UNIT:4 CRO & MULTIMETER

Electronic Instruments :-

Those instruments which employ electronic devices for measuring various electrical quantities are known as electronic instruments.

Eg- voltage , current , resistance etc.

There are three type of electronic instruments:-

i) Multimeter
ii) Electronic voltmeters.
iii) Cathode ray oscilloscope.

Multimeter :-

A multimeter is an electronic instrument which can measure resistance , currents and voltages. It is an indispensable instrument and can be used for measuring d.c. as well as a.c voltages and currents. Multimeter is the most inexpensive equipment and can make various electrical measurements with reasonable accuracy.

Construction :-

A multimeter consists of an ordinary pivoted type of moving coil galvanometer. This galvanometer consists of a coil pivoted on jeweled bearings between the poles of a permanet magnet. The indicating needle is fastened to the coil. When electric current is passed through the coil , mechanical force acts and the pointer moves over the scale.

Functions :-

A multimeter can measure voltages, currents and resistances. To achieve this objecetive, proper circuits are incorporated with the galvanometer. The galvanometer in a multimeter is always of left zero type.

ie normally its needle rests in exteeme left position as compared to centee zero posistion of ordinary galvanometers.

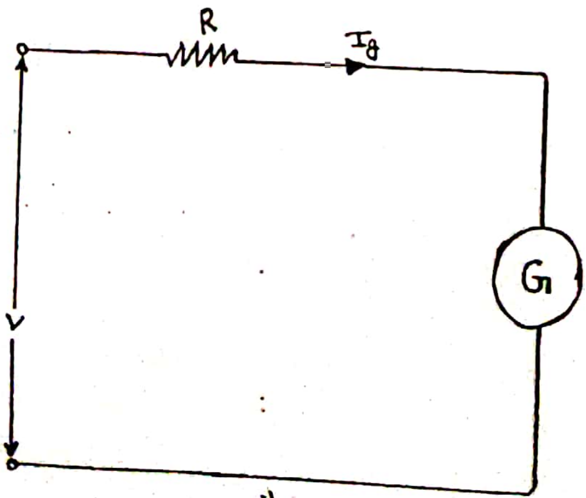
Multimeter as voltmeter :-

When a high resistance is connected in series with a galvanometer, it becomes a voltmeter. Fig i) shows a high resistance R connected in series with the galvanometer of Resistance G. If I_g is the full scale deflection current, then the galvanometer becomes a voltmeter of range 0-V volts. The requried valus of resistance in series R is given by :

