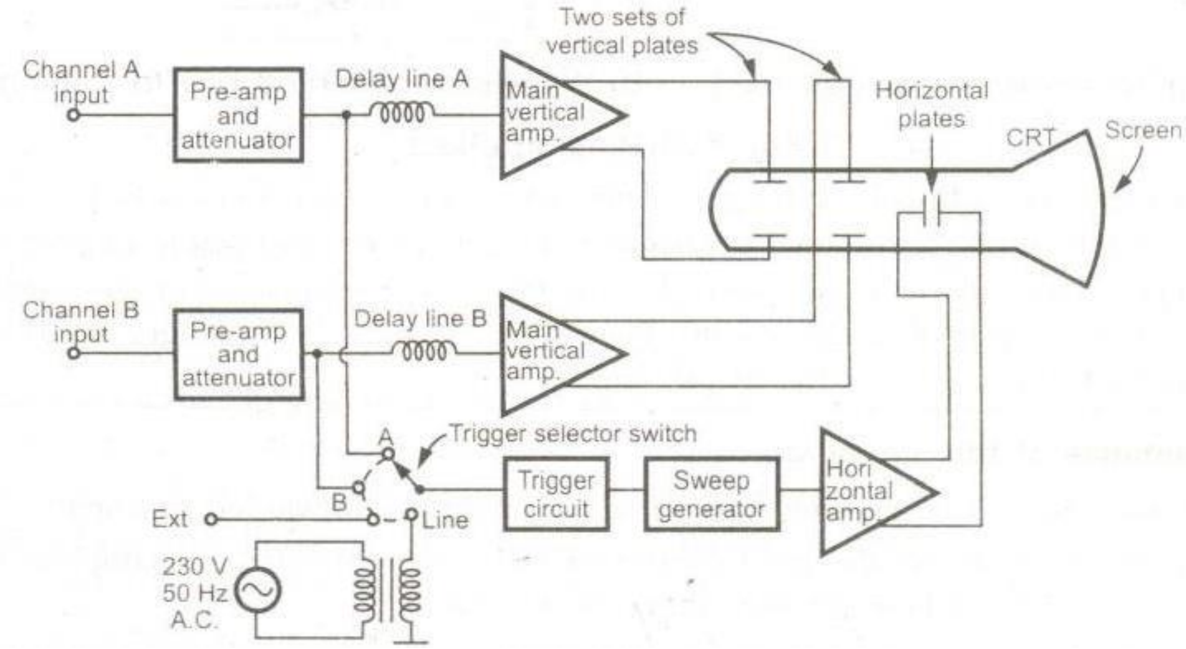


Fig 2 Dual Beam CRO with separate time bases

Multiple beam oscilloscopes:

Multiple beam oscilloscope has a single tube but several beam producing systems inside. Each system has separate vertical deflecting pair of plates and generally (l common time base system.

The triggering can be done internally using eith.er of the multiple inputs or externally by an external signal or line voltages.

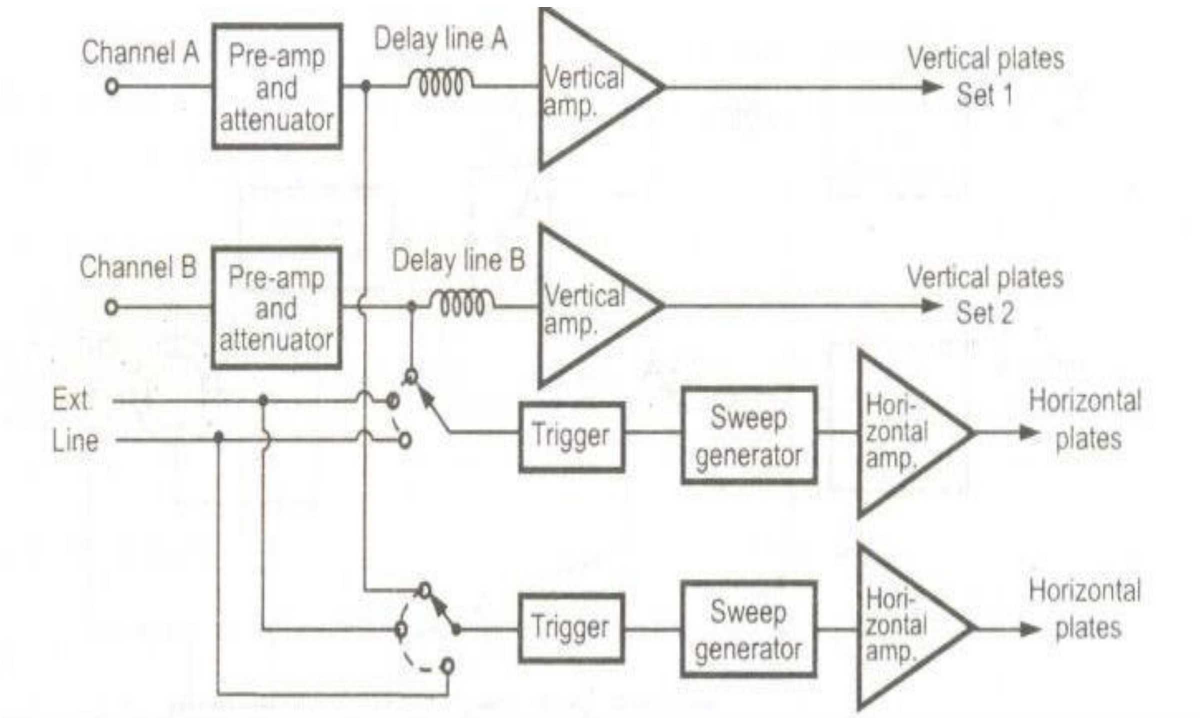


Fig 3 Dual Beam CRO with multiple time base

OSCILLOSCOPE

Oscilloscope is probably the single most versatile and useful Test and Measurement instrument invented for Electronic measurement applications. It is a complex instrument capable of measuring or displaying a variety of signals. This is the basic equipment used in almost all electronic circuit design and testing applications. The major subsystems in an oscilloscope are Power supplies (high and low voltage supplies), Display subsystem, Vertical and Horizontal amplifiers and display systems. There are two major types of oscilloscopes, viz. Cathode Ray Oscilloscopes (CRO) also called Analog Oscilloscopes, and Digital Storage Oscilloscopes (DSO), occasionally called Digital oscilloscopes. There are some analog oscilloscopes which also have the extra facility to store waveforms in digital form; these are called mixed-mode (i.e. Analog/Digital) oscilloscopes.

The main use of an oscilloscope is to obtain the visual display of an electrical voltage signal. If the signal to be displayed is not in the voltage form, it is first converted to this form. The signal voltage is then transmitted to the oscilloscope along a cable (usually a coaxial cable) and enters the oscilloscope where the cable is connected to the scope input terminals. Often the signal at this point is too small in amplitude to activate the scope display system. Therefore, it needs to be amplified.

Analog Oscilloscope: Cathode Ray Oscilloscope (CRO)

In a CRO the X and Y signals are applied to the horizontal and vertical plates, respectively of the cathode ray tube (CRT) after amplification. Within the CRT, an electron beam is created by an electron gun. The electron beam is focused and directed to strike the fluorescent screen, creating a spot of light, where impact is made with the screen. The beam is deflected vertically in proportion to the amplitude of the voltage applied to the CRT vertical deflection plates. The amplified input signal is also monitored by the horizontal deflection system. This subsystem has the task of sweeping the electron beam horizontally across the screen at a uniform rate. A sawtooth type signal (a triangular/ramp signal with long time duration for the rising part of the ramp and very small time duration for the falling part) is internally generated in a CRO as a time-base signal (sweep signal). This signal is amplified and applied to the horizontal deflection plates of the CRO. Again, the beam is deflected horizontally in proportion to the amplitude of the voltage applied to the CRT horizontal deflection plates. The simultaneous deflection of the electron beam in the vertical direction (by the vertical deflection system and the vertical deflection plates) and in the horizontal direction (by the time-base circuitry and the horizontal deflection plates) causes the spot of light produced by the electron beam to trace a path across the CRT screen. For example, if the input signal to the CRO were a sine wave, the trace produced on the CRT screen will be a sine wave. It is important to obtain a stable display on the CRT screen. If the input signal is periodic and the time base circuitry properly synchronizes the horizontal sweep with the vertical deflection, the spot of light will trace the same path on the screen over and over again. For a periodic signal the input signal can be synchronized with the time-base signal using the Trigger controls and the time base controls. If the frequency of the periodic signal is high enough (say greater than 40 Hz), the repeating trace will appear to be a steady pattern painted by solid lines of light on the screen.

Digital Storage Oscilloscope (DSO)

A DSO samples the input waveform and uses an analog-to-digital converter (or ADC) to convert the voltage being measured into digital information. It then uses this digital information to reconstruct the waveform on the screen. The ADC in the acquisition system samples the signal at discrete points in time and converts the signal's voltage at these points to digital values called sample points. The horizontal system's sample clock determines how often the ADC takes a sample. The rate at which the clock "ticks" is called the sample rate and is measured in samples per second. The sample points from the ADC are stored in memory as waveform points. More than one sample point may make up one waveform point.

Together, the waveform points make up one waveform record. The number of waveform points used to make a waveform record is called the record length. The trigger system determines the start and stop points of the record. The display receives these record points after being stored in memory. Depending on the capabilities of the oscilloscope, additional processing of the sample points may take place, enhancing the display. Pretrigger may be available, allowing you to see events before the trigger point. Fundamentally, with a digital oscilloscope as with an analog oscilloscope, you need to adjust the vertical, horizontal, and trigger settings to take a measurement.

Analog Oscilloscopes and digital oscilloscope

Oscilloscopes also come in analog and digital types. An analog oscilloscope works by directly applying a voltage being measured to an electron beam moving across the oscilloscope screen. The voltage deflects the beam up and down proportionally, tracing the waveform on the screen. This gives an immediate picture of the waveform. In contrast, a digital oscilloscope samples the waveform and uses an analog-to-digital converter (or ADC) to + _ 4 convert the voltage being measured into digital information. It then uses this digital information to reconstruct the waveform on the screen.

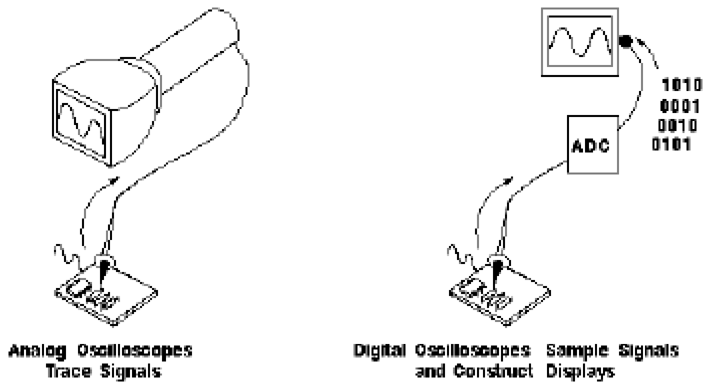


Fig 4 **Analog Oscilloscopes and digital oscilloscope**

Analog Oscilloscopes

An analog oscilloscope displays the voltage waveforms by deflecting an electron beam generated by an electron gun inside a cathode-ray tube on to a fluorescent coating. Because of the use of the cathode ray tube, analog oscilloscopes are also known as cathode ray oscilloscopes. To understand how an analog scope displays the voltage waveforms, it is necessary to understand what is inside the unit. The following section describes the general principles of the operation of cathode ray oscilloscopes.

Analog uses continuously variable voltages. Digital uses discrete binary numbers that represent voltage samples.

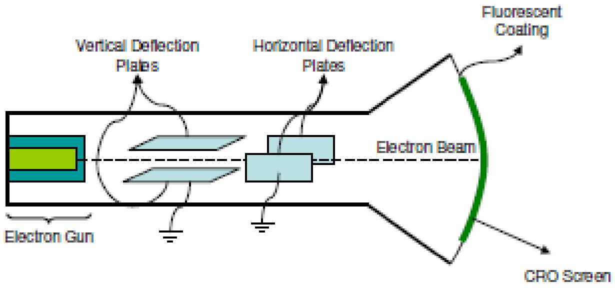
Analog osc. works by directly applying a voltage being measured to an electron beam moving across the osc. screen. The voltage deflects the beam up and down proportionally, tracing the waveform on the screen.

