SWAMI VIVEKANANDASCHOOL OF ENGG. & TECH.

MADANPUR, BBSR

LECTURE NOTES

ON

ELECTRONICS MEASUREMENT & INSTRUMENTATION

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[CHAPTER-01]
QUALITIES OF MEASURMENT

1. *INSTRUMENT AND MEASUREMENT-*

1. *INSTRUMENT-*

It is a device for determining values or magnitude of a quantity or variable through a given set of formulas.

2. *MEASUREMENT-*

It is a process of comparing an unknown quantity with an accepted standard quantity.

1.1. *ELECTRONIC MEASUREMENT &INSTRUMENTATION-*

It is the branch of Electronics which deals with the study of measurement and variations of different parameters of various instruments.

- *Why measurement of parameters and study of variations for a particular instrument are required?*

  The measurement of parameters and its variations for a particular instrument is required because it helps in understanding the behaviour of an instrument.

1.2. *CONDITION FOR A MEASURING INSTRUMENT:-*

The measuring instrument must not affect the quantity which is to be measured.

2. *MEASUREMENT SYSTEM PERFORMANCE:-*

The performance of the measurement system/instruments are divided into two categories.

1. *Static Characteristics*
2. *Dynamic Characteristics*

2.1. ***STATIC CHARACTERISTICS OF INSTRUMENT-***

These are those characteristics of an instrument which do not vary with time and are generally considered to check if the given instrument is fit to be used for measurement.
The static characteristics are from one form or another by the process called Callibration.
They are as follows:-

1. *ACCURACY- It is defined as the ability of a device or a system to respond to a true value of a measure variable under condition.*
2. *PRECISION-Precision is the degree of exactness for which an instrument is design or intended to perform.*
3. *REPEATABILITY- The repeatability is a measuring device may be defined as the closeness of an agreement among a number of consecutive measurements of the output for the same value of the input under save operating system.*
4. *REPRODUCIBILITY- Reproducibility of an instrument is the closeness of the output for the same value of input. Perfect reproducibility means that the instrument has no drift.*
5. *SENSITIVITY- Sensitivity can be defined as a ratio of a change output to the change input at steady state condition.*

6. *RESOLUTION- Resolutions the least increment value of input or output that can be detected, caused or otherwise discriminated by the measuring device.*
7. *TRUE VALUE-True value is error free value of the measure variable it is given as difference between the Instrument Reading and Static error.*
Mathematically,

True value= Obtained Instrument reading – static error.

Note- $\%Error = \frac{\text{Standard Reference Value} - \text{Obtained Reading}}{\text{Standard Reference Value}} * 100$

2.2. *DYNAMIC CHARACTERISTICS OF INSTRUMENT-*

The Dynamic Characteristics are those which change within a period of time that is generally very short in nature.

1. *SPEED OF RESPONSE-It is the rapidity with which an instrument responds to the changes to in the measurement quantity.*
2. *FIDELITY-The degree to which an instrument indicate the measure variable without dynamic error.*
3. *LAG-It is retardation or delay in the response an instrument to the changes in the measurement.*

2.3. *ERROR- The deviation or change of the value obtained from measurement from the desired standard value.*

Mathematically,

Error = Obtained Reading/Value – Standard Reference Value.

There are three types of error. They are as follows:-

1. *GROSS ERRORS-This are the error due to humans mistakes such as careless reading mistakes in recoding observation incorrect application of an instrument.*

A. *SYSTEMATIC ERROR-A constant uniform deviation of an instrument is as systematic error. There are two types of systematic error.*

a) *STATIC ERROR-*

The static error of a measuring instrument is the numerical different between the true value of a quantity and its value as obtained by measurement.

b) *DYNAMIC ERROR-*

1. *It is the different between true value of a quantity changing with and value indicated by the instrument.*
2. *The Dynamic Errors are caused by the instrument not responding fast enough to follow the changes in the measured value.*

B. *RANDOM ERROR-The cause of such error is unknown or not determined in the ordinary process of making measurement.*

2.3.1. *TYPES OF STATIC ERROR-*

i. *INSTRUMENTAL ERROR- Instrumental error are errors inherent in mastering instrument because of the mechanical construction friction is bearing in various moving component. It can be avoided by*

   a. *Selecting a suitable instrument for the particular measurement.*
   b. *Applying correction factor after determining the amount of instrumental error.*

ii. *ENVIROMENTAL ERROR –Environmental error are due to conditions external to the measuring device including condition al in the area surrounding the instrument such as effect of change in temperature , humidity or electrostatic field it can be avoided*

   a. *Providing air conditioning.*
   b. *Use of magnetic shields.*

iii. *OBSERVATIONAL ERROR- The errors introduced by the observer. These errors are caused by habits of the observers like tilting his/her head too much while reading a "Needle – Scale Reading".*

CHAPTER-02

INDICATING INSTRUMENT

2.1. INTRODUCTION

2.1.1. MEASURING INSTRUMENTS:-

Measuring instruments are classified according to both the quantity measured by the instrument and the principle of operation.

There are three general principles of operation:

- electromagnetic, which utilizes the magnetic effects of electric currents;
- electrostatic, which utilizes the forces between electrically-charged conductors;
- Electro-thermic, which utilizes the heating effect.

The essential requirements of measuring instruments are:-

- It must not alter the circuit conditions.
- It must consume very small amount of power.

Electric measuring instruments and meters are used to indicate directly the value of current, voltage, power or energy.

An electromechanical meter (input is as an electrical signal results mechanical force or torque as an output) that can be connected with additional suitable components in order to act as an ammeters and a voltmeter.

The most common analogue instrument or meter is the permanent magnet moving coil instrument and it is used for measuring a dc current or voltage of an electric circuit.

2.1.2. TYPES OF FORCES/TORQUES ACTING IN MEASURING INSTRUMENTS:

1. DEFLECTING TORQUE/FORCE:

- The defection of any instrument is determined by the combined effect of the deflecting torque/force, control torque/force and damping torque/force.
- The value of deflecting torque must depend on the electrical signal to be measured.
- This torque/force causes the instrument movement to rotate from its zero position.

2. CONTROLLING TORQUE/FORCE:

- This torque/force must act in the opposite sense to the deflecting torque/force, and the movement will take up an equilibrium or definite position when the deflecting and controlling torque are equal in magnitude.
- The Spiral springs or gravity usually provides the controlling torque.

3. DAMPING TORQUE/FORCE:

- A damping force is required to act in a direction opposite to the movement of the moving system.
- This brings the moving system to rest at the deflected position reasonably quickly without any oscillation or very small oscillation.

- This is provided by
  - i) Air friction
  - ii) Fluid friction
  - iii) Eddy current.
- It should be pointed out that any damping force shall not influence the steady state deflection produced by a given deflecting force or torque.
- Damping force increases with the angular velocity of the moving system, so that its effect is greatest when the rotation is rapid and zero when the system rotation is zero.

2.2. BASIC METER MOVEMENT &PMMC MOVEMENT

2.2.1. BASIC METER MOVEMENT OR D'ARSONVAL METER MOVEMENT

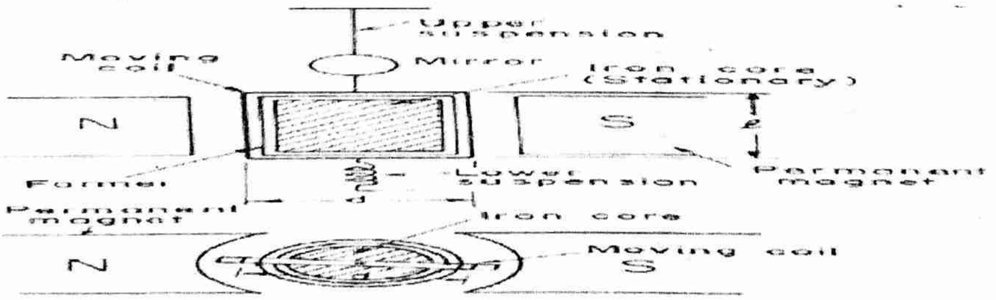
PRINCIPLE:-

Whenever electrons flow through a conductor, a magnetic field proportional to the current is created. This effect is useful for measuring current and is employed in many practical meters.

- The basic dc meter movement is known as the D'Arsonval meter movement because it was first employed by the French scientist, D'Arsonval, in making electrical measurement.
- This type of meter movement is a current measuring device which is used in the ammeter, voltmeter, and ohmmeter.
- An ohmmeter is also basically a current measuring instrument, it differs from the ammeter and voltmeter in that it provides its own source of power and contains other auxiliary circuits.

D'ARSONVAL GALVANOMETER:

This instrument is very commonly used in various methods of resistance measurement and also in d.c. potentiometer work.



Fig

1) MOVING COIL:

- It is the current carrying element.
- It is either rectangular or circular in shape and consists of number of turns of fine wire.
- This coil is suspended so that it is free to turn about its vertical axis of symmetry.
- It is arranged in a uniform, radial, horizontal magnetic field in the air gap between pole pieces of a permanent magnet and iron core.

- The iron core is spherical in shape if the coil is circular but is cylindrical if the coil is rectangular.
- The iron core is used to provide a flux path of low reluctance and therefore to provide strong magnetic field for the coil to move in.
- This increases the deflecting torque and hence the sensitivity of the galvanometer. The length of air gap is about 1.5mm.
- In some galvanometers the iron core is omitted resulting in of decreased value of flux density and the coil is made narrower to decrease the air gap.
- Such a galvanometer is less sensitive, but its moment of inertia is smaller on account of its reduced radius and consequently a short periodic time.

2) DAMPING:

- There is a damping torque present owing to production of eddy currents in the metal former on which the coil is mounted.
- Damping is also obtained by connecting a low resistance across the galvanometer terminals.
- Damping torque depends upon the resistance and we can obtain critical damping by adjusting the value of resistance.

3) SUSPENSION:

- The coil is supported by a flat ribbon suspension which also carries current to the coil.
- The other current connection in a sensitive galvanometer is a coiled wire. This is called the lower suspension and has a negligible torque effect.
- This type of galvanometer must be leveled carefully so that the coil hangs straight and centrally without rubbing the poles or the soft iron cylinder.
- The upper suspension consists of gold or copper wire of nearly 0.012-5 or 0.02-5 mm diameter rolled into the form of a ribbon.
- This is not very strong mechanically so that the galvanometers must he handled carefully without jerks.

4) INDICATION:

- The suspension carries a small mirror upon which a beam of light is cast. The beam of light is reflected on a scale upon which the deflection is measured. This scale is usually about 1 meter away from the instrument, although ½ meter may be used for greater compactness.

5) ZERO SETTING:

- A torsion head is provided for adjusting the position of the coil and also for zero setting.

2.2.2. PMMC INSTRUMENTS:

- These instruments are used either as ammeters or voltmeters and are suitable for d.c work only.
- PMMC instruments work on the principle that, when a current carrying conductor is placed in a magnetic field, a mechanical force acts on the conductor.
- The current carrying coil, placed in magnetic field is attached to the moving system.
- With the movement of the coil, the pointer moves over the scale to indicate the electrical quantity being measured.
- This type of movement is known as D' Arsenoval movement.

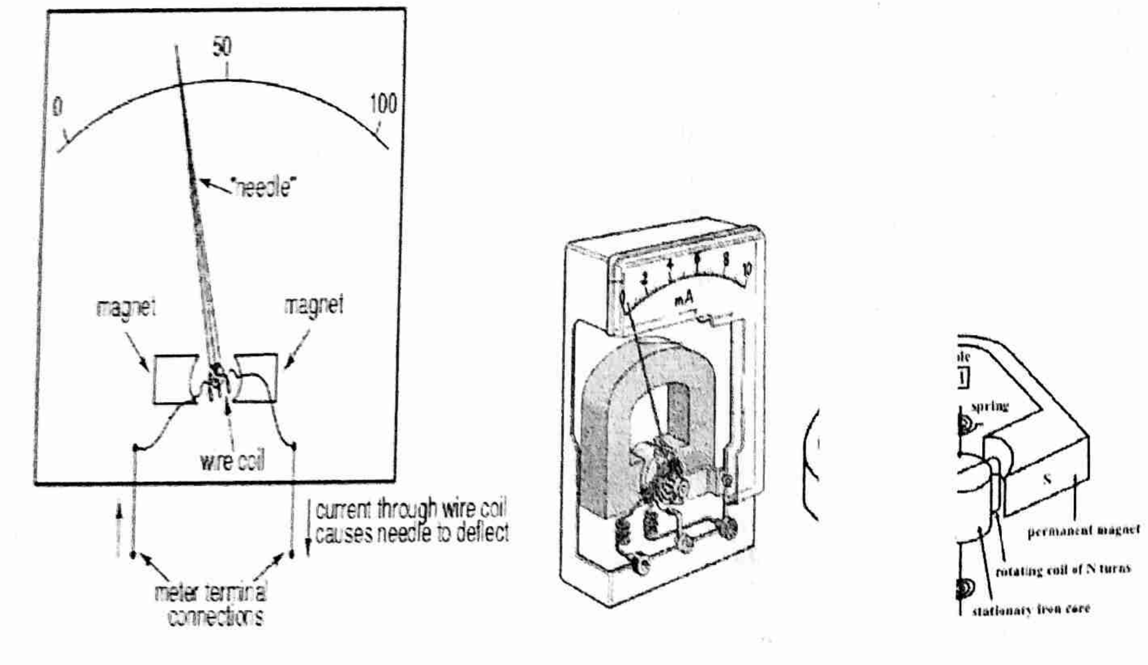
CONSTRUCTION:

- It consists of a light rectangular coil of many turns of fine wire wound on an aluminium former inside which is an iron core as shown in fig.
- The coil is delicately pivoted upon jewel bearings and is mounted between the poles of a permanent horse shoe magnet.
- Two soft-iron pole pieces are attached to these poles to concentrate the magnetic field.
- The current is led in to and out of the coils by means of two control hair- springs, one above and other below the coil, as shown in Fig.
- These springs also provide the controlling torque. The damping torque is provided by eddy currents induced in the alluminium former as the coil moves from one position to another.

WORKING:

- When the instrument is connected in the circuit to measure current or voltage, the operating current flows through the coil.
- Since the current carrying coil is placed in the magnetic field of the permanent magnet, a mechanical torque acts on it.
- As a result of this torque, the pointer attached to the moving system moves in clockwise direction over the graduated scale to indicate the value of current or voltage being measured.
- This type of instruments can be used to measure direct current only.
- This is because, since the direction of the field of permanent magnet is same, the deflecting torque also gets reversed, when the current in the coil reverses.
- Consequently, the pointer will try to deflect below zero. Deflection in the reverse direction can be prevented by a "stop" spring.

Permanent magnet, moving coil (PMMC) meter movement



Fig

DEFLECTING TORQUE EQUATION:-

- The magnetic field in the air gap is radial due to the presence of soft iron core. Thus, the conductors of the coil will move at right angles to the field. When the current is passed through the coil, forces act on its both sides which produce the deflecting torque.

Let, B = flux density, Wb/m2
l = length or depth of coil, m
b = breadth of the coil.
N = no. of turns of the coil.

- If a current of 'I' Amperes flows in the coil, then the force acting on each coil side is given by,

Force on each coil side, F = BIlN Newtons.

- Deflecting torque, T_d = Force × perpendicular distance
= (BIlN) × b
T_d = BINA Newton metre.

Where, A = l × b, the area of the coil in m^2.

- Thus, $T_d \alpha I$
- The instrument is spring controlled so that, $T_c \alpha \theta$
- The pointer will comes to rest at a position, where $T_d = T_c$
- Therefore, $\theta \alpha I$.
- Thus, the deflection is directly proportional to the operating current.
- Hence, such instruments have uniform scale.

ADVANTAGES:

a) Uniform scale.ie, evenly divided scale.
b) Very effective eddy current damping.
c) High efficiency.
d) Require little power for their operation.
e) No hysteresis loss (as the magnetic field is constant).
f) External stray fields have little effects on the readings (as the operating magnetic field is very strong).
g) Very accurate and reliable.

DISADVANTAGES:

a) Cannot be used for a.c measurements.
b) More expensive (about 50%) than the moving iron instruments because of their accurate design.
c) Some errors are caused due to variations (with time or temperature) either in the strength of permanent magnet or in the control spring.

APPLICATIONS:

a) In the measurement of direct currents and voltages.
b) In d.c galvanometers to detect small currents.
c) In Ballistic galvanometers used for measuring changes of magnetic flux linkages.

2.3. OPERATION OF MOVING IRON INSTRUMENT:-

Moving Iron instruments are mainly used for the measurement of alternating currents and voltages, though it can also be used for d.c measurements.

PRINCIPLE OF MOVING IRON INSTRUMENT:-

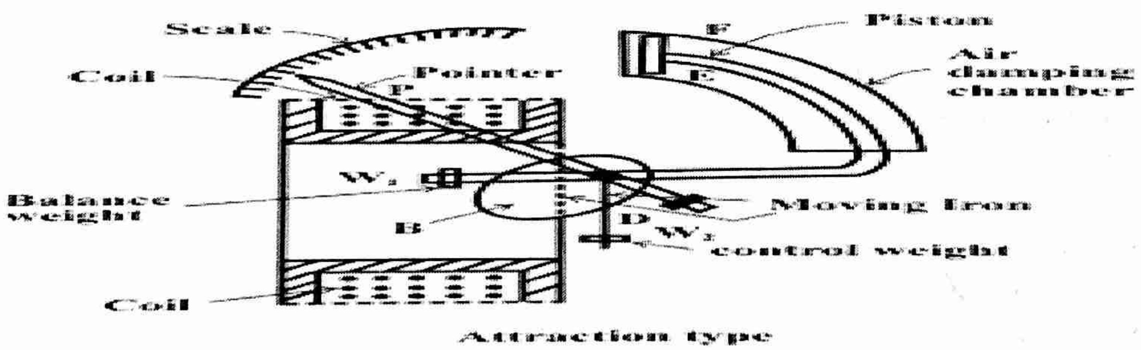
- Let a plate or vane of soft iron or of high permeability steel forms the moving element of the system.
- The iron vane is situated so as, it can move in a magnetic field produced by a stationary coil.
- The coil is excited by the current or voltage under measurement.
- When the coil is excited, it becomes an electromagnet and the iron vane moves in such a way so as to increase the flux of the electromagnet.
- Thus, the vane tries to occupy a position of minimum reluctance.
- Thus, the force produced is always in such a direction so as to increase the inductance of the coil.

TYPES OF MOVING IRON INSTRUMENTS:

There are two types of Moving- iron instruments

1. **ATTRACTION TYPE:**

In this type of instrument, a single soft iron vane (moving iron) is mounted on the spindle, and is attracted towards the coil when operating current flows through it.



Fig

DEFLECTING TORQUE EQUATION:

- The force F, pulling the soft -iron piece towards the coil is directly proportional to
    a) Field strength (H) produced by the coil.
    b) Pole strength (m) developed in the iron piece.
- $F \alpha Mh$ Since $m \alpha H$,
- Therefore $F \alpha H^2$
- Instantaneous deflecting torque αH^2.
- The field strength $H = \mu i$.
- If the permeability (μ) of the iron is assumed constant, then $H \alpha I$.
  Where $i \rightarrow$ instantaneous coil current (Ampere).
- Instantaneous deflecting torque αi^2.
- Average deflecting torque, $T_d \alpha$ mean of i^2 over a cycle.
- Since the instrument is spring controlled, hence $T_c \alpha \theta$.

- In the steady position of deflection, $T_d = T_c$.
- Therefore θ α mean of i^2 over a cycle => θ α I^2(mean of i^2 over a cycle = I^2).
- Since the deflection is proportional to the square of coil current, the scale of such instruments is non-uniform (being crowded in the beginning and spread out near the finishing end of the scale).

2. **REPULSION TYPE:-**

- In this two soft iron vanes are used; one fixed and attached the stationary coil, while the other is movable (moving iron), and mounted on the spindle of the instrument.
- When operating current flows through the coil, the two vanes are magnetized, developing similar polarity at the same ends.
- Consequently, repulsion takes place between the vanes and the movable vane causes the pointer to move over the scale.
- It is of two types:-

a) Radial vane type: - vanes are radial strips of iron.
b) Co-axial vane type:-vanes are sections of coaxial cylinders.

DEFLECTING TORQUE:

- The deflecting torque results due to repulsion between the similarly charged soft- iron pieces or vanes.
- If the two pieces develop pole strength of m_1 and m_2 respectively, then Instantaneous deflecting torque is α $m_1 m_2$ α H^2.
- If the permeability of iron is assumed constant, then H α i, where i is the coil current.
- Instantaneous deflecting torque α i^2.
- Average deflecting torque, T_d α mean of i^2 over a cycle.
- Since the instrument is spring controlled, T_c α θ.
- In the steady position of deflection, $T_d = T_c$ i.e. θ α mean of i^2 over a cycle => θ α I^2 (mean of i^2 over a cycle = I^2).
- Thus, the deflection is proportional to the square of the coil current.
- The scale of the instrument is non- uniform being crowded in the beginning and spread out near the finish end of the scale.
- However, the non- linearity of the scale can be corrected to some extent by the accurate shaping and positioning of the iron vanes in relation to the operating coil.

2.4. PRINCIPLE OF OPERATION OF DC AMMETER AND MULTIRANGE AMMETER

2.4.1. D.C. AMMETER:-

- The PMMC galvanometer constitutes the basic movement of a dc ammeter.
- The coil winding of a basic movement is small and light, so it can carry only very small currents.
- A low value resistor (shunt resistor) is used in DC ammeter to measure large current.
- PMMC movement can be used as DC ammeter by connecting resistor in shunt with it, so that shunt resistance allows a specific fraction of current [excess current greater than full scale deflection current (IFSD)] flowing in the circuit to bypass the meter movement.

- The fractions of the current flowing in the movement indicate the total current flowing in the circuit.
- DC ammeter can be converted into multirange ammeter by connecting number of resistances called multiplier in parallel with the PMMC movement.
- Let R_m = internal resistance of the movement.
  - ⇨ I = full scale current of the ammeter + shunt (i.e. total current)
  - ⇨ R_{sh} = shunt resistance in ohms.
  - ⇨ I_m = full-scale deflection current of instrument in ampere.
  - ⇨ $I_{sh} = (I - I_m)$ = shunt current in ampere.
- Since the shunt resistance is in parallel with the meter movement, the voltage drop across the shunt and movement must be the same.
- Therefore, $V_{sh} = V_m$
  - ⇨ $I_{sh}R_{sh} = I_mR_m$,
  - ⇨ $R_{sh} = (I_mR_m)/I_{sh}$
- But $I_{sh} = I - I_m$
  - ⇨ Hence $R_{sh} = (I_mR_m) / (I-I_m)$.
  - ⇨ $(I-I_m)/I_m = R_m/R_{sh}$
  - ⇨ $(I/I_m)-1 = R_m/R_{sh}$
  - ⇨ $I/I_m = 1+ R_m/R_{sh}$.
- The ratio of the total current to the current in the movement is called Multiplying Power of the Shunt i.e Mathematically, Multiplying Power (m) $= I/I_m = 1+ R_m/R_{sh}$.

2.4.2. MULTIRANGE DC AMMETER:

- The range of the dc ammeter is extended by a number of shunts, selected by a range switch. Such a meter is known as Multirange DC Ammeter.
- The resistors is placed in parallel to give different current ranges.

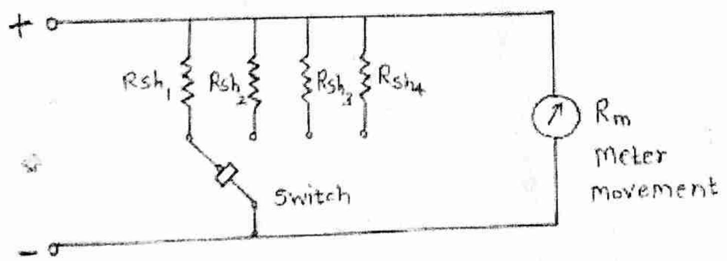


Fig.2.5

- Above figure shows a diagram of multirange ammeter.
- The circuit has 4 shunts R_{sh1}, R_{sh2}, R_{sh3} and R_{sh4} which can be put in parallel with meter movement to give 4 different current ranges I_1, I_2, $I_3$and I_4.

  Let m_1, m_2, m_3 and m_4 be the shunt multiplying powers for currents I_1, I_2, I_3 and I_4.
  - ⇨ $R_{sh1} = R_m/(m_1-1)$
  - ⇨ $R_{sh2} = R_m/(m_2-1)$
  - ⇨ $R_{sh3} = R_m/(m_3-1)$
  - ⇨ $R_{sh4} = R_m/(m_4-1)$
- In the Ammeter the multiposition make-before-break switch is used.

- This type of switch is essential in order that meter movement is not damaged when changing from the current range one to another.
- If we provide an ordinary switch the meter remains without a shunt and it is unprotected and therefore it can be damaged when the range is changed.
- Multirange Ammeters are used for the range from the 1 to 50 A.

2.5. AC AMMETER AND MULTIRANGE AMMETERS:

- The PMMC movement cannot be used directly for ac measurements since the inertia of PMMC acts as an averager.
- Because A.C. current has zero average value and it produces a torque that has also zero average value, the pointer just vibrates around zero on the scale.
- In order to make ac measurements, a bridge rectifier circuit is combined with PMMC as shown below.

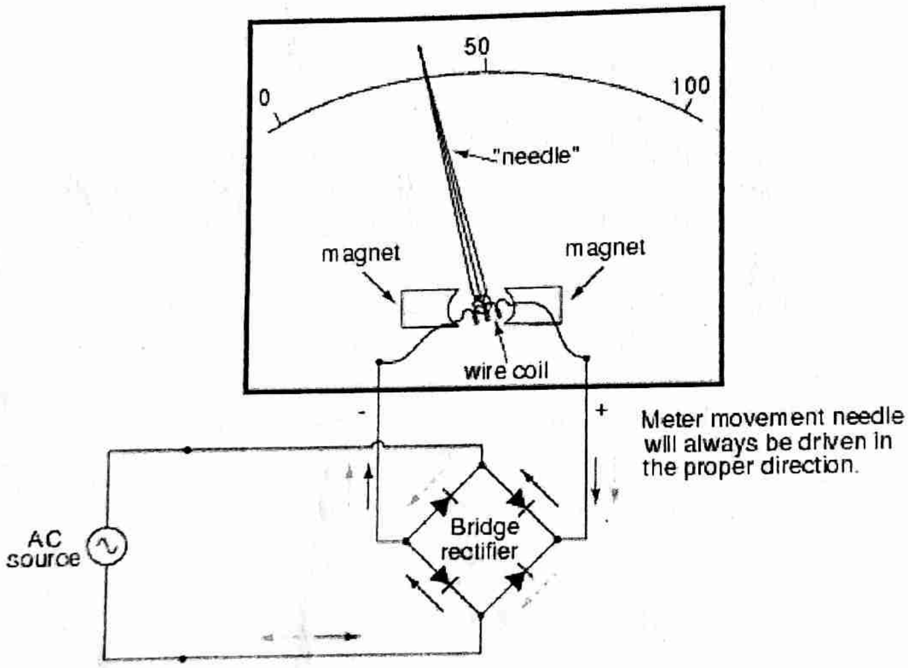


Fig.

2.6. BASIC OPERATION OF OHMMETER:

ELECTRICAL RESISTANCE:

- Electrical resistance is a measure of how much an object opposes allowing an electrical current to pass through it.

OHMMETER:

- It is an electronic device used to measure electrical resistance of a circuit element of low degree of accuracy.
- This resistance reading is indicated through a meter movement.

- The ohmmeter must then have an internal source of voltage to create the necessary current to operate the movement, and also have appropriate ranging resistors to allow desired current to flow through the movement at any given resistance.
- An ohmmeter is useful for
  1. Determining the approximate resistance of circuit components such as heater elements or machine field coils.
  2. Measuring and sorting of resistors used in electronic circuits.
  3. Checking of semiconductor diodes and for checking of continuity of circuit.
  4. To help the precision bridge to calculate the approximate value of resistance which can save time in balancing the bridge.
- There are two types of schemes are used to design an ohmmeter –

a) series type

b) shunt type.

- The series type of ohmmeter is used for measuring relatively high values of resistance, while the shunt type is used for measuring low values of the resistance.

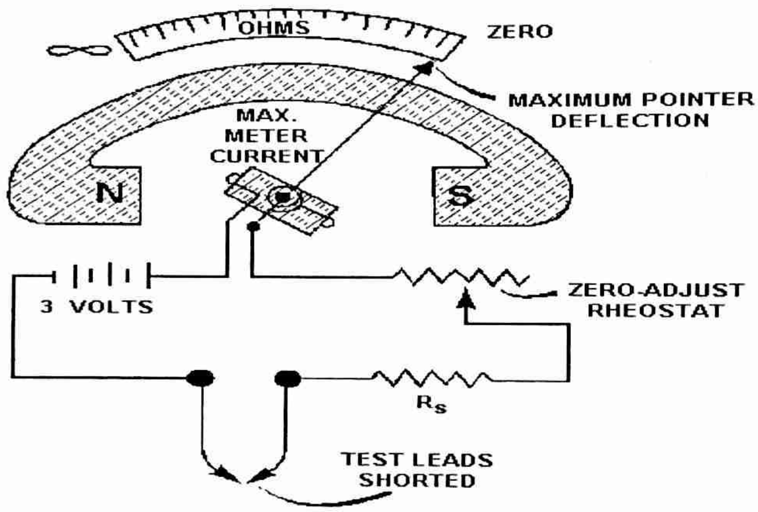
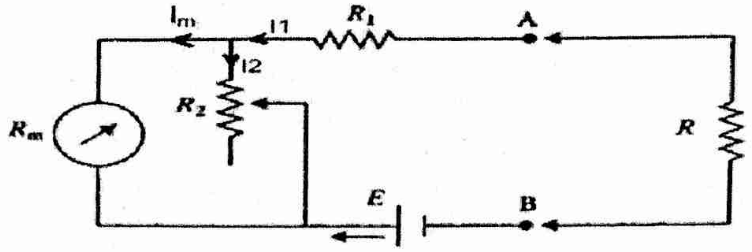


Fig.

- Ohmmeters come with different levels of sensitivity.
- Some Ohmmeters are designed to measure low-resistance materials, and some are used for measuring high-resistance materials.
- A Micro Ohmmeter is used to measure extremely low resistances with high accuracy at particular test currents and is used for bonding contact applications.
- Mega Ohmmeter is used to measure large resistance values.
- Milli-Ohmmeter is used to measure low resistance at high accuracy confirming the value of any electrical circuit.

SERIES TYPE OHMMETER:

- It consists of basic d'Arsonval movement connected in parallel with a shunting resistor R_2.
- This parallel circuit is in series with resistance R_1 and a battery of emf E.
- The series circuit is connected to the terminals A and B of unknown resistor R_x.

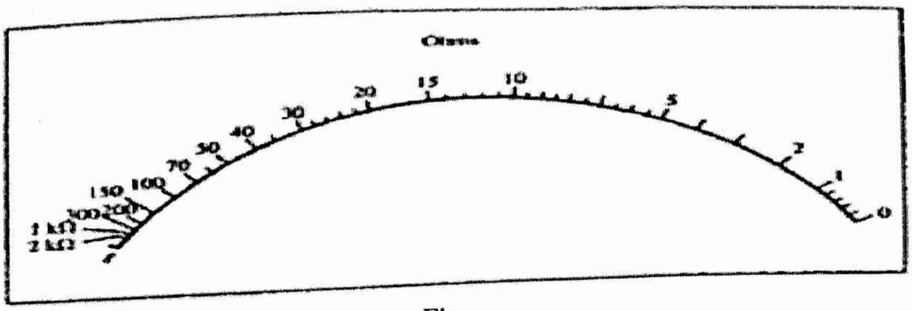


Fig

- From the figure,

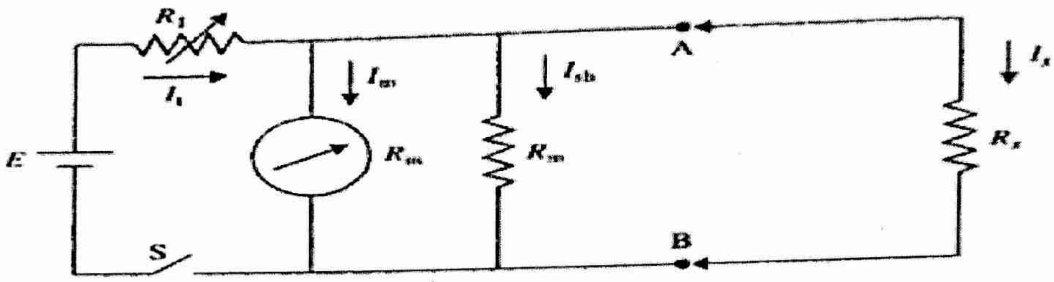
  R_1 = current limiting resistor; R_2 = zero adjusting resistor; E = emf of internal battery; R_m = internal resistance of d'Arsonval movement.

  - When the unknown resistance $R_x = 0$ (terminals A and B shorted) maximum current flows through the meter. Under this condition resistor R_2 is adjusted until the basic movement meter indicates full scale current Ifs.
  - The full scale current position of the pointer is marked "0Ω" on the scale.
  - Similarly when R_x is removed from circuit $R_x = \infty$ (i.e. when terminal A and B are open), the current in the meter drops to the zero and the movement indicates zero current which is the marked "∞".
  - Thus the meter will read infinite resistance at the zero current position and zero resistance at full scale current position.
  - Since zero resistance is indicated when current in the meter is the maximum and hence the pointer goes to the top mark.
  - When the unknown resistance is inserted at terminal A, B the current through the meter is reduced and hence pointer drops lower on the scale.
  - Therefore the meter has "0" at extreme right and "∞" at the extreme left.
  - Intermediate scale marking may be placed on the scale by different known values of the resistance R_x to the instrument.
  - A convenient quantity to use in the design of the series ohmmeter is the value of the R_x which causes the half scale deflection of the meter.
  - At this position, the resistance across terminals A and B is defined as the half scale position resistance R_h.
  - The design can be approached by recognizing the fact that when R_h is connected across A and B the meter current reduces to one half of its full scale value or with $R_x = R_h$, $I_m = 0.5\ I_{fs}$, where I_m = current through the meter, I_{fs} = current through the meter for full scale deflection.
  - This clearly means that R_h is equal to the internal resistance of the ohmmeter looking into terminals A and B.



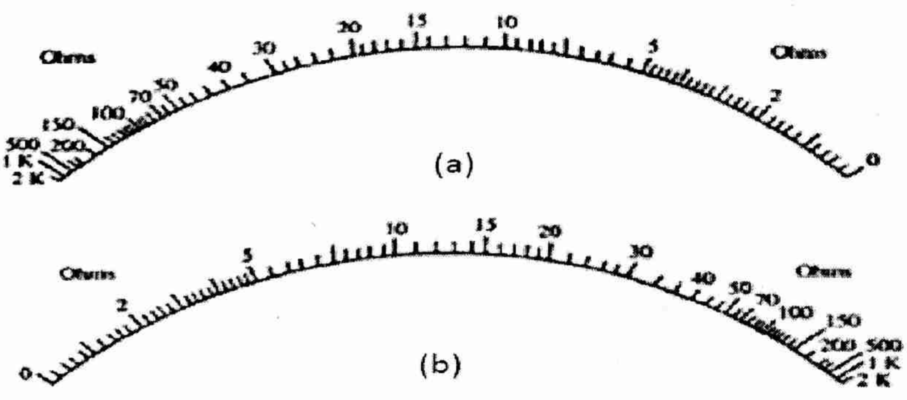
Fig

SHUNT TYPE OHMMETER:-



Fig

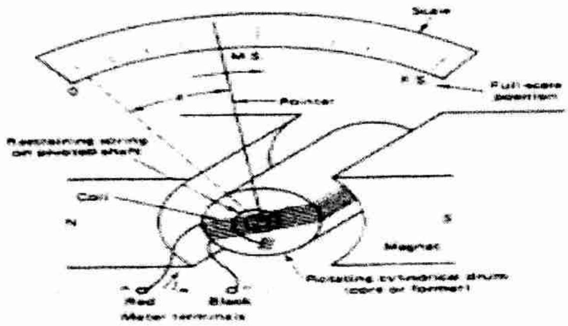
- This circuit consists of a battery in series with an adjustable resistor R_1 and a basic D'Arsonval movement (meter).
- The unknown resistance is connected across terminals A and B, parallel with the meter.
- In this circuit it is necessary to have an ON-OFF switch to disconnect the battery from the circuit when the instrument is not in use.
- When the unknown Resistor R_x= 0Ω, (i.e. A and B are shorted), the meter current is zero.
- If the unknown Resistor R_x=∞Ω, (i.e. A and B are open), the meter current flows only through the meter and by selecting a proper value of the resistance R_1, the pointer may be made to read full scale.
- This ohmmeter therefore, has zero marking on the left hand side of the scale (no current) and ∞ mark on the right hand side of the scale.



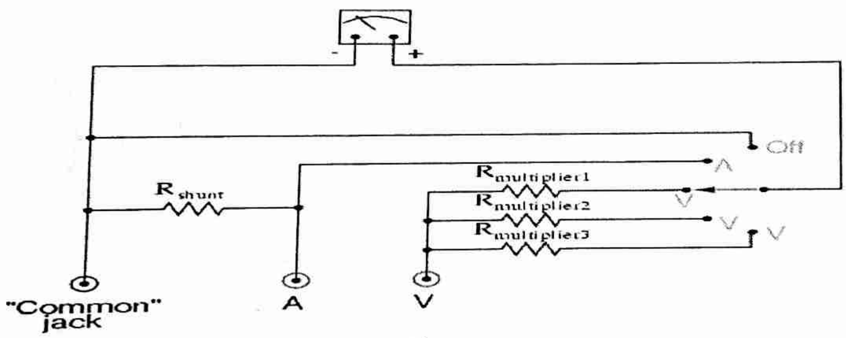
Fig

2.7. ANALOG MULTIMETER:-

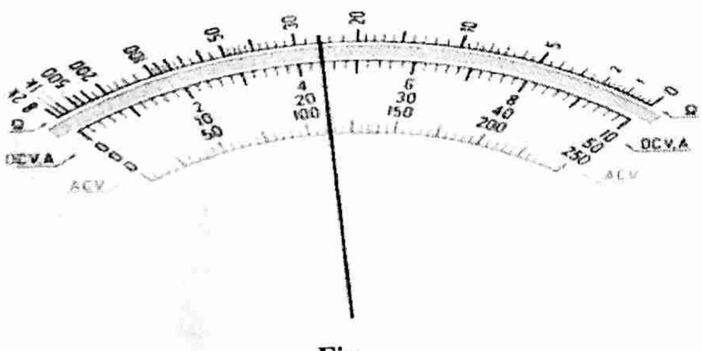
- The main part of an analog multi meter is the D'Arsonval meter movement also known as the permanent-magnet moving-coil (PMMC) movement.
- This common type of movement is used for dc measurements.



Fig



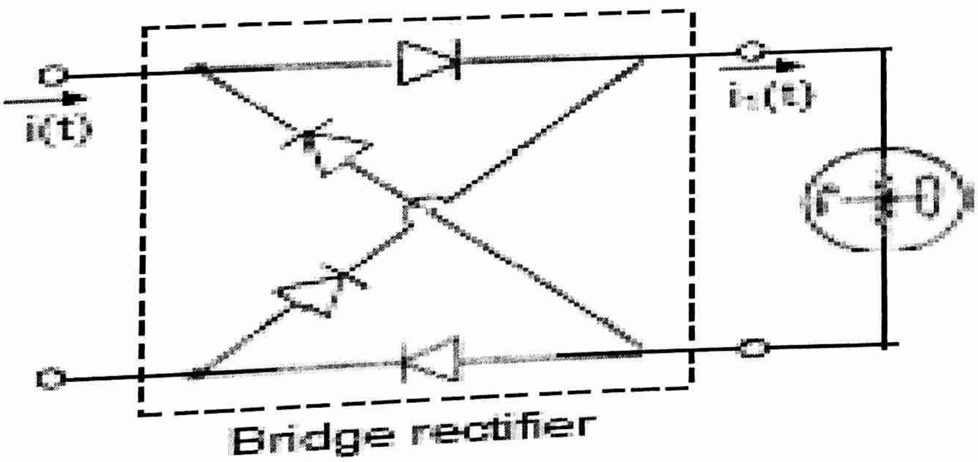
Fig



Fig

- When the meter current I_m flows in the wire coil in the direction indicated in figure a magnetic field is produced in the coil.
- This electrically induced magnetic field interacts with the magnetic field of the horseshoe-type permanent magnet.

- The result of such an interaction is a force causing a mechanical torque to be exerted on the coil.
- Since the coil is wound and permanently fixed on a rotating cylindrical drum as shown, the torque produced will cause the rotation of the drum around its pivoted shaft.
- When the drum rotates, two restraining springs, one mounted in the front onto the shaft and the other mounted onto the back part of the shaft, will exhibit a counter torque opposing the rotation and restraining the motion of the drum.
- This spring-produced counter-torque depends on the angle of deflection of the drum, θ or the pointer. At a certain position (or deflection angle), the two torques are in equilibrium.
- Each meter movement is characterized by two electrical quantites
  a) R_m: the meter resistance which is due to the wire used to construct the coil
  b) I_{FS}: the meter current which causes the pointer to deflect all the way up to the full-scale position on the fixed scale.
- This value of the meter current is always referred to as the full scale current of the meter movement.
- The PMMC movement cannot be used directly for ac measurements since the inertia of PMMC acts as an averager.
- Since ac current has zero average value and it produces a torque that has also zero average value, the pointer just vibrates around zero on the scale.
- In order to make ac measurements, a bridge rectifier circuit is combined with PMMC as shown in figure below.



Fig

3rd CHAPTER

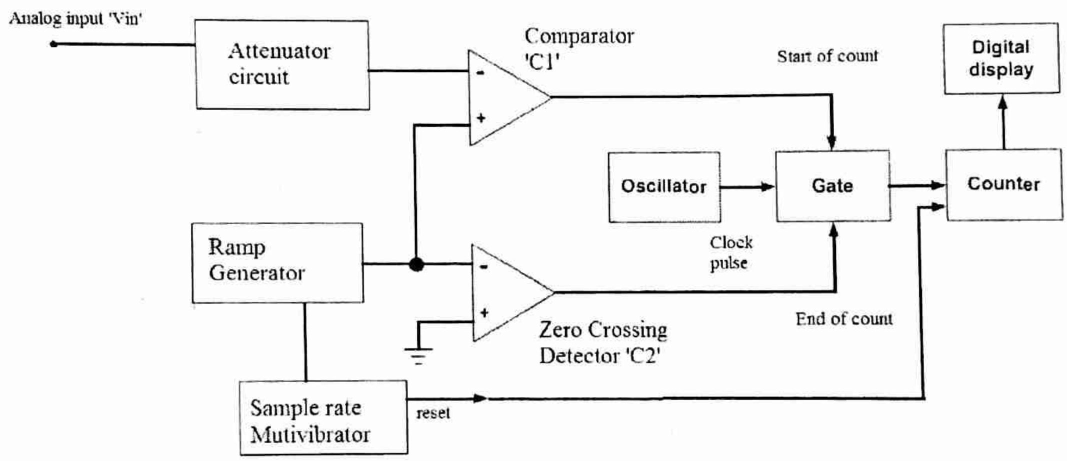
DIGITAL INSTRUMENTS

Ramp-type DVM

The principle of operation of the ramp-type DVM is based on the measurements of the time it takes for linear lamp voltage to rise from 0 V to the level of input voltage, or decrease from the level of the input voltage to zero. This interval of time is measured with an electronic time interval counter, and the count is displayed as a number of digits on electronic indicating tubes.

Fig. shows the 'voltage-to-time conversion' using gated clock pulses.

Block Diagram - Ramp type DVM



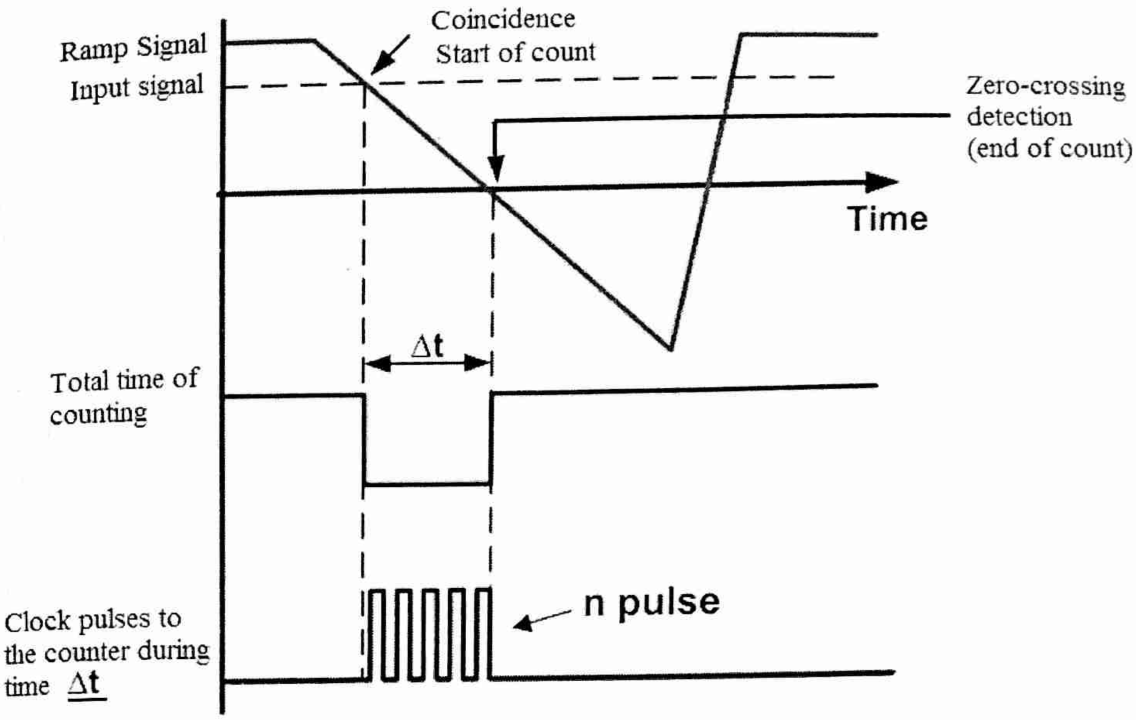
At the start of the measuring cycle, a ramp voltage is initiated; this voltage can be positive going or negative going. The negative going ramp, shown in the fig. is continuously compared with the unknown input-voltage.

At the instant that the ramp voltage equals the unknown voltage , a coincidence circuit, comparator, generates a pulse which open a gate[see fig.].The ramp voltage continues to decrease with time until it finally reaches 0 V[or ground potential] and a second comparator generates an output pulses which closes the gate.

An oscillator generates clock pulses which are allowed to pass through the gate to a number of decade counting units [DCUs] which totalise the number of pulses passed through the gate.

The decimal number, displayed by the indicator tubes associated with the DCUs, is a measure of the magnitude of the input voltage.

Waveform Analysis



The sample-rate multi-vibrator[MV] determines the rate at high the measurement cycle are initiated. The sample-rate circuit provides an initiating pulse for the ramp generator to start its next ramp voltage. At the same time ,a reset pulse is generated which returns all the DCUs o their zero state, removing the display momentarily from the indicator tubes.

Characteristics of Digital Meters

Following are the few specifications which characterise digital meters:

1.Resolution- It is defined as the number of digit positions or simply the number of digits used in a meter.

If a number of full digits is n, then resolution,

$$R=1/10^n$$

For n=4 $R=1/10^4=0.0001$ or 0.01%.

A three-digit display on the digital meter for 0-1 V range will be able to indicate from 000 to 999mV, with smallest increment (resolution) of 1mV.

2.Sensitivity-It is the smallest change in input which a digital meter is able to detect. Thus, it is the full-scale value of the lowest voltage range multiplied by the resolution of the meter .In other words,

$$\text{Sensitivity},S=(fs)_{min} * R$$

Where, (fs)=Lowest full-scale value of digital meter, and

R=Resolution is decimal.

DIGITAL FREQUENCY METER

Principle of Operation

Frequency is one of the most basic parameters in electronic, it has very close relationship with many measurement schemes of electric parameter and measurement results, so the frequency measurement becomes more important, it has been widely used in aerospace, electronics, measurement and control field .

Digital frequency meter composed by oscillator, frequency dividers, shaping circuit, counting & decoding IC circuit. Oscillation circuit generates frequency signal, we can get a 0.5HZ signal when the frequency signal through frequency divider.

Diagram of digital frequency meter as shown

in Fig.

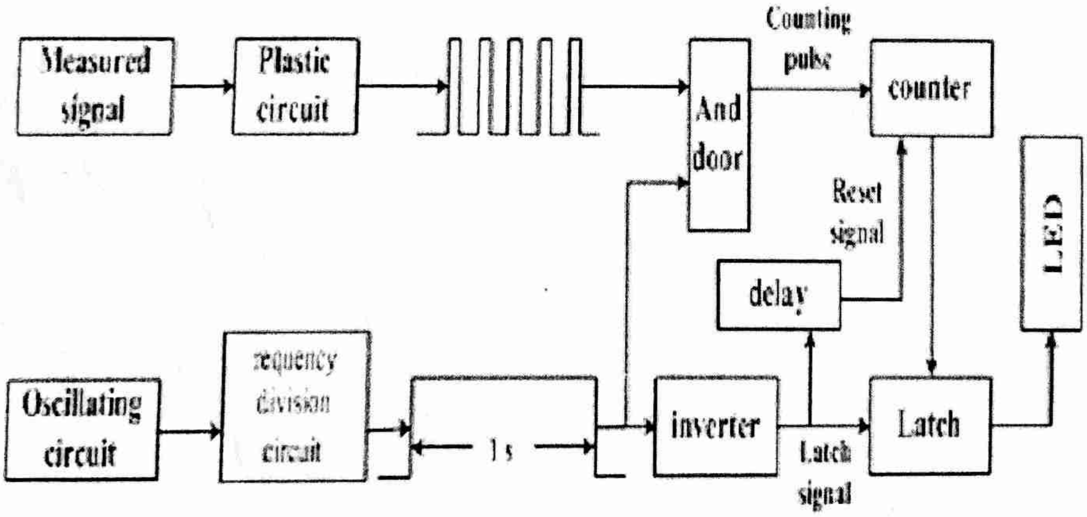


Fig .1 Digital frequency meter principle diagram

Design and simulation of digital frequency meter : Two types are circuits being used in the frequency meter.

Oscillator circuit and frequency division circuit

(1) Oscillator circuit

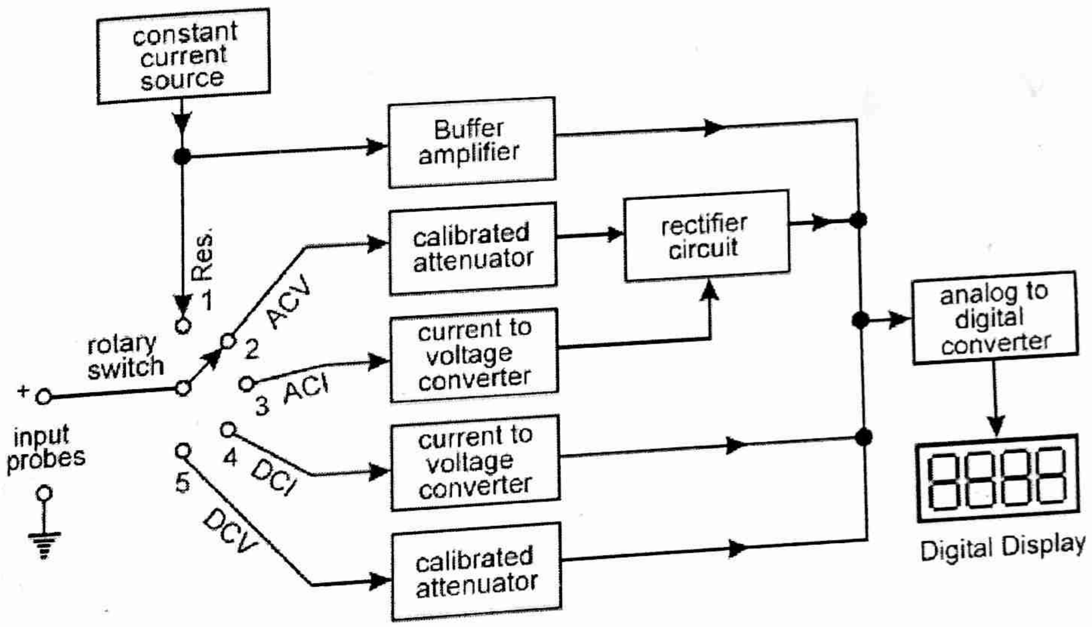
Oscillator is the core of timer, stability and the accuracy of oscillator frequency determine the timer accuracy[9-10], using IC 555 timing and RC constitute the oscillator which frequency is 500HZ,

(2) Frequency division circuit : Oscillator produce a rectangle wave is 500Hz, using frequency dividers to get 0.5Hz timer signal, 74LS90 is a 2-5 -10 decimal additions counter, use frequency dividers which composed by three 74LS90 can divided 500HZ rectangular pulse into 0.5 HZ.

DIGITAL MULTIMETER

A Digital multimeter offers increased versatility due to its additional capability to measure A.C voltage and current, D.C voltage and current, resistance.

The FIG. Shows the block diagram of a digital multimeter (DMM)



- In the "A.C voltage mode" ,the applied input is fed through a calibrated/ compensated attenuator ,to a precision fu;; wave rectifier circuit followed by a ripple reduction filter
- The resulting D.C fed to ADC and the subsequent display system.
- Fr current measurements the drop across an internal calibrated shunt is measured ,directly By the ADC in the "D.C current mode" , and after A.C to D. C conversion in the " A.C current mode". This drop is often in the range of 200 mv.
- Due to lack of precision in the A.C –D.C conversions, the accuracy in the A.C range is in general of the order of 0.2 to 0.5%. In addition , the measurement range is often limited to about 50 Hz at the lower frequency end due to the ripple in the rectified signal becoming a non negligible percentage of the display and hence in fluctuation of the displayed number.
- In the resistance range the multimeter operates by measuring the voltage across the externally connected resistance ,resulting from a current forced through it from a calibrated internal current source.

- The accuracy of resistance measurement is of the order of 0.1 to0.5% depending on the accuracy and stability of the internal current sources the accuracy may be proper in the highest range which is often about 10 to 20 MΩ. In the lowest range the full scale may be 200Ω with a resolution of about 0.01Ω for a digital multimeter.

Measurement of Time (Period Measurement)

- In some cases it is necessary to measure the time period rather than the frequency. This is especially true in the measurement of frequency in the low frequency range. To obtain good accuracy at low frequency, we should take measurements of the period, rather than make direct frequency measurements. The circuit used for measuring frequency (Fig.) can be used for the measurement of time period if the counted signal and gating signal are interchanged.
- Figure shows the circuit for measurement of time period. The gating signal is derived from the unknown input signal, which now controls the enabling and disabling of the main gate. The number of pulses which occur during one period of the unknown signal are counted and displayed by the decade counting assemblies. The only disadvantage is that for measuring the frequency in the low frequency range, the operator has to calculate the frequency from the time by using the equation/= l/T.

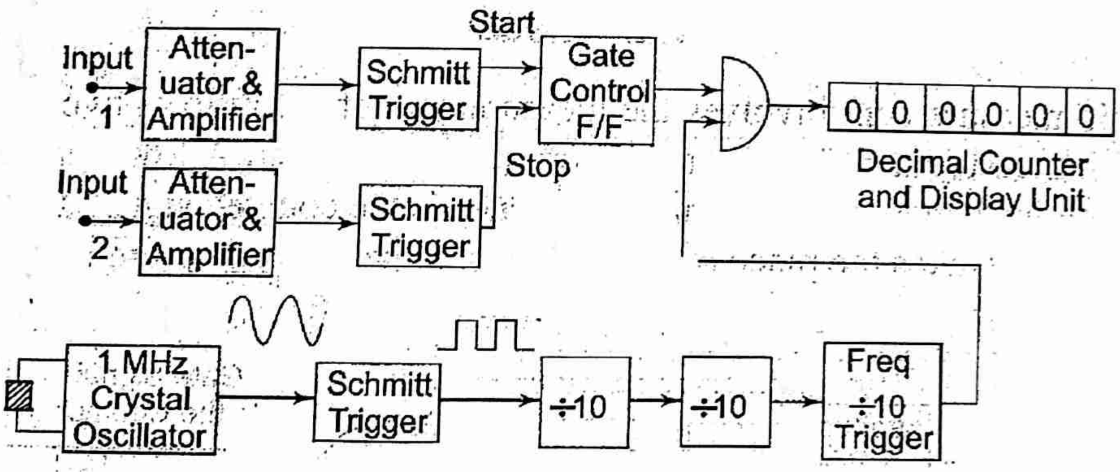


Fig. Basic Block Diagram of Time Measurement

•

The accuracy of the period measurement and hence of frequency can be greatly increased by using the multiple period average mode of operation. In this mode, the main gate is enabled for more than one period of the unknown signal. This is obtained by passing the unknown signal through one or more decade divider assemblies (DDAs) so that the period is extended by a factor of 10,000 or more.

Hence the digital display shows more digital of information, thus increasing accuracy. However, the decimal point location and measurement units are usually changed each time an additional decade divider is added, so that the display is always in terms of the period of one cycle of the input signal, even though the measurements may have lasted for 10,100 or more cycles.

Figure 6.10 show the multiple average mode of operation. In this circuit, five more decade dividing assemblies are added so that the gate is now enabled for a much longer interval of time than it was with single DDA.

DIGITAL MEASUREMENT OF FREQUENCY (MAINS)

The conventional method of measuring the frequency of an electrical signal consists of counting the number of cycles of the input electrical signal during a specified gate interval. The length of the gate interval decides the resolution of the measurement. The shorter the gate interval, the lesser is the resolution. Now, for frequencