1.a) Voltage sensitivity is the measure of the responsiveness of an appliance to the transform of applied voltage across it. A galvanometer is a type of ammeter. It is an appliance for detecting and measuring electric current

So, the voltage sensitivity of a galvanometer is defined as the deflection per unit voltage across the galvanometer.

So, **Voltage sensitivity = $\theta/V = \theta/IG = nBA/CG$**

where G is the galvanometer resistance.

**Unit:** rad $V^{-1}$ or mm $V^{-1}$

High voltage sensitivity is desirable in circuits of relatively low resistance.

An interesting point to note is that increasing the current sensitivity does not necessarily, increase the voltage sensitivity. When the number of turns (n) is doubled, current sensitivity is also doubled (equation). But increasing the number of turns correspondingly increases the resistance (G). Hence voltage sensitivity remains unchanged.

So, we can say, Voltage Sensitivity = $\theta/V$ = (NAB/KR)

where,

- $\theta$ is the angular displacement, i.e. the reading you see on the galvanometer
- V is, of course, the voltage across the galvanometer for which the reading is $\theta$
- N is the number of turns of the moving-coil in the galvanometer.
- A is the length of the rectangular-coil, B is the breadth of the rectangular-coil,

Therefore AB represents the area of the 2D-coil.

K is the torsion-constant of the galvanometer, i.e., the spring constant of the spring that's used in the galvanometer.

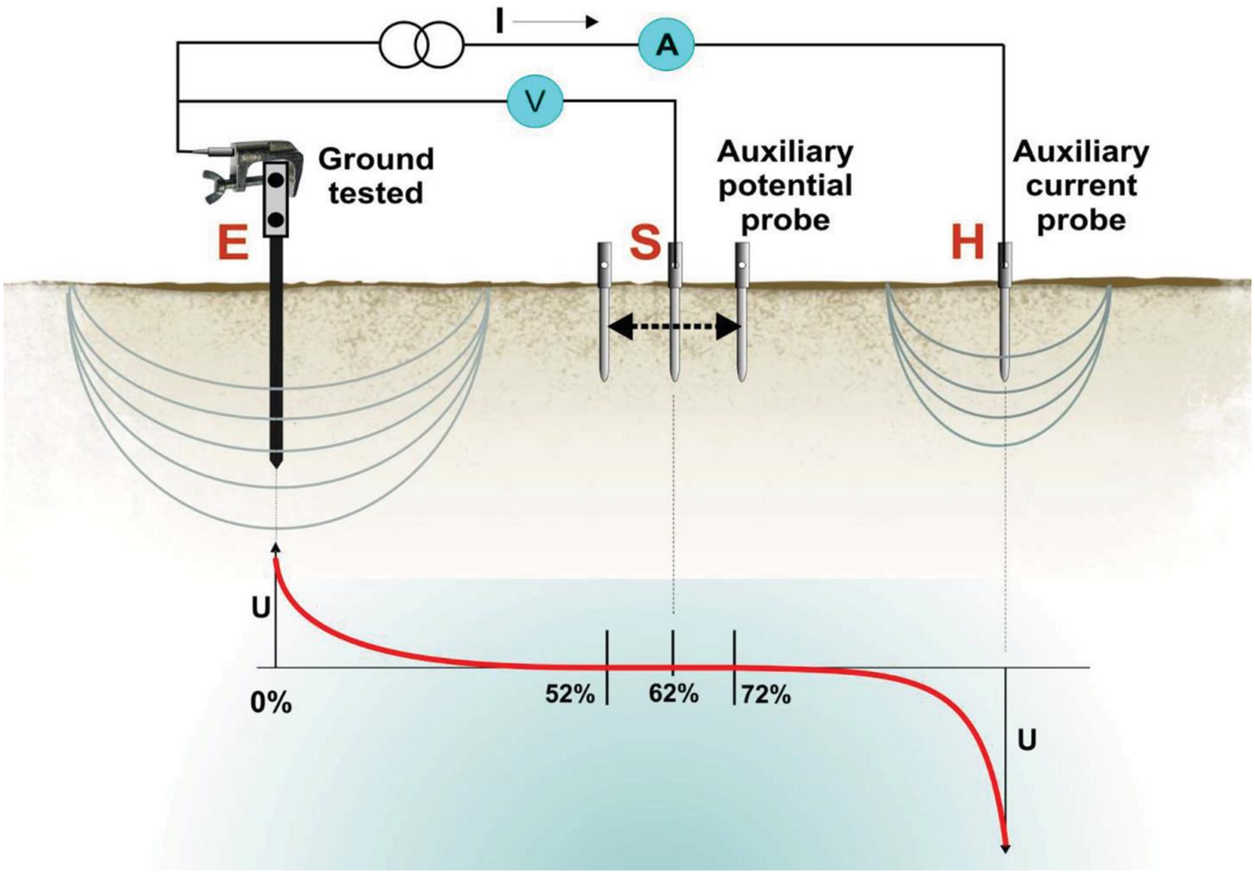
R is the resistance of the coil.

Now, increasing the number of turns N of the coil will result in the same increase in the resistance of the coil R as $R \propto l$ and surface-area of the coil is kept stable.

Therefore, the increasing number of turns N of the coil does not affect the voltage-sensitivity of the galvanometer.

Therefore, in order to increase the voltage-sensitivity of the galvanometer,

1 B)




**The general procedure for a single-earth grounding point, and a description of a modified approach using a current probe for testing ground resistance of multiple-earth grounding point systems.**

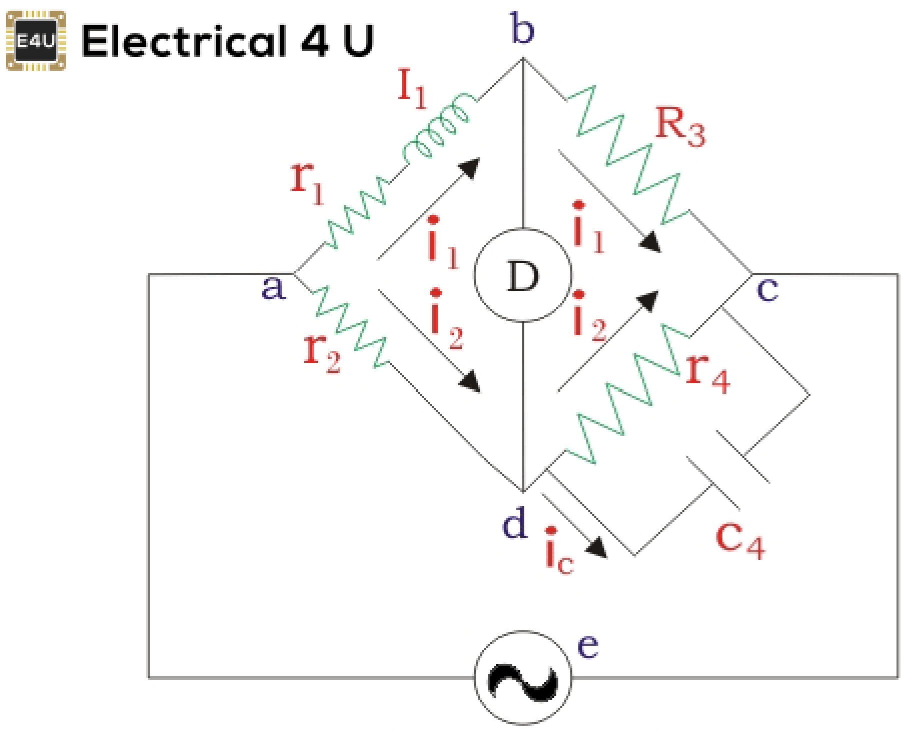
To measure the earth ground resistance of a single ground electrode at E in Fig. 1, a current is forced to flow to E by driving auxiliary test probe H into the ground at a certain distance from electrode E and connecting probe H to a current source.

In this case, the ground resistance test meter is the current source which generates an alternating current. An electrical circuit is formed between H and E, with current flowing between them in the ground. Electrical potentials are created at points between E and H. A path of resistance between E and H causes a voltage to develop at points along this path, due to the current.

A second auxiliary test probe, S, is driven into the ground between E and H to measure electrical potential (voltage). This voltage varies along the path between E and H; maximum voltage occurs at E and zero at H, hence the term "fall of potential": the voltage potential falls away when moving probe S away from E, towards H. With the voltage recorded at S, we can determine the earth resistance from the voltage and current values.

1.C) A **Maxwell Inductance Capacitance Bridge** (known as a Maxwell Bridge) is a modified version of a Wheatstone bridge which is used to measure the self-inductance of a circuit. A

Maxwell bridge uses the null deflection method (also known as the "bridge method") to calculate an unknown inductance in a circuit. When the calibrated components are a parallel capacitor and resistor, the bridge is known as a Maxwell-Wien bridge.
The working principle is that the positive phase angle of an inductive impedance can be compensated by the negative phase angle of a capacitive impedance when put in the opposite arm and the circuit is at resonance (i.e., no potential difference across the detector and hence no current flowing through it). The unknown inductance then becomes known in terms of this capacitance.




Maxwell Induction Capacita

Here $Z_1$, $Z_2$, $Z_3$ and $Z_4$ are the arms of the bridge.
Now at the balance condition, the potential difference between b and d must be zero. From this, when the voltage drop from a to d equals to drop from a to b both in magnitude and phase. Thus, we have from figure $e_1 = e_2$

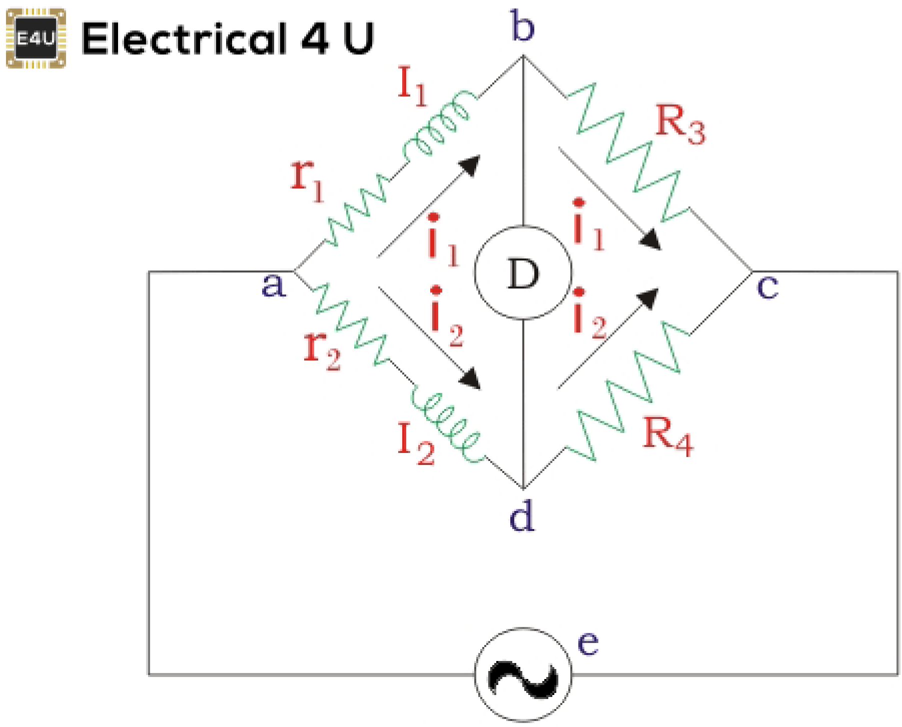
$$i_1 \cdot Z_1 = i_2 \cdot Z_2 \cdots\cdots\cdots(1)$$

$$i_1 = i_2 = \frac{e}{Z_1 + Z_3} \cdots\cdots\cdots(2)$$

$$i_2 = i_4 = \frac{e}{Z_2 + Z_4} \cdots\cdots\cdots(3)$$

From equation 1, 2 and 3 we have $Z_1.Z_4 = Z_2.Z_3$ and when impedance are replaced by admittance, we have $Y_1.Y_4 = Y_2.Y_3$.

Now consider the basic form of an AC bridge. Suppose we have bridge circuit as shown below,




In this circuit $R_3$ and $R_4$ are pure electrical resistances. Putting the value of $Z_1$, $Z_2$, $Z_3$ and $Z_4$ in the equation that we have derived above for AC bridge.

$$We\ get\ (r_1 + j\omega l_1) \cdot R_4 = (r_2 + j\omega l_2) \cdot R_3$$

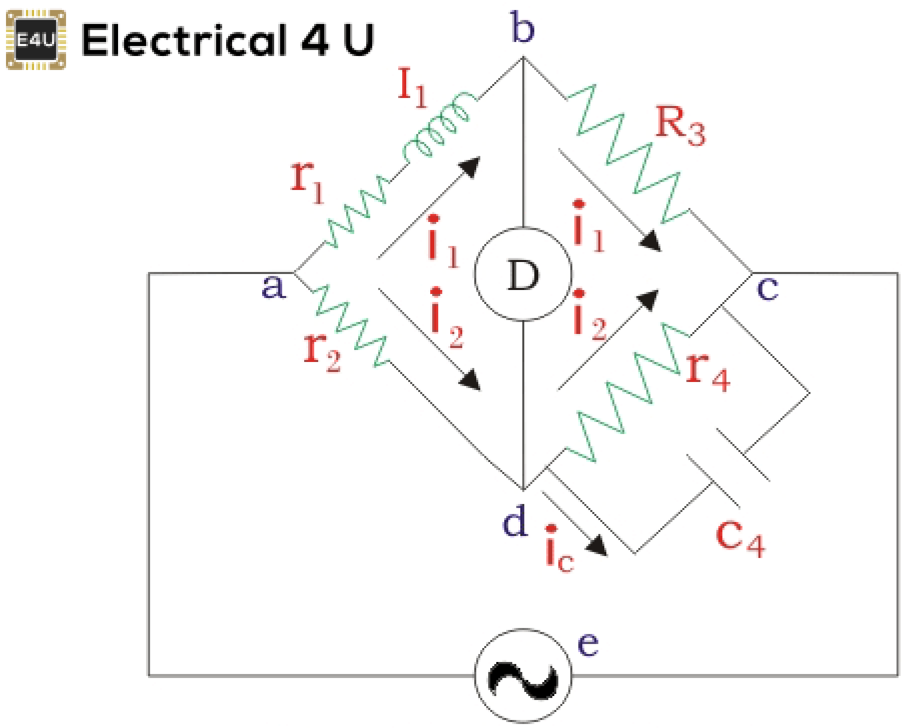
Now equating the real and imaginary parts, we get:

$$r_1 = \frac{R_3}{R_4} \cdot r_2\ and\ l_1 = \frac{R_3}{R_4} \cdot l_2$$

Following are the important conclusions that can be drawn from the above equations:

1. We get two balanced equations that are obtained by equating real and imaginary parts this means that for an ac bridge both the relation (i.e.magnitude and phase) must be satisfied at the same time. Both the equations are said to be independent if and only if both equations contain a single variable element. This variable can be inductor or resistor.
2. The above equations are independent of frequency that means we do not require exact frequency of the source voltage and also the applied source voltage waveform need not to be perfectly sinusoidal.

In this **Maxwell Bridge**, the unknown inductor is measured by the standard variable capacitor. Circuit of this bridge is given below,




Maxwell Induction Capacita

Here, $l_1$ is unknown inductance, $C_4$ is a standard capacitor.
Now under balance conditions, we have from AC bridge that $Z_1.Z_4 = Z_2.Z_3$

$$(r_1 + j\omega l_1)\frac{r_4}{1 + j\omega C_4 r_4} = r_2 \cdot r_3$$

$$r_1 \cdot r_4 + j\omega l_1 \cdot r_4 = r_2 \cdot r_3 + j\omega r_2 r_3 C_4 r_4$$

Let us separate the real and imaginary parts, then we have,

$$r_1 = r_2 \cdot \frac{r_3}{r_4} \; and \; l_1 = r_2 \cdot r_3 \cdot C_4$$

Now the quality factor is given by,

$$Q = \frac{\omega l_1}{r_1} = \omega C_4 \cdot r_4$$

**Advantages of Maxwell's Bridge**

The advantages of a Maxwell Bridge are:

1. The frequency does not appear in the final expression of both equations, hence it is independent of frequency.
2. **Maxwell's inductor capacitance bridge** is very useful for the wide range of measurement of inductor at audio frequencies.

The disadvantages of a Maxwell Bridge are:

1. The variable standard capacitor is very expensive.

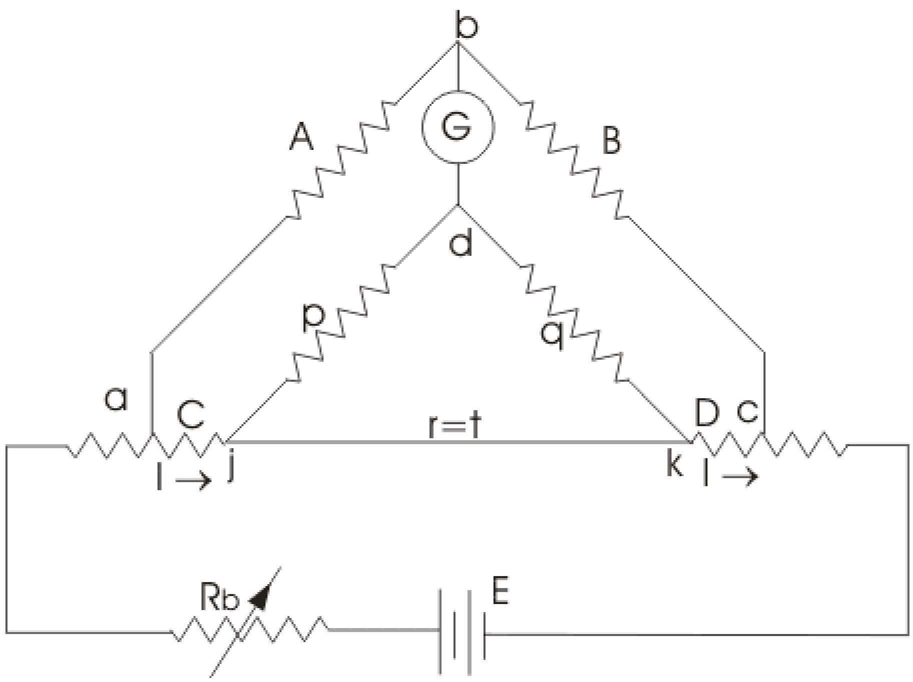
2. The bridge is limited to measurement of low quality coils (1 < Q < 10) and it is also unsuitable for low value of Q (i.e. Q < 1) from this we conclude that a Maxwell bridge is used suitable only for medium Q coils.

The above all limitations are overcome by the modified bridge which is known as Hay's bridge which does not use an electrical resistance in parallel with the capacitor.

2 A) Before we introduce **Kelvin Bridge**, it is very essential to know what is the need of this bridge, though we have Wheatstone bridge which is capable of measuring electrical resistance accurately (usually an accuracy of around 0.1%).

To understand the need of Kelvin bridge we must first recognize 3 important ways to categorize electrical resistance:

1. **High Resistance**: Resistance that is greater than 0.1 Mega-ohm.
2. **Medium Resistance**: Resistance that ranges from 1 ohm to 0.1 Mega-ohm.
3. **Low Resistance**: Under this category resistance value is lower than 1 ohm.




$$Hence,\ E = \frac{A}{A + B} \times F$$

$$\Rightarrow F = I \times \left( C + D + \frac{p + q}{p + q + t} \times t \right)$$

$$Hence,\ G\ i.e.\ (voltage\ drop\ between\ a\ and\ d) = I \times \left( C + \frac{p \times t}{p + q + t} \right)$$

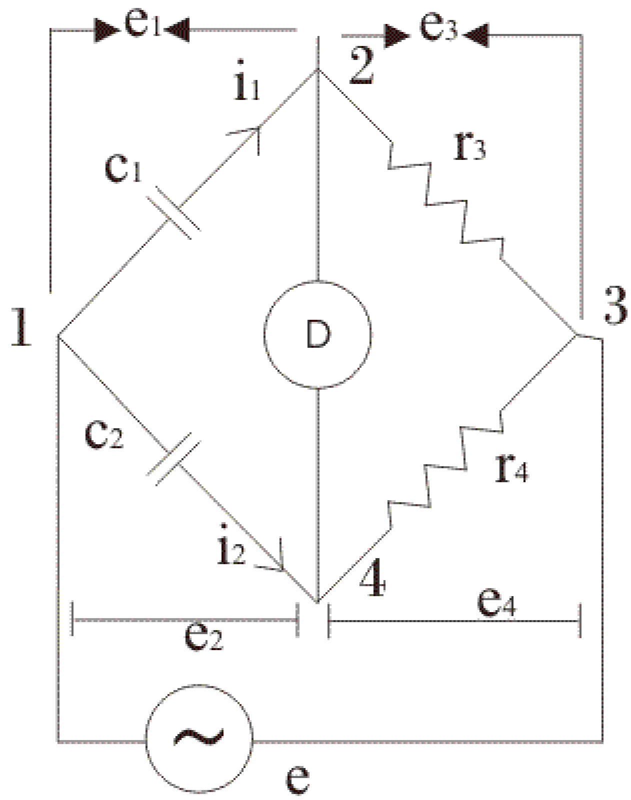
Why it is called double bridge? It is because it incorporates the second set of ratio arms as shown below:

In this the ratio arms p and q are used to connect the galvanometer at the correct point between j and k to remove the effect of connecting lead of electrical resistance t. Under balance condition voltage drop between a and b (i.e. E) is equal to F (voltage drop between a and c)

For zero galvanometer deflection, E = F

Again we reach the same result – t has no effect. However equation (2) is useful as it gives error .

2C) This bridge provide us the most suitable method for comparing the two values of capacitor if we neglect dielectric losses in the bridge circuit. The circuit of **De Sauty's bridge** is shown below.



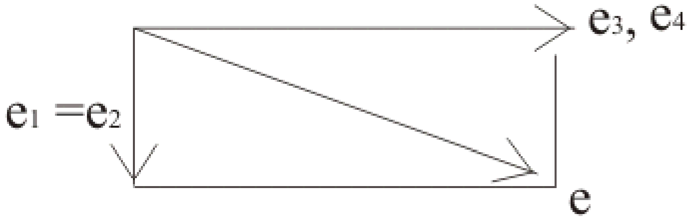

Battery is applied between terminals marked as 1 and 4. The arm 1-2 consists of capacitor $c_1$ (whose value is unknown) which carries current $i_1$ as shown, arm 2-4 consists of pure resistor (here pure resistor means we assuming it non inductive in nature), arm 3-4 also consists of pure resistor and arm 4-1 consists of standard capacitor whose value is already known to us. Let us derive the expression for capacitor $c_1$ in terms of standard capacitor and resistors. At balance condition we have,

$$\frac{1}{j\omega c_1} \times r_4 = \frac{1}{j\omega c_2} \times r_3$$

It implies that the value of capacitor is given by the expression $c_1 = c_2 \times \frac{r_4}{r_3}$

In order to obtain the balance point we must adjust the values of either $r_3$ or $r_4$ without disturbing any other element of the bridge. This is the most efficient method of comparing the two values of capacitor if all the dielectric losses are neglected from the circuit.

Now let us draw and study the phasor diagram of this bridge. Phasor diagram of **De Sauty bridge** is shown below:




Phasor diagram

3 A) There are two types of coils present in the electrodynamometer. They are : MovingCoil:

Moving coil moves the pointer with the help of spring control instrument. Limited of current flows through the moving coil so as to avoid heating. So in order to limit the current we have connected the high value resistor in series with the moving coil. The moving is air cored and is mounted on a pivoted spindle and can move freely. In **electrodynamometer type wattmeter**, moving coil works as pressure coil. Hence moving coil is connected across the voltage and thus the current flowing through this coil is always proportional to the voltage.

FixedCoil:

The fixed coil is divided into two equal parts and these are connected in series with the load, therefore the load current will flow through these coils. Now the reason is very obvious of using two fixed coils instead of one, so that it can be constructed to carry considerable amount of electric current. These coils are called the current coils of **electrodynamometer type wattmeter**. Earlier these fixed coils are designed to carry the current of about 100 amperes but now the modern wattmeter are designed to carry current of about 20 amperes in order to save power.

Control System

Out of two controlling systems i.e.

1. Gravity control

2. Spring control, only spring controlled systems are used in these types of wattmeter. Gravity controlled system cannot be employed because there will be appreciable amount of errors.

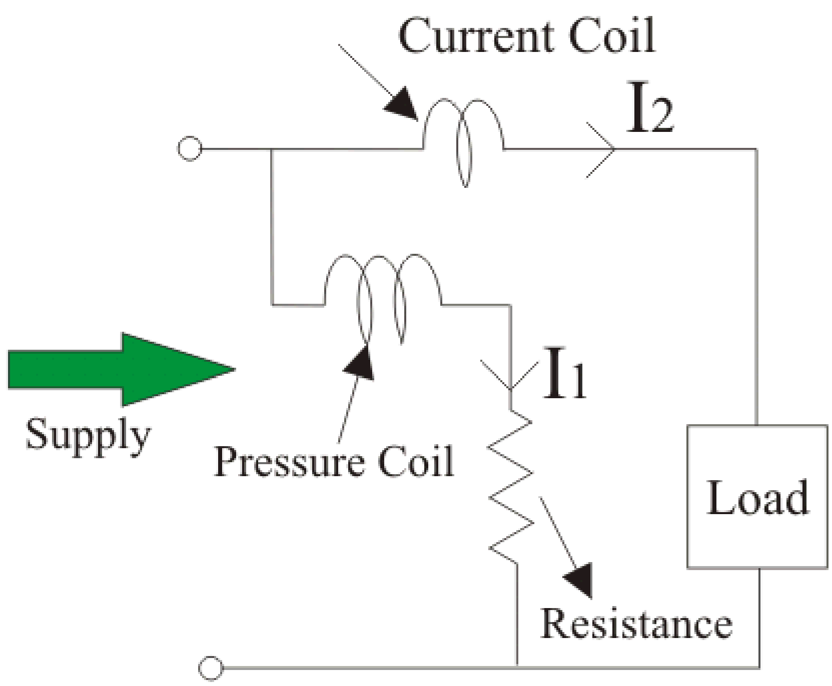
Damping System

Air friction damping is used, as eddy current damping will distort the weak operating magnetic field and thus it may leads to error.

Scale

There is uniform scale which is used in these types of instrument as moving coil moves linearly over a range of 40 degrees to 50 degrees on either side.

Now let us derive the expressions for the controlling torque and deflecting torques. In order to derive these expressions let us consider the circuit diagram given below:




We know that instantaneous torque in electrodynamic type instruments is directly proportional to the product of instantaneous values of currents flowing through both the coils and the rate of change of flux linked with the circuit.

Let $I_1$ and $I_2$ be the instantaneous values of currents in pressure and current coils respectively. So the expression for the torque can be written as:

$$T = I_1 \times I_2 \times \frac{dM}{dx}$$

Where, x is the angle.

Now let the applied value of voltage across the pressure coil be

$$v = \sqrt{2} V sin\omega t$$

Assuming the electrical resistance to the pressure coil be very high hence we can neglect reactance with respect to its resistance. In this the impedance is equal to its electrical resistance therefore it is purely resistive.

The expression for instantaneous current can be written as $I_2 = v / R_p$ where $R_p$ is the resistance of pressure coil.

$$I_2 = \sqrt{2} \times \frac{V sin\omega t}{R_p}$$

If there is phase difference between voltage and electric current, then expression for instantaneous current through current coil can be written as

$$I_1 = I(t) = \sqrt{2} I sin(\omega t - \phi)$$

As current through the pressure coil is very very small compared to the current through current coil hence current through the current coil can be considered as equal to total load current. Hence the instantaneous value of torque can be written as

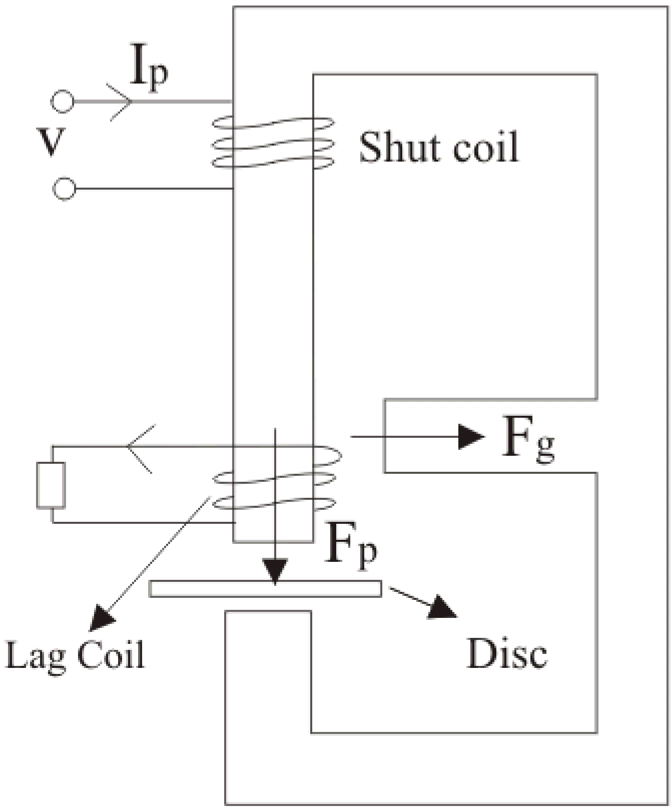
$$\sqrt{2} \times \frac{V sin\omega t}{R_p} \times \sqrt{2} \times I \times sin(\omega t - \phi) \times \frac{dM}{dx}$$

Average value of deflecting torque can be obtained by integrating the instantaneous torque from limit 0 to T, where T is the time period of the cycle.

$$T_d = deflecting\ torque = \frac{VI}{R_p} cos\phi \times \frac{dM}{dx}$$

Controlling torque is given by $T_c = K_x$ where K is spring constant and x is final steady state value of deflection.

3 B) We know that in induction type energy meters, in order to maintain speed of rotation proportional to power "The phase angle between supply voltage and pressure coil flux should be equal to $90^{o}$". However in actual practice, the angle between supply voltage and pressure coil flux is exactly not $90^{o}$ but few degrees less. Therefore, some lag adjustment devices are used for adjustment of lag angle. Let us consider the figure given beside:



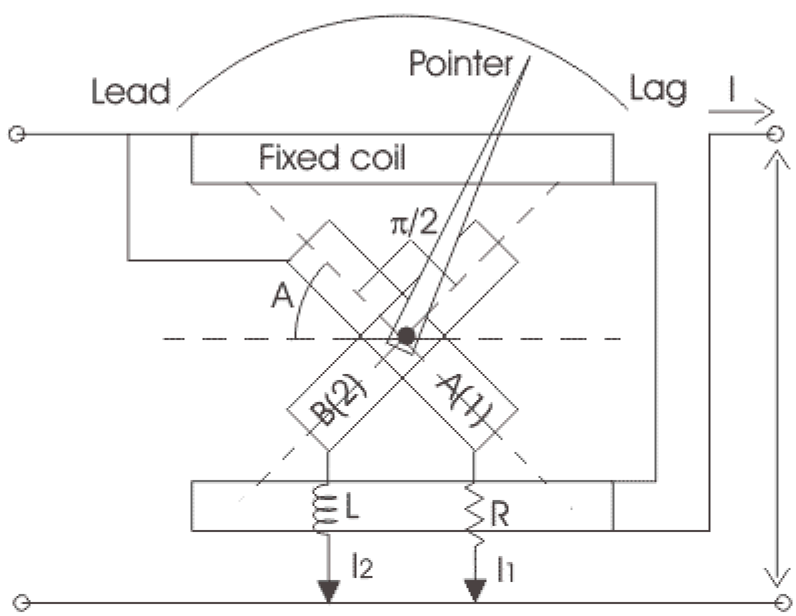

In the beside figure we have introduced another coil which is located on the central limb with number of turns equal to N. This coil is called lag coil. When we give supply voltage to the pressure coil it produces flux F. Now this flux is divided into two parts $F_p$ and $F_g$, $F_p$ flux cuts the moving disc and also links with the lag coil. Due to lag coil there induces an emf $E_l$ which lags behind the flux $F_p$ by angle of $90^o$, also $I_l$ is lagging behind $E_l$ by an angle of $90^o$. The lagging coil produces a flux $F_l$. The resultant flux so obtained that cuts the moving disc is the combination of $F_l$ and $F_p$. Now the resultant value of this flux is in phase with resultant mmf of lag or shading coil and the resultant value of mmf of shading coil can adjusted by using two methods

1. By adjusting electrical resistance.
2. By adjusting shading bands.

3 C) Before we introduce various types of **power factor meters** it is very essential to understand what are the needs of power factor meter? Why we do not directly calculate power factor in an AC circuit just by dividing the power with product of current and voltage because these readings can be easily obtained from wattmeter, ammeter and voltmeter. Obviously there various limitations of using this method as it may not provide high accuracy, also chances of increment of error is very high. Therefore this method is not adopted in industrial world. Measurement of power factor accurately is very essential everywhere.
In power transmission system and distribution system we measure power factor at every station and electrical substation using these **power factor meters**.Power factor measurement provides us the knowledge of type of loads that we are using and helps in calculation of losses happening during the power transmission system and distribution.

Hence we need a separate device for calculating the power factor accurately and more precisely. General construction of any power factor meter circuit include two coils namely pressure coil and current coil. Pressure coil is connected across the circuit while current coil is connected such that it can carry circuit current or a definite fraction of current. By measuring the phase difference between the voltage and current the electrical power factor can be calculated on suitable calibrated scale. Usually the pressure coil is splits into two parts namely inductive and non-inductive part or pure resistive part. There is no requirement of controlling system because at equilibrium there exist two opposite forces which balance the movement of pointer without any requirement of controlling force.

The general circuit diagram of single phase electrodynamometer power factor meter is given below.




Now the pressure coil is split into two parts one is purely inductive another is purely resistive as shown in the diagram by resistor and inductor. At present the reference plane is making an angle A with coil 1. And the angle between both the coils 1 and 2 is 90°. Thus the coil 2 is making an angle (90° + A) with the reference plane. Scale of the meter is properly calibrated as shown the value values of cosine of angle A. Let us mark the electrical resistance connected to coil 1 be R and inductor connected to coil 2 be L. Now during measurement of power factor the values of R and L are adjusted such that R = wL so that both coils carry equal magnitude of current. Therefore the current passing through the coil 2 is lags by 90° with reference to current in coil 1 as coil 2 path is highly inductive in nature.
Let us derive an expression for deflecting torque for this **power factor meter**. Now there are two deflecting torques one is acting on the coil 1 and another is acting on the coil 2. The coil winding are arranged such that the two torques produced, are opposite to each other and therefore pointer

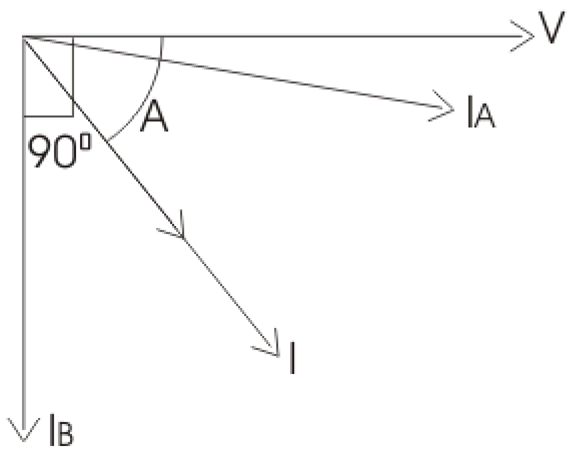
will take a position where the two torques are equal. Let us write a mathematical expression for the deflecting torque for coil 1-

$$T_1 = KVIM \cos A \sin B$$

Where M is the maximum value of mutual inductance between the two coils, B is the angular deflection of the plane of reference. Now the mathematical expression for the deflecting torque for coil 2 is-

$$T_2 = KVIM \cos(90 - A)\sin(90 + B) = KVIM \sin A \cos B$$

At equilibrium we have both the torque as equal thus on equating $T_1$=$T_2$ we have A = B. From here we can see that the deflection angle is the measure of phase angle of the given circuit. The phasor diagram is also shown for the circuit such that the current in the coil 1 is approximately at an angle of 90$^o$ to current in the coil 2.




Given below are some of the advantages and disadvantages of using electrodynamic type power factor meters.

**Advantages of Electrodynamic Type Power Factor Meters**

1. Losses are less because of minimum use of iron parts and also give less error over a small range of frequency as compared to moving iron type instruments.
2. They high torque is to weight ratio.

**Disadvantages of Electrodynamic Type Power Factor Meters**

1. Working forces are small as compared to moving iron type instruments.
2. The scale is not extended over 360$^o$.
3. Calibration of electrodynamometer type instruments are highly affected by the changing the supply voltage frequency.
4. They are quite costly as compared to other instruments.

## 4 A)(i) **Phase Sequence Indicator**

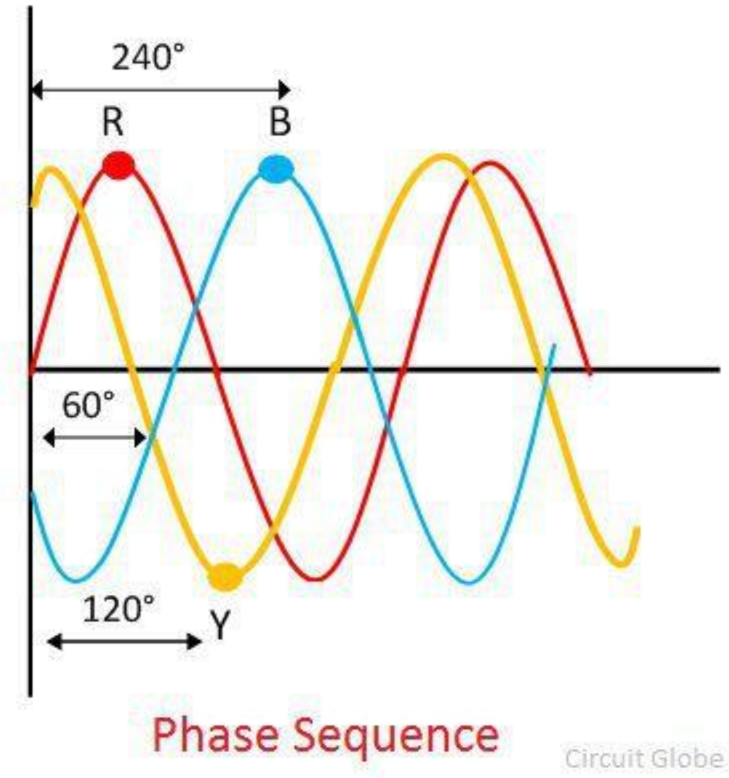
**Definition:** The instrument uses for determining the sequence of the three-phase system is known as the phase sequence indicator. The change in the sequence of the power supply changes the direction of rotation of the machine. Because of which the entire supply system will be affected.

For proper connection, it is essential to know the sequence of the phases which can be done by the use of the phase sequence indicator.

### What is Phase Sequence?

The phase sequence is the order of the phases in which the polyphase system attains their maximum value. Consider the R, Y and B are the three phases of the supply system. The phase angle between the three phases can determine by dividing the total number of phases by the 360°. In three phase system, the phases are split by an angle of 120°.

The waveforms for the three phases is shown in the figure below.




The below-given equations represent the value of each phase.

$$V_R = V_m Sin\omega t$$

$$V_Y = V_m Sin\omega t(\omega t - 120°)$$

$$V_B = V_m Sin\omega t(\omega t - 240°)$$

### Types of Phase Sequence Indicator

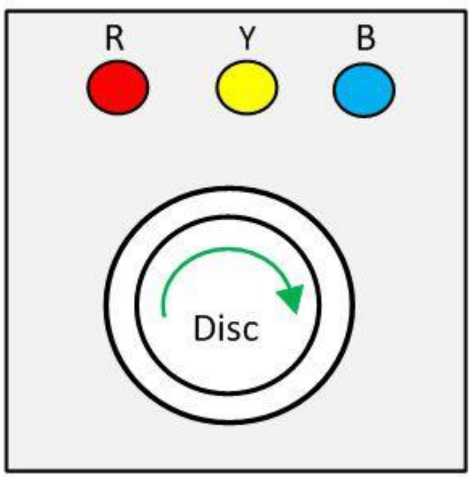
The phase sequence indicator is of two types. They are

- Rotating Type
- Static Type

Rotating Type Phase Sequence Indicators

The rotating type phase sequence indicators show the direction of the phase sequence by rotating the disc placed at the centre of the instrument. It has three terminals which are connected to the terminals of the measurand devices.

**The working principle of the rotating phase sequence indicator is similar to that of the induction motor**. The coils of the induction motor are star connected. The phase sequence of the power supply is RYB. When the supply is given to the motor coils, rotating magnetic fields induce in the coils. This rotating magnetic field induces the eddy EMF in the aluminium disc.

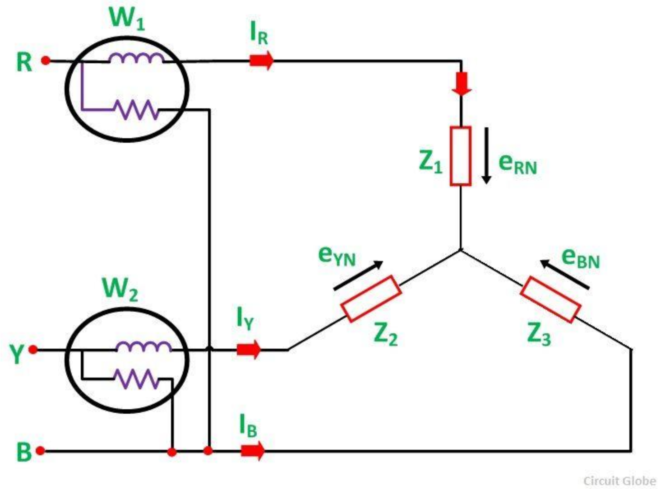


Rotating Type Phase Sequence Indicator

The eddy EMF causes the eddy current in the disc. The interaction of the eddy current and the rotating magnetic field produces the torque because of which the disc starts rotating.

The direction of the disc shows the phase sequence of the supply system. **If the disc rotates in the clockwise direction, the phase sequence is RYB. The anticlockwise direction of the aluminium disc is because of the reverse phase sequence.**

(ii) **Two Wattmeter** Method can be employed to measure the power in a 3 phase, three wire star or delta connected the balanced or unbalanced load. In Two wattmeter method the current coils of the wattmeter are connected with any two lines, say R and Y and the potential coil of each wattmeter is joined on the same line, the third line i.e. B as shown below in figure (A).




Considering the above figure (A) in which Two Wattmeter $W_1$ and $W_2$ are connected, the instantaneous current through the current coil of Wattmeter, $W_1$ is given by the equation shown below.

$$W_1 = i_R$$

Instantaneous potential difference across the potential coil of Wattmeter, $W_1$ is given as

$$W_1 = e_{RN} - e_{BN}$$

Instantaneous power measured by the Wattmeter, $W_1$ is

$$W_1 = i_R (e_{RN} - e_{BN}) \dots\dots\dots (1)$$

The instantaneous current through the current coil of Wattmeter, $W_2$ is given by the equation

$$W_2 = i_Y$$

Instantaneous potential difference across the potential coil of Wattmeter, $W_2$ is given as

$$W_2 = e_{YN} - e_{BN}$$

Instantaneous power measured by the Wattmeter, $W_2$ is

$$W_2 = i_Y (e_{YN} - e_{BN}) \quad \ldots\ldots\ldots..(2)$$

Therefore, the Total Power Measured by the Two Wattmeters $W_1$ and $W_2$ will be obtained by adding the equation (1) and (2).

4c) The Weston frequency meter is a moving iron instrument used for measuring the unknown frequency of a signal. The frequency meter consists one inductive and one resistive coil. When the frequency of the signal varies from standard frequency, the current distribution across the coils becomes changes.

**Working Principle of Weston Frequency Meter**

The Weston frequency meter works on the principle that whenever the frequency of the measurand 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.

**Note:** The inductive impedance is the opposition offered by the circuit in the flow of current whenever the voltage applied to the circuit.

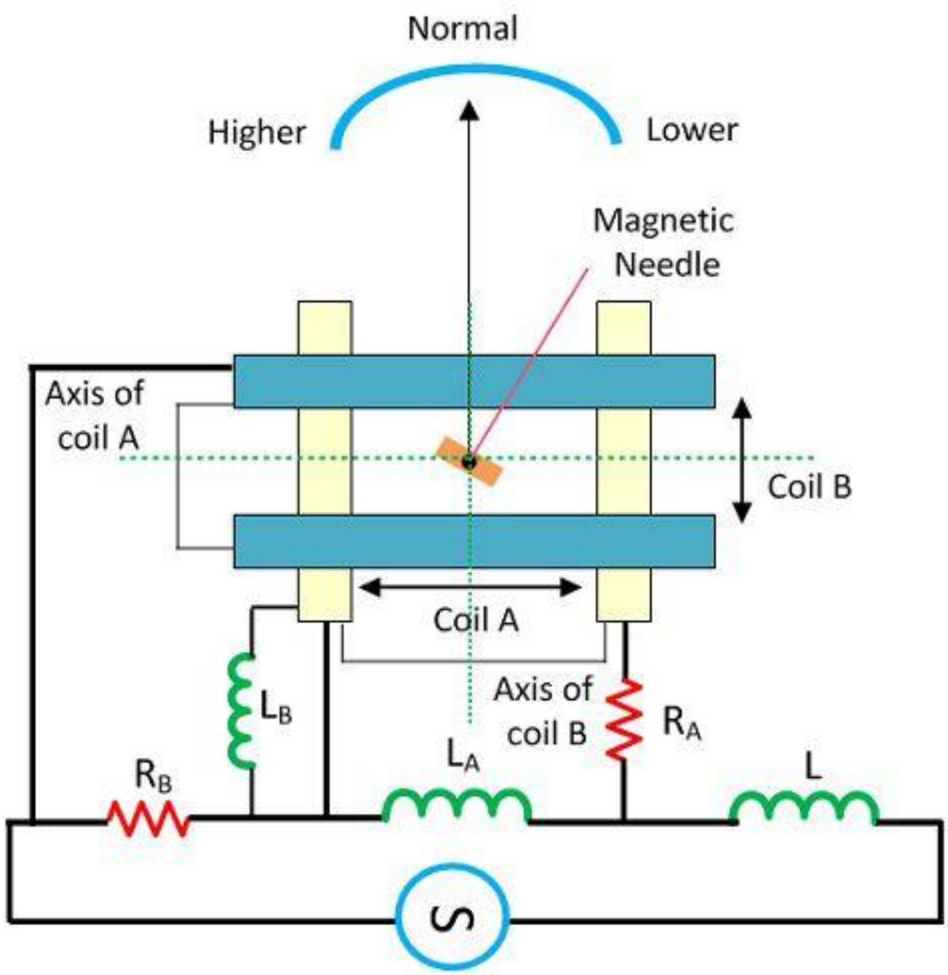
Construction of Weston Frequency Meter

The meter consists two coils which are placed perpendicular to each other. The resistor $R_A$ is connected in series with the coil A and the inductor $L_B$ is connected in series with the coil B. The inductor $L_A$ is connected in parallel with the coil A and the resistance $R_B$ is 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. The inductor L is connected in series with the $L_A$ and $R_B$. The L reduces the harmonics present in circuit current. Thereby, reduces the error of the instrument.

Working of Weston Frequency Meter

The circuit diagram of the Weston frequency meter is shown in the figure below.



Weston Frequency Meter
Circuit Globe

When the supply is given to the Weston frequency meter, 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 the same magnitude occurs across the reactance $L_A$ and resistance $R_B$. Hence equal current passes through the coil A and coil B.

The meter designs such a way that when the normal frequency passes through the coil then the voltage drops across the $L_A$, $L_B$, $R_A$, and $R_B$ remains same. Thus, same magnitude current passes through the coils. In this situation, the magnetic needle makes an angle of 45° concerning the coils and the soft iron needle places at the centre of the scale.

When the high frequency passes through the meter, the reactance $L_A$ and $L_B$ of the coil increases and the $R_A$ and $R_B$ remains same. The inductance increase 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, A current also decreases.

The more current flows through the coil B because of the parallel connections with coil A. The magnetic field develops in the coil B becomes stronger than the coil A. The magnetic needles align themselves parallel to the axis of the strong magnetic field, and the pointer deflects towards the coil B or strong magnetic field.

When the frequency of the measure and signal reduces from the normal value, the opposite action takes place, and the pointer deflects towards the left.

5 a) A Shunt is a passive element, usually resistive, that is used to bypass current around another element, like a meter, that is not able to handle the full current flow.

The voltage equivalent of this is the voltage Divider, once again usually resistive, which is used to block excessive voltage from an element that is not able to withstand the whole voltage.

A Multiplier is an active element that amplifies a voltage or current to enable a less sensitive device or circuit to make use of it.

5 b) **Instrument Transformers** are used in AC system for measurement of electrical quantities i.e. voltage, current, power, energy, power factor, frequency. **Instrument transformers** are also used with protective relays for protection of power system.
Basic function of **Instrument transformers** is to step down the AC System voltage and current. The voltage and current level of power system is very high. It is very difficult and costly to design the measuring instruments for measurement of such high level voltage and current. Generally measuring instruments are designed for 5 A and 110 V.

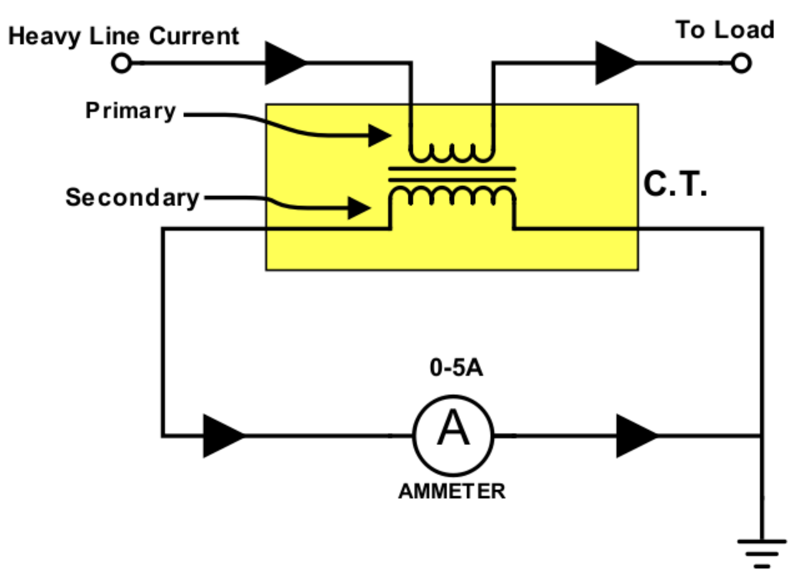
The measurement of such very large electrical quantities, can be made possible by using the Instrument transformers with these small rating measuring instruments. Therefore these instrument transformers are very popular in modern power system.

A transformer is a transformer whether *intended* for current sensing use or power conversion use. All transformers work on the same principle.
However, there is considerable latitude in various parameters when designing a transformer. These different tradeoffs give the transformer different characteristics and therefore make it suitable for different applications.

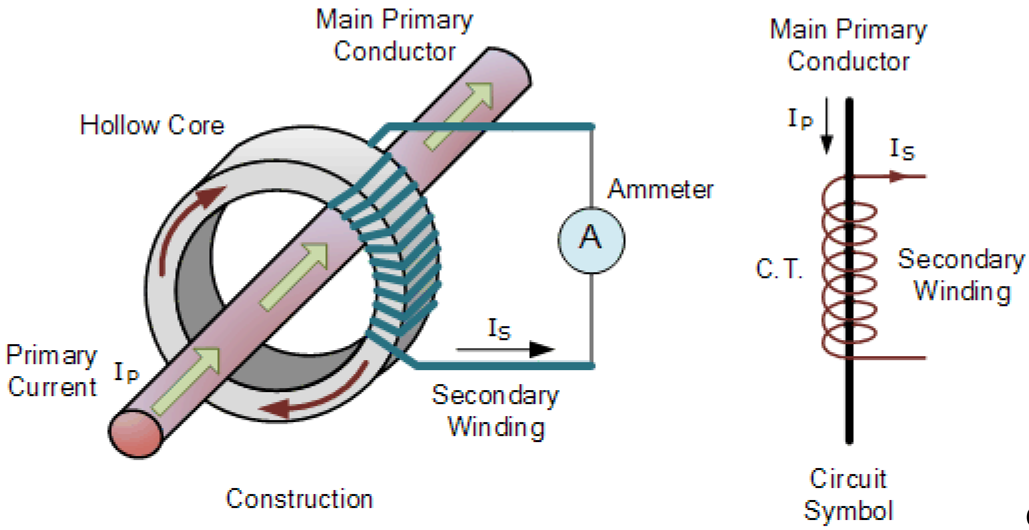
A current sense transformer is optimized to have small primary impedance so as to minimize the voltage drop in the line it is intended to measure current in. The secondary is also intended to be connected to a low resistance. This reflects a lower impedance to the primary. The transformer is run primarily in short-circuit output mode. Note that little power is transferred thru the transformer. Energy is taken from the magnetic field by the secondary almost as soon as it is put there by the primary. As a result, the core can be small since it never has to hold much energy at any one time.

A power transformer has a different purpose, which is to transfer power from the primary to the secondary. Sometimes they are just for isolation, but often it is also to get a different combination of voltage and current on the output than the input. To get power, you need both voltage and current, which means the transformer needs to be operated somehwere between short circuit output where there is no voltage and open circuit output where there is no current. Generally power transformers are designed so that the secondary looks reasonably low impedance and therefore it's voltage doesn't sag too much at the rated power output. They also have to behave reasonably with light load or no load, meaning the open circuit case. Again you want low impedance so that the voltage in the light load case is not too different from the full load case. This type of transformer has to be able to handle larger energy in the magnetic field. This means a physically larger and therfore heavier core.

5 c) A current transformer (CT) is a type of transformer that is used to measure AC current. It produces an alternating current (AC) in its secondary which is proportional to the AC current in its primary. Current transformers, along with voltage or potential transformers are Instrument transformer.
Current transformers are designed to provide a scaled-down replica of the current in the HV line and isolate the measuring instruments, meters, relays, etc., from the high voltage power circuit.
The large alternating currents which can not be sensed or passed through the normal ammeter, and current coils of wattmeters, energy meters can easily be measured by use of current transformers along with normal low range instruments.
**Current Transformer Symbol / Circuit Diagram**




Current Transformer Circuit Diagram
A **current transformer** (CT) basically has a primary coil of one or more turns of heavy cross-sectional area. In some, the bar carrying high current may act as a primary. This is connected in series with the line carrying high current.




CT construction and Circuit SymbolCurrent Transformer Circuit Symbols according to IEEE and IEC Standards

The secondary of the current transformer is made up of a large number of turns of fine wire having a small cross-sectional area. This is usually rated for 5A. This is connected to the coil of normal range ammeter._Working Principle of Current Transformer

These transformers are basically step-up transformers i.e. stepping up a voltage from primary to secondary. Thus the current reduces from primary to secondary.

So from the current point of view, these step down transformer, stepping down the current value considerably from primary to secondary.

Let,

$N_1$ = Number of Primary Turns

$N_2$ = Number of Secondary Turns

$I_1$ = Primary Current

$I_2$ = Secondary Current

For a transformer,

$\mathbf{I_1/I_2 = N_2/N_1}$

As $N_2$ is very high compared to $N_1$, the ratio $I_1$ to $I_2$ is also very high for current transformers. Such a current ratio is indicated for representing the range of the current transformer.

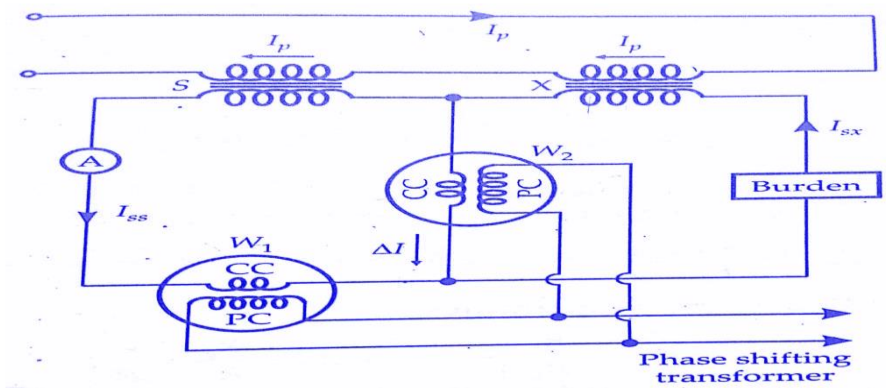
For example, consider a 500:5 range then it indicates that C.T. steps down the current from primary to secondary by a ratio 500 to 5.

$I_1/I_2 = 500/5$

Knowing this current ratio and the meter reading on the secondary, the actual high line current flowing through the primary can be obtained.

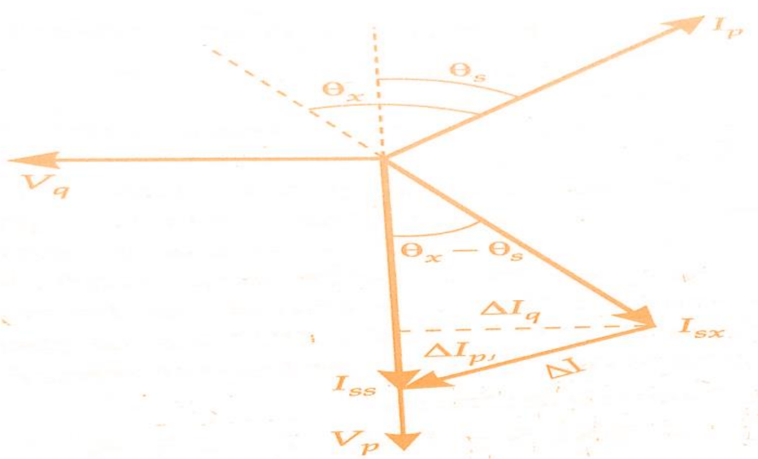
### 6 A) Silsbee's method of Testing:

Silsbee's method is a comparison method used for **Current Transformers testing**.There are two types of **Silsbee's methods**; deflectional and null.Only the deflectional method is described here. The arrangement for this method is shown schematically in below figure.Here the ratio and phase angle of the **test transformer** X are determined, in terms of that of a standard transformer S having the same nominal ratio.




The two transformers are connected with their primaries in series. An adjustable burden is put in the secondary circuit of the transformer under test.An ammeter is included in the secondary circuit of the standard transformer so that the current may be set to the desired value.W1 is a wattmeter whose current coil is connected to carry the secondary current of the standard transformer.

The current coil of wattmeter W2 carries a current ΔI which is the difference between the secondary currents of the standard and test transformers. The voltage circuits of the wattmeters (i.e., their pressure coils) are supplied in parallel from a phase shifting transformer at a constant voltage V.The phasor diagram is shown in the below figure.




1.The phase of the voltage is so adjusted that wattmeter W1 reads zero. Under these conditions, voltage V is in quadrature with current Iss.The position of voltage phasor for this case is shown as Vq.

Reading of wattmeter, W1,

$$W1q = Vq\ Iss \cos 90° = 0$$

Reading. of wattmeter, W2,

W2q = Vq x component of current ΔI in phase with

Vq = VqIq = Vq Isx sin(θx - θs)

where θx = phase angle of **current transformer under test**,
θs = phase angle of standard current transformers.

2. The phase of voltage V is shifted through 90° so that it occupies a position Vp and is in phase with Iss

Reading of wattmeter W1,

W1p = Vp Iss Cos θ = VpIss

Reading of wattmeter W2,

W2p = Vp x component of current Δl in phase with Vp

= Vp x ΔIp = Vp[Iss —Isx Cos(θx — θs)]

If the voltage is kept same for both sets of readings, then

V = Vp - Vq.

We have,

W2q = VIsx Sin(θx -θs), W1p =VIss

= VIss — Isx Cos(θx - θs)

= VIss —VIsx Cos(θx - θs)

≈ W1p —VIsx cos(θx - θs) ≈ W1p - VIsx

as (θx - θs) is very small and, therefore, cos (θx - θs) =1.

For above, VIsx =W1p — W2p.

Actual ratio of current transformer under test, Rx = Ip / Isx.

Actual ratio of the standard transformer, Rs = Ip /Iss.

$$\frac{R_x}{R_s} = \frac{I_{ss}}{I_{sx}} = \frac{VI_{ss}}{VI_{sx}} = \frac{W_{1p}}{W_{1p} - W_{2p}}$$

$$= \frac{1}{1-(W_{2p}/W_{1p})} \approx 1 + \frac{W_{2p}}{W_{2p}}$$

$$R_x = R_s\left(1+\frac{W_{2p}}{W_{1p}}\right),$$

$$\sin(\theta_x-\theta_s)=\frac{W_{2q}}{VI_{sx}},$$

$$(\cos\theta_x-\theta_s)=\frac{VI_{ss}-W_{2p}}{VI_{sx}}=\frac{W_{1p}-W_{2p}}{VI_{sx}}$$

$$\therefore \quad \tan(\theta_x-\theta_s)=\frac{W_{2q}}{W_{1p}-W_{2p}}$$

or $$(\theta_x-\theta_s)=\frac{W_{2q}}{W_{1q}-W_{2q}} \text{ rad.}$$

or phase angle of test transformer

$$\theta=\frac{W_{2q}}{W_{1p}-W_{2p}}+\theta_s \text{ rad.}$$

$$\approx\frac{W_{2q}}{W_{1p}}+\theta_s \text{ rad as } W_{2p} \text{ is small.}$$

Hence if the ratio and phase angle errors of the standard transformer are known, we can compute the errors of the **test transformer**.W2 must be a sensitive instrument.Its current coil may be designed for small values. It is normally designed to carry about 0.25 A for **testing Current Transformers** having a secondary current of 5A.

6 B) **ADVANTAGES OF CURRENT TRANSFORMERS**

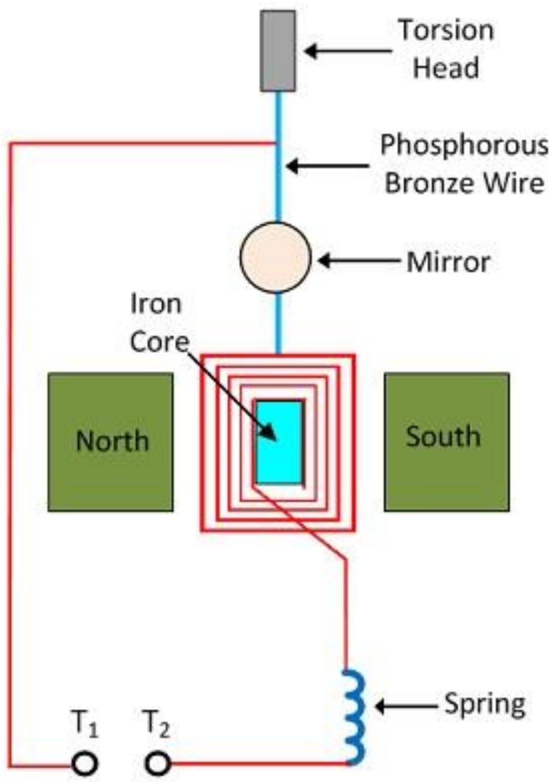
1. Very large currents can be measured through Instrument Transformer.
2. The readings do not depend upon resistance or inductance or capacitance of the transformer. Note that the primary and secondary windings of a Current transformer are not pure inductive coils. But they consist of all the three parameters i.e. R, L and C.
3. The ammeter is connected in the secondary winding. In this way, the measuring current is isolated from the power circuit which is very important point in high voltage system.
4. Several measuring instruments can be operated from a single Current transformer
5. The current transformers can be used to measure power or energy consumed by a circuit. In this case, a wattmeter or energy meter is connected with secondary of the current transformer. Current Transformer can also be used in power system to operate various relays.
6. They can also indicate power factor, frequency etc. of a power system.
7. They enable the small range instruments to measure large range. The 5A ammeter can read up to 1000 A.

6 C) **Ballistic Galvanometer**

**Definition: The galvanometer which is used for estimating the quantity of charge flow through it is called the ballistic galvanometer**. The working principle of the ballistic galvanometer is very simple. It depends on the deflection of the coil which is directly proportional to the charge passes through it. The galvanometer measures the majority of the charge passes through it in spite of current.

**Construction of Ballistic Galvanometer**

The ballistic galvanometer consists coil of copper wire which is wound on the non-conducting frame of the galvanometer. The phosphorous bronze suspends the coil between the north and south poles of a magnet. For increasing the magnetic flux the iron core places within the coil. The lower portion of the coil connects with the spring. This spring provides the restoring torque to the coil.




Ballistic Galvanometer

Circuit Globe

When the charge passes through the galvanometer, their coil starts moving and gets an impulse. The impulse of the coil is proportional to the charges passes through it. The actual reading of the galvanometer achieves by using the coil having a high moment of inertia. The moment of inertia means the body oppose the angular movement. If the coil has a high moment of inertia, then their oscillations are large. Thus, accurate reading is obtained.

Theory of Ballistic Galvanometer

Consider the rectangular coil having N number of turns placed in a uniform magnetic field. Let **l** be the length and **b** be the breadth of the coil. The area of the coil is given as

$$A = l \times b \ldots\ldots equ(1)$$

When the current passes through the coil, the torque acts on it. The given expression determines

$$\tau = NiBA \ldots\ldots equ(2)$$

the magnitude of the torque.

Let the current flow through the coil for very short duration says dt and it is expressed as

$$\tau dt = NiBAdt \ldots\ldots equ(3)$$

If the current passing through the coil for t seconds, the expression becomes

$$\int_0^t \tau dt = NBA \int_0^t idt = NBAq \ldots\ldots equ(4)$$

The q be the total charge passes through the coil. The moment of inertia of the coil is given by **l,** and the angular velocity through **ω.** The expression gives the angular momentum of the coil

$$Angular\ momentum\ = \ l\omega \ldots\ldots. equ(5)$$

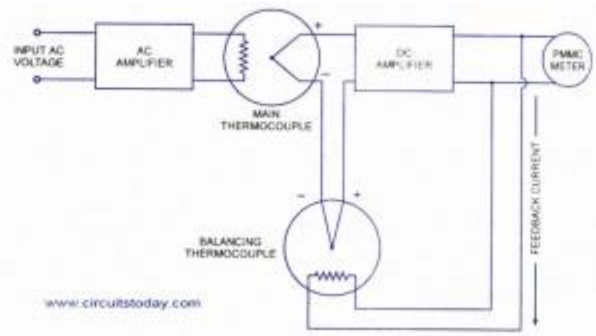
The angular momentum of the coil is equal to the force acting on the coil. Thus from equation (4) and (5), we get.

Calibration of Galvanometer

**The calibration of the galvanometer is the process of determining its constant value by the help of the practical experiments**. The following are the methods used for determining the constant of the ballistic galvanometer.

7 A) **Advantages of Electronic Measurement** The advantages of an electronic measurement are 1. Most of the quantities can be converted by transducers into the electrical or electronic signals. 2. An electrical or electronic signal can be amplified, filtered, multiplexed, sampled and measured. 3. The measurement can easily be obtained in or converted into digital form for automatic analysis and recording. 4 The measured signals can be transmitted over long distances with the help of cables or radio links, without any loss of information. 5. Many measurements can be carried either simultaneously or in rapid succession. 6. Electronic circuits can detect and amplify very weak signals and can measure the events of very short duration as well. 7. Electronic measurement makes possible to build analog and digital signals. The digital signals are very much required in computers. The modern development in science and technology are totally based on computers. 8. Higher sensitivity, low power consumption and a higher degree of reliability are the important features of electronic instruments and measurements. But, for any measurement, a well defined set of standards and calibration units is essential. This chapter provides an introduction to different types of errors in measurement, the characteristics of an instrument and different calibration standards.

**7 B) True RMS Reading Voltmeter**




*Block Diagram of True RMS Reading Voltmeter*

RMS Reading Voltmeter

RMS value of the sinusoidal waveform is measured by the **average reading voltmeter** of which scale is calibrated in terms of rms value. This method is quite simple and less expensive. But sometimes rms value of the non-sinusoidal waveform is required to be measured. For such a measurement a true rms reading voltmeter is required. True rms reading voltmeter gives a meter indication by sensing heating power of waveform which is proportional to the square of the rms value of the voltage.

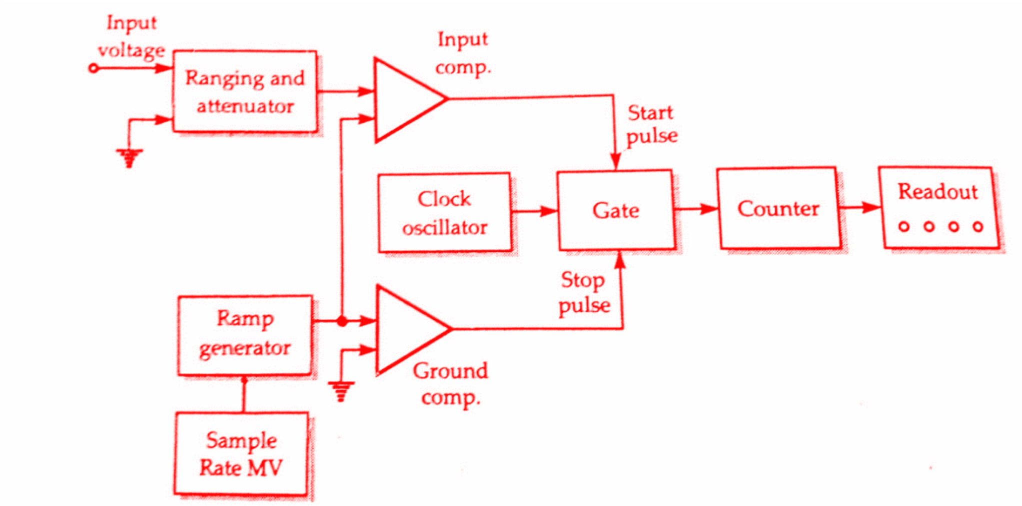
Thermo-couple is used to measure the heating power of the input waveform of which heater is supplied by the amplified version of the input waveform. Output voltage of the thermocouple is proportional to the square of the rms value of the input waveform. One more thermo-couple, called the balancing thermo-couple, is used in the same thermal environment in order to overcome the difficulty arising out of non-linear behaviour of the thermo-couple. Non-linearity of the input circuit thermo-couple is cancelled by the similar non-linear effects of the balancing thermo-couple. These thermo-couples form part of a bridge in the input circuit of a dc amplifier, as shown in block diagram.

AC waveform to be measured is applied to the heating element of the main thermocouple through an ac amplifier. Under absence of any input waveform, output of both thermo-couples are equal so error signal, which is input to dc amplifier, is zero and therefore indicating meter connected to the output of dc amplifier reads zero. But on the application of input waveform, output of main thermo-couple upsets the balance and an error signal is produced, which gets amplified by the dc amplifier and fedback to the heating element of the balancing thermo-couple. This feedback current reduces the value of error signal and ultimately makes it zero to obtain the balanced bridge condition. In this balanced condition, feedback current supplied by the dc amplifier to the heating element of the balance thermo-couple is equal to the ac current flowing in the heating element of main thermo-couple. Hence this direct current is directly proportional to the rms value of the input ac voltage and is indicated by the meter connected in the output of the dc amplifier. The PMMC meter may be calibrated to read the rms voltage directly.

By this method, rms value of any voltage waveform can be measured provided that the peak excursions of the waveform do not exceed the dynamic range of the ac amplifier.

7 C) What is Ramp Type Digital Voltmeter?

As we discussed already, the working principle of the basic digital voltmeter(DVM), now we will discuss one of its types **Ramp type digital voltmeter**. Digital voltmeter is an electrical measuring instrument used to display the potential difference between two points in the form of digits.




### Ramp Type Digital Voltmeter(DVM) Working Principle:

The block diagram shown above is **ramp type digital voltmeter(DVM)**. You can see there is a ramp generator. This is generating a waveform which is representing a ramp. The heart of the circuit is the ramp generator. Therefore it is called **ramp type digital voltmeter(DVM)**. The input which should be measured is given at input voltage. This input is fed to ranging and attenuator circuit which will amplify the signal if it is small or attenuates the signal if it is large.
This is given to an input comparator which will compare two signals and generates the output. One input to the input comparator is from the input voltage and another input is from the ramp. This input voltage and ramp signal are compared and output is given. If the ramp signal is more than input voltage there will be no output but if the input voltage is greater than the ramp signal then a is generated which will open the gate. Now when the gate gets opened, clock oscillator will send clock pulses which are counted by the counter and displayed on the screen.

The ground comparator will compare the ramp signal and ground and output is given. This output will stop the flow of purchase from clock by closing the gate. The sample rate multivibrator is used to reset the ramp generator. The operating **principle of ramp type digital voltmeter** is to measure the time that a linear ramp voltage takes to change from the level of the input voltage to zero voltage (or vice versa). This time interval is measured with an electronic time interval counter and the count is displayed as a number of digits on electronic indicating tubes of the output readout of the voltmeter.

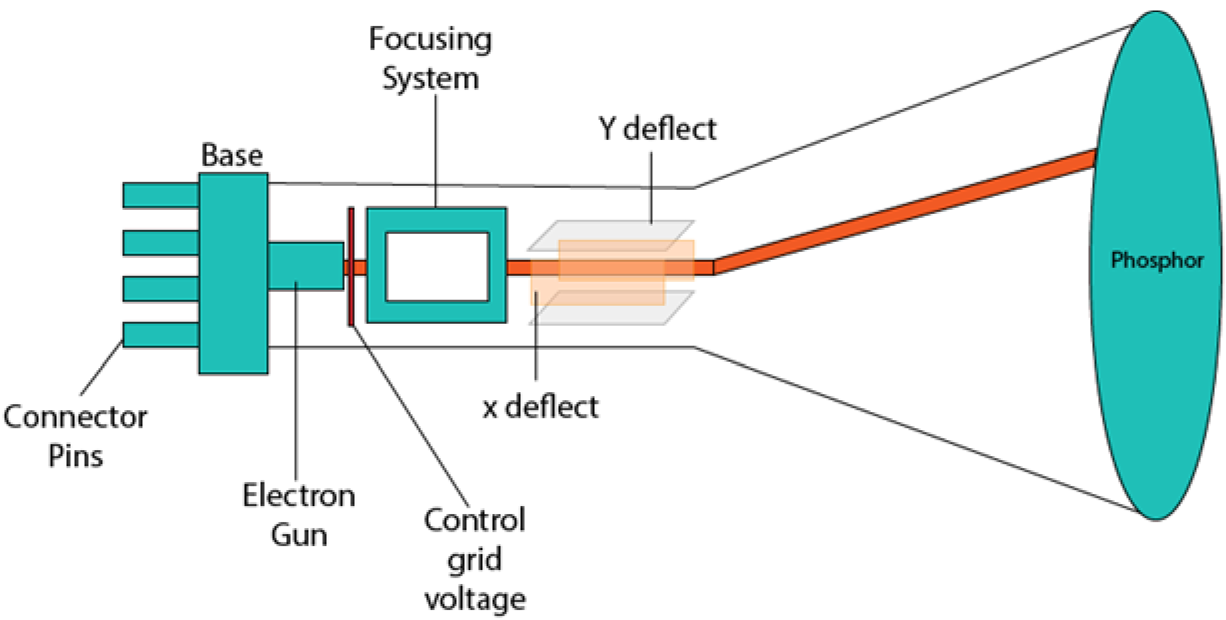
The conversion of a voltage value of a time interval is shown in the below timing diagram. At the start of measurement, a ramp voltage is initiated. A negative going ramp is shown in the below figure but a positive going ramp may also be used. The ramp voltage value is continuously compared with the voltage being measured (unknown voltage). At the instant, the value of ramp voltage is equal to that of unknown voltage a coincidence circuit, called an input comparator, generates a pulse which opens a gate (see above block diagram).

The ramp voltage continues to decrease till it reaches ground level (zero voltage). At this instant, another comparator called ground comparator generates a pulse and closes the gate. The time elapsed between the opening and closing of the gate is t as indicated in the below timing diagram of **ramp type digital voltmeter**. During this time interval pulses from a clock pulse generator pass through the gate and are counted and displayed.

## 8 A) Cathode Ray Tube (CRT):

CRT stands for Cathode Ray Tube. CRT is a technology used in traditional computer monitors and televisions. The image on CRT display is created by firing electrons from the back of the tube of phosphorus located towards the front of the screen.

Once the electron heats the phosphorus, they light up, and they are projected on a screen. The color you view on the screen is produced by a blend of red, blue and green light.




Cathode Ray Tube

## Components of CRT:

Main Components of CRT are:

**1.Electron Gun:** Electron gun consisting of a series of elements, primarily a heating filament (heater) and a cathode. The electron gun creates a source of electrons which are focused into a narrow beam directed at the face of the CRT.

**2. Control Electrode:** It is used to turn the electron beam on and off.

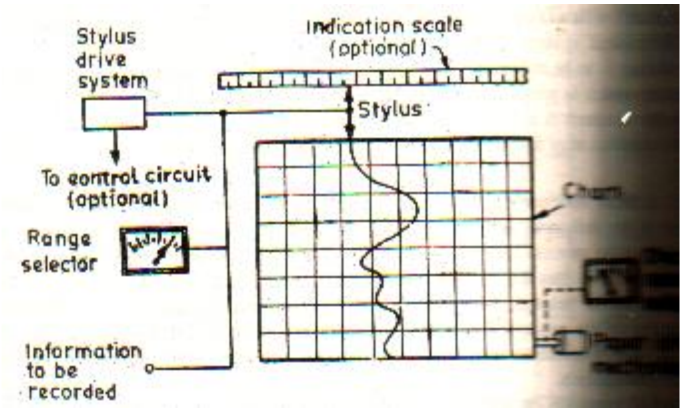
**3. Focusing system:** It is used to create a clear picture by focusing the electrons into a narrow beam.

**4. Deflection Yoke:** It is used to control the direction of the electron beam. It creates an electric or magnetic field which will bend the electron beam as it passes through the area. In a conventional CRT, the yoke is linked to a sweep or scan generator. The deflection yoke which is connected to the sweep generator creates a fluctuating electric or magnetic potential.

**5. Phosphorus-coated screen:** The inside front surface of every CRT is coated with phosphors. Phosphors glow when a high-energy electron beam hits them. Phosphorescence is the term used to characterize the light given off by a phosphor after it has been exposed to an electron beam.

9 B) STRIP CHART RECORDER It records one or more variables with respect to time. It is a X-t recorder. A strip chart recorder consists of: 1. A long roll of graph paper moving vertically. 2. A system for driving a paper at some selected speed. A speed selector switch is generally provided. Chart speed of 1-100 m/s are usually used. 3. A stylus driving system which moves the stylus in a near exact replica or analog of the quantity being recorded. A range selector switch is used so that input to the recorder drive system is with in the acceptable level. A. Paper drive system: The paper system should move the paper at a uniform speed. A spring would may be used but in most of the recorder a synchronous motor is used for driving the paper. B. Marking Mechanism: There are many types of mechanism used for making marks on the paper. The most commonly used ones are: 1. Marking with ink filled stylus. The stylus is filled with ink by gravity or capillary actions. This requires that ihe pointer shall support an ink reservoir and a pen, or capillary connection between the pen and a pen reservoir. In general red ink is used but other colours are available and in instrumentation display a colour code can be adopted. 2. Marking with headed stylus. Some recorders use a heated stylus which writes on a special paper. This method overcomes the difficulties encountered in ink writing systems. 3. Chopper Bar. If a chart made from a pressure sensitive paper is used a simple recording process is possible. A V-shaped pointer is passed under a chopper bar which presses the pen into the paper once per second thus making a series on the special paper. In fact this system is not purely continuous and hence is suitable for recording some varying quantities. 4. Electric stylus marking. This method employs a paper with a special coating which a sensitive to current. When current is conducted from the stylus to the paper, a trace appears on the paper. It is clear that the electric stylus marking method has a wide range of marking speeds, has low stylus friction and a long stylus life. The disadvantage is that the cost of paper is very high. C. Tracing system: There are two types of tracing system used for producing graphic representation. 1. Curvilinear system. In the curvilinear system, the stylus is mounted on a central pivot and moves through an are which allows a full width chart marking. If the stylus makes a full range recording, the line drawn across the chart will be curved and the time intervals will be along the curved segments. 2. Rectilinear system. It is notices that a line of constant time is perpendicular to the time axis and therefore this system produces a straight line across the width of the chart. Hence the stylus is actuated by a drive cord over pulleys to produce the forward and reverse motion

as determined by the drive mechanism. The stylus may be actuated by a self-balancing potentiometer system, a photoelectric deflection system, a photoelectric potentiometer system, or a bridge balance system. This system is usually used with thermal or electric wiring.




## Galvanometer Type Recorder:

The D'Arsonval movement used in moving coil indicating instruments can also provide the movement in a Galvanometer Type Recorder.

The D'Arsonval movement consists of a moving coil placed in a strong magnetic field, as shown in Fig. 12.2(a).

In a galvanometer type recorder, the pointer of the D'Arsonval movement is fitted with a pen-ink (stylus) mechanism. The pointer deflects when current flows through the moving coil. The deflection of the pointer is directly proportional to the magnitude of the current flowing through the coil.

As the signal current flows through the coil, the magnetic field of the coil varies in intensity in accordance with the signal. The reaction of this field with the field of the permanent magnet causes the coil to change its angular position. As the position of the coil follows the variation of the signal current being recorded, the pen is accordingly deflected across the paper chart.

The paper is pulled from a supply roll by a motor driven transport mechanism. Thus, as the paper moves past the pen and as the pen is deflected, the signal waveform is traced on the paper.

The recording pen is connected to an ink reservoir through a narrow bore tube. Gravity and capillary action establish a flow of ink from the reservoir through the tubing and into the hollow of the pen.

Galvanometer type recorders are well suited for low frequency ac inputs obtained from quantities varying slowly at frequencies of upto 100 c/s, or in special cases up to 1000 c/s.

Because of the compact nature of the galvanometer unit (or pen motor) this type of recorder is particularly suitable for multiple channel operation. Hence it finds extensive use in the simultaneous recording of a large number of varying transducers outputs.

This recorder uses a curvilinear system of tracing. The time lines on the chart must be arcs of radius R (where R is the length of the pointer), and the galvanometer shaft must be located exactly at the center of curvature of a time line arc. Improper positioning of the galvanometer or misalignment of the chart paper in the recorder can give a distorted response, i.e. having a negative rise time or a long rise time. One method of avoiding the distorted appearance of recordings in curvilinear coordinates is to produce the recording in rectangular coordinates. In this design, the chart paper is pulled over a sharp edge that defines the locus of the point of contact between the paper and the recording stylus. The stylus is rigidly attached to the galvanometer coil and wipes over the sharp edge as the coilrotates.

In one of the recorders, the paper used is usually heat sensitive, and the stylus is equipped with a heated tip long enough to guarantee a hot point of contact with the paper, regardless of the stylus position on the chart. Alternatively the paper can be electrically sensitive, in which case the stylus tip would serve to carry current into the paper at the point of contact.

The recorders can work on ranges ranging from a few mA/mV to several mA/mV. These moving galvanometer type recorders are comparatively inexpensive instruments, having a narrow bandwidth of 0 — 10 Hz. They have a sensitivity of about 0.4 V/mm, or from a chart of 100 mm width a full scale deflection of 40 mV is obtained.

In most instruments, the speed of the paper through the recorder is determined by the gear ratio of the driving mechanism. If it is desired to change the speed of the paper, one or more gears must be changed.

Paper speed is an important consideration for several reasons.

1. If the paper moves too slowly, the recorded signal variations are bunched up and difficult to read.
2. If the paper moves too fast, the recorded waveform will be so spread out that greater lengths of paper will be required to record the variations of the signal. It also makes the task of reading and interpreting the waveforms more difficult.
3. Also, the operator can determine the frequency components of the recorded waveform, if he knows how fast the paper has moved past the pen position. The paper is usually printed with coordinates, such as graph

Some recorders contain a timing mechanism that prints a series of small dots along the edge of the paper chart, as the paper moves through the recorder. This time marker produces one mark per second.

These types of recorders are mostly used as optical recorders, and contain a light source provided by either an ultra violet or tungsten lamp.

A small mirror is connected to the galvanometer movement and the light beam is focussed on this mirror, as shown in Fig. 12.2(b).

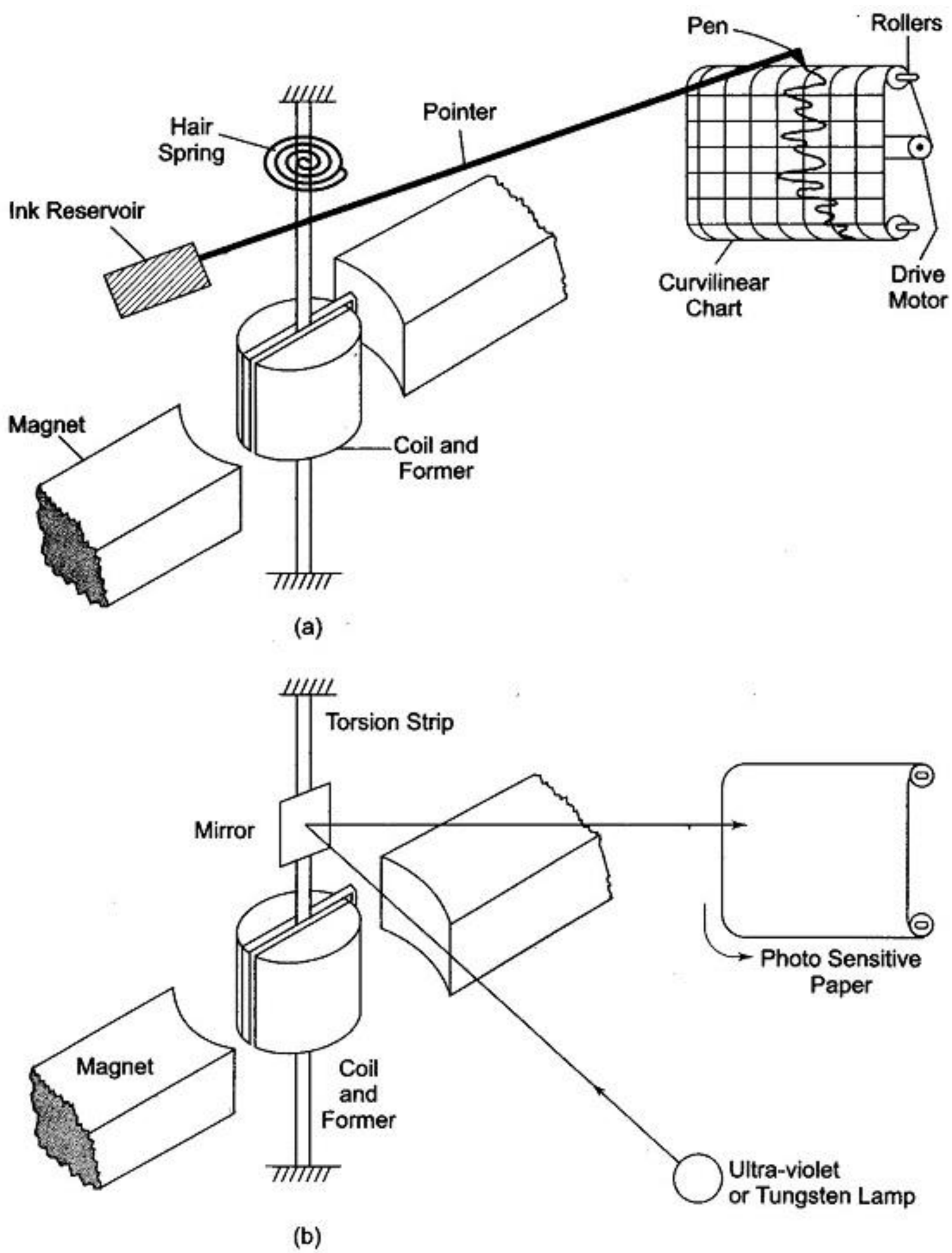



**Fig. 12.2** (a) Galvanometer Type Recorder
(b) Optical Galvanometer Recorder

The beam reflected from the mirror is focussed into a spot on a light sensitive paper.

As the current passes through the coil, the mirror deflects. The movement of the light beam is affected by the deflection of the small mirror, and the spot on the paper also varies for the same reason, thus tracing the waveform on the paper.

9 C) All of the PCs that we use need to have some displays. Normally there are the standard monitors, but they now are available in various varieties like LEC, LED. The evolution of the displays has not just only made the space that they contain become less, but also has made them more efficient. But, there are some certain disadvantages as well which are associated with the new types of displays, like in the CRT's, one could see the screen from any angel since the screen shape was a bit round. Now the flat screen has made the restriction that only that person, who is viewing it from the 180 degree angle, can see the screen properly. Following are the few displays types and their features in which these monitors are available;

Types:

The types of the displays that are being used currently and have been used since long are as follows;

CRT: CRT stands for Cathode Ray Tubes and is the very old style display which uses the florescent blue tube in itself and it projects the electrons to the screen at a time. These projections are responsible for creating the images on the screen. These monitors are pretty heavy and have been configured for some various sizes. They are available in the sizes of 15 inches, 19 inches and the 21 inches. Also, the cathode ray tubes have some other types of options as well. The thing is, the large would be the screen, the larger would be the tube and due to that, the weight would increase as well. Some of them come along with some specified types of the resolutions which can be 1028 x 1025, XGA etc. these displays contained the refresh rate which is that how fast the electrons can actually get sprayed on the screen and how fast the image can be changed and produced.

LCD: now the time has changed and CRT has been obsoleted. Now the new technology is of LCDs. It is the very common type of the display that one can find anywhere. This contains the liquid crystals and these displays do not contain the tubes. So, there isn't any electronic gun as well and one doesn't have to worry about the electrons painting the display. Instead, there is a back light that always keeps the liquid crystal display on. The power is given to a transistor which then repolarizes light and that's what enables the light to come out and show a specific colour. Since there is always a light that is shining through, the LCD displays do not contain the black set blacks. Also, if one does lots of the graphical work and hence the lots of work have to be shown, one should ensure that the backlight is always there and quality of LCD is pretty high.

LED: LED is another new technology which also has captured many of the consumer's choices. It is known as led since the backlight used in it is normally a fluorescent light and it is used instead of using a normal backlight. But, there is always the LCD there which gives the screen information and helps us having the view. So, it's even better if it is called LED Backlit LCD. The LED technology has been embedded in many ways. One of the ways is to have the LEDs at the edge of screen. Inside the display, there is a component named defuser which is responsible for the distribution of the light that comes through the whole back. Another method to use this technology is the usage of a whole array of LEDs. This array isn't just there on the edges, but they are spread across the all back side of the display. Hence the display gets lighter since it has more control of it. There is new type of LED too which has been introduced. It's called the organic LED display. It is created of some organic material which lights up if it is provided with a current. The cost of such LED is pretty low and this LED is mostly used in the mobile phones due to it fast speed and the good response time. The angel of viewing is also pretty wide. It all happens since the material used inside it is pretty organic.

Plasma: This is another new invention and it is named as the plasma display since there are some really small sized cells are present there. These cells are of the Nobel gases and when the voltage is provided to them, the ultra-violate ray is generated and the each light is brightened and hence the light is emitted through the display. Now, the phosphorus is being used instead of these cells and hence the colour quality has been improved a lot. So for those who work for the video editing and they require some good displays, this one is the good option. They use much power and the radio interfaces are put off as well. The interesting fact is that if one is living at some place which is above the sea level, the display won't be so effective so if one is living on some mountain area, he should make sure to check whether the specifications would work or not.

Projector: The projectors are now also being used and almost every organization use this to spread the information on the screen. The data can be projected at the wall and it can become visible to many people at the same time. These are also known as the CD projectors but the truth is, that there are many various technologies which are being used for that displays and the LCD is not the only option.

OLED: This technology is the new technology. It stands for the Organic Light emitting Diodes. This technology is the flat light emission one and it is made through some thin films which are organic and they are placed between two conductors. Whenever it gets hit by the electricity, the bright light comes out of it. These displays do not require some backlight and they are pretty thinner. So, they are better than all the LED and the LCD since they don't use the backlight to project an image.

## Refresh Rates

Refresh rate is actually important when one talks about the CRT displays. The rate was the measurement to tell how fast and efficient a CRT display is. The rate describes that how fast an electrons gun can throw electrons on the screen and how fast the display can be shown. The refresh rates for the devices, which were considered good, were between 65 and 75. Also, sometimes they reach 85 hertz as well. It meant that the screen could be refreshed around 85 times in just one second. But the thing is, the when the screens got bigger, it became a problem since the electrons has to cover the wider areas and the number of screen updates got reduced dramatically. When the refresh rate turned to 72 Hz or near it, that used to be a big problem since at the rate, the human eye started flickering. Also, it became so annoying while watching the display. Also, the important thing is that the display which could support some resolution desired by the people was shown at above 72 Hz. But the modern technology has allowed the LED and the LCD displays to update every single pixel on the screen instantly and hence one doesn't have to face the flickering or any other problem in viewing the display.

## Resolution

Doesnt matter what kind of display is owned by one. The most important thing that really matters is that what the resolution of that display is. The resolution is normally presented with the number of the pixels wide, the width, and the number of the pixels height. It indicates the pixel dimension, which is the total number of the pixel in every direction, regardless of the fact that the size is big or small. The XGA screens are the 1024 by 788 pixels. The other one is the SXGA, and has 1024 x 1024 pixels and they both are considered really well for the resolution. But now the pixels have been improved too and one can find the displays with some really high pixels which give some quality screen to the users.

Native Resolution: The LCD has some important specification and it is known as the native resolution for that display. When the CRTs were used, one could simply change the pixel size since it was in the tube. But now on the LCDs, it cannot be changed. The reason is that it would always have the specific number of the pixels high and the certain amount of the pixel wide. On the computers, the resolution can be changed easily and quickly. Also, the LCDs we use these days can adjust themselves according to that resolution that has been set by the user. If there is some mismatch that is happened between the pixel high and the wide, then the screen would look weird and some letters would be thin and some would be fat, as if they are trying to figure out what resolution should be adjusted to show the right images.

## Brightness/Lumens

When we talk about seeing some clear displays, we also talk about having the clear brightness. The brightness can be increased and decreased. The measurement of brightness is done through the luminance. It is also measures as the candela that is per square meter. One might also find it as the CD/M2. If the brightness is increased, the number would also shoot up the better quality is the display would be seen. Also, the brightness can be measured using the lumens. Many digital projectors use this one and if a projector's display has around three thousand lumens, it would work great in a room having some dim light. If it is six thousand, then it would work perfectly in the very dim room and if the light coming from outside isn't covered that much.

## Analog vs. Digital

The video signals that are sending to the display from the computers vary in their nature. There are the Analog signals which are mostly simple. The VGA display most likely send these simple and the continuous signals which are called the analoge signals. If the VGA display is pretty huge and it is plugged in, one would notice that it would take some time to get on. That's because we lose the signals. The Analog signals are lost during that time when they are being transited from the DE-15 interface of VGA that is installed on computers. Now, the modern monitors are having the digital signals. These signals are pretty much common in some HDMI interface since that can provide some really good output not only to the computers, but the TVs as well.

## Privacy/Antiglare Filters

Filters are added to the displays by the people and they have become pretty common. Especially if the work is being carried out in some environment where security is some important issue, then one would like putting up the security filter. These filters are easily visible and can be seen easily whether they are installed in the PC or a laptop. But if one changes the angel of view, the screen turns into the black or the golden colour. Since the monitors today are pretty glossy, there is another filter used for this which is the antiglare filter. It helps preventing the ambient light block our visions by creating some images on the screen. So, the visuals become really clear and the work can be done easily using this filter.

## Multiple Displays

If one is using a workstation, he might need more than one display so that the information can be seen all at once and it becomes easier for the user to work on it. One can put some various applications at the various places in the multiple screens. One can have the different things grouped up and shown on the other screens. Also, these displays can be used as the mirror as well and they can be shown to the other people who can know what one is doing on the computer.

Hence, knowing about the right monitor is very important since one might need the normal monitor but if he doesn't know what monitor to use, he might spend up lots of money on it. Another thing is, the location of the sure matters a lot as it is mentioned that at some places which are above the sea level, the displays may get distorted.

10 A) What is an Electrocardiograph (ECG) recorder?

A cardiac event recorder is a battery-powered portable device that you control to record your heart’s electrical activity (ECG) when you have symptoms.
Why ECG recorder is needed?
We know that ECG test can let your doctor look at your heart’s activity at rest and at one point in time, but heart attack is sporadic and started suddenly and nobody can predict when an attack will happen. Sometimes after you arrive at hospital, the symptom is disappeared and the doctor cannot diagnose your disease because your ECG result is normal at that time.
‘I kept feeling this pounding in my chest. My doctor suggested I wear an ECG event recorder, and soon I was put on medicine to control my fast heartbeat’, said Kay, age 61.

Kay provided a tip that ECG recorder can solve the problem mentioned above. An ECG recorder can monitor your ECG when the symptom come, then your doctor can analyze your cardiac event and find the reason of your symptom to adjust your medicines.
Specifically, not only people have symptoms such as chest pain, dizziness, faintness or feeling uncomfortable in heart need ECG recorder to monitor their health condition of heart. People age over 50 suffer from a great risk of coronary heart disease as their body function start to decay. What's more, you may find that a great number of middle age people are sub-healthy because they have to undertake heavy burden and work hard to beat against the increasingly competitive world. This could be serious potential health hazard and these people should monitor ECG periodically to record daily cardiac condition, which can help to discover healthy problem early and get treatment started ASAP before it's too late.
On the other hand, modern sports medicine now consider the ECG recorder as a biofeedback instrument and evaluator. From a study by Lee in 1966, it's found that a great part of male with CAD cannot reach target heart rate in sport.
What are the risks of ECG recorders?
Wearing an ECG recorder has no risks and causes no pain. If you wear electrode patches attached to your body and test ECG just like before, the adhesive might irritate your skin. But a new method which did not ask for an electrode patches emerged -- Simply touch certain points on the surface of the recorder can give you the ECG result, which causes no pain at all.

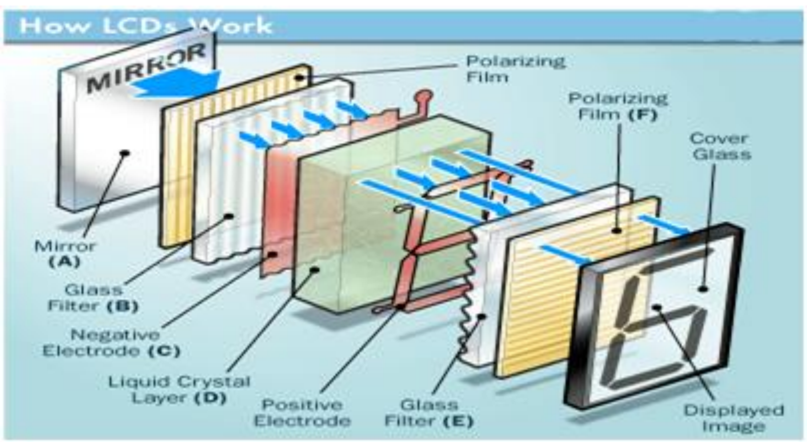
## 10 B) What is a LCD(Liquid Crystal Display)?

A liquid crystal display or LCD draws its definition from its name itself. It is combination of two states of matter, the solid and the liquid. LCD uses a liquid crystal to produce a visible image. Liquid crystal displays are super-thin technology display screen that are generally used in laptop computer screen, TVs, cell phones and portable video games. LCD's technologies allow displays to be much thinner when compared to cathode ray tube (CRT) technology.
Liquid crystal display is composed of several layers which include two polarized panel filters and electrodes. LCD technology is used for displaying the image in notebook or some other electronic devices like mini computers. Light is projected from a lens on a layer of liquid crystal. This combination of colored light with the grayscale image of the crystal (formed as electric current flows through the crystal) forms the colored image. This image is then displayed on the screen.

An LCD is either made up of an active matrix display grid or a passive display grid. Most of the Smartphone's with LCD display technology uses active matrix display, but some of the older displays still make use of the passive display grid designs. Most of the electronic devices mainly depend on liquid crystal display technology for their display. The liquid has a unique advantage of having low power consumption than the LED or cathode ray tube.

Liquid crystal display screen works on the principle of blocking light rather than emitting light. LCD’s requires backlight as they do not emits light by them. We always use devices which are made up of LCD’s displays which are replacing the use of cathode ray tube. Cathode ray tube draws more power compared to LCD’s and are also heavier and bigger.

## How LCDs are Constructed?



LCD Layered Diagram

Simple facts that should be considered while making an LCD:

1. The basic structure of LCD should be controlled by changing the applied current.
2. We must use a polarized light.
3. Liquid crystal should able be to control both of the operation to transmit or can also able to change the polarized light.

As mentioned above that we need to take two polarized glass pieces filter in the making of the liquid crystal. The glass which does not have a polarized film on the surface of it must be rubbed with a special polymer which will create microscopic grooves on the surface of the polarized glass filter. The grooves must be in the same direction of the polarized film. Now we have to add a coating of pneumatic liquid phase crystal on one of the polarized filter of the polarized glass. The microscopic channel cause the first layer molecule to align with filter orientation. When the right angle appears at the first layer piece, we should add a second piece of glass with the polarized film. The first filter will be naturally polarized as the light strikes it at the starting stage.

Thus the light travels through each layer and guided on the next with the help of molecule. The molecule tends to change its plane of vibration of the light in order to match their angle.  When the light reaches to the far end of the liquid crystal substance, it vibrates at the same angle as that of the final layer of the molecule vibrates. The light is allowed to enter into the device only if the second layer of the polarized glass matches with the final layer of the molecule.

A Light Emitting Diode (LED) is one of the latest inventions and is extensively used these days. From your cell phone to the large advertising display boards, the wide range of applications of these magical light bulbs can be witnessed almost everywhere. Today their popularity and applications are increasing rapidly due to some remarkable properties they have. Specifically, LEDs are very small in size and consume very little power. The magnificent, beautiful, dazzling colors involved with LEDs may be quite picturesque, but do you really know how these effects are actually created in them or rather how do LED light bulbs work?

## *Working Principle:*

A light-emitting diode is a two-lead semiconductor light source. It is a p–n junction diode that emits light when activated. When a suitable voltage is applied to the leads, electrons are able to recombine with electron holes within the device, releasing energy in the form of photons. This effect is called electroluminescence, and the color of the light (corresponding to the energy of the photon) is determined by the energy band gap of the semiconductor.

## 10 C) Liquid Vapour Display(LVD):

Liquid Vapour Display are the latest in economical display technology. They employ a new reflective passive display principle and depend on the presence of ambient lights for their operation. Figure 2.25 gives the structure of a typical LVD cell.

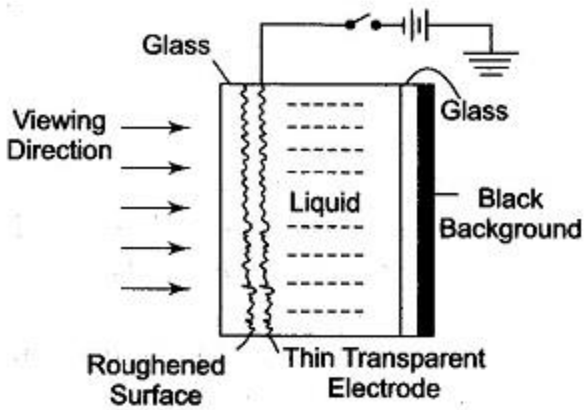


**Fig. 2.25** Structure of an LVD Cell

It consists of a transparent volatile liquid encased between two glass plates and side spacers. The rear glass plate has a black background and the front glass surface in contact with the liquid is roughened,
so that the liquid wets it, i.e. in its simplest form, an LVD consists of a roughened glass surface wetted with a transparent volatile liquid of the same refractive index as that of the glass. The rear surface is blackened.

The transparent electrode is heated by using a voltage drive, which is the basis for the display function.

In the OFF condition of display with no voltage applied across the transparent electrode, the viewer sees the black background through the front transparent glass electrode and the liquid.

To achieve an ON condition of the display, a voltage is applied to the transparent electrode. This causes sufficient heat in the electrode, which evaporates the liquid in contact with it, and a combination of vapour film and vapour bubbles is formed around the roughened glass surface. As the refractive index of vapour is approximately 1, there is a discontinuity established at the interface between the front glass plate and the liquid, which gives rise to light scattering. This makes it a simple display device.

The organic liquid selected for Liquid Vapour Display should have the following features.

1. **Refractive index close to that of the glass plate.**
2. **Minimum energy for vapourising the liquid in contact with the roughened**

The electrical heating of a thin film of liquid adjacent to the roughened surface using transparent electrodes and the applied voltage, makes it an unusually good display with a better contrast ratio than an LCD. The speed of operation of LVDs is low.