Digital osc. samples the waveform and uses an analog to digital converter to convert the voltage measured into digital format. It then uses this digital format to display the waveform. It enables one 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.

Cathode Ray Oscilloscope Principles

Figure 5 shows the structure, and the main components of a cathode ray tube (CRT). Figure 6shows the face plane of the CRO screen.



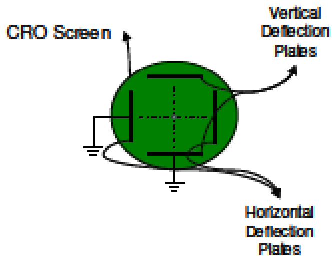


Fig 5 CRT

Fig 6 CRO SCREEN

Electron beam generated by the electron gun first deflected by the deflection plates, and thendirected onto the fluorescent coating of the CRO screen, which produces a visible light spoton the face plane of the oscilloscope screen.

A detailed representation of a CRT is given in Figure 7.

The CRT is composed of two mainparts,

Electron Gun

Deflection System

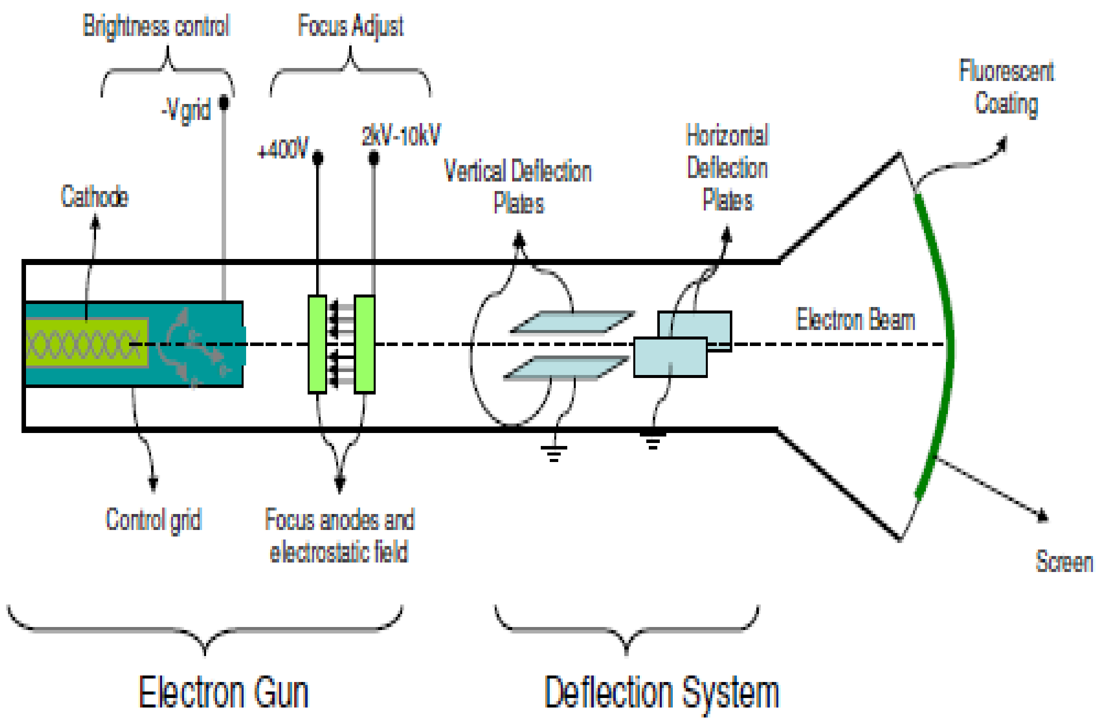


Fig 7 CRT

Electron Gun

Electron gun provides a sharply focused electron beam directed toward the fluorescent-coatedscreen. 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 ofelectrons in the beam.

The momentum of the electrons determines the intensity, or brightness, of the light emittedfrom the fluorescent coating due to the electron bombardment. Because electrons are6negatively charged, a repulsion force is created by applying a negative voltage to the controlgrid, to adjust their number and speed. A more negative voltage results in less number ofelectrons 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 isbecause the similar (negative) charges on the electrons repulse each other. To compensate forsuch repulsion forces, an adjustable electrostatic field is created between two cylindrical anodes, called the focusing anodes. The variable positive voltage on the second anodecylinder 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.

