3RD SEMESTER, ELECTRICAL ENGINEERING
ELECTRICAL AND ELECTRONIC MEASUREMENTS(TH-3)

Fundamentals of Measurements
Unit-1

1.
a) Define sensitivity? [2]

 Ans: Sensitivity is the ratio of change in output of the instrument to a change of input or measured quantity at steady state condition. The sensitivity of an instrument should be high.

     Sensitivity=**changeinoutput/ changeininput**

b) Define damping torque? [2]

Ans:A *damping torque* is produced by a damping or stopping force which acts on the moving system only when it is moving and always opposes its motion. Such a torque is necessary to bring the pointer to rest quickly. If there is no damping torque, then the pointer will rest, due to the inertia of the moving system.

c) Define Accuracy?   [2]

Ans:Accuracy is the degree of closeness with which an instrument reading approaches the true value of the quantity being measured. The measured quantity may be different from the true quantity due to effects of temperature humidity etc.

 Example- three readings taken for a quantity (whose true value is 5.00) are 4.85,4.90,4.95, then 4.95 is more accurate among three readings as it is much closer to 5.00.

d) What is shunt? [2]

Ans : A low shunt resistance is connected in parallel with the ammeter to extent the range of instrument. A Large current can be measured in a low rated ammeter by using a shunt.

e) Define Controlling torque? [2]

Ans:The controlling torque (T_c) opposes the deflecting torque and increases with the deflection of the moving system. The pointer comes to rest at a position where the two opposing torques are equal

i.e., $T_d = T_c$. The controlling torque performs two functions.

f) Define Tolerance?

Ans:Tolerance is the term which specifies the maximum allowable deviation of a manufactured device from a mentioned value. Example- length of a quantity is 10± 2 cm. Then tolerance is from minimum value as (10-2) =8 to maximum value as (10+2) =12.

g)) Define Deflecting torque? [2]

 Ans:The torque causes the moving system to move from its zero position is called deflecting torque. It is also called as operating force. So we can say the deflecting system of an instrument can convert the electric current or voltage into a mechanical force.it is denoted by T_d.

h)What is Error? [2]

Ans:The difference of magnitude between measured value (Am) and true value (At) is called as error.it can be positive or negative.

i) Define Resolution? [2]

Ans: Resolution if the input is slowly increased from some arbitrary value, it will be found that the output does not change at all until a certain increment is exceeded. This increment is known as resolution, in other words it is the smallest change in a measured variable to which an instrument will respond.

j) Define Calibration? [2]

Ans:Calibration is the process of comparing a device under test (DUT) of an unknown value with a reference standard of a known value.

2(a) Explain spring control method of indicating type instrument? [5]
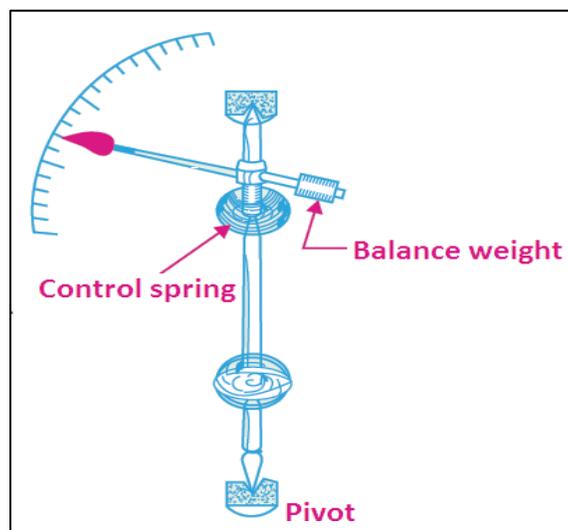
This is the most common method of providing controlling torque, in electrical instruments. A spiral hairspring made of some non-magnetic material like phosphor bronze is attached to the moving system of the instrument as shown in the figure.

Springs also serve the additional purpose of leading current to the moving system (i.e. operating coil). With that deflection of the pointer, the spring is twisted in the opposite direction. This twist in the spring provides the controlling torque.

As the torsion torque of a spiral spring is proportional to the angle of twist, the controlling torque (T_c) is directly proportional to the angle of deflection of pointer (θ) i.e. $T_c \propto \theta$. The pointer will come to rest at a position where controlling torque is equal to the deflecting torque i.e. $T_d = T_c$.

 In an instrument where the deflecting torque is uniform, spring control provides a uniform scale over the whole range. The balance weight is attached to counterbalance the weight of the pointer and other moving parts

b) Explain Gravity control method of indicating type instrument?[5]
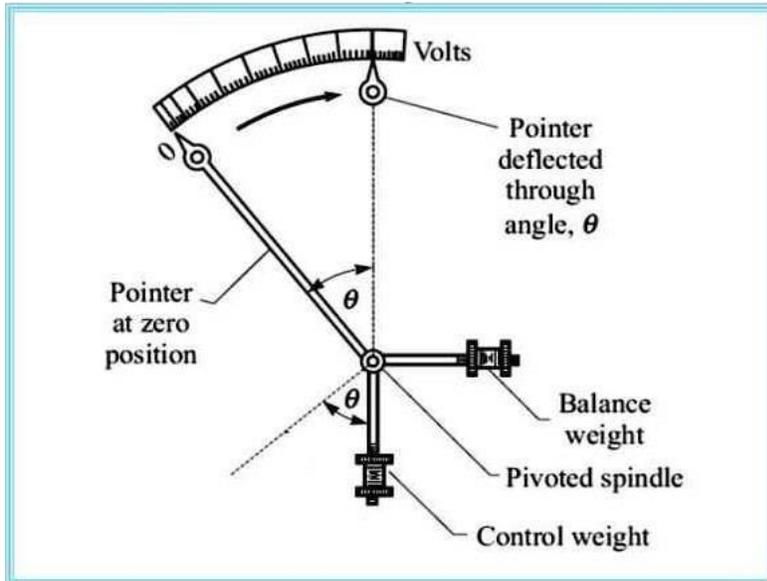
In this method, a small weight is attached to the moving system, which provides necessary controlling torque. In the zero position of the pointer, the control weight hangs vertically downward and therefore provides no controlling torque.

However, under the action of deflecting torque, the pointer moves from zero position and control weight moves in opposite direction. Due to gravity, the control weight would tend to come in original position (i.e. vertical) and thus provides an opposing or controlling torque. The pointer comes to rest at a position where controlling torque is equal to the deflecting torque.In this method, controlling torque (T_C) is proportional to the sin of angle of deflection (θ) i.e. $T_C \alpha \sin \theta$.

Because in this method controlling torque (T_C) is not directly proportional to the angle of deflection (θ) but it is proportional to $\sin \theta$ therefore, gravity control instruments have non-uniform scales; being crowded in beginning.

(c) What are the benefits of Calibration? [5]

Ans:Calibration is a process of testing and comparing the errors of measurement instruments and processes with accepted standards in order to detect and correct variations in performance. Therefore, calibration ensures that equipment and procedures function as planned while maintaining accuracy and levels that are generally accepted.

Benefits:

- It determines whether measurements made before the calibration were valid.

- It gives confidence that the future measurements will be accurate.

- It assures consistency and compatibility with those made elsewhere.

- It leads to repeatability and reproducibility assessments of the instruments and processes.

- Without calibration, the product quality may be poor, thus opening up legal challenges and high failure rates of the products, thus increasing costs.

- It increases efficiency by ensuring that measurements are correct.

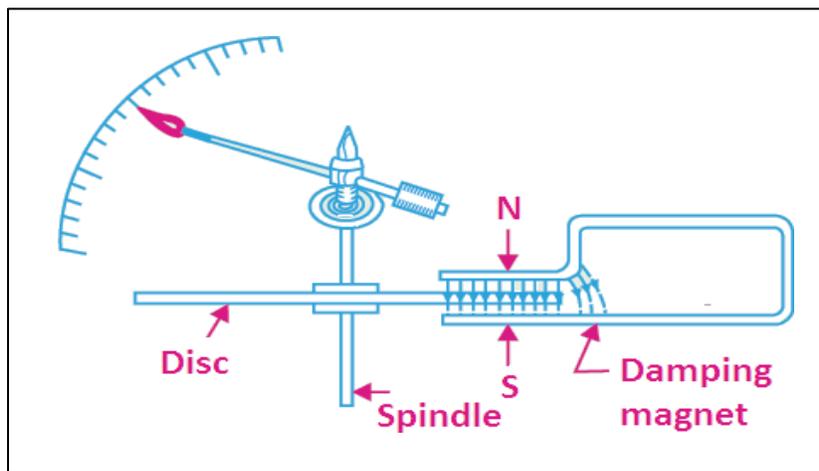(d) What is the Error in Measurements? Classify various types of error? [5]

Ans:Error is the deviation of the true value from the desired value.

Error = Measured value - true value.

Classification of errors
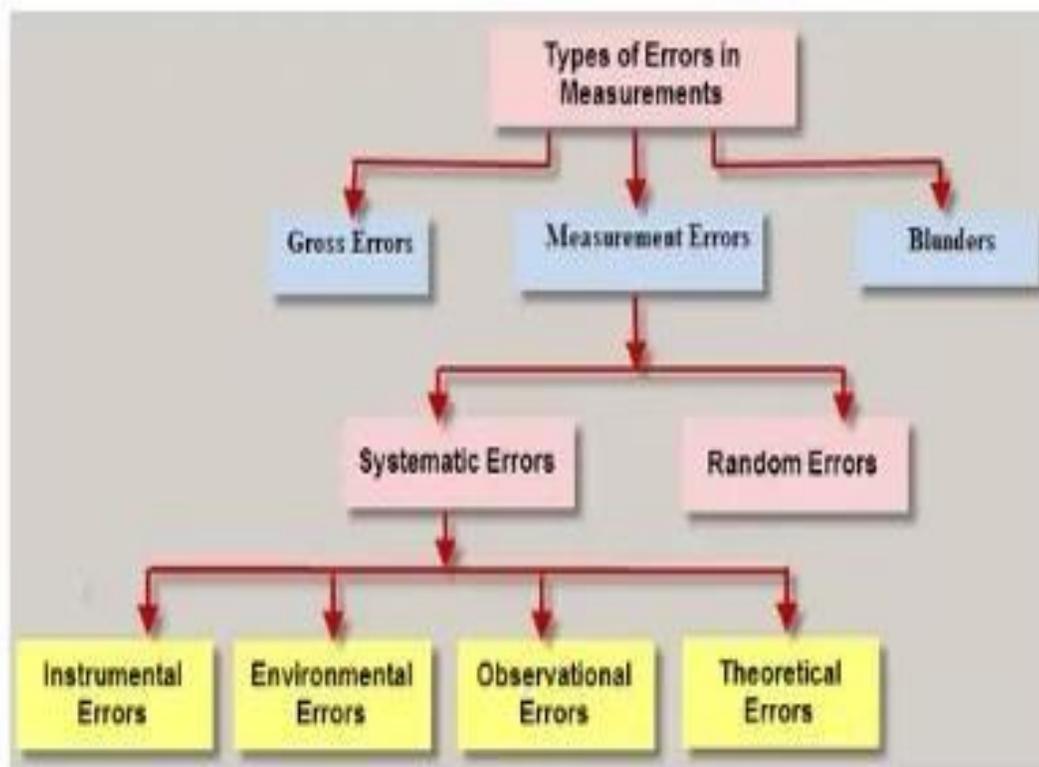
## 2e) What is Eddy Current Damping explain with diagram?

Two methods of *eddy current damping* are generally used. In the first method, as shown in the figure, a thin aluminum or copper disc is attached to the moving system is allowed to pass between the poles of a permanent magnet. As the pointer moves, the disc cuts across the magnetic field and eddy currents are induced in the disc.

These eddy currents react with the field of the magnet to produce a force which opposes the motion according to Lenz's Law. In this way, eddy current damping torque reduces the oscillations of the pointer.

In the second method, the coil which produces the deflecting torque is wound on aluminum former. As coil moves in the field of the instrument, eddy currents are induced in the aluminum former to provide the necessary damping torque.

3(a) Classify measuring instrument and explain in brief? [10]
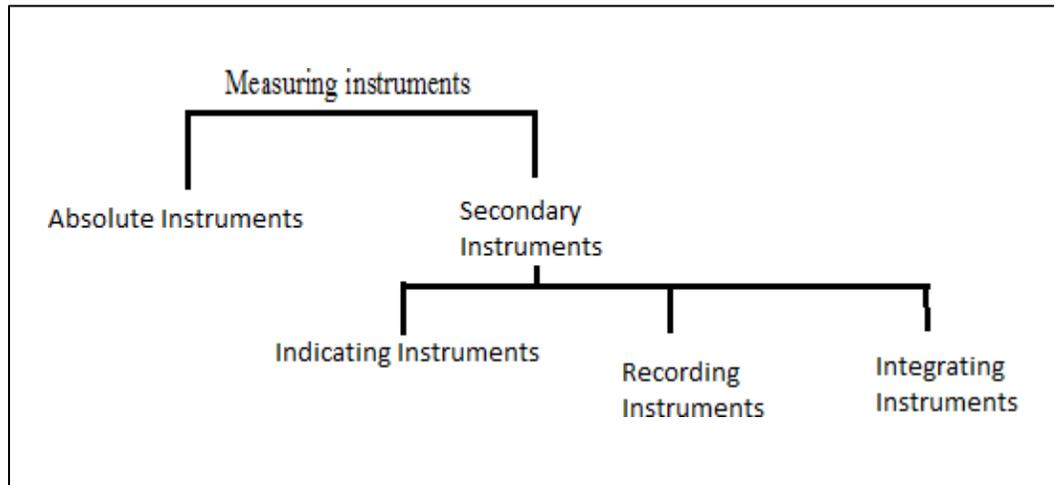
A device for calculating the magnitude or value of a quantity or variable is known as an instrument. The means by which the variables and the relations between variables are produced are measuring instruments. Electrical measurements of different parameters like current, voltage, power, energy, etc. are most essential in any industry. The various electrical instruments may be broadly divided into two categories i.e. absolute and secondary instruments. Further the secondary instruments are classified as indicating, recording and integrating instruments.

Absolute or Primary Instruments:This kind of instrument shows how much a quantity should be measured in terms of the instrument constant and deflection. These devices don't need to be compared to other standards. Example: Galvanometer. 1.11.2 Secondary Instruments

Secondary Instruments These instruments indicate the magnitude of the measuring electrical quantity. Before using, these instruments require calibration with either an absolute instrument or with an already calibrated secondary instrument. The output of this type of device is directly obtained, and no mathematical calculation requires for knowing their value Secondary instruments are further classified: (a) Indicating instruments: Instruments that provide an indication of the magnitude of an electrical quantity at the time of measurement are known as indicating instruments. The movement of pointer or the deflection is not constant but depends on the quantity it measures. As the needle deflects and indicates the amount of current, voltage or any quantity, these are called deflection type of instruments. Ordinary ammeters, voltmeters and watt meters are examples of this type of instrument as shown below

Indicating instruments: These instruments indicate the value of voltage, current, poweretc. directly on a graduated dial in analog meters and LCD or LED display in digitalmeters. Ex: Ammeter, voltmeter, Wattmete
Integrating Instruments: These instruments measures the total amount, either the quantity

of electricity or the electric energy supplied to a circuit over a period of time. Ex: Energy meter, Ampere hour meter

Recording Instruments: These instruments register the quantity to be measured in a given time, and are provided with a pen which moves over graph paper. Ex: Recording voltmeter, ECG, EEG.

(b) What are the essential requirement of Indicating types instrument ? [10]

Deflecting, controlling and damping arrangements in indicating type of instruments

In order to ensure proper operation of indicating instruments, the following three torques are required:

- Deflecting torque.
- Controlling torque.
- Damping torque.

DEFLECTING TORQUE

The torque causes the moving system to move from its zero position is called deflecting torque. It is also called as operating force. So we can say the deflecting system of an instrument can convert the electric current or voltage into a mechanical force.it is denoted by T_d.