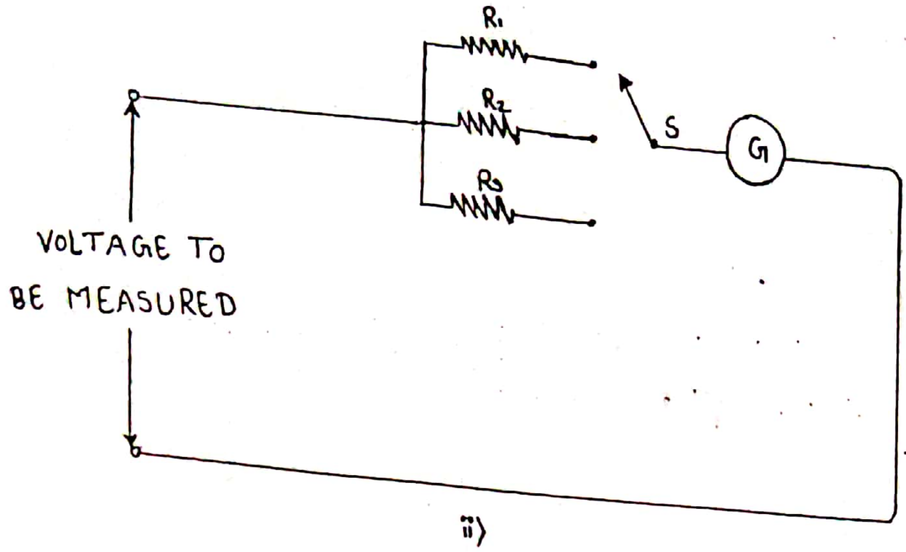
$$V = I_g R + I_g G$$

or $$V/I_g = R + G$$

or $$R = V/I_g - G$$

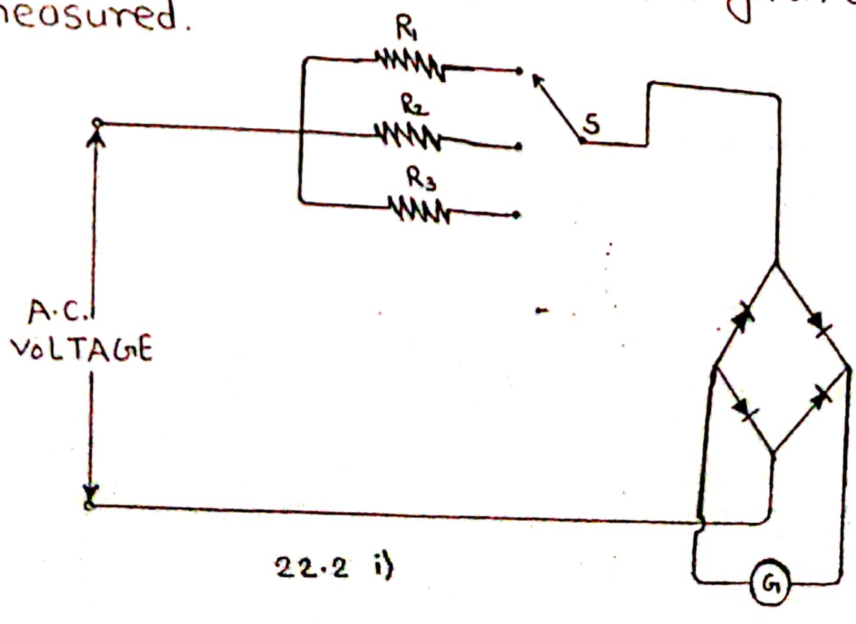


i)



ii)

For maximum accuracy, a multimeter is always provided with a number of voltage ranges. This is achieved by providing a number of high resistances in the multimeter as shown in fig ii) Each resistance corresponds to one voltage range. With the help of selector switch s, we can put any resistance (R_1, R_2 and R_3) in series with the galvanometer. When d.c voltages are to be measured, the multimeter switch is turned on to d.c. position. This puts the circuit shown in fig ii) in action. By throwing the range selector switch s to a suitable position, the given dc. voltage can be measured.



22.2 i)

The multimeter can also measure a.c. voltages. To permit it to perform this function, a full-wave rectifier is used as shown in fig. 22.2. The rectifier converts a.c. into d.c for application to the galvanometer. The desired a.c. voltage range can be selected by the switch S. When a.c. voltage is to be measured, the multimeter switch is thrown to a.c. position. This puts the circuit shown in Fig. 22.2 in action. By throwing the range selector switch S to a suitable position, the given a.c. voltage can be measured. It may be mentioned here that a.c. voltage scale is calibrated in r.m.s. values. Therfore, The mete will give the r.m.s. value of a.c. voltage under measurement.

VVV Imp

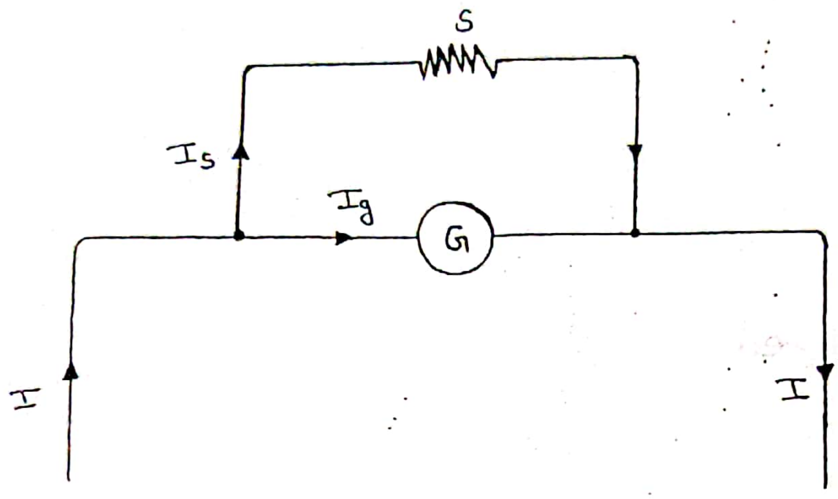
ii) Multimeter as ammeter :-

When low resistance is connected in parallel with a galvanometer, it becomes an ammeter. Fig i) showing A law resistance S (generally called shunt) connected in parallel with the galvanometer of resistance G. If I_g is the full scale deflection current, then the galvanometer becomes an ammeter of range 0–I amperes. The requried value of shunt resistance S is given by :

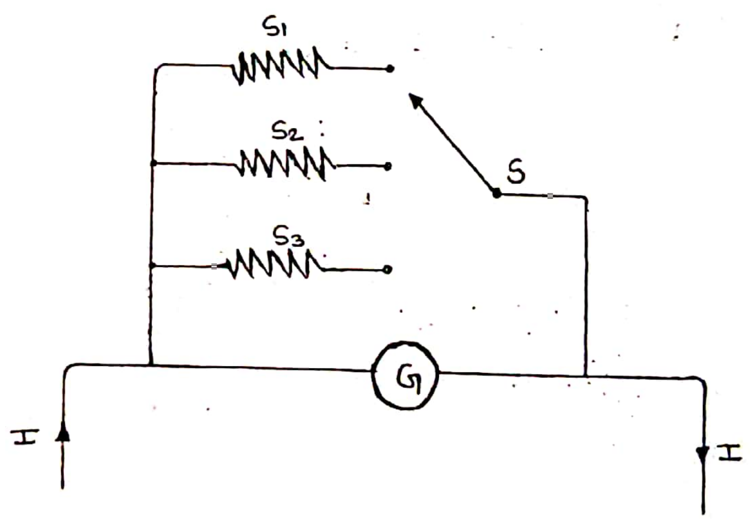
$$I_s S = I_g G$$

or $$I_s / I_g = G/S \quad \text{or} \quad \frac{I_s}{I_g} + 1 = \frac{G}{S} + 1$$

or $$\frac{I_s + I_g}{I_g} = \frac{G+S}{S} \quad \text{or} \quad \frac{I}{I_g} = \frac{G+S}{S}$$



i)



ii)

In practice, a number of Law resistances are connected in parallel with the galvanometer to provide a number of current ranges as shown in fig ii) With the help of range selector switch S, any shunt can be put in parallel with the galvanometer. When d.c. current is to be measured, the multimeter switch is turned on d.c. position. This puts the circuit shown in fig ii) in action. By throwing the range selector switch S to a suitable position, the desired d.c. current can be measured.

The multimeter can also be used to measure alternating current. for this purpose, a full-wave rectifier is used as shown in fig. The rectifier converts a.c. into d.c. for application to the galvanometer. The desired current range can be selected by switch S. By throwing the range selector switch S to a suitable position, the given a.c current can be measured. Again, the ac. current scale is calibrated in r.m.s. values so that the instrument will give r.m.s. value of alternating current under measurement.

iii] Multimeter as ohmmeter :-

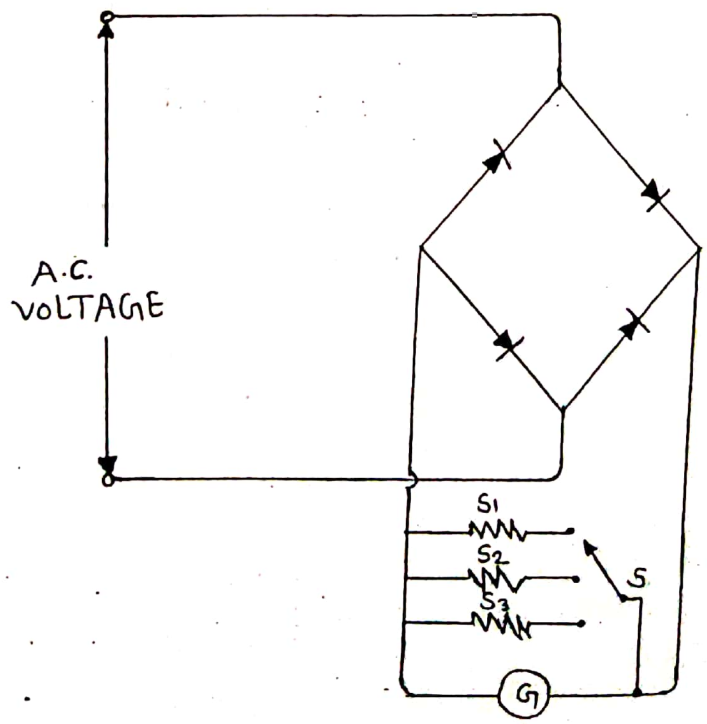
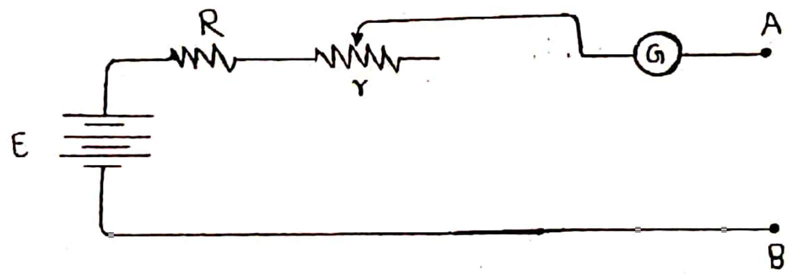
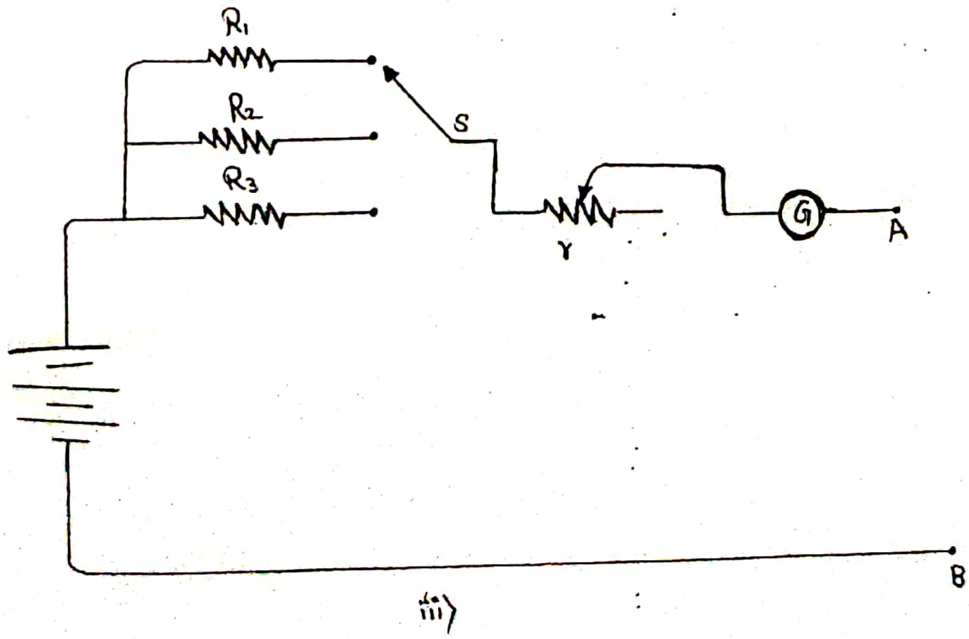


Fig i)

Fig i) shows the circuit of ohmmeter. The multimeter employs the internal battery. A fixed resistance R & a variable resistance r are connected in series with the battery and galvanometer. The fixed resistance R limits the current within the range desired and variable resistance r is zero-adjustment reading. The resistance to be measured is connected between terminals A and B. The current flowing through the circuit will depends upon the value of resistor connected across the terminals. The ohmmeter scale is calibrated in terms of ohms. The ohm's meter is generally made multirange instrument by using different values of R as shown in Fig iii)



ii)



iii)

Applications of Multimeter :-

A multimeter is an extremely important electronic instrument and is extensively used for carrying out various tests and measurements in electronic circuit. It is used:

i) For checking the circuit continuity. When the multimeter is employed as continuityity - checking device, the ohmmeter scale is utilised and the ~~equation~~ equipment to be cheaked is shut off or disconnected from the power mains.

ii) For measuring d.c. current flowing through the cathode, plate, screen and other vacuum tube circuits.

iii) For measuring d.c. voltages across various resistors in electronic circuits.

iv) For measuring a.c. voltages across power supply transformers.

v) For ascertaining whether or not open or short circuit exists in the circuit under study.

Sensitivity of Multimeter :-

Imp

The resistance offered per volt of full scale deflection by the multimeter is known as multimeter sensitivity.

Multimeter sensitivity indicates the internal resistance of the multimeter. For example, if the total resistance of the meter is 5000 ohms and the meter is to read 5 volts full scale, then internal resistance of the meter is $1000\,\Omega$ per volts. ie meter sensitivity is $1000\,\Omega$ per volts. Conversly, if the meter sensitivity is $400\,\Omega$ per volts which does reads from 0 to 100V, then meter resistance is 40,000 ohms. If the meter is to read v volts and I_g is the full scale deflection current, then,

$$\text{Meter resistance} = \frac{v}{I_g}$$

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Meter sensitivity = Resistance per volts full scale deflection.

$$= \frac{V}{I_g} / V = \frac{I}{I_g}$$

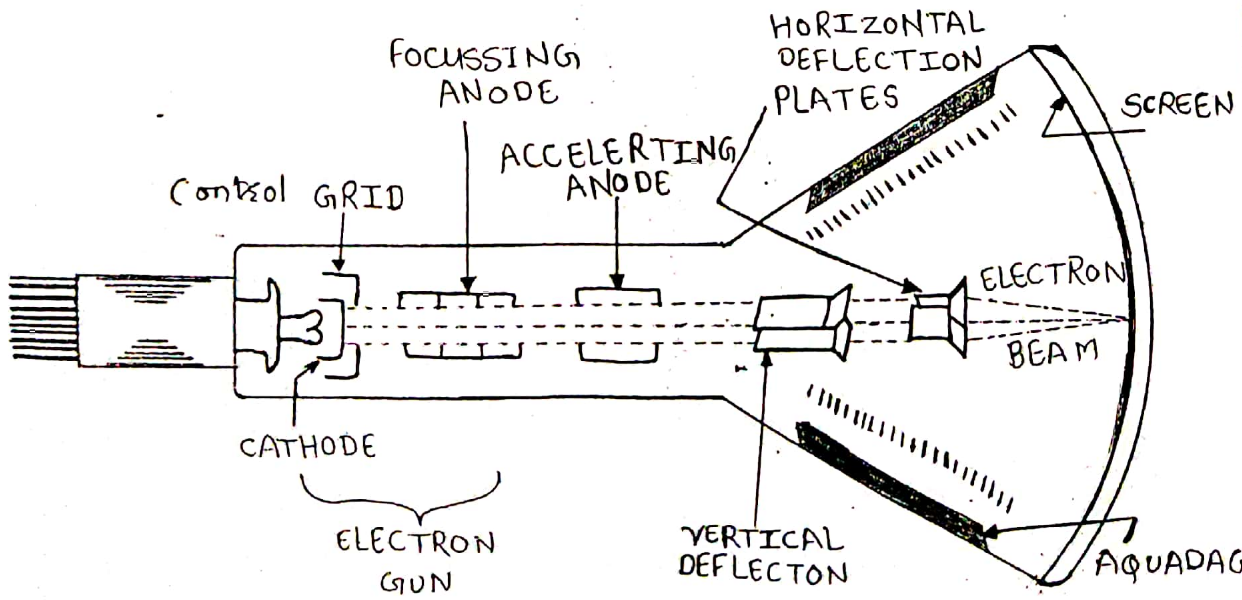
Sensitivity is the most important characteristic of a multimeter. If the sensitivity of a multimeter is high, it means that it has high internal resistance. When such a meter is connected in the circuit to read voltages, it will draw a very small current. Consequently, there will be no change in the circuit current due to the introduction of the meter. Hence, it will measure the voltage correctly. On the other hand, if the sensitivity of multimeter is Law, it would cause serious error in voltage in measurment. The Sensitivity of multimeters available in the market range from 5k Ω per volts to 20k Ω per volt.

Cathode Ray Oscilloscope :-

The cathod ray oscilloscope (commonly abbreviated as CRO) is an electronic device which is capable of giving a visual indication of a signal waveform. No other instrument used in the electronic industy is as versatile as the cathode ray oscilloscope. It is widely used for trouble shooting radio and televison receivers as well as for laboratory work involving research and design. With an oscilloscope, the waveshape of a ~~single~~ signal can be studied with repect to amplitude distortion and deviation from the normal. In addition, the oscilloscope can also be used for measuring voltage, frequency and phase. shift.

Cathode Ray Tube :-

A cathode ray tube (commonly abbreviated as CRT) is the heart of the oscilloscope. It is a vacuum tube of special geometrical shape and converts an electrical signal into visual one. A cathod ray tube make available plenty of electrons. These electrons are accelerated of to high velocity and are brought to focus on a fluorescent screen. The electron beam produces a spot of light wherever it strikes. The electron beam is deflected on its journey in response to the electrical signal under study. The result is that electrical signal waveform is displayed visually. Fig I) shows the various parts of cathod ray tube.



i] <u>Glass envelope</u> :-

It is conical highly evacuated glass housing and maintains vacuum inside and supports the various electrodes. The inner walls of CRT between neck and screen are usually coated with a conducting material, called aquadag. This coating is electrically connected to the accelerating anode so that electrons which accidentally strike the walls are returned to the anode. This prevents the walls of the tube from changing to a high negative potential.

ii] <u>Electron gun assembly</u> :-

The arrangement of electrod-es which produce a focussed beam of electrons is called the electron gun. It essentially consist of an indirectly heated cathod, a control grid, a focussing anode and an accelerating anode. The control grid is held at negative potential w.r.t. cathode whereas the two anodes are maintained at high positive potential w.r.t. cathode.

The cathode consist of a nickel cylinder coated with oxide coating and provides plenty of electrons. The control grid enclbses the cathod and consists of a metal cylinder with a tiny circular opening to keep the electron beam small in size. The focussing anode focuses the electron beam into a shap pin-point by controlling the positive potential on it. The positive potential (about 10,000v) on the accelerating anode is much higher than on the focusing anode.

For this reason, this anode accelerates the narrow beam to high velocity. Therefore, the electron gun assembly forms a narrows, accelerated beam of electrons which produces a spot of light when it strikes the screen.

iii] Deflection plate assembly :-

The deflection of the beam is accomplished by two sets of deflecting plates placed within the tube beyond the accelerating anode as shown in fig I) one set is the vertical deflection plates and the other set is the horizontal deflection plates.

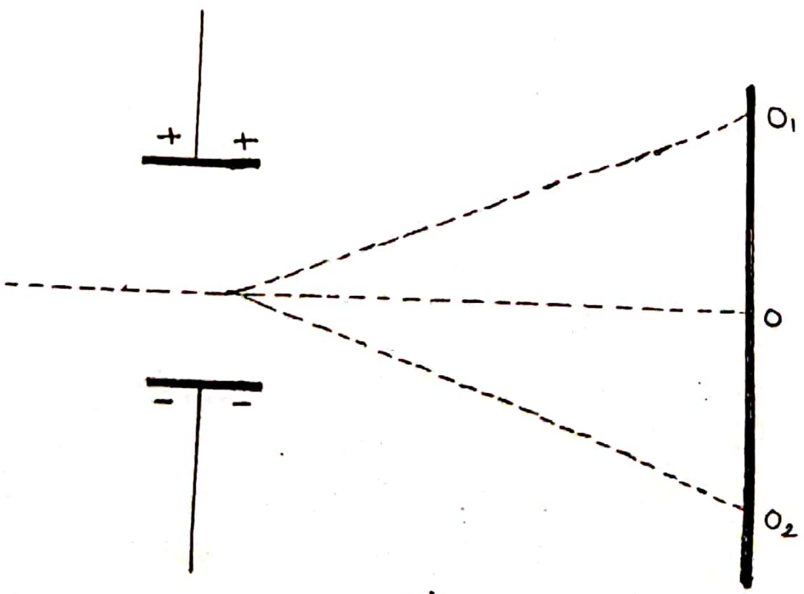
The vertical deflection plates are mounted horizontally in the tube. By applying proper potential to these plates, the electron beam can be made to move up and down vertically on the fluorescent screen. The horizontal deflection plates are mounted in the vertical plane. An appropriate potential on these plates can cause the electron beam to move right and left horizontally on the screen.

iv] Screen :-

The screen is the inside face of the tube and is cathode with some fluorescent material Such as zinc orthosilicate, zinc oxide etc. When high velocity electron beam strikes the screen, a sport of light is produced at a point of impact. The colour of The spot depends upon the nature of fluorescent material. If zinc orthosilicate is used as the fluorescent material, green light spot is produced.

ACTION OF CRT :-

When the cathode is heated, it emits plenty of electrons. These electrons pass through control grid on their way to screen. The control grid influences the amount of the current flow as in standard vacuum tubes. If negatives potential on the control grid is high, fewe electrons will pass through it and the electron beam or striking the screen will produce a dim spot of light. Reversed will happen if the negative potential on the control grid is redused. Thus, the intensity of light spot on the screen can be changed by changing the negati potenital on the control grid. As the electron beam leaves the control grid, it comes under the influence of focussing and accelerating anodes. As the two anodes are maintained at high positive potential, therefore, they produce a field which acts as an electrostatic lens to converge the electron beam at a point on the screen.



I)

As the electron beam leaves the accelerating anode, it comes under the influence of vertical and horizontal deflection plates. If no voltages is applied to the deflecation plates, the electron beam will produce spot of light at the centre (point o in fig II)) of the screen. If the voltage is applied to vertical plates only as shown in fig II); The electron beam and hence the spot of light will be deflected upwords (point o_1). The spot of light will be deflected downwards (point o_2) if the potentical on the plates is reversed. similarly, the spot of light can be moved horizontally by applying voltage across the horizontal plates.

Deflection Sensitivity of CRT :-

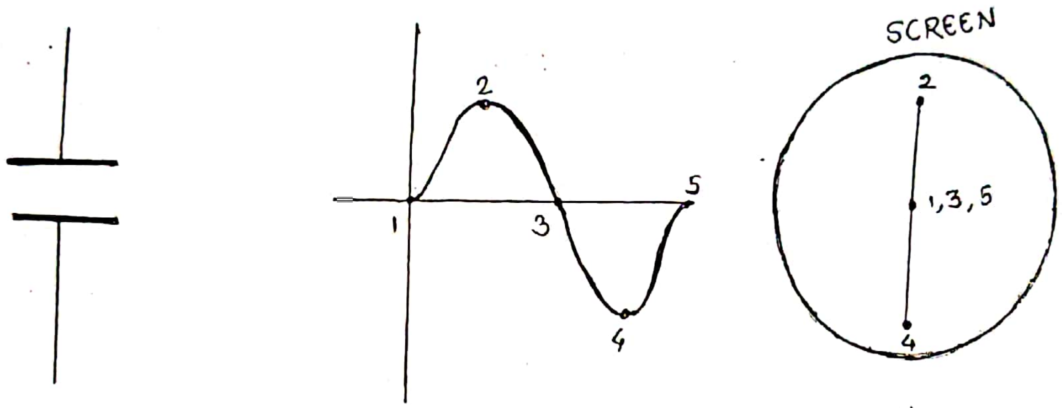
The shift of the spot of light on the screen per unit change in voltage across the deflection plates is known as deflection sensitivity of CRT. For instance, if a voltage of 100V applied to the vertical plates produces a vertical shift of 3mm in the spot, then deflection sensitivity is 0.03 mm/V. In general,

spot deflection = Deflection sensitivity × Applied voltage

The deflection sensitivity depends not only on the design of the tube but also on the voltage applied to the accelerating anode. The deflection sensitivity is Low at high accelerating voltages and vice-versa.