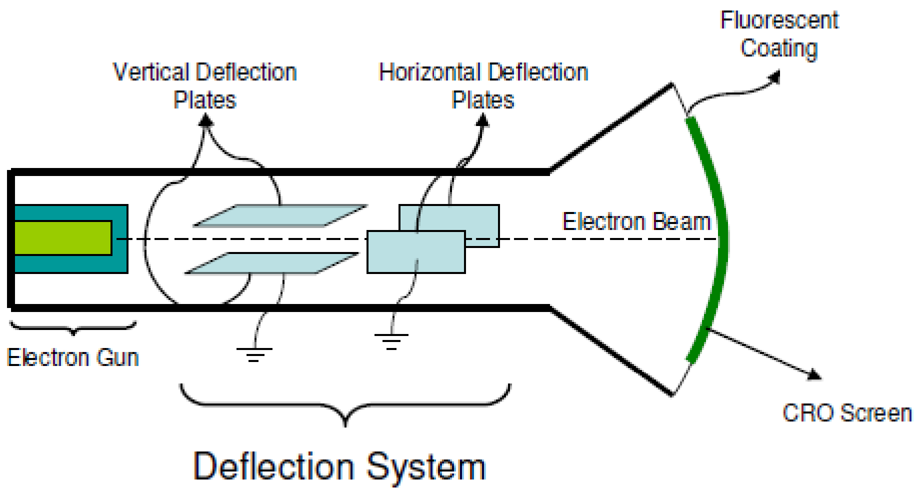


Fig 8 DEFLECTION SYSTEM

As shown in Figure 8, the electron beam passes through the deflection plates. In reference to the schematic diagram in Figure 9, a positive voltage applied to the Y input terminal causes the electron beam to deflect vertically upward, due to attraction forces, while a negative voltage applied to the Y input terminal causes the electron beam to deflect vertically downward, due to repulsion forces. Similarly, a positive voltage applied to the X input terminal will cause the electron beam to deflect horizontally toward the right, while a negative voltage applied to the X input terminal will cause the electron beam to deflect horizontally toward the left of the screen.

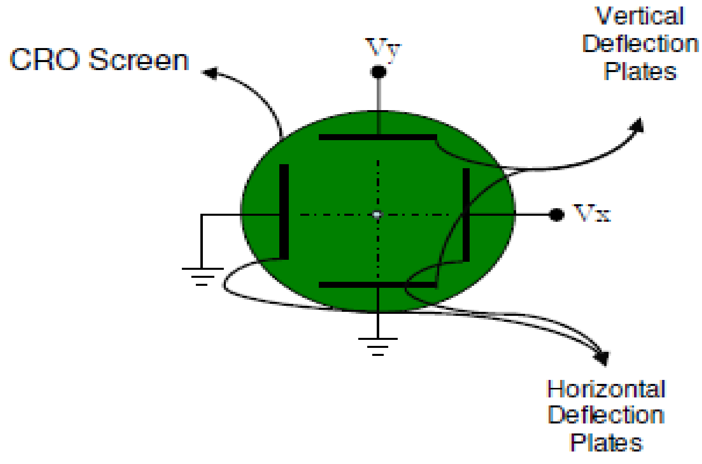


Fig 9 CRT SCREEN

The amount of vertical or horizontal deflection is directly proportional to the corresponding applied voltage. When the electrons hit the screen, the phosphor emits light and a visible lightspot is seen on the screen. Since the amount of deflection is proportional to the applied voltage, actually the voltages Vy and Vx determine the coordinates of the bright spot created by the electron beam.

Advantages and disadvantages

Despite the fact that technology has moved on and digital scopes are tending to dominate the market, there are still many areas where the analogue oscilloscope can provide very valuable service.

Advantages:

- ***Cost:*** Analog scopes are generally much less expensive than their digital counterparts. The technology is well established and is therefore less expensive than leading edge technologies where large levels of development costs have to be recovered in addition to the component and production costs being higher
- ***Performance:*** Analog oscilloscopes are able to provide a good level of performance that is more than adequate for many laboratory and service situations.
- ***In company availability:*** It is often found that analog oscilloscopes may be available in an equipment store when all the

other digital scopes are in use. Provided that their performance is satisfactory, the analogue option may provide an ideal way forwards.

Disadvantages:

- ***High end performance:*** In view of the way in which they operate using analogue technology, these oscilloscopes are not able to provide all the capabilities of many of the high end digital oscilloscopes.

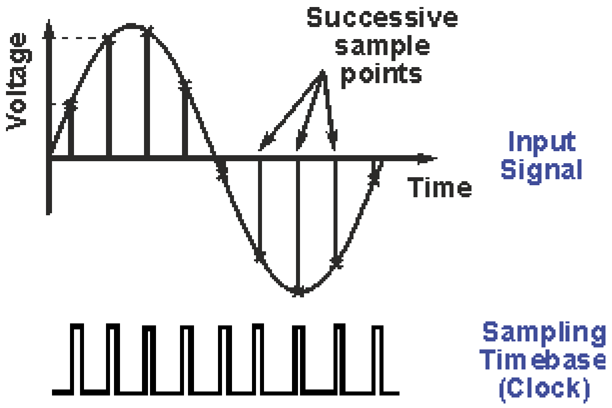
Ranges available: In view of the bias towards digital oscilloscopes, oscilloscope manufacturers and suppliers have focussed on the newer digital scopes. Accordingly the ranges of analogue scopes available are much less than they were some years ago. Nevertheless some are still available new, and others from used test equipment suppliers. Often it is possible to pick up some very good deals from used test equipment suppliers, provided that approved or trustworthy suppliers are used and the proper safeguards are in place

Digital oscilloscope technology

The basic concept behind digital oscilloscopes / DSOs is the conversion of the incoming analogue signal into a digital format where it can be processed using digital signal processing techniques.

When the signal enters the scope it is first pre-conditioned by some analogue circuits to ensure that the optimum signal is presented to the next stage.

This next stage involves the acquisition of the digital samples. To achieve this, an analog-to-digital converter, ADC, takes samples are discrete regular time intervals.



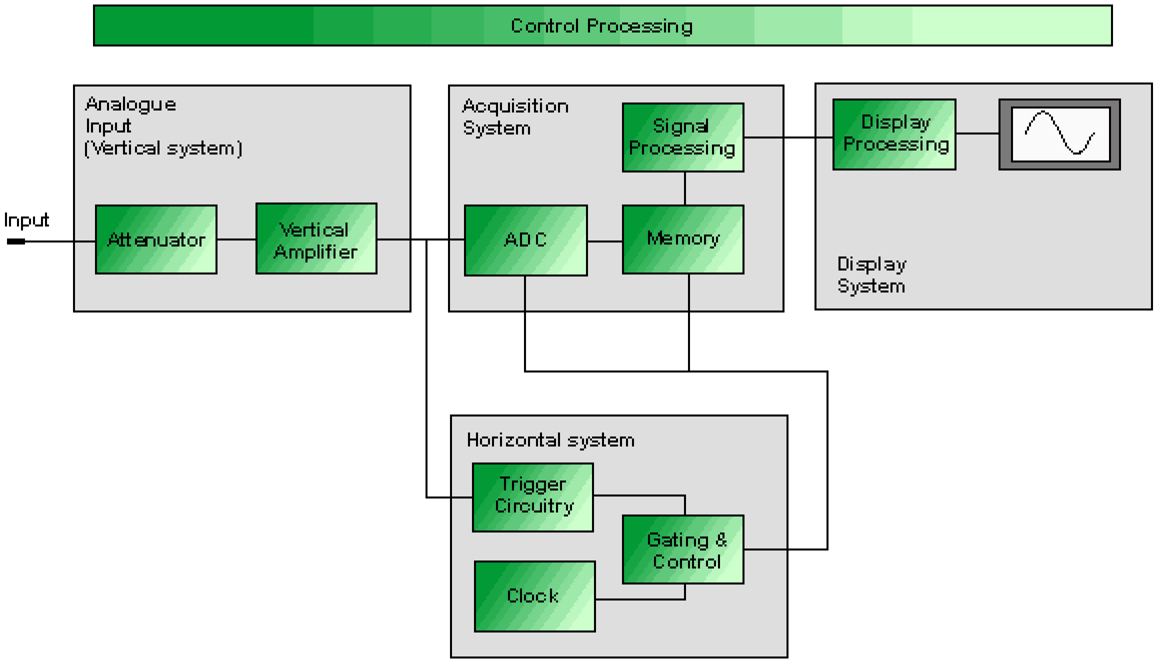


Fig 10 Digital oscilloscope basic block diagram

The times and rate at which samples are taken is determined by the system clock. The rate at which samples are taken is often defined as part of the specification of the scope. This is measured in samples per second, and often quoted in Mega samples per second M samples per second.

The samples from the ADC are stored in memory and referred to as waveform points and together these points make up the overall waveform record. The number of waveform points within the record is referred to as the waveform length.

The waveform record is initiated by the trigger and again stopped by the timebase circuit after the given amount of time.

The waveform record is then processed by the processing circuitry and presented to the display for visual inspection by the user.

In DSO, the waveform to be stored is digitized, stored in a digital memory and retrieved for display on the storage oscilloscope.
Stored waveform is continuously displayed by repeatedly scanning it. Therefore a conventional
CRT can also be used for the display. The stored display can be displayed continuously as long as the power is applied to the memory which can be supplied from a small battery.
Digitized waveform can be analyzed by oscilloscope or by reading the contents of the memory into the computer. Display of the stored data is possible in both amplitude versus time and x-y modes.
In DSO, fast memory readout is used for CRT display in addition to this a slow readout is also possible which is used for development of hard copy externally.

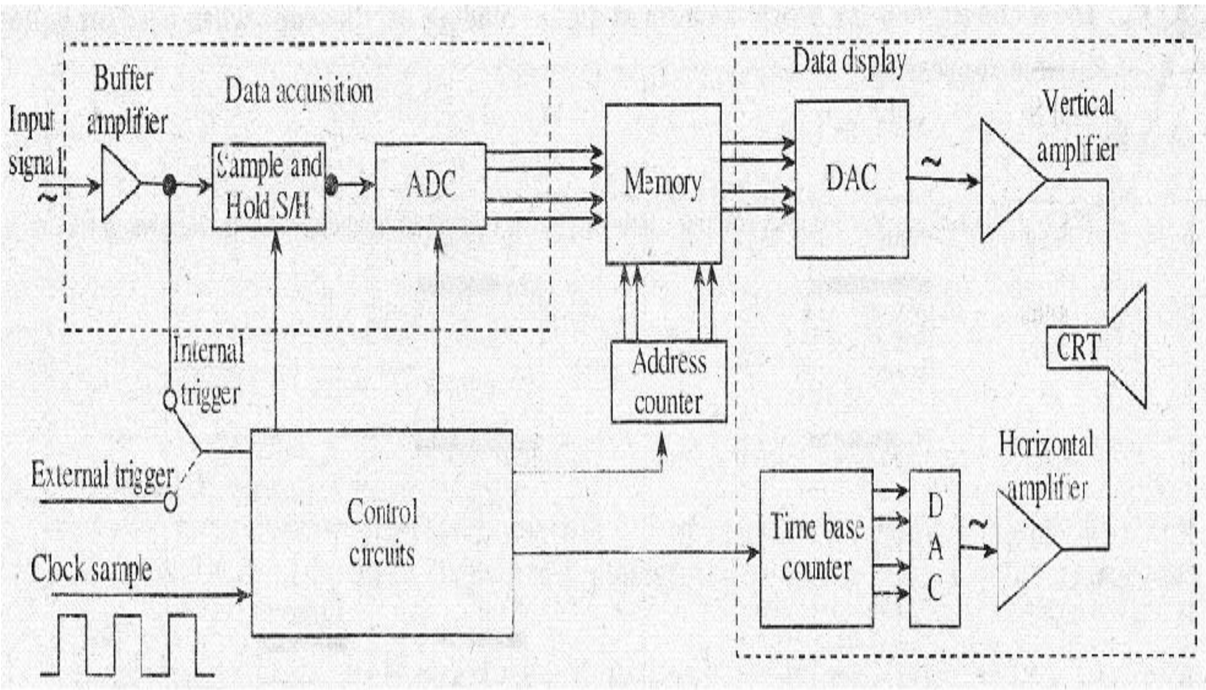


fig 3.1 Block diagram DSO

Fig 11 block diagram of DSO

Figure11 shows the block diagram of DSO as consists of,

1. Data acquisition
2. Storage
3. Data display.

Data acquisition is earned out with the help of both analog to digital and digital to analog converters, which is used for digitizing, storing and displaying analog waveforms. Overall operation is controlled by control circuit which is usually consists of microprocessor.