The deflecting torque causes the moving system to move from its zero position. The deflecting torque is produced by utilizing one or more of the following effects of current or voltage.

CONTROLLING TORQUE

The controlling torque (T_C) opposes the deflecting torque and increases with the deflection of the moving system.

The pointer comes to rest at a position where the two opposing torques are equal

i.e. **T_d = T_C.**

controlling torque performs two functions.

1) Controlling torque increases with the deflection of the moving system so that the final position of the pointer on the scale will be according to the magnitude of an electrical quantity (i.e. current or voltage or power) to be measured.

2) Controlling torque brings the pointer back to zero when the deflecting torque is removed. If it were not provided, the pointer once deflected would not return to zero position on removing the deflecting torque. The *controlling torque* in indicating instruments may be provided by one of the following two methods:

1. Spring control.
2. Gravity control.

DAMPING TORQUE

A *damping torque* is produced by a damping or stopping force which acts on the moving system only when it is moving and always opposes its motion. Such a torque is necessary to bring the pointer to rest quickly. If there is no damping torque, then the pointer will keep moving to and fro about its final deflected position for some time before coming to rest, due to the inertia of the moving system.

This damping torque acts only when the pointer is in motion and always opposes the motion. The position of the pointer when stationary is, therefore, not affected by damping torque. The degree of damping decides the behavior of the moving system.

If the instrument is under-damped, the pointer will oscillate about the final position for some time before coming to rest. On the other hand, if the instrument is over damped, the pointer will become slow and lethargic.

Types of Damping Torque

The damping torque in indicating instruments can be provided by:
- Air friction damping.
- Fluid friction damping.
- Eddy current damping.

In this method, discs or vanes attached to the spindle of the moving system are kept immersed in a pot containing oil of high viscosity. As the pointer moves, the friction between the oil and vanes opposes the motion of the pointer and thus necessary damping is provided.

The fluid friction damping method is not suitable for portable instruments because of the oil contained in the instrument. In general, fluid friction damping is not employed in indicating instrument, although one can find its use in Kelvin electrostatic voltmeter.

Measurement of voltage and current
UNIT-2

1(a) What is Shunt?
Ans:A low shunt resistance is connected in parallel with the ammeter to extend the range of instrument. A Large current can be measured in a low rated ammeter by using a shunt.

b) What is multiplier?
Ans:A large resistance is connected in series with voltmeter is called multiplier. A large voltage can be measured in a low rated voltmeter by using multiplier.

c) what is multiplying factor for ammeter shunt?
Ans:The ratio of main current I and current through the meter Im known as multiplying factor, m. Mathematically, it can be represented "m"

d) Define CT?
Ans:CT is a current transformer, an instrument transformer used to measure high alternating currents (AC) by reducing them to a lower, proportional value. The CT is connected in series with the circuit and its primary winding consists of a single conductor or wire that carries the high current. This reduced current from the secondary winding can be safely measured by standard ammeters

e)Define PT?
Ans:Potential transformers are used to operate voltmeters, the potential coils of wattmeters and relays from high voltage lines. The primary winding of the transformer is connected across the line carrying the voltage to be measured and the voltage circuits connected across the secondary winding. The design of a potential transformer is quite similar to that of a power transformer but the loading of a potential transformer is always small, sometimes only a few volt-amperes.

f)What are the applications of Current Transformers?
Ans:Thesetransformersareused to measure electricpower inpowerhouses, industries, grid stations, control rooms in industries for metering & analyzing the flow of current in the circuit and also for protection purposes.

g) DefineLoadingEffectofVoltmeter?
Ans:The loading effect of a dc voltmeter refers to the phenomenon in which a negative error is produced in the voltmeter reading (measured voltage), due to the low internal resistance (i.e., low sensitivity of the voltmeter).

h)How ammeter and voltmeter are connected in a circuit?
Ans:Ammeter connected in series whereas voltmeter connected in parallel in a circuit.

i)What is the DifferencebetweenC.T.andP.T.?

The potential transformer maybe considered as 'parallel' transformer with its secondary winding operating nearlyunder open circuit conditions whereas the current transformer maybe thought as a 'series' transformer under virtual short circuit conditions. Thus the secondary winding of a P.T. can be open circuited without any damage being caused either to the operator or to the transformer

The primarywinding current in a C.T. is independent of the secondary winding circuit conditions while the primary winding current in a P.T. certainly depends upon the secondary circuit burden.

Inapotentialtransformer,fulllinevoltageisimpresseduponitsterminalswhereasa

C.T. is connected in series with one line and a small voltage exists across its terminals. However, the C.T. carries the full line current.

j) What are the applicationsofPotentialTransformers?

primarily used for voltage measurement, system protection, and electrical isolation in high-voltage systems. They step down high voltages to a safe, measurable level, enabling applications like accurate billing in utility metering, fault detection by protective relays, and voltage monitoring in power plants, substations, and industrial facilities.

2(a) A 1 mA ammeter has its internal resistance of 100 Ω is to be converted into a 0-100 mA ammeter.Calculate the shunt resistance and total resistance of circuit.

*ANS: -   Given **Rm** =100 Ω , Im =1 mA ,   I=100 mA*

$$\text{Then multiplication Factor (m)} = \frac{I}{Im} = \frac{100\ mA}{1mA} = 100$$

$$Rsh = \frac{Rm}{m-1} = \frac{100\Omega}{100-1} = 1.01\ \Omega$$

$$\text{Total resistance of circuit} = \frac{Rm\ X\ Rsh}{Rm+Rsh} = \frac{100\ X\ 1.01}{100+1.01} = 0.99\Omega$$

b) Explain DC basic ammeter with diagram?

Ans:Current is the rate of flow of electric charge. When an electric charge solely moves in one direction, it is referred to as direct current (DC). The device used to measure direct current is known as a DC ammeter. If we place a resistor in parallel with the Permanent Magnet Moving Coil (PMMC) galvanometer, then the entire combination acts as DC ammeter. The parallel resistance, which is used in DC ammeter is also called shunt resistance or simply, shunt. The value of this resistance should be

considered small in order to measure the DC current of large value. The circuit diagram of DC ammeter is shown in figure as follows
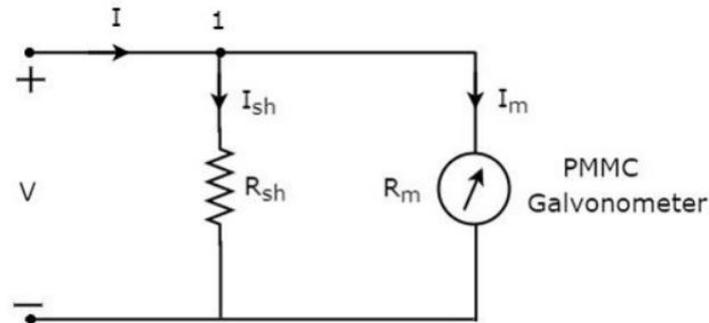

Figure DC Ammeter

where,

R_{sh} is the shunt resistance

R_m is the internal resistance of galvanometer

I is the total Direct Current that is to be measured

I_m is the full scale deflection current.

This DC ammeter must be connected in series with the electrical circuit branch where the DC current will be measured. The voltage across the elements, which are connected in parallel is same.So,thevoltage acrossshuntresistor, R_{sh}andthevoltageacrossgalvanometer resistance, R_m is same, since those two elements are connected in parallel in above circuit. Mathematically, it can be written as

$$I_{sh}R_{sh} = I_m R_m$$

KCL eqn. at node 1 is

$$-I + I_{sh} + I_m = 0$$

$$I_{sh} = I - I_m$$

Substitute the value of I_{sh} in (1),

$$R_{sh} = \frac{I_m R_m}{I - I_m} \tag{2}$$

$$= \frac{R_m}{(I/I_m) - 1}$$

Take, I_m as common in the denominator term, which is present in the right hand side of (2),

$$R_{sh} = \frac{I_m R_m}{I_m (\frac{I}{I_m} - 1)}$$

The ratio of I and I_m is known as multiplying factor, m. Mathematically, it can be represented as:

$$m = \frac{I}{I_m}$$

c)Explain DC basic voltmeter with diagram?

Ans:DC voltmeter is a measuring instrument, which is used to measure the DC voltage across any two points of electric circuit. If we place a resistor in series with the Permanent Magnet Moving Coil (PMMC) galvanometer, then the entire combination together acts as DC voltmeter. The series resistance, which is used in DC voltmeter is also called series multiplier resistance or simply, multiplier. It basically limits the amount of current that flows through galvanometer in order to prevent the meter current from exceeding the full scale deflection value. The circuit diagram of DC voltmeter is shown in below
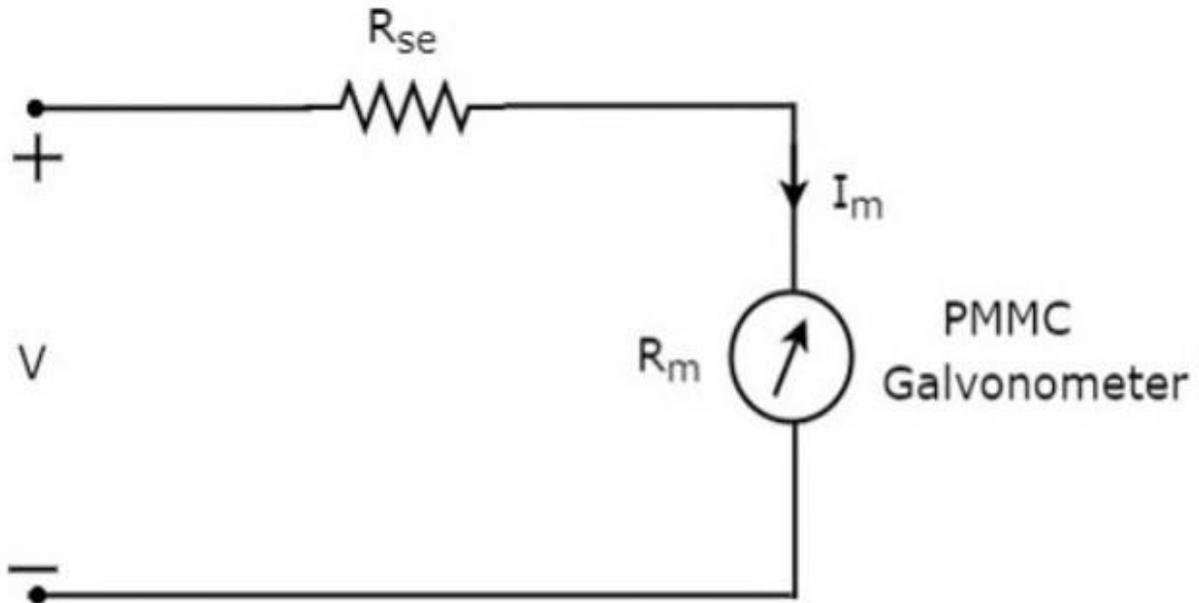
We have to place this DC voltmeter across the two points of an electric circuit, where the DC voltage is to be measured. Apply KVL around the loop of above circuit.

$$V - I_m R_{se} - I_m R_m = 0$$

$$\Rightarrow R_{se} = \frac{V - I_m R_m}{I_m}$$

$$R_{se} = \frac{V}{I_m} - R_m$$

Where,

$R_{se}$is the series multiplier resistance

$V$is the full range DC voltage that is to be measured

$I_m$is the full scale deflection current

$R_m$is the internal resistance of galvanometer

The ratio of full range DC voltage that is to be measured, $V$and the DC voltage drop across the galvanometer, $V_m$is known as multiplying factor.

d)Explain DC Multi-Range DC Voltmeter with diagram?

Ans:In previous section, we had discussed DC voltmeter, which is obtained by placing a multiplier resistor in series with the PMMC galvanometer. This DC voltmeter can be used to measure a particular range of DC voltages. If we want to use the DC voltmeter for measuring the DC voltages of multiple ranges, then we have to use multiple parallel multiplier resistors instead of single multiplier resistor and this entire combination of resistors is in series with the PMMC galvanometer. The circuit diagram of multi range DC voltmeter is shown in Fig. below.
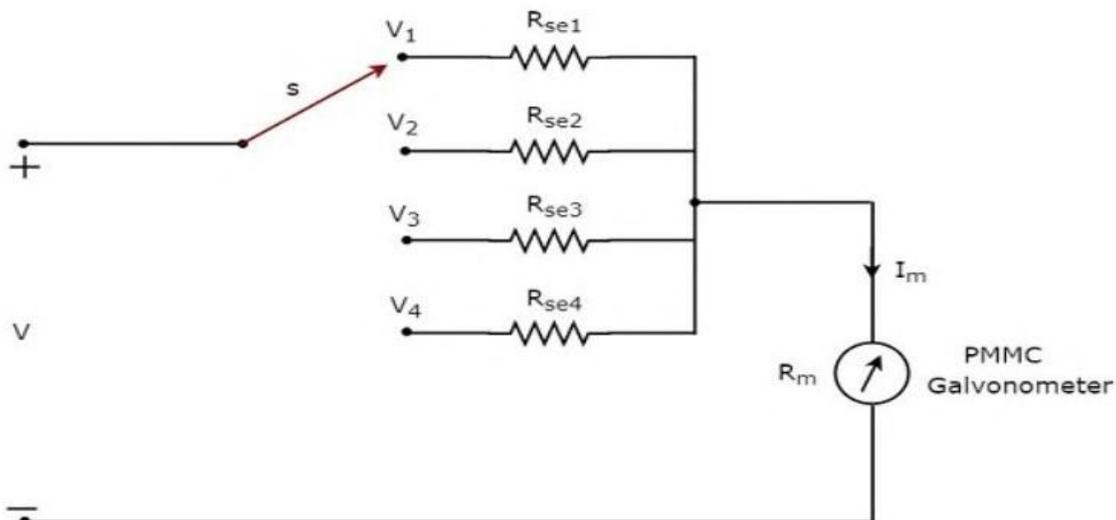
We have to place this multi range DC voltmeter across the two points of an electric circuit, where the DC voltage of required range is to be measured. We can choose the desired range of voltages by connecting the switch s to the respective multiplier resistor.
Let, m_1, m_2, $m_3$and
$m_4$are the multiplying factors of DC voltmeter when we consider the full range DC voltages to be measured as, $V1$, $V2$, $V3$and $V4$respectively. Following are the formulae corresponding to each multiplying factor.

Multi-Range DC Ammeter

A specific range of Direct Currents can be measured using this DC ammeter. Instead of using a single resistor, we must utilize several parallel resistors to measure the Direct Currents of various ranges with the DC ammeter, and this entire arrangement of resistors is parallel to the PMMC galvanometer. The circuit diagram of multi range DC ammeter is shown in figure below.
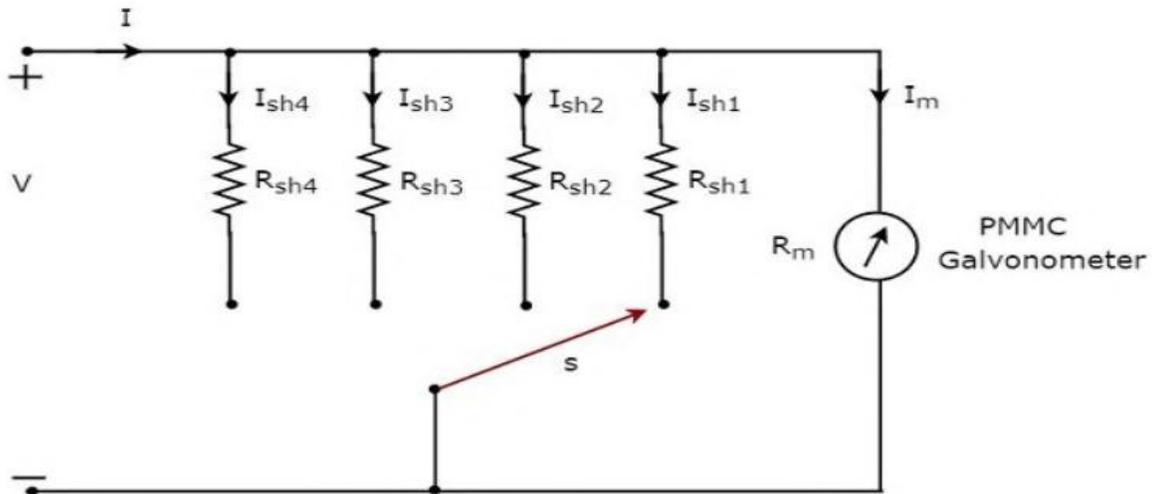

Place this multi range DC ammeter in series with the branch of an electric circuit, where the Direct Current of required range is to be measured. The desired range of currents is chosen by connecting the switch, s to the respective shunt resistor.