Applying signal Across vertical plates:-

If a sinusoidal voltage is applied to the vertical deflection plates, it will make the plates alternatly positive and negative. Thus, in the positive half of the signal, upper plate will be positive and lower plate negative While in the negative half-cycle, the plate polarities will be reversed.



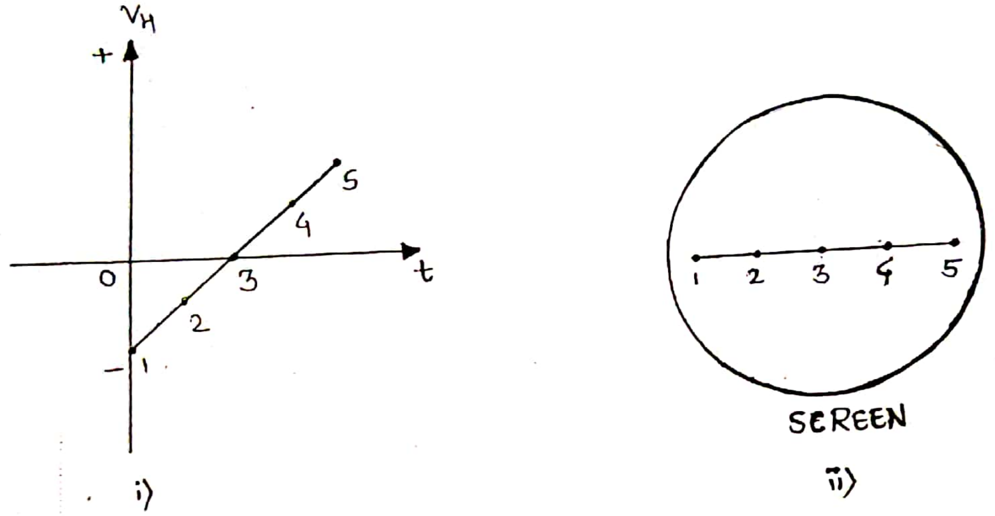
i) ii) iii)

The result is that the spot moves up and down at the same rate as the frequency of the applied voltage. As the frequency of applied voltage is 50HZ, therefore, due to persistence of vision, we will see a continuous vertical line 2-1-4 on the screen as shown in fig III). The line gives no indication of the manner in which the voltag is alternating since it does not reveal the waveform.

Disply of signal Waveform on CRO:-

one interesting application of CRO is to present the wave shape of the signal on the screen. as discussed before, if sinusoidal signal is applied to the vertical deflection plates, we gets a vertical line.

However, it is desired to see the signal voltage variations with time on the screen. This is possible only if we could also move the beam horizontally from left to right at a uniform speed while it is moving up and down. Further, as soon as a full cycle of the signal is traced, the beam should return quickly to the left hand side of the screen so that it can start tracing the second cycle.