Data acquisition portion of the system consist of a Sample-and-Hold (S/H) circuit and an analog to digital converter (ADC) which continuously samples and digitizes the input signal at a rate determined by the sample clock and transmit the digitized data to memory for storage. The control circuit determines whether the successive data points are stored in successive memory location or not, which is done by continuously updating the memories.

When the memory is full, the next data point from the ADC is stored in the first memory location writing over the old data.

The data acquisition and the storage process is continues till the control circuit receive a trigger signal from either the input waveform or an external trigger source. When the triggering occurs, the system stops and enters into the display mode of operation in which all or some part of the memory data is repetitively displayed on the cathode ray tube.

In display operation, two DACs are used which gives horizontal and vertical deflection voltagefor the CRT Data from the memory gives the vertical deflection of the electron beam, while the time base counter gives the horizontal deflection in the form of staircase sweep signal.

The screen display consist of discrete dots representing the various data points but the number of dot is very large as 1000 or more that they tend to blend together and appear to be a smooth continuous waveform.

The display operation ends when the operator presses a front-panel

button and commands the digital storage oscilloscope to begin a new data acquisition cycle.

Digital Storage Oscilloscope:- (DSO)

- DSO use the digital memory. It can store data as required with out degradation.
- DSO also uses for complex processing of the signal with high speed with the hepl of digital signal processing circuits .
- in this A/D converter use to create the data that is stored in microprocessors memory, and data sent to display on screen
- DSO convert analog in to digital form using to A/D convertor ,it stores digital data in memory.
- then processes the signals and to be display on screen.
- the wave form is stored in digital ,advantage of using DSO ,that stored data can be used to visualize the signal at any time.

Advantages :-

1. Allows for automation.
2. In this,slow traces like the temperature variation across a day can be recorded
3. With colour Bigger and brighter display, to distinguish multiple traces
4. peak detection

Disadvantage:-

Digital Oscilloscope is the limited refresh rate of the screen.

Difference between digital storage oscilloscope and conventional storage oscilloscope

Digital StorageOscilloscope (DSO):

1. It can store the given signal indefinitely as long as the small amount of power is supplied to the memory.

2. It always collects the data and stops when triggered.

3. It employs normal CRT, hence the cost of the tube is much cheaper than the storage tube used in ASO.
4. It can produce bright image even for high frequency signals.
5. In this oscilloscope, time base is generated, by a crystal clock.
6. It has higher resolution than ASO.
7. It has less operating speed than ASO.
8. Because of aliasing effect the useful storage ' bandwidth is limited.

Conventional Storage Oscilloscope
(Analog Storage Oscilloscope (ASO)):

1. In this oscilloscope heavy amount-of power is to be supplied to the storage CRT.
2. It collects the data only after triggering.
3. The cost of the tube is costlier than the storage tube used in DSO.
4. It cannot produce bright image for high frequency signals.
5. In this oscilloscope, time base is generated by a ramp circuit.
6. It has lower resolution than DSO.
7. It has high operating speed than DSO.
8. It doesn't have aliasing effect

APPLICATION OF CRO

1. **Meaurement of voltage** – Voltage waveform will be made on the oscilloscope screen. From the screen of the cro, the voltage can be measured by seeing its amplitude variation on the screen.
2. **Measurement of current** – Current waveform will be read from the oscilloscope screen in the similar way as told in above point. The peak to peak, maximum current value can be measured from the screen.
3. **Measurement of phase** – Phase measurement in cro can be done by the help of Lissajous pattern figures. Lissajous figures can tell us about the phase difference between two signals. Frequency can also be measured by this pattern figure.

4. **Measurement of frequency** – Frequency measurement in cathode ray oscilloscope can be made with the help of measuring the time period of the signal to be measured.