Let m_1, m_2, m_3 and m_4 be the multiplying factors of DC ammeter when we consider the total Direct Currents to be measured as, I_1, I_2, I_3 and I_4 respectively. Following are the formulae corresponding to each multiplying factor.
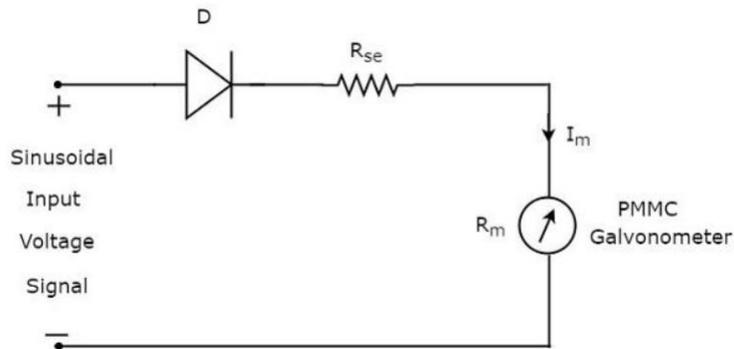
e)Explain AC voltmeter using Half Wave Rectifier with diagram?

Ans:If a Half wave rectifier is connected ahead of DC voltmeter, then that entire combination together is called AC voltmeter using Half wave rectifier. The block diagram of AC voltmeter using Half wave rectifier is shown in below figure below.
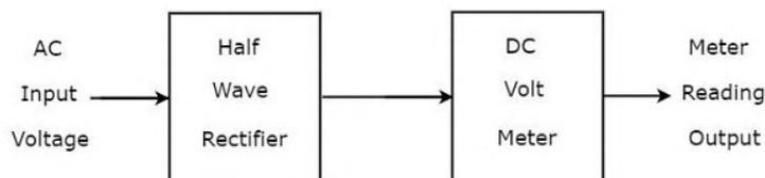
Block diagram of AC voltmeter using half wave rectifier

The above block diagram consists of two blocks: half wave rectifier and DC voltmeter. We will get the corresponding circuit diagram, just by replacing each block with the respective components in above block diagram. So, the circuit diagram of AC voltmeter using Half wave rectifier will look like as shown in below figure below.

AC voltmeter using half wave rectifier

The rms value of sinusoidal (AC) input voltage signal is

$$V_{rms} = \frac{V_m}{\sqrt{2}}$$

$$V_m = \sqrt{2}V_{rms}$$

Where,

V_m is the maximum value of sinusoidal (AC) input voltage signal. The DC or average value of the Half wave rectifier's output signal is

$$V_{dc} = \frac{V_m}{\pi}$$

Substitute, the value of V_m in above eqn..

$$V_{dc} = \frac{\sqrt{2}V_{rms}}{\pi}$$

$$V_{dc}= 0.45V_{rms}$$

Therefore, the AC voltmeter produces an output voltage, which is equal to 0.45 times the rms value of the sinusoidal (AC) input voltage signal.

f)Explain AC Voltmeter using Full Wave Rectifier with diagram?

Ans:If a Full wave rectifier is connected ahead of DC voltmeter, then that entire combination together is called AC voltmeter using Full wave rectifier. The block diagram of AC voltmeter using Full wave rectifier is shown in below figure.
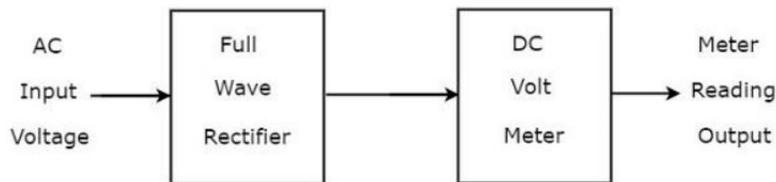

Figure: Block diagram of AC voltmeter using Full wave rectifier

The above block diagram consists of two blocks: full wave rectifier and DC voltmeter. We will get the corresponding circuit diagram just by replacing each block with the respective component(s) in above block diagram. So, the circuit diagram of AC voltmeter using Full wave rectifier will look like as shown in below figure
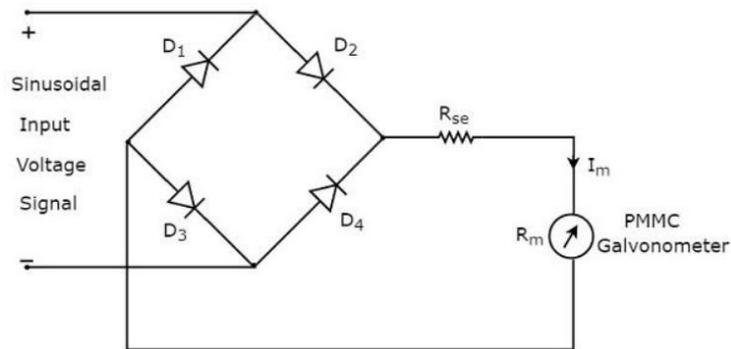

Figure: AC voltmeter using Full wave rectifier

The RMS value of sinusoidal (AC) input voltage signal is

$$V_{rms}= \frac{V_m}{\sqrt{2}}$$

—

$$V_m = \sqrt{2}V_{rms}$$

3a) Explain the Construction & Working principle of Current Transformers, also states its application?

1. Ans:The current transformers may be classified as:

2. Wound type: A wound current transformer is a transformer with separate primary and secondary windings wrapped around a laminated core. A current transformer having a primary winding of more than one full turn wound on core.
3. Bar type: A current transformer in which the primary winding consists of a bar of suitable size and material forming an integral part of transformer.
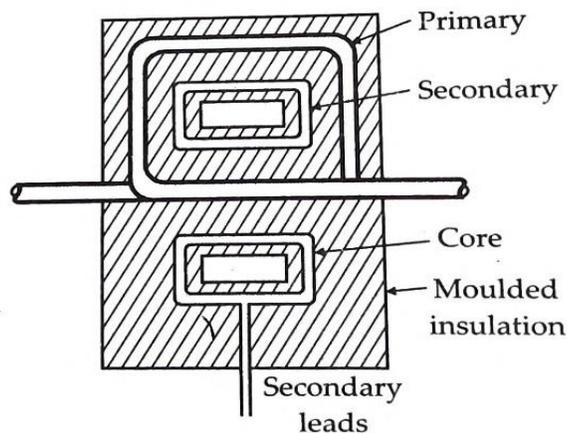
The simplest form any current transformer can take, is the ring type or window type, examples of which are given in figure 2.21 which shows three commonly used shapes i.e ., stadium, circular and rectangular orifices. The core, if of a nickel-iron alloy or an oriented electrical steel is almost certainly of the continuously wound type. But current transformers using hot rolled steel will consist of stack of ring stampings. Before putting secondary winding on the core, the latter is insulated by means of end collars and circumferential wraps of elephantide or presspahn. These pressboards, in addition to acting as insulating medium, must also protect the secondary winding conductor from mechanical damage due to sharp corners. The secondary winding conductor is put on the core by a toroidal winding machine although hand winding is still frequently adopted if the number of secondary winding turns is small. After the secondary winding has been placed on the core, the ring type transformer is completed by exterior taping with or without first applying exterior end collars and circumferential insulating wraps.

Working of Current Transformer

The working principle of the current transformer is somewhat different when we compare it with a normal voltage transformer. Similar to the voltage transformer, it includes two windings. Whenever AC supplies throughout the primary winding, then alternating magnetic flux can be generated, then AC will be induced within the secondary winding. In this type, the load impedance is very small. Thus, this transformer works under short circuit conditions. So the current within the secondary winding depends on the current in the primary winding but doesn't depend on the load impedance.
Applications of Current Transformers

These transformers are used to measure electric power in powerhouses, industries, grid stations, control rooms in industries for metering & analyzing the flow of current in the circuit and also for protection purposes.

3b)Explain the Construction &working principle of Potential Transformers (P.T)& its Uses?

Ans:The design and construction of potential transformers are basically the same as those of power transformers but there are a few major points of difference:
Power transformers are designed keeping in view the efficiency, regulation and cost; the cost being reduced by using small core and conductor sizes. In designing
a potential transformer, economy in materials is not a big consideration and the transformers are designed to give desired performance, i.e., constancy of ratio and smallness of phase angle. Compared to power transformer a potential transformer has larger core and conductor sizes. Economic designs may lead to large ratio and phase angle errors which are undesirable features.
The output of a potential transformer is always small and the size is quite large. Therefore, the temperature rise is small and hence there are no thermal problems caused by overloads as in power transformers. In fact, the loading of a potential transformer is limited by accuracy considerations while in a power transformer the load limitation is on heating basis. Actually, the potential transformers are able to carry loads on a thermal basis many times their rated loads. These loads range from 2 to 3 times for low voltage potential transformers and upto 30 or more times for some high voltage transformers.
Core: The core may be of shell or core type of construction. Shell type of construction is normally only used for low voltage transformers. Special precautions should be taken to assemble and interleave the core laminations so that the effect of air gaps at the joints may be minimized.
Windings: The primary and secondary windings are coaxial to reduce the leakage reactance to the minimum. In order to simplify the insulation problems, the low voltage winding (secondary) is put next to the core. The primary winding may be a single coil in low voltage transformers but must be subdivided into a number of short coils in high voltage transformers in order to reduce the insulation needed between coil layers.
Insulation: Cotton tape and varnished cambric are used as insulation for coil construction. Hard libre separators are used between coils. At low voltages, the transformers are usually filled without compound but potential transformers for use at voltages above 7 kV are oil immersed. Dry type, porcelain insulated transformers have been developed in the continent for use upto 45 kV.
Bushings: Oil filled bushings are usually used for oil filled potential transformers as this minimizes the overall size of the transformer. Two bushings are used when neither side of the line is at ground potential. Some potential transformers, connected from line to neutral of grounded neutral systems, have only one high voltage bushing.
It is pertinent to point out here that a current transformer needs only one bushing as leads from the

two ends of the primary winding are brought through the same insulator since there is only a small voltage between them, thus saving the expense of another high voltage insulator. A 2- winding single phase potential transformer is shown in Figure below
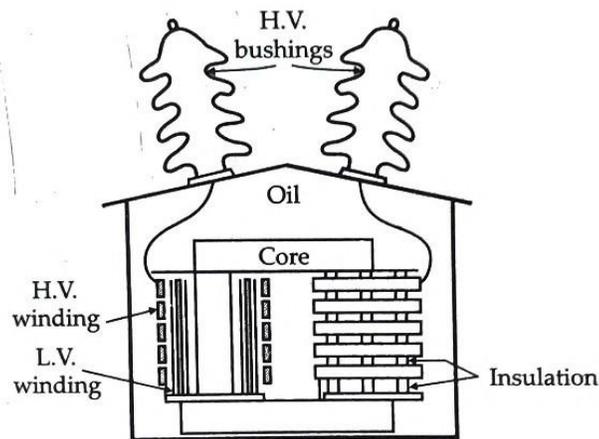

Figure. Single Phase Potential Transformer

Working of Potential Transformer

The potential transformer connected to the power circuit whose voltage should be measured is connected between the phase and the ground. That means the primary winding of a potential transformer is connected to the high voltage circuit and the secondary winding of a transformer is connected to a voltmeter. Due to the mutual induction, the two windings are magnetically coupled to each other and work on the principle of electromagnetic induction. The decreased voltage is measured across the secondary winding with respect to the voltage across the primary winding using multimeter or voltmeter. Due to the high impedance in the potential transformer, the small current flows through the secondary winding and operates similarly to the ordinarytransformer with no or low load. Hence these types of transformers are operated at a range of 50 to 200 VA.
According to the conventional transformer, the transformation ratio is K

$$\frac{V_1}{V_2} = \frac{N_1}{N_2|}$$

Where,

V_1= voltage of the primary winding

V_2= voltage of the secondary winding

N_1= number of turns in the primary winding

N_2= number of turns in the secondary winding

The high voltage of a circuit can be determined by using the above eqn..

Application of Potential transformer

- Use in relay and metering circuits

- Use in power line carrier communication circuits

- Use in protection systems electrically

- Use for protecting feeders

- Use for the protection of impedance in the generators

- Used in synchronization of generators and feeders.

- Used as protection voltage transformers

1a) Write different torques provided by different parts of PMMC instruments.

Ans: Two torques i.e Control Torque and Damping Torque are provided by different parts
of PMMC instruments. The control torque is provided by two phosphor bronze hair
springs. These springs alsoact as current carrying element to the moving coil.
Damping torque is provided by movement of the 'Al' former in the magnetic field of
the permanent magnet.

b) Define voltage sensitivity of PMMC instrument.

Ans:Voltage Sensitivity is expressed as inverse of full scale
current of the meter. $S_v = 1/I_{fs} = 1/i_m$ (Ω/V).

c)A PMMC ammeter has the following specification Coil dimension are 1cm×1cm. Spring constant is 0.15 × 10−6N −m / rad, Flux density is 1.5 ×10 −3 wb/ m² . Determine the no. of turns required to producea deflection of 90⁰ when a current 2mA flows through the coil.

Ans:According to working principle of PMMC instrument at steady state condition

Deflectingtorque=Controlling torque

OrBANI=Kθ

GivenA=1×10^{-4}m²;

K= 0.15×10^{-6}N −m/ rad ; B=$1.5\times10−3$wb/m ²

I=2×10^{-3}A

θ=90°= Π/2rad

N=(Kθ)/ (BAI)=785

d)Define Current sensitivity of PMMC instruments.
Ans:Current Sensitivity isdefinedasthedeflectionperunitcurrent.
CurrentsensitivityS$_i$canbeexpressedasS$_i$=θ/i.

e) State different errors occur in PMMC instruments.
Ans: Different errors occur in PMMC instruments are
- Frictionalerrors
- Temperatureerror
- Errorduetoweakeningofpermanentmagnetand
- Thermo-electricerror.

f) Write two advantages of PMMC instruments.
Ans: Two advantages of PMMC instruments are
- Lowpowerconsumption(25–200μW)
- Hightorque-weightratioresultinginhighaccuracy

g) What are the types of Moving Iron (MI) instruments. State its names

Ans: There are two types of moving iron instruments are used.
- Attraction type M.I. instrument
- RepulsiontypeM.I instrument

h) State different types of coils in electrodynamometer instruments.

- Fixed coil:The coil is divided in to two sections to give a more uniform field near the centre and to allow the passage of the instrument shaft. The fixed are coils are usually wound with heavy wire carrying the main current
- Moving Coil:A single element instrument has one moving coil. The moving coil is wound either as a self-sustaining coil or else on a non-metallic former.

i)Write down two advantages of electrodynamometer instruments.

Ans: Two advantage are

- As the coils are air-cored, these instruments are free from hysteresis and eddy current errors.

- They have precision grade accuracy for frequencies up to 40- 500 Hz, the lower range being decided by the oscillation of the pointer. Lower grade instruments can be used for a frequency range of 15 to 1000 Hz.

j) Define maximum demand indicator.

Ans:A smart meter is a digital energymeter that measures the consumption of electrical energyand provides other additional information as compared to the traditional energy meter. It is important to note that while maximum demand is recorded, it is not the instantaneous demand drawn,as is often misunderstood, but the time integrateddemand overthe predefined.

MEDIUM ANSWER TYPES (5 MARKS)

1)Describe the detail construction of PMMC instruments with diagram.

Ans:The PMMC instrument is the most accurate type for D.Cmeasurement. When a current carrying conductor is placed in a magnetic field, a mechanical force is experienced on the conductor, which tends to move the conductor in a direction given by Fleming's left-hand rule.

Construction

The construction of PMMC instrument is asshowninfig
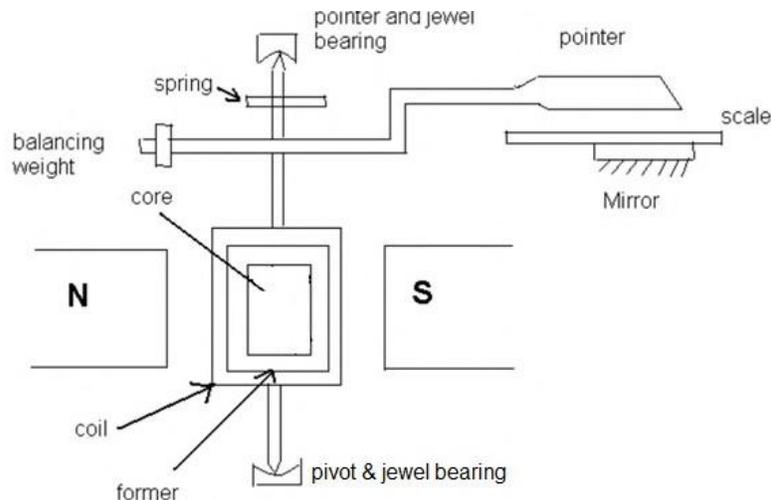
Construction of PMMC instrument

Movingcoil:

The moving coil is wound with many turns of enameled or silk-covered copper wire. The coil is mounted on a rectangular aluminum former, which is pivoted on jewel bearings. The coil moves freely in the field of a permanent magnet.

In the case of voltmeter coils, a metallic former provides the required electromagnetic damping. Most ammeter coils, however, are wound on non-magnetic formers because the coil turns are effectively shorted by the ammeter shunt.Older systems consisted of long U-shaped permanent magnets having soft iron pole pieces. Due to the development of materials such as **Alnico** and **Alcomax**, which have a high coercive force, these have been replaced by smaller magnets. The flux densities used in PMMC instruments vary from **0.1 Wb/m² to 1 Wb/m²**.Thus, in small instruments, it is possible to use a small coil having a smaller number of turns, thereby reducing the overall volume. Concentric magnetic construction is employed to obtain larger movement of the pointer and a longer angular swing of the coil.To protect the system from external magnetic fields, **core magnetic construction** is used, where the magnet itself acts as the core. This construction also eliminates magnetic shunting effects and removes the need for magnetic shielding in the form of external cases.

Control:

The control torque is provided by two phosphor bronze hair springs. These springs alsoact as current carrying element to the moving coil.

Damping:

Damping torque is provided by movement of the 'Al' former in the magnetic field of the permanent magnet.

Pointerandscale:

The pointer is carried by spindle and moves over a graduated scale. The pointer is oflightweight construction, and is often twisted to form a fine blade. This helps to reduce the parallax errors in the reading.

2)How to find extension of range of ammeter. Explain with suitable diagram.

Ans:The basic PMMC instrument is useful for measuring only small currents. To measure heavy currents, major part of current is bypassed through a low resistance called a "shunt". The construction of such a system is as shown in Fig.
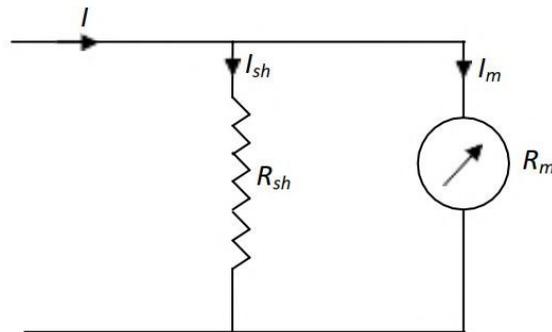
Shunt resistance with PMMC

Let

R_m be the internal resistance of movement (coil) in ohms
Rshbe the resistance of shunt in ohms
I_m = Ifs = full scale deflection current of movement in Amps Ish=
shunt current in Amps
I=currenttobemeasuredinAmps

Now,fromtheabove
$Ish*Rsh=Iim*Rm$

$$R_{sh} = \frac{I_m R_m}{I_{sh}}$$

but, $I=I_{sh}+I_m$

or $I_{sh}=I-I_m$

$$R_{sh} = \frac{I_m R_m}{I-I_m}$$

$R_{sh}=R_m/(m-1)$

where, $m=I/I_m$ multiplying power of shunt $=1+(R_m/R_{sh})$ The

general requirements for shunts are:

- The temperature co-efficient of shunt and the instrument should be low and should be same.

- The resistance of the shunt should not vary with time.

- They should carry the current without excessive temperature rise.

    Manganin is generally used for shunts.

3)State the Principle and construction of PMMI instructions.
Ans:Moving Iron (MI) instruments One of the most accurate instrument used for both AC and DC measurement is moving iron instrument. Therearetwotypesofmovingironinstrumenti.e.AttractiontypeandRepulsiontype

Attraction type M.I. instrument Construction: The moving iron fixed to the spindle is kept nearthehollowfixedcoil.Thepointerandbalanceweightareattachedtothespindle,which is supportedwith jeweledbearing. Here airfriction dampingis usedshown in figure

Fig3.2.1AttractiontypeMovingironinstrument

Principle of operation: The current to be measured is passed through the fixed coil. As the current is flow through the fixed coil, a magnetic field is produced. Bymagnetic induction the moving iron gets magnetized. The north pole of moving coil is attracted by the south pole of fixedcoil. Thus the deflecting force is produced due to force of attraction. Since the moving iron is attached with the spindle, the spindle rotates and the pointer moves over the calibrated scale.But the force of attraction depends on the current flowing through the coil.
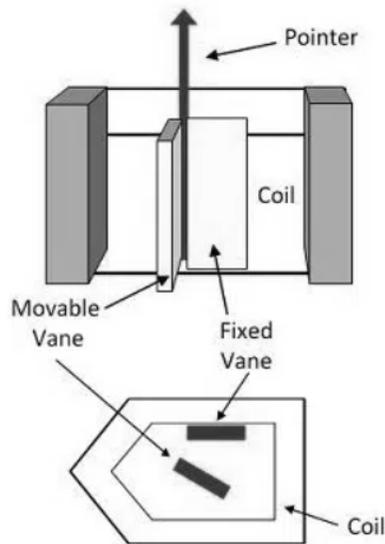
Advantages:-

- MIcanbeusedinACandDC

- It is cheap

- Supplyisgiventoafixedcoil,notin movingcoil

- Simpleconstruction

- Lessfrictionerror.

Disadvantages:-

- Itsuffersfromeddycurrentandhysteresiserror

- Scaleisnotuniform

- Itconsumedmorepower

- CalibrationisdifferentforACandDCoperation

Repulsiontypeinstrument:

The repulsion type instrument has a hollow fixed iron attached to it. The moving iron is connected to the spindle. The pointer is also attached to the spindle in supported with jeweled bearing as shown in fig .

Repulsion type MI

Principle of Operation:
When current flows through the coil, a magnetic field is produced by it. As a result, both the fixed iron and the moving iron are magnetized with the same polarity since they are placed in the same magnetic field. The similar poles of the fixed and moving iron repel each other. Thus, a deflecting torque is produced due to magnetic repulsion. Since the moving iron is attached to the pointer, the pointer deflects accordingly.

4)Describe the construction and working of Dynamometer type wattmeter.
Ans: **Construction and working:-**

A transfer instrument is one that may be calibrated with a D.C source and then used without modification to measure a.c. This requires the transfer type instrument to have same accuracy for both a.c and d.c. This type of phenomena can be noticed in Dynamometer type instruments as shown in Fig.
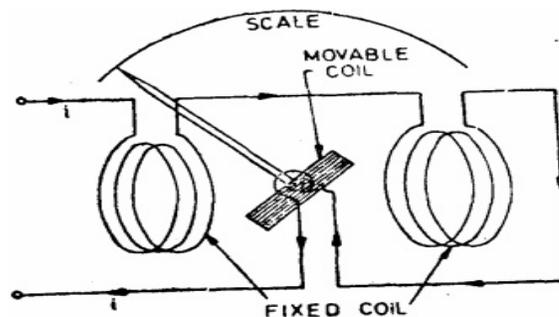
Construction of dynometer type Instrument

We can understand the working principle of this instrument by considering a PMMC instrument and observing how it behaves on **AC**. It would produce torque in one direction during one half of the cycle and an equal torque in the opposite direction during the other half. If the frequency were very low, the pointer would swing back and forth around the zero point.

However, in an ordinary meter, the inertia is so great that at power frequencies, the pointer does not move far in either direction but merely stays around zero. If, however, we reverse the direction of the flux each time the current through the moving coil reverses, a **unidirectional torque** will be produced during both the positive and negative halves of the cycle.

In **electrodynamometer instruments**, the fields can be made to reverse simultaneously with the current in the moving coil if the fixed coil is connected in series with the moving coil.

.

Fixed Coils:

The coil is divided in to two sections to give a more uniform field near the centre and to allow the passage of the instrument shaft. The fixed are coils are usually wound with heavy wire carrying the main current. Thewire is strandedwhere necessary toreduce eddy current losses in conductors. The coil is usually varnishedandpackedin the from of a solidassembly.

Moving Coil:

A single element instrument has one moving coil. The moving coil is wound either as a self- sustaining coil or else on a non-metallic former. A metallic former cannot be used, as it will introduce eddy currents in it by alternating field, if instrument is used on A.C. Light but rigid construction is used for moving coil. It should be noted that the fixed and moving coils are air cored.

Control:

Thecontrollingtorqueisprovidedbytwocontrollingsprings.

Moving System:

The moving coil is mounted on an aluminum spindle. The moving system also carries the counter weights and truss type pointer. Sometimes, a suspension may be used in case a high sensitivity is desired.

Damping:

Air friction damping is employed for these instruments and is provided bya pair of aluminium vanes, attached to the spindle at the bottom. These vanes move in sector shaped chambers.Eddy current damping cannot be usedin theseinstrument as theoperating fieldisvery weak.

Shielding:

Thefieldproduced by thefixedcoilissomewhatweakerthan in othertypeofinstruments.It is nearly0.005 to 0.006 wb/m^2. Ind.cmeasurements, eventheearth's magnetic field mayaffect the readings. Thus, it is necessary to shield an electro dynamometer type instrument from the effect of stray magnetic fields. Air cored electro dynamometer type instrument are protected againstexternal magneticfields by enclosing them in acasing ofhigh permeability alloy

5)Explain the effect of power factor on wattmeter reading in two wattmeter method.

Ans:In an ideal dynamo-meter type watt meter the current in pressure coil in phase withthe applied voltage.But in practically the pressure coil of watt meter has an inductance andcurrent in it will lagbehind the applied voltage. If there is no inductance the current in pressure coil will be in phase with the applied voltage. In the absence of inductance in pressure coil of wattmeter, it will read correctly in all power factors and frequency. The wattmeter will read high when the load powerfactor is lagging ,as in that case the effect of pressure coil inductance is to reducethe phase angle between load current and pressure coil current . Hence the wattmeter will read high. This is very serious error. The wattmeter will read low when the load power factor is leading as in that case the effect of pressure coil inductance is to increase the phase angle between load current and pressure coil current. Hence the wattmeter will

read low. Compensation for inductance of pressure coil. Inductance of pressure coil can be reduced by means of capacitor connectedin parallel with a portion of multiplier(series resistance).

VERY LONG ANSWER TYPES. (10 MARKS)

1)State and explain in details the construction, working, merits and demerits of PMMC instructions.

Ans:ThePMMCinstrumentisthemostaccuratetypeforD.Cmeasurement.

Principle

When a current carrying conductor is placed in a magnetic field, a mechanical force is experienced on the conductor, which tends to move the conductor in a direction given by Fleming's left hand rule.

The difference between a galvanometer and a PMMC instrument is thatinstead ofthe lightand mirrorarrangement used fortheformer, hereinPMMC instrument, a pointer and scale arrangement is provided for direct reading ofthe quantity being measured

Construction

The construction of PMMC instrument is as shown in fig
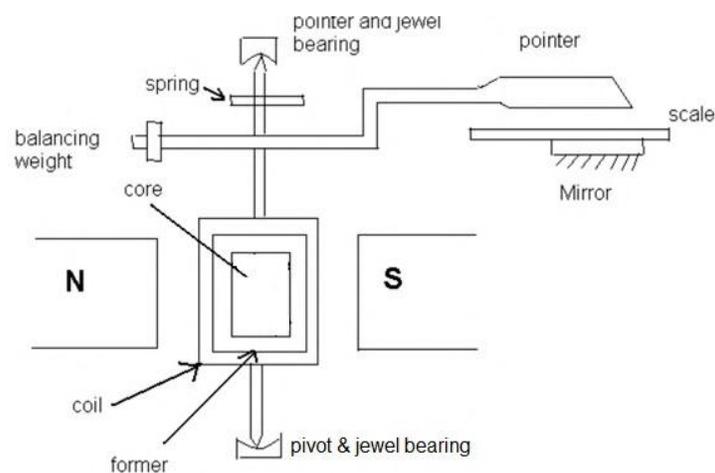
Movingcoil:

Themoving coil iswoundwith many turnsof enameledor silk coveredcopper wire. Thecoil ismountedonarectangularaluminumformerwhichispivotedonjewelbearings. Thecoil moves freely in the field of apermanent magnet. In the case of voltmeter coils, metallic former provide the required electro-magnetic damping.

Mostammetercoils,howeverarewoundonnon-magneticformersbecausecoilturnsare effectively shorted by the ammeter shunt.

Magnetsystems:

Oldsystems consistedof long U shaped permanent magnets having softiron pole pieces. Due to development of materials such as Alnico and Alcomax, which have a high coercive force, thesearereplacedbysmaller magnets.ThefluxdensitiesusedinPMMCinstrumentsvaryfrom
0.1 wb/m^2 to 1 wb/m^2. Thus in small instruments, it is possible to use a small coil having small number of turns andhence reduction of volume is achieved. Concentric magnetic constructionisemployedto obtain larger movement of pointerandlong angular swing of coil. To protect the system from externalmagnetic fields, coremagnetic construction is used,where the magnet itself acts as core. This construction also eliminates the magnetic shunting effects. This construction alsoeliminates the needformagneticshielding in the form of cases.

Control:

The control torque is provided by two phosphor bronze hair springs. These springs alsoact as current carrying element to the moving coil.

Damping:

Damping torque is provided by movement of the 'Al' former in the magnetic field of the permanent magnet.

Pointerandscale:

The pointer is carried by spindle and moves over a graduated scale. The pointer is oflightweight construction, and is often twisted to form a fine blade. This helps to reduce the parallax errors in the reading.

Advantages of PMMC instruments:

- Uniformscale

- Lowpowerconsumption(25–200μW)

- Nohysteresisloss

- Effectiveandreliableeddy-currentdamping

- Hightorque-weightratioresultinginhighaccuracy

- Can be used for both current and voltage measurements byuse of shunts and

  multipliers

- Notaffectedbystraymagneticfieldsastheradialfieldisused

- Due to self - shielding propertyof core magnets, these can be used for air-craft and aerospace applications that require mounting of meters in close proximity.

Disadvantages of PMMCinstruments:

- Can beusedforD.Cmeasurementsonly

- Costlycomparedtomovingironinstruments

- Affectedbyfrictionandtemperatureerrors

- Affectedbyageingofmagnetsandsprings.

2)State and explain in details the construction, working, merits and demerits of PMMI instructions.

Ans:

Permanent Magnet Moving Iron(PMMI)Meter:

Moving Iron (MI) instruments One of the most accurate instrument used for both AC and DC measurement is moving iron instrument.

Therearetwotypesofmovingironinstrumenti.e.AttractiontypeandRepulsiontype

Attraction type M.I. instrument Construction:

The moving iron fixed to the spindle is kept nearthehollowfixedcoil.Thepointerandbalanceweightareattachedtothespindle,which is supportedwith jeweledbearing. Here airfriction dampingis usedshown in figure

AttractiontypeMovingironinstrument:

Principle of operation: The current to be measured is passed through the fixed coil. As the current is flow through the fixed coil, a magnetic field is produced. Bymagnetic induction the moving iron gets magnetized. The north pole of moving coil is attracted by the south pole of fixedcoil. Thus the deflecting force is produced due to force of attraction. Since the moving iron is attached with the spindle, the spindle rotates and the pointer moves over the calibrated scale.But the force of attraction depends on the current flowing through the coil.

Advantages:

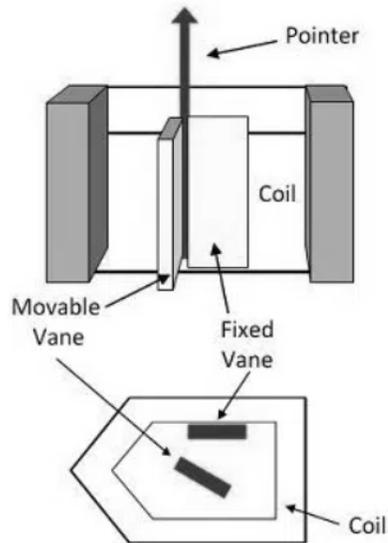- MIcanbeusedinACandDC

- It is cheap

- Supplyisgiventoafixedcoil,notin movingcoil

- Simpleconstruction

- Lessfrictionerror.

Disadvantages

- Itsuffersfromeddycurrentandhysteresiserror

- Scaleisnotuniform

- Itconsumedmorepower

- CalibrationisdifferentforACandDCoperation

Repulsiontypeinstrument:

The repulsion type instrument has a hollow fixed iron attached to it. The moving iron is connected to the spindle. The pointer is also attached to the spindle in supported with jeweled bearing as shown in fig .

RepulsiontypeMI

Principle of operation: When the current flows through the coil, a magnetic field is produced byit. So both fixed iron and moving iron are magnetized with the same polarity, since theyare kept in the same magnetic field. Similar poles of fixed and moving iron get repelled. Thus the deflectingtorqueisproducedduetomagneticrepulsion.Sincemovingironisattachedto spindle, the spindle will move. So that pointer moves over the calibrated scale. Damping: Air friction damping is usedto reduce the oscillation. Control: Spring control is used.

IV Measurement of Electric Energy

Short Type Questions with Answers. (2 Marks)

1a) Define Electrical Energy.

Ans:Energy is the total power delivered or consumed over a time interval that is expressed by Energy = powerXtime

$$W = \int_0^t vi\, dt$$

If v (voltage) is expressed in V, and i (current) in A and t (time) in s, then the unit of energyis joule or watt second which is 1 watt over an interval of one second

b) Why induction type single phase energy meter is used for energy measurement.

Ans:The induction type single phase energy meters are universally used for energy measurements in domestic and industrial establishments. The advantages of single-phase energy meter areease of maintenance, lower friction, higher torque weight ratio and cheaper. Figure 4.1 shows the schematic of single-phase induction energy meter.

c)Define driving system in 1-phase Energy meter.

Ans:Driving system: It consists of a series magnet and a shunt magnet. The coil of the series magnet is excited by load current while that of the shunt magnet is excited by a current proportional to the supply voltage. These two coils are respectively referred to as current coil and potential coil (or pressure coil) of the energy meter

d) Define moving system in 1-phase Energy meter.

Ans:Movingsystem: It consists of a freely suspended, light aluminium disc mounted on an alloy shaft and placed amidst the air-gap of the two electromagnets

e) Define braking system in 1-phase Energy meter.

Ans:Braking system: It consists of a position-adjustable permanent magnet placed near oneedge of the disc. When the disc rotates in the gap between the two poles of the brake magnet, eddy currents are set up in the disc. These currents react with the brake magnetfield and provide the required braking torque damping out the disc motion if any, beyondthe required speed. The braking torque can be adjustedas required byvarying the position of the braking magnet.

f) Define Recording system in 1-phase Energy meter.

Ans:Recording system: It is a mechanism used to record continuously a number whichisproportionalto the revolutionsmadebythe disc.Thusit isthecounter partof the pointer and scale of indicating instruments. The shaft that supports the disc is connected bya gear arrangement to a clock mechanism on the front of the meter. It is provided with a decimally calibrated read out of the total energy consumption in kWh.

g) Write the role of pressure coil in 1-phase Energy meter.

Ans:The shunt magnet has the pressure coil.The pressure coil creates the magnetic field because ofthe supplyvoltage, and the current coilproduces the magnetic field because of the current. The field induces by the voltage coil is lagging by 90º on the magnetic field of the current coil because of which eddycurrent induced in the disc. The interaction of the eddycurrent and the magneticfieldcauses torque, which exerts a force on the disc.Thus, the disc starts rotating

h) Wite the role of current coil in 1-phase Energy Meter.

Ans:The series magnet has the current coilThe pressure coil creates the magnetic field because ofthe supplyvoltage, and the current coilproduces the magnetic field because of the current. The field induces by the voltage coil is lagging by 90º on the magnetic field of the current coil because of which eddycurrent induced in the disc. The interaction of the eddycurrent and the magneticfieldcauses torque, which exerts a force on the disc.Thus, the disc starts rotating.

i)Write two errors caused by braking system of Energy Meter.

Ans:

- Changeinthestrengthofbrakemagnetduetovariationsintemperatureetc.

- Self-brakingeffectofseriesmagnetfluxduetoovercurrent(orloads).

- Variationsindiscresistancewithtemperature.

- Frictionerrorsatlightloads.

## j) Write two errors caused by driving systems of Energy Meter.

Ans :

- Errors due to the incorrect magnitude of fluxes. These are mainly due to variations in supply voltage or load current. The flux produced by the shunt magnet varies with variations in supply frequency or coil resistance.

- Incorrect phase angles between various parameters like induced emf, current, and flux. These are mainly due to variation in supply frequency, incorrect lag adjustments,change in resistance of coils with temperature, etc.

Medium Answer Types (5 Marks)

1) Explain the working principle of 1-phase Energy meter with diagram.

Ans: The induction type single phase energy meters are universally used for energy measurements in domestic and industrial establishments. The advantages of single-phase energy meter are ease of maintenance, lower friction, higher torque weight ratio and cheaper. Figure 4.1 shows the schematic of single-phase induction energy meter.
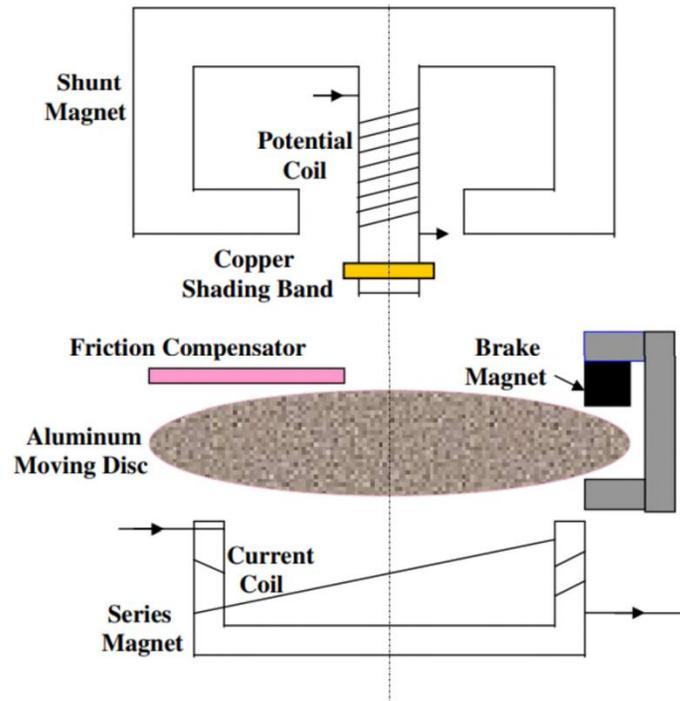
Schematic of single-phase induction energymeter.

Working Principle
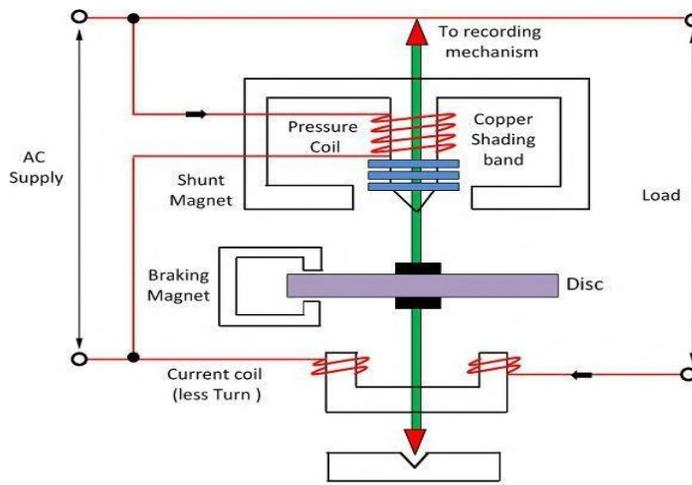
Working of single-phase induction energymeter

The working principle of single-phase induction energymeter is shown in figure. For better understanding the figure is shown in more elaborately. The energy meter has the aluminum disc whose rotation determines the power consumption of the load. The disc is placed between the air gap of the series and shunt electromagnet. The shunt magnet has the pressure coil, and the series magnet has the current coil. The pressure coil creates the magnetic field because ofthe supplyvoltage, and the current coilproduces the magnetic field because of the current. The field induces by the voltage coil is lagging by 90º on the magnetic field of the current coil because of which eddycurrent induced in the disc. The interaction of the eddycurrent and the magneticfieldcauses torque, which exerts a force on the disc.Thus, the disc starts rotating. The force on the disc is proportional to the current and voltage of the coil. The permanent magnet controls their rotation. The permanent magnet opposes the movement of the disc and equalizes it on the power consumption. The cyclometer counts the rotation of the disc.Other mechanisms other than cyclometer can be used to measure the rotation of the disc and hence the power consumption of the load. mechanisms other than cyclometer can be usedto measure the rotation of the disc andhencethe power consumption of the load.

2)Explain the construction of 3-Phase Energy Meter.

Ans:In a two-element, three phase energy meter, the two discs are mounted on a common spindleand each disc has its own brake magnet. The moving system drives a single gear train. Eachunit is provided with its own copper shading ring, shading band, friction compensator, etc., for adjustments to be made to obtain the correct reading.

ThreePhaseEnergy Meter:

Figure shows a two-element energy meter used for three phase energy measurements in three phase, three wire systems. It is essential that for the same power/ energy, the driving torque should be equal in the two elements. This is checked by torque adjustment. For torque adjustment, the two current coils are connected in series opposition and the two potential coils are connected in parallel. Full load current is allowed to pass through the current coil. This set up causes the two torques to be in opposition and so, if the torques are equal, then the disc should not move. If there is anyslight motion indicatinginequalityof the two torques, then the magnetic shunt is adjusted until the disc stalls. Thus the torque balancing is obtained before testing the meter. The friction compensator and brake magnet positions are adjusted to each of the two/three elements separately, treating each of them as a single phase element on single phase AC supply. The calibration of three phase meter can also be performed in a similar manner, as that described earlier, for single phase energy meters.

3) Explain different errors and their compensations in Energy meter.

Ans:

Different Errors and their Compensation in EnergyMeters:

Phase Error and Compensation: It is necessary that the energy meter should give correct reading on all power factors, which is only possible when the field setup byshunt magnet lags behind the applied voltage by 90º. But the flux due to shunt magnet does not lag behind the applied voltage exactlyby 90º because of winding resistance and iron losses. This is called as phase error.

The flux in the shunt magnet can be made to lag behind the supply voltage by exactly 90º by adjustingthe position of shadingband (or shading ring or shading coil) placed round the lower part of the central limb of the shunt magnet. This Compensation/adjustment is known as lag adjustment or power factor adjustment.

Friction or Low load Error and Compensation: The friction errors are serious at low loads. To ensure proper reading at low loads, friction compensators are used, which provide a small torque, independent of the load. This torque is equal and opposite to the friction torque. The friction compensator consists of a small shading loop placed between the disc and shuntmagnet, slightly towards one side of the disc, as shown in figure. It is correctlyadjusted to ensure minimum friction at low loads.

Creep Error and Compensation: In some energy meters, when the pressure coilis energized,a slow, but continuous rotation of the disc is observed even when there is no current in the current coil. This is called Creeping. This can be due to several reasons such as overcompensation for friction, vibrations, stray fieldeffects andexcessive pressure coil voltage. To prevent creeping, two diametricallyopposite holes are drilled on the disc. The disc will stall when one of the holes comes under one of the poles of the shunt magnet. Thus, the rotation is restricted to a maximum of half a revolution.

Voltage Variation Error and Compensation: The errors due to voltage variations are compensatedby increasingthereluctanceofside limbsofshuntmagnet.Holesareprovided on the side limbs of shunt magnet for this purpose.

Temperature Error and Compensation: Owing to temperature effects, the energy metersmay run faster and register wrong values. In such cases, the compensation is provided by a temperature shunt on the brake magnet.

Over load Error and Compensation: Over load compensators are used to minimize the self- braking action of energy meters. They are in the form of a saturable magnetic shunt for the series magnet.

4)Explain the constructional features of of 1-phase energy meter.

Ans:

The induction type single phase energy meters are universally used for energy measurements in domestic and industrial establishments. The advantages of single-phase energy meter are ease of maintenance, lower friction, higher torque weight ratio and cheaper. Figure.Shows the schematic of single-phase induction energy meter.
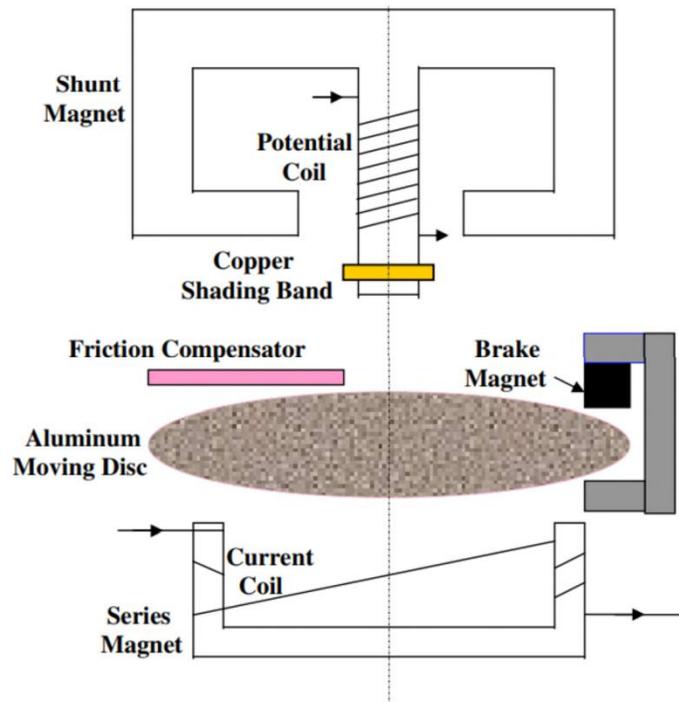
Schematicofsingle-phaseinductionenergymeter

ConstructionalFeatures:

Ithasfoursystemsforitsoperation,namely:

    (i)   Drivingsystem.

    (ii)   Movingsystem.

    (iii)   Brakingsystem

    (iv)   Recordingsystem.

Driving system: It consists of a series magnet and a shunt magnet. The coil of the series magnet is excited by load current while that of the shunt magnet is excited by a current proportional to the supply voltage. These two coils are respectively referred to as current coil and potential coil (or pressure coil) of the energy meter.

Movingsystem: It consists of a freely suspended, light aluminium disc mounted on an alloy shaft and placed amidst the air-gap of the two electromagnets.

Braking system: It consists of a position-adjustable permanent magnet placed near oneedge of the disc. When the disc rotates in the gap between the two poles of the brake magnet, eddy currents are set up in the disc. These currents react with the brake magnetfield and provide the required braking torque damping out the disc motion if any, beyondthe required speed. The braking torque can be adjustedas required byvarying the position of the braking magnet.

Recording system: It is a mechanism used to record continuously a number whichisproportionalto the revolutionsmadebythe disc.Thusit isthecounter partof the pointer and scale of indicating instruments. The shaft that supports the disc is connected bya gear arrangement to a clock mechanism on the front of the meter. It is provided with a decimally calibrated read out of the total energy consumption in kWh.

5) State in brief different errors and compensations.

Ans:Different ErrorsandtheirCompensationinEnergyMeters

Phase Error and Compensation: It is necessary that the energy meter should give correct reading on all power factors, which is only possible when the field setup byshunt magnet lags behind the applied voltage by 90o. But the flux due to shunt magnet does not lag behind the applied voltage exactlyby 90o because of winding resistance and iron losses. This is called as phase error.

The flux in the shunt magnet can be made to lag behind the supply voltage by exactly 90o by adjustingthe position of shadingband (or shading ring or shading coil) placed round the lower part of the central limb of the shunt magnet. This Compensation/adjustment is known as lag adjustment or power factor adjustment.

Friction or Low load Error and Compensation: The friction errors are serious at low loads. To ensure proper reading at low loads, friction compensators are used, which provide a small torque, independent of the load. This torque is equal and opposite to the friction torque. The friction compensator consists of a small shading loop placed between the disc and shuntmagnet, slightly towards one side of the disc, as shown in figure. It is correctlyadjusted to ensure minimum friction at low loads.

Creep Error and Compensation: In some energy meters, when the pressure coilis energized,a slow, but continuous rotation of the disc is observed even when there is no current in the current coil. This is called Creeping. This can be due to several reasons such as overcompensation for friction, vibrations, stray fieldeffects andexcessive pressure coil voltage. To prevent creeping, two diametrically opposite holes are drilled on the disc. The disc will stall when one of the holes comes under one of the poles of the shunt magnet. Thus, the rotation is restricted to a maximum of half a revolution.

Voltage Variation Error and Compensation: The errors due to voltage variations are compensated by increasing the reluctance of side limbs of shunt magnet.Holesareprovided on the side limbs of shunt magnet for this purpose.

Temperature Error and Compensation: Owing to temperature effects, the energy metersmay run faster and register wrong values. In such cases, the compensation is provided by a temperature shunt on the brake magnet.
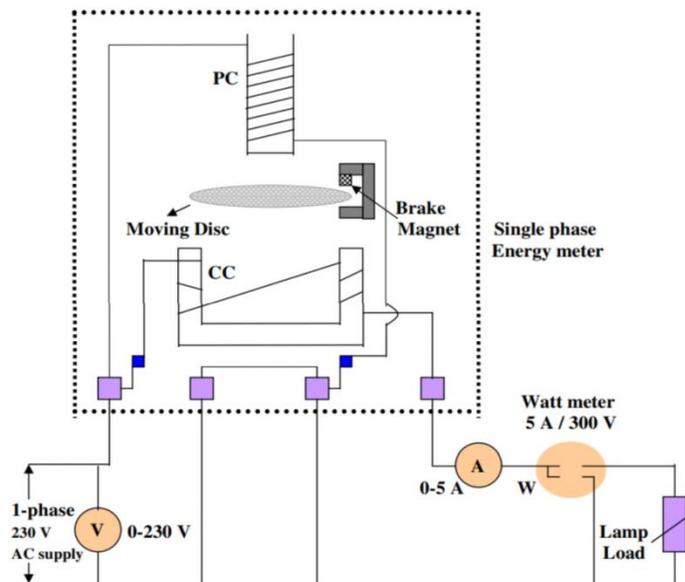
Over load Error and Compensation: Over load compensators are used to minimize the self- braking action of energy meters. They are in the form of a saturable magnetic shunt for the series magnet.

Very Long Answer Types. (10 Marks)
1)Explain the details calibrations of 1-phase Energy meter with sample calibration curve.

Ans:

CalibrationofSingle-PhaseEnergyMeter:

Calibration of Energy Meter

In case of energy meters, it is necessary to first carry out sequentially all the required adjustments on the given meter, before proceeding for calibration. After successfully carrying out all adjustments, the calibration is done using the circuit connections as shown in figure 4.3. The AC supply is fed at 230 V, 50 Hz. and load is applied on to the circuit up to full load by using the lamp load arrangement. In all the trials, the readings of ammeter (A), voltmeter (V), wattmeter (W) are taken. Also, the time taken bythe disc for a given number of revolutions, is recorded for each trial, using a stop clock. The actual reading can

be calculated from the name plate details as described next.

Considering the design data given for the energy meter, the energy meter test constant kE, represented inWh/rev.can be calculated.If for example,the nameplatereadingis,say,3000 rev./kWh, then, the test constant, kEequals 1/3. Thus the indicated value of energy, IRE in watt hours as per the energy meter name plate details for given time period and for N number of revolutions is given by:

$$IRE=kEN$$

Onthe other hand, the true value of energy, TRE in watthours in terms of the wattmeterreading, W andtime, tin hours recordedbythe stopclock for N revolutions is given by:

$$TRE=(W)(t)$$

Thus,Error=TRE-IRE

andpercentageerrorasapercentofthetruereadingisgivenby:

$$Error=(1/TRE)(TRE-IRE)x100\%$$

The percentage errors in disc speed, time taken for given number of rotations or wattage consumption can also be similarly determined. It is to be noted that the accuracy of calibration depends on the accuracy with which the wattage is measured using a standard wattmeter. It is also needful to ensure the accuracy of the stop clock used for time measurements. Finally, a calibration curve can be drawn as a plot of the percentage error on the y axis and indicated energy reading IREor ammeter reading I on the x axis as shown in figure 4.4. It should be observed that the different points so obtained are joined using straight lines to get the complete calibration curve. The use of calibration curves are obvious. Whenever an already calibrated meter is used for measurements, the reading shown by the meter can be converted to its true valueby using thecalibrationcurve.Themeterisusually adjustedtoreadwithin ±0.5% of the correct registration.

Sample Calibration Curve

2)Explain the construction and working of 3-phase Energy meter.

Ans:

Introduction:

Itis well established that for measurement oftotal poweror energy in a " n" conductor system, itisrequiredtousea meter with (n-1)elements.Theprincipleof singlephaseenergy meter can as well be extended to obtain a poly-phase energy meter, in particular a three phase energy meter.Usually, a three-phase energy meter is available as a 2-element meter or 3-element meter, each element being similar in construction to the single phase meter and all elements mounted on a common shaft. The torque developed by each element is summed upmechanically and the total number of revolutions made bythe shaft is proportional to the total three phase energy consumption.

Construction and Workingof Three Phase EnergyMeter:

In a two-element, three phase energy meter, the two discs are mounted on a common spindleand each disc has its own brake magnet. The moving systemdrives a single gear train. Eachunit is provided with its own copper shading ring, shading band, friction compensator, etc., for adjustments to be made to obtain the correct reading.

Three PhaseEnergy Meter:

Figure shows a two-element energy meter used for three phase energy measurements in three phase, three wire systems. It is essential that for the same power/ energy, the driving torque should be equal in the two elements. This is checked by torque adjustment. For torque adjustment, the two current coils are connected in series opposition and the two potential coils are connected in parallel. Full load current is allowed to pass through the current coil. This set up causes the two torques to be in opposition and so, if the torques are equal, then the disc should not move. If there is anyslight motion indicatinginequalityof the two torques, then the magnetic shunt is adjusted until the disc stalls. Thus the torque balancing is obtained before testing the meter. The friction compensator and brake magnet positions are adjusted to each of the two/three elements separately, treating each of them as a single phase element on single phase AC supply. The calibration of three phase meter can also be performed in a similar manner, as that described earlier, for single phase energy meters.

Errors in EnergyMeters:

The various types of errors in an energymeter are caused bythe driving system and braking system.

Errors Caused by DrivingSystem:

- Errors due to the incorrect magnitude of fluxes. These are mainly due to variations in supply voltage or load current. The flux produced by the shunt magnet varies with variations in supply frequency or coil resistance.

- Incorrect phase angles between various parameters like induced emf, current, and flux. These are mainly due to variation in supply frequency, incorrect lag adjustments,change in resistance of coils with temperature, etc.

- Lackof symmetryin the magnetic circuit. Due to this, driving torque is produced in the disc even with no current flowing through the current coil, and hence the metercreeps.

Errors Caused by Braking System:

- Change in the strength of brake magnet due to variations in temperature etc.

- Self-brakingeffectofseriesmagnetfluxduetoovercurrent(orloads).

- Variationsindiscresistancewithtemperature.

- Frictionerrorsatlightloads.

V Circuit Parameter Measurement, CRO and Other Meters
## Short Type Questions with Answers. (2 Marks)

1a) How many categories of resistances available depending on their values. Give their name.
Ans: Resistance are divided into three categories according to their value:

  i.   Lowresistance$\leq 1\Omega$

  ii. Mediumresistance$1\Omega \leq R \leq 100k\Omega$

  iii. HighresistanceR$>100k\Omega$

b) Which instrument is used to lower category of resistance .Draw its diagram.
Ans: Kelvin's double bridge is used for precision measurement of four-terminal low resistances.
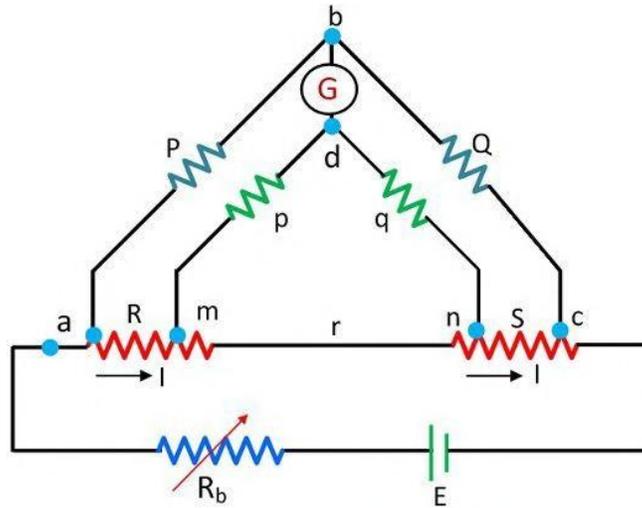
c) How to measure the frequency using oscilloscope?

Ans: To measure frequency with an oscilloscope, connect the signal, stabilize the waveform, and measure the time period of one cycle by counting the horizontal divisions on the screen and multiplying by the time/division setting. The frequency is then calculated using the formula f=1/T

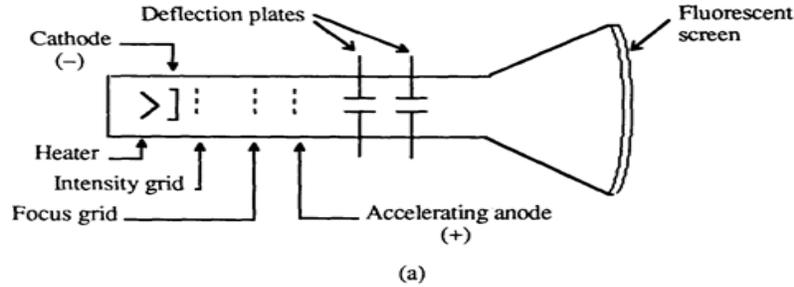d)Write down the different methods to measure high resistance.
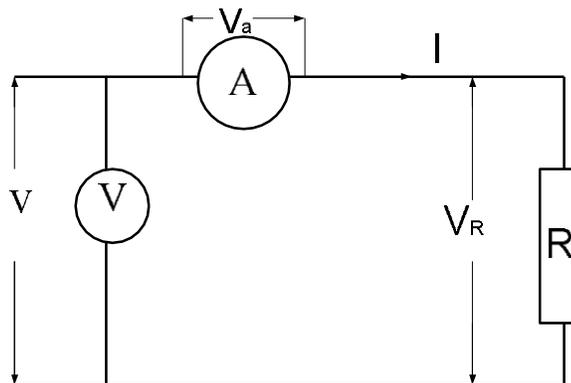
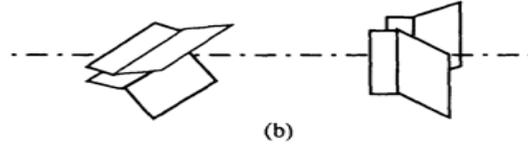Ans: Following Methods are used to measure high resistance.
   i)Meggar
   ii)OhmMeter

e) Draw the schematic diagram of CRT.

Ans:

(a)

f) Define Earth Tester.
Ans: The instrument usedformeasuring theresistanceof the earthisknownasearthtester. All the equipment of the power systemis connected to the earth through the earth electrode. The earth

(b)

protects the equipment and personnel from the faultcurrent. The resistance of the earthis very low. The fault current throughthe earth electrodepasses to the earth.

g) Whatis LCR Meter.

Ans: **Definition**: LCR meters can be understood as a multimeter, this is because it can measure resistance, inductance, and capacitance as per the requirement shown infigure 5.17. Thus, it is termed as LCR meter. L in its name signifies inductance, C stands for capacitance and Rdenotes resistance.

h) Define Synchroscope.

Ans: The synchroscope is a device which shows the correct instant at which the two systems are synchronised in terms of equal frequency (speed). Synchro is the instrument that displays the exact instant where the two alternating current generators are in exact phase relation to be in parallel connection. It also shows whether the incoming generator has more operating speed when compared with that of an on-line generator.

i)DefineTri-vectorMeter.

Ans: Tri-vector meter is an energy meter which accurately measures all the parameters of supplysuchas voltage, current, power factor,active load, reactive load,apparent load etc. Nowadays, static electronic meters are used for commercial and industrial applications. These electronic meters use micro controllers with their own programming language.

j) Define Signal Generator.

Ans: A signal generator is an equipment that is used to produce signals of varying amplitude and frequency.It is a device that generates signals ina laboratoryenvironment. It can troubleshoot or test electronic devices.

It is also called anoscillator, since it produces periodic signals.

Medium Answer Types (5 Marks)

1)State and explain construction and working of meger for measurement of high resistance.

Ans:

      i.   *Meggar*

Working principle of a megger is based on the working principle of moving coil instruments, which states that when a current carryingconductor is placed in a magnetic field, a mechanical force is experienced byit. The magnitude and direction of this force depend upon the strength and direction of the current and magnetic field.

ConstructionofaMegger

     Thepartsofmeggarareasshownbelowinfig5.4a.

    • ItconsistsofahanddrivenDCgeneratorandadirectreadingohmmeter.

- There are two coils A and B which are fixed together at same shaft at an angle 90° to one another and are free to rotate about a common axis between the poles of a permanent magnet.
- The coils are connected in the circuit by means of flexible leads (or ligaments) which exerts no restoring torque on the moving system.
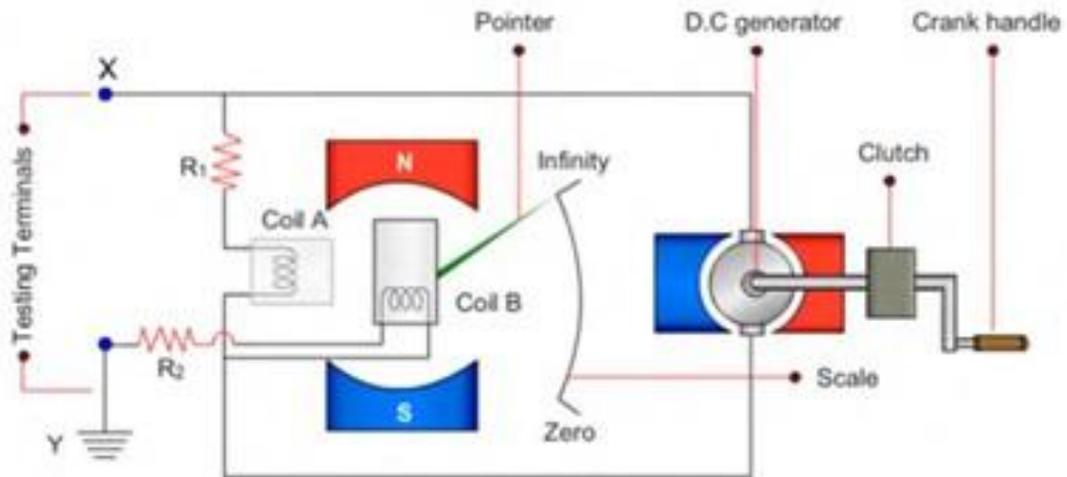

Meggar

- The coil connected with unknown resistance Rx across the point XY and safety resistance R2 is called a current coil.

- Whereas the coil connected in series with fixed resistance R1 is called pressure coil.

- These two coils move in the air gap of two permanent magnets are energised by a generator.

- The current in the coils interact with the magnetic flux and produce equal and opposite torques at equilibrium.

When the crank handle is rotated, a voltage is generated in the generator. This generator voltage is applied acrossthe voltage coil A through a resistance R1. This generator voltage is applied across the voltage coil A through a resistance R1.
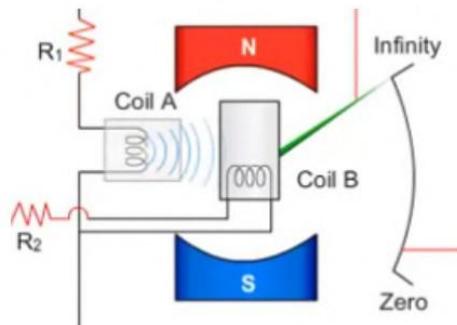
When the terminal X & Y are free initially, no current flows through the coil B. The torque produced bythe coilA rotates the moving element to show infinityas shown in fig 5.4b. While testing, the terminals X & Y are connected across the terminaland the bodyof the machine for measurement. The deflecting torque produced by the coil B interacts with the torque of coil A and rotates the moving element to indicate the resistance value.

2) Write short notes on electron gun assembly?

Ans: - The electron gun assembly consists of an indirectly heated cathode, a control grid, a focusing anode and an accelerating anode and it is used to produce a focused beam of electrons. The control grid is held at negative potential w.r.t. cathode. However, the two anodes are held at high positive potential w.r.t. cathode. The cathode consists of a nickel cylinder coated with oxide coating and provides a large number of electrons. The control grid encloses the cathode and consists of a metal cylinder with a tiny circular opening to keep the electron beam small. By controlling the positive potential on it, the focusing anode focuses the electron beam into a sharp pin point. Due to the positive potential of about 10,000 V on the accelerating anode which is much larger than on the focusing diode, the electron beam is accelerated to a high velocity. In this way, the electron gun assembly forms a narrow, accelerated electron beam which produces a spot of light when it strikes the screen.

3) Explain the Working of Digital Multimeter with Block Diagram

Ans: A Digital Multimeter (DMM) is an electronic instrument that measures voltage (AC/DC), current, and resistance. It replaces traditional analog meters by providing accurate readings through a digital display. DMMs are commonly used in the electrical and electronic sectors to troubleshoot, test, and repair circuit

Digital Multimeter Block Diagram –
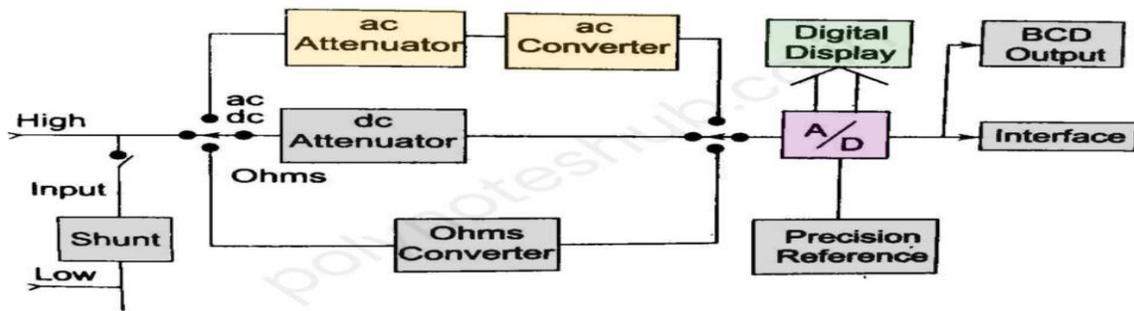
Block Diagram of Digital Multimeter or DMM

- **Input Section:** The input terminals are used to attach test leads that measure voltage, current, and resistance. The input part comprises a shunt for measuring current and a switch for selecting AC, DC, or resistance measurements.

- **AC Attenuator:** When measuring AC voltage, the AC Attenuator lowers the high AC voltage to a level that is suitable for processing. This assures that the circuit components can safely withstand the voltage.

- **AC Converter:** Before proceeding with any further processing, the AC Converter converts the AC voltage signal into a DC signal. This is important because digital circuitry employ DC signals.

- **DC Attenuator:** The DC Attenuator decreases large DC voltages to lower levels, ensuring precise and safe measurements.

- **Ohms Converter:** When measuring resistance, the circuit sends the input signal to the Ohms converter. This block applies a known voltage and monitors the resulting current to determine resistance using Ohm's Law.

- **Analog to Digital Converter:** The A/D converter is a critical component that converts the processed analog signal to a digital signal. The digital data is then displayed and processed.

- **Precision Reference:** The Precision Reference offers a constant reference voltage, ensuring accurate analog-to-digital conversion. This increases the reliability and precision of the readings.

- **Digital Display:** The final measurement result is shown numerically on the digital display (often an LCD screen or LED screen).

- **BCD Output & Interface:** The BCD (Binary-Coded Decimal) Output and Interface connect the multimeter to external devices such as computers or printers for data logging and analysis.

3. Writedown the advatages and application of Digital Multimeter.
     Advantages of Digital Multimeter:

     Here are listed some digital multimeter advantages –

- This type of meter provides precise readings compared to analog meters.
- The Digital display on this meter eliminates human errors in reading scale values.
- The digital multimeter is compact and portable.

- This meter operated on battery. It has low power consumption.
- It can measure voltage, current, resistance, and more in a single device.

Digital Multimeter Applications

Here are listed some applications of digital multimeter –

- Used by technicians for testing circuits, troubleshooting faults, and repairing devices.
- Essential for checking voltage, current, and resistance in wiring and electrical systems.
- Helps in testing car batteries, sensors, and electronic components.
- Used in power plants, manufacturing units, and automation industries for maintenance.
- Used by students and professionals for learning electrical and electronic concepts.
- Important in labs for prototyping and testing electronic components.

4)Describe Digital storage oscilloscope with Block Diagram.

Ans: A digital CRO can store analyse and display a signal. It uses digital acquisition system including an analog to digital converter (ADC), digital memory, digital to analog converter (DAC), and also a display system as shown in Fig.. In the memory unit, the stored signal can be analysed and manipulated as desired.
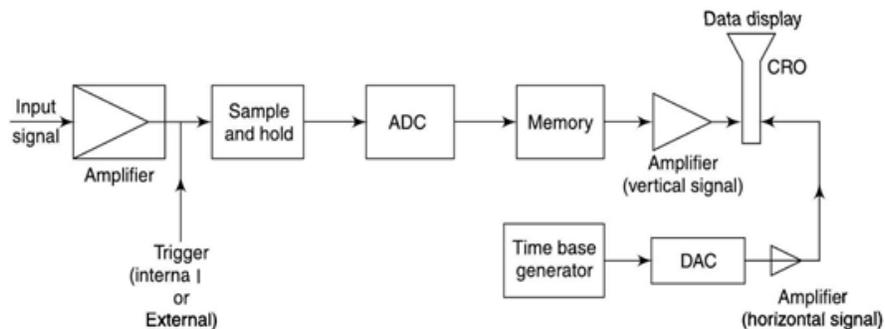

DigitalStorageOscilloscope

The frequencyresponse ofthe digital storage oscilloscopeis limited bythe samplingfrequency, the maximum signal frequencybeing about one-fourth of the sampling frequency. The hold in the sample and hold device is meant to keep the instantaneous signal waiting till the previous signal isbeing digitizedin theADC.Thememory can storethesignal aslong asneededtillit is deleted as in a personal computer.

i. MultiTrace

A block diagram illustrating the principle of the dual trace oscilloscope is given in Figure It consists ofa CR Tube, the usual deflecting system consistingofthe sweep generator, vertical amplifier, horizontal amplifier.There are two vertical amplifierstages.An additional stage is an "eIectron switch" in this CRO. As the vertical amplifiers are two in number the delay lines are also two.

With the above arrangement the dual trace oscilloscope is nothing but a single beam oscilloscope, with the input switched alternately to give the impression of two patterns on the screen. The beam produced by the cathode ray follows the signals of channel A, once and channel B, the other time. The sweep is common for both the channels. The following display modes are possible with the dual trace oscilloscope.
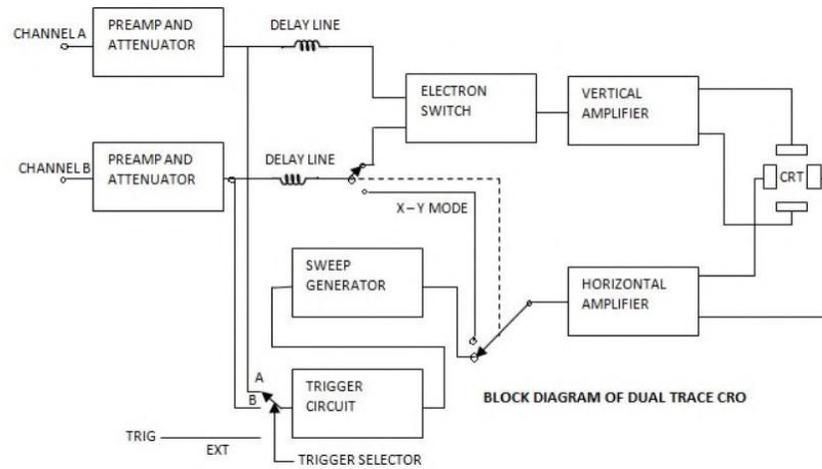
BlockDiagramofDualtraceCRO

Aonly.

B only.

AandBchopped.

AandBalternate.

AandBadded.

AvsB(X-Ymode).

A mode selector on the front panel to select the required mode of operation. In the alternate mode the electron switch alternately connects the main vertical amplifier to channel A and channel B. Each of the vertical preamplifiers have a calibrated attenuator, and positioncontrol. Therefore, the individual positions of the pattern and also the amplitude can be individually controlled.Theelectron switchswitchesthetwochannelsinsynchronizationwiththesweep.

One channel is covered in one sweep cycle. This results in the two images being stable on the screen. This mode is suited for fast sweep rates, when the two images appear as one simultaneous and stable display. The sweep trigger signal is obtained from either of thechannels before the electron switch. This gives the correct phase relation between the A and B channels.

Inthechoppedmodethesweepgeneratorismadefreerunningattherateof100to500kHz. If the choping rate is faster than the sweep rate the individual little segments fed to the main vertical amplifier form original channel A and B waveforms without the interruptions. If the sweeprate is close tothe chopping rate the continuity in the waveform will be lost.

In the mode 'add' the signals of A and B channels are added algebraically. The sum signal is displayedonthescreen.Usingthepolarityinversionswitches in bothchannels wecanhave the following displays. A + B, B — A and A — B.

In the X-Y mode, the signal on both channels are plotted to against each other. As the calibration of the two preamplifiers is the same and they have the same delay time, accurate measurements canbe made. In additionto the above modes of operation, this CRO can be used as single trace one using either of the channels individually. When cost is the problem in acquiring a dual beam CRO this dual trace oscilloscope is advantageous.

5) Describe the Weston type frequency meter.
Ans: FrequencyMeter:

Westotype

Definition: The Weston frequency meter is a moving iron instrument used for measuring the unknown frequency of a signal. The frequency meter consists of one inductive and one resistive coil. When the frequencyof the signal varies from standard frequency, the current distribution across the two coils changes.

Working Principle of Weston Frequency Meter

The Weston frequency meter works on the principle that whenever the frequency of the measured signal varies, the distribution of current between the inductive and the resistive circuit of the meter changes. In other words, the change in frequency causes the change in the inductive impedance of the circuit because of which the variation occurs in the distribution of current between the parallel paths. It means that the inductive impedance is the opposition offered by the circuit in the flow of current whenever the voltage applied to the circuit.

ConstructionofWestonFrequencyMeter

The meter consists of two coils which are placed perpendicular to each other shown in figure .The resistor RA is connected in series with the coil A and the inductor LBis connected in series with the coilB.Theinductor LA is connected inparallel with the coil A and the resistance RBis in parallel with the coil B.

The meter has the soft iron pointer and magnetic needle which are mounted at the centre of the coils.Due to presence of magnetic field ofcoils magnetic needle is used. The inductorL is connected inseries with the LAand RB. The L reduces the harmonics present in circuit current, thereby, reduces the error of the instrument.

WorkingofWestonFrequencyMeter

The circuit diagram of the Weston frequency meter is shown in the figure.
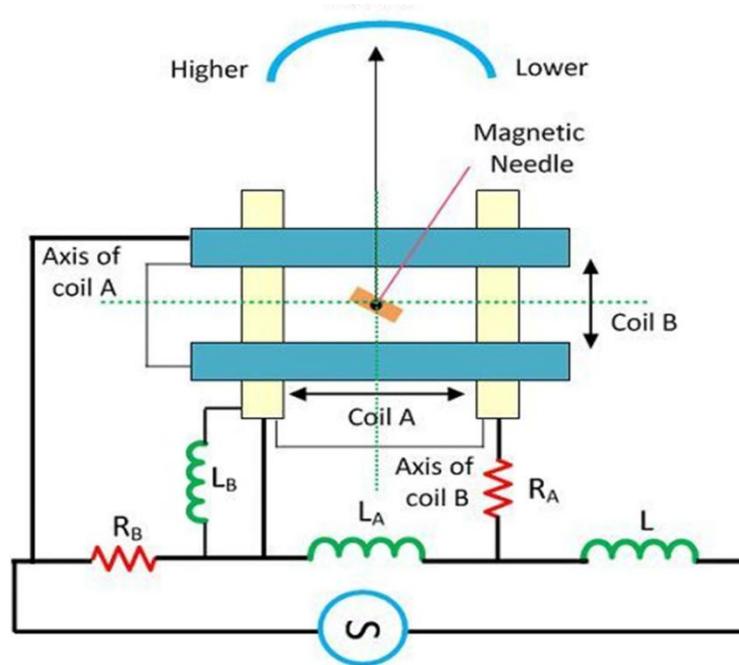
circuitParameterMeasurement,CROandotherMeters

Westonfrequencymeter

When the supplyis given to the Weston frequencymeter, the current starts flowing into the coil A and B. The perpendicular magnetic field set up in the coils because of the current. The magnitude of the field depends on the current passes through the coils.

The magnetic field of both the coil A and coil B acts on the soft iron and the magnetic needle. The position of the needle depends on the relative magnitude of the magnetic field acts on it.

When the supply of normal frequency applies across the meter, the voltage drop of th esame magnitude occurs across the reactance LAand resistance RB. Hence equal current passes through the coil A and coil B.

The meter is designed such a way that when the normal frequency passes through the coil then the voltage drops across the LA, LB, RA, and RBremains same. Thus, same magnitude current passes through the coils. In this situation, the magnetic needle makes an angle of45° concerning the coils (A, B)and the soft iron needle places at the centre of the scale.

When the high frequency passes through the meter, the reactances LA and LBof the coil increase and the RAand RB remain same. The inductance increases the impedance of the coil A.The impedance means the opposition offered by the circuit in the flow of current.As the magnitude of current in the coil A decreases, the field develops because of the coil, The more current flows through the coil B because of the parallel connections with coil A. The magnetic field developed in the coil B becomes stronger than that of the coil A. The magnetic needle aligns themselves   parallel to the axis of the strong magnetic field, and the pointer deflects towards the coil B or strong magnetic field.

VERY LONG ANSWER TYPE. (10 MARKS)
1)Describe in details about Tri-vector meter.

Ans: Tri-vectormeter

Tri-vector meter is an energy meter which accurately measures all the parameters of supply suchas voltage, current, power factor,active load, reactive load,apparent load etc. Nowadays, static electronic meters are used for commercial and industrial applications. These electronic meters use micro controllers with their own programming language. The block diagram is shown in figure5.26.

Tri-vector meter gets the input supplyto be measured using CT/PTs. That is current input from CurrentTransformersandvoltageinputfromPotential Transformersconnectedinthecircuit. It can be divided into two categories (i) two quandranttrivector meterand (ii)four quadrant trivector meter . Fourquadrant modelcanmeasure both the incoming (import) and the outgoing power (export) while the two quandranttrivector meter can measure either imported orexported power.LCD display with annunciators forshowing various critical events isused.

ThefollowingmeasurementvaluescanbeobtainedusingTrivectormeter.

ActiveEnergy

ReactiveEnergy

ApparentEnergy

MaximumDemand

Voltagesofallthephases

Currentsofallthephases

Powerfactorofallthephases

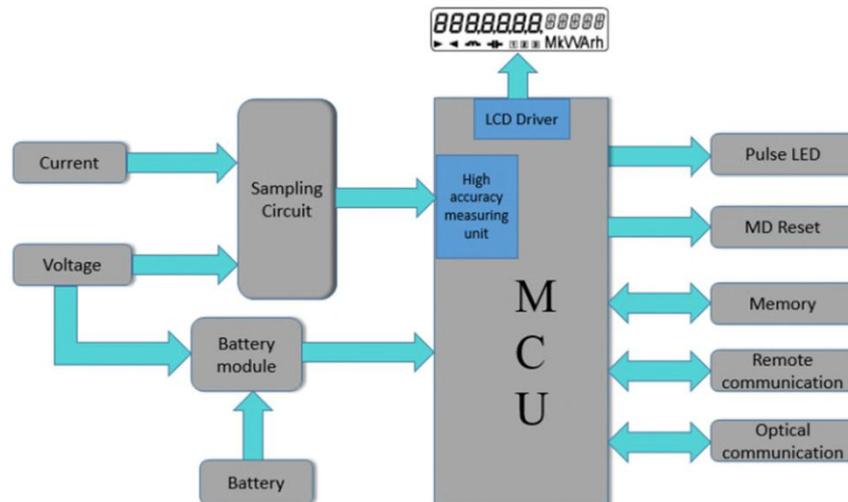Principle of Operation:The principle of operationof tri-vector energymeter is explained with the help of block diagram.

Fig. 5.26 Block diagram of tri-vector meter

It mainly consists of the following units.

Energy measuring unit:The function of this unit is voltage sampling, current sampling, measuring integrated circuit.An analog to digital converter is used to sample voltage and currentrelativetoincoming waveform. For getting accurateresults,thesampling rateshould be high.

Data processing unit: It consists of Micro Controller Unit (MCU), Memory storage cards which are highly reliable and efficient for calculation.There is Read Only Memory (ROM) which is used to retain the data for so many years even if there is no power.

Powersupplyunit:ItisACpowersupplywithbattery.

Input/output unit: In this unit there are LCD display, Optical communication, extra port/ registered jack for remote communication. Data from ROM can either be displayed on themeter LCD or communicated via an optical communication port on to a hand-held Meter Reading Instrument (MRI).
MajorComponentsofTrivectorMeterare:

EnergyRegisters:

These are used for measuring Active, Reactive, and Apparent energy. These can be configured according to user's requirement.

MaximumDemandRegisters:

Maximum Demand (MD) is indicated for a particular time period. The demand is monitored during each demand interval and the maximum value of these demands is stored in the Maximum Demand register. Whenever MD is reset, the registered MD value gets stored along with date and time of its occurrence.

LCDDisplay:

LCD display is used to show reading value indicators, energy unit indicators, phase status indicators, energydirection indication import or export, and load status indicators inductive or capacitive as shown in the Block diagram.

TODRegisters:

These are usedtosupport Time-of-Day (TOD) metering, means to divide a day intocertain time slots with tariff rates arranged in such a way so as to encourage consumers to reduce consumption during high demand hours and shift it to lower demand.

Data Communication: For local communication optical port is used to establish communication

between meter and Meter Reading Instrument (MRI). The registered jack(RJ11)port isused to establishremote communicationbetweenmeter and a compatible modem which uses base computer software (BCS).

2) Draw the Block Diagram of CRO (Cathode Ray Oscilloscope) and explain the role of each block.

Ans: The cathode Ray Oscilloscope or mostly called as CRO is an electronic device used for giving the visual indication of a signal waveform. It is an extremely useful and the most versatile instrument in the electronic industry. CRO is widely used for trouble shooting radio and television receivers as well as for laboratory research and design. Using a CRO, the wave shapes of alternating currents and voltages can be studied. It can also be used for measuring voltage, current, power, frequency and phase shift. Different types of oscilloscopes are available in the market for various purposes.

The figure below shows the block diagram of a general purpose CRO .
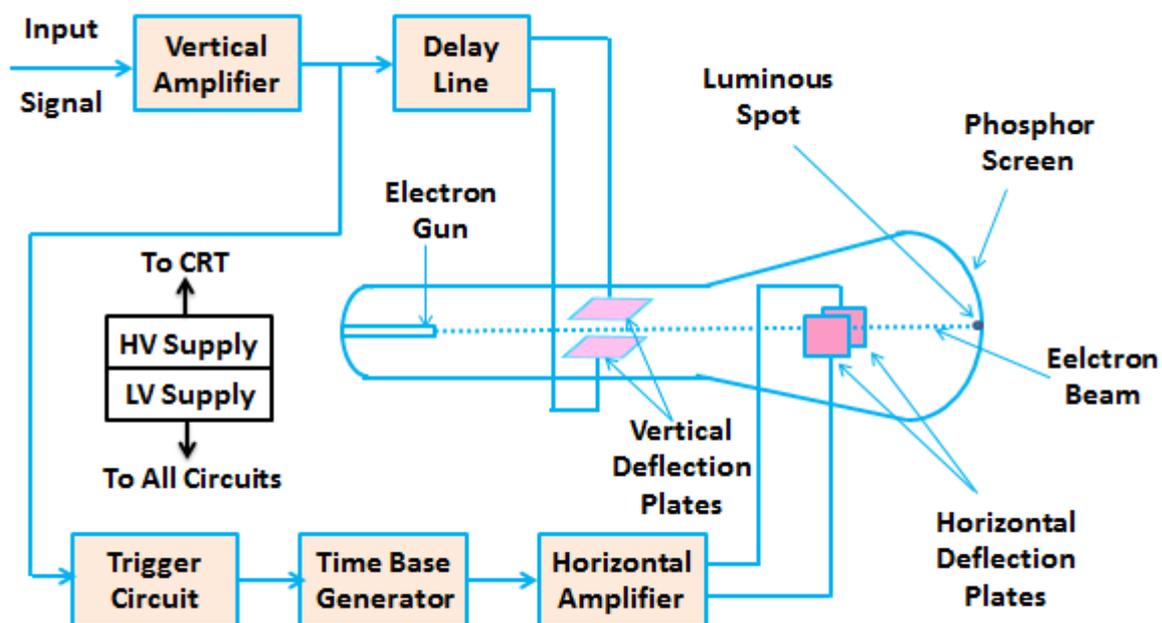
Block Diagram of Cathode Ray Oscilloscope (CRO)

Cathode Ray Tube

As we can see from the above figure above, a CRO employs a cathode ray tube (CRT), which acts as the heart of the oscilloscope. In an oscilloscope, the CRT generates the electron beam which are accelerated to a high velocity and brought to focus on a fluorescent screen. This screen produces a visible spot where the electron beam strikes it. By deflecting the beam over the screen in response to the electrical signal, the electrons can be made to act as an electrical pencil of light which produces a spot of light wherever it strikes. For accomplishing these tasks various electrical signals and voltages are needed, which are provided by the power supply circuit of the oscilloscope. Low voltage supply is required for the heater of the electron gun to generate the electron beam and high voltage is required for the cathode ray tube to accelerate the beam. Normal voltage supply is required for other control units of the oscilloscope. Horizontal and vertical deflection plates are fitted between the electron gun and the screen so that these can deflect the beam according to the input signal.

Time base Generator

To deflect the electron beam on the screen in horizontal direction i.e. X-axis with constant time

dependent rate, a time base generator is provided in the oscilloscope.

Vertical Amplifier
The signal to be viewed is supplied to the vertical deflection plate through the vertical amplifier, so that it can amplify the signal to a level that will provide usable deflection of the electron beam.

Triggering circuit
As the electron beam is deflected in X-axis as well as Y-axis, a triggering circuit is provided for synchronizing these two types of deflections so that horizontal deflection starts at the same point of the input vertical signal each time it sweeps.

Horizontal amplifier:
This is used to amplify the saw-tooth voltage, which is then applied to the X-plates.

Delay Line:
It is used to delay the signal for some time in the vertical sections.

HV and LV power supply:
   a. Two voltages are generated in the CRO which are used in CRT.
   b. The low voltage supply is from +300 to 400 V.
   c. The high voltage supply is from –1000 to –1500 V.

b) Explain the working of CRT. [10 marks]
   d. The cathode ray tube or CRT is a vacuum tube of special geometrical shape which converts an electrical signal into a visual one. A CRT makes available a large number of electrons which are accelerated to high velocity and are brought to focus on a fluorescent screen where it produces a spot when strikes it. The electron beam is deflected during its journey in response to the applied electrical signal. As a result, the electrical signal waveform is displayed visually.

   The figure below shows various parts of a cathode ray tube (CRT) .
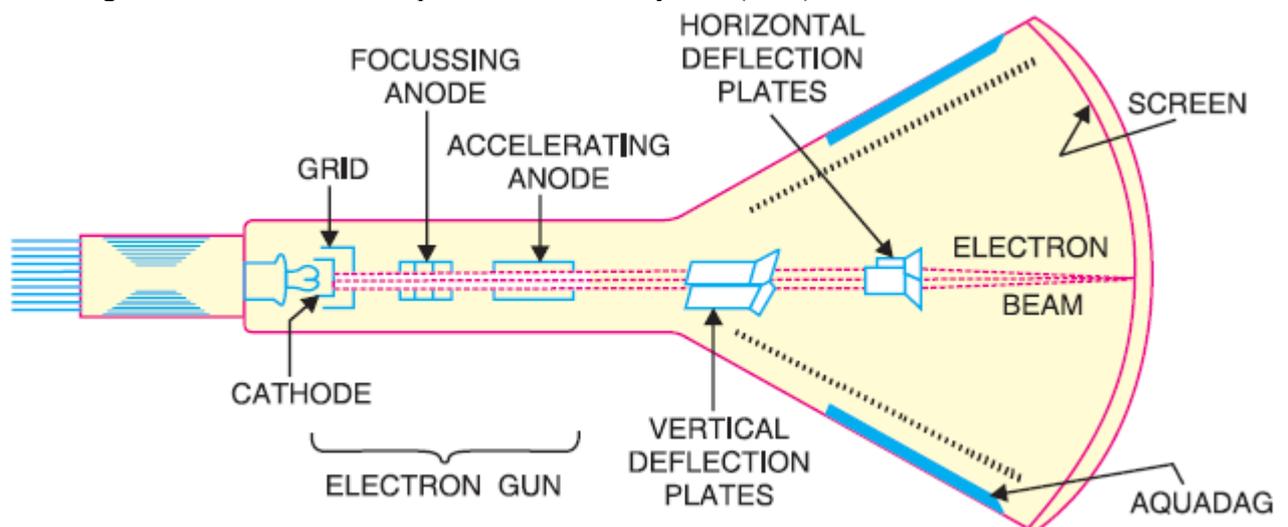
Now we will discuss each part of the CRT in detail.

(i) Glass Envelope

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

(ii) Electron Gun Assembly

The electron gun assembly consists of an indirectly heated cathode, a control grid, a focusing anode and an accelerating anode and it is used to produce a focused beam of electrons. The control grid is held at negative potential w.r.t. cathode. However, the two anodes are held at high positive potential w.r.t. cathode. The cathode consists of a nickel cylinder coated with oxide coating and provides a large number of electrons. The control grid encloses the cathode and consists of a metal cylinder with a tiny circular opening to keep the electron beam small. By controlling the positive potential on it, the focusing anode focuses the electron beam into a sharp pin point. Due to the positive potential of about 10,000 V on the accelerating anode which is much larger than on the focusing diode, the electron beam is accelerated to a high velocity. In this way, the electron gun assembly forms a narrow, accelerated electron beam which produces a spot of light when it strikes the screen.

(iii) Deflection Plate Assembly

It consists of two sets of deflecting plates within the tube beyond the accelerating anode and is used for the deflection of the beam. One set is called as vertical deflection plates and the other set is called horizontal deflection plates. The vertical deflection plates are mounted horizontally in the tube. On application of proper potential to these plates, the electron beam can be made to move up and down vertically on the screen. The horizontal deflection plates are mounted vertically in the tube. On application of proper potential to these plates, the electron beam can be made to move right and left horizontally on the screen.

(iv) Screen

The screen is coated with some fluorescent materials such as zinc orthosilicate, zinc oxide etc and is the inside face of the tube. When high velocity electron beam strikes the screen, a spot of light appears at the point of impact. The colour of the spot depends upon the nature of fluorescent material.

Working of Cathode Ray Tube

As the cathode is heated, it produces a large number of electrons. These electrons pass through the control grid on their way to the screen. The control grid controls the amount of current flow as in standard vacuum tubes. If negative potential on the control grid is high, fewer electrons will pass through it. Hence the electron beam will produce a dim spot of light on striking the screen. Reverse will happen when the negative potential on the control grid is reduced. Therefore, the intensity of the light spot on the screen can be controlled by changing the negative potential on the control grid. After leaving the control grid, the electron beam comes under the influence of focusing and accelerating anodes. Since, the two anodes are at high positive potential, therefore, they produce a field which acts as electrostatic lens to converge the electron beam at a point on the screen. After leaving the accelerating anode, the electron beam comes under the influence of vertical and horizontal deflection plates. When no voltage is applied to these deflection plates, the electron beam produces a spot of light at the centre as shown by point O in fig below on the screen.
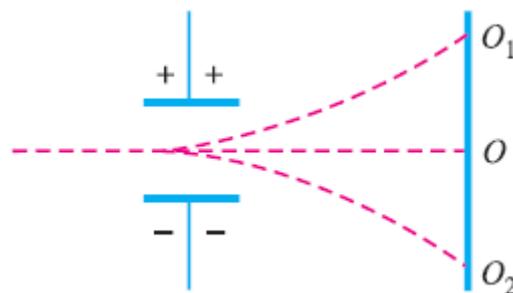
If the voltage is applied to the vertical deflection plates only, the electron beam and so as the spot of

light will be deflected upwards i.e. point O1. Ans if the potential on the plates is reversed, the spot of light will be deflected downwards i.e. point O2. Similarly, the spot of light can be deflected horizontally by applying voltage across the horizontal deflection plates.

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