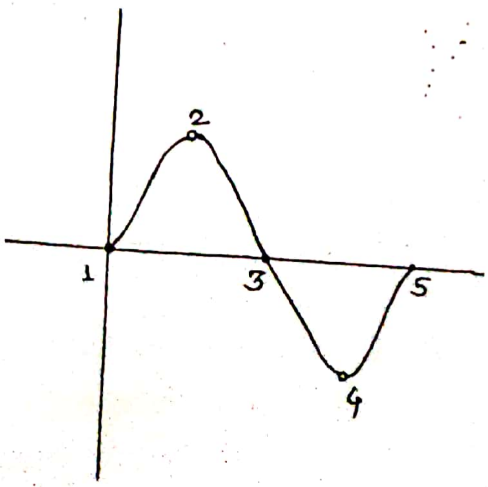


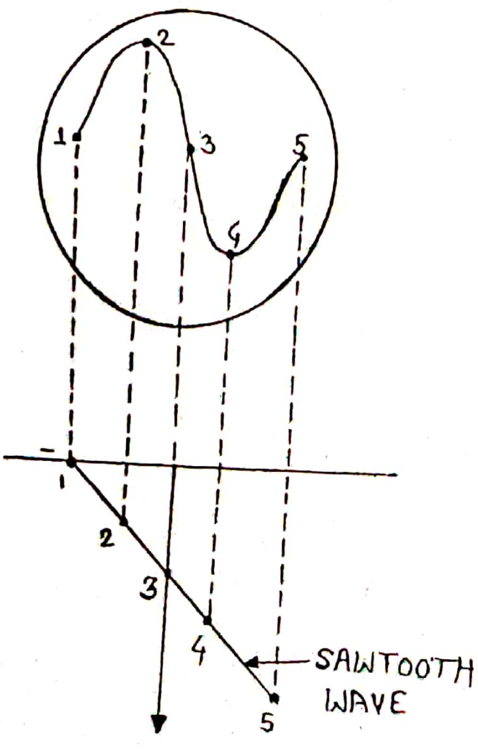
In order that the beam moves from left to right at a uniform rate, a voltage that varies linearly with time should be applied to the Horizontal plates. This condition is exactly met in the saw tooth wave shown in Fig i).

When time t=0, the negative ~~both~~ a voltage on the horizontal plates keeps the beam to the exteeme left on the screen as shown in Fig ii). As the time progresses, the negative voltage decreases linearly with the time and the beam moves towards right forming a horizontal line. In this way, the sawtooth wave applied to horizontal plates moves the beam from left to right at a uniform rate.

Signal pattern on Screen :-

If the signal voltage is applied to the vertical plates and sew-tooth wave to the horizontal plates, we get the exact Pattern of the signal as shown in fig When the signal is at the instant 1, its amplitude is zero. But at this instant, maximum negative voltage is applied to horizontal plates. The result is that the beam is at the extreme left on the screen as shown. When the signal is at the instant 2, its amplitude is maximum. However, the negative voltage on the horizontal plates is decreased. Therefore, the beam is deflected upwords by the signal and towoords the right by the saw tooth wave. The result is that the beam now strikes the screen at point 2. on similar reasoning, the beam strikes the screen at points 3, 4 and 5. In this way, we have the exact signal Pattern on the screen.





Winter-2016

Various controls of CRO :-

In order to facilitate the proper functioning of CRO, various controls are provieded on the face of CRO. A few of them are given below:

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 of 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 focussing 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 ~~vertical~~ horizontal position control regulates the amplitude of d.c. 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 requried.

iv) Vertical position control :-

The knob of vertical Position control regulates the amplitude of d.c. Potential which is applied to the vertical deflection plates in addition to the signal. By adjusting this control, the

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iv) Vertical position Control :-

The knob of vertical position control regulates the amplitude of d.c. 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 requried.

* Problems :-

1) A multimeter has full scale deflection current of 1mA. Determine its sensitivity.

Solution :-

Full scale deflection current,

$I_g = 1mA$

$I_g = 10^{-3} A$

∴ Multimeter sensitivity $= 1/I_g$

$= 1/10^{-3}$

$= 1000\ \Omega$ per volt.

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2) A multimeter has a sensitivity of 1000Ω per volt and reads 50V full scale. If the meter is to be used to measure the voltage across 50000Ω resistor, will it read correctly ?

Solution :-

Meter sensitivity = 1000Ω per volt

Full scale volts = 50V

Meter resistance = 50 × 1000

= 50,000Ω

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3) The deflection sensitivity of CRT is 0.01mm/v. Find the shift produced in the spot when 400v are applied to the vertical plates.

Solution :- As voltage is applied to the vertical plates only, therefore, the spot will be shifted vertically.

spot shift = deflection sensitivity × applied voltage

= 0.01 × 400

= 4mm.

4) The deflection sensitivity of a CRT is 0.03mm/v. If an unknown voltage is applied to the horizontal plates, to the horizontal plates, the spot shifts 3 mm horizontally. Find the value of unkown voltage.

<u>Solution</u> -

Deflection Sensitivity = 0.03mm/v

Spot shift = 3mm

Now, <u>spot shift = deflection sensitivity x applied voltage.</u>

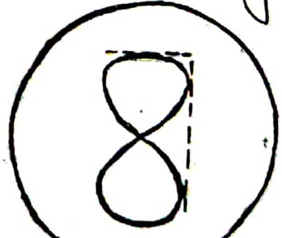
$$\therefore \text{Applied voltage} = \frac{\text{spot shift}}{\text{deflection sensitivity}}$$

$$= \frac{3mm}{0.03 mm/v}$$

$$\therefore \text{Applied voltage} = \underline{100V}$$

5] In an oscilloscope, 200v, 50Hz signal produces a deflection of 2cm corresponding to a certain setting of vertical gain control. If another voltage produces 3cm deflection, What is the value of this voltage?

<u>Solution</u> -



<u>Deflection sensitivity = 200v/2 cm = 100v/cm</u>

unknown voltage = d.s. x deflection

= 100 X 3

unknown voltage = <u>300V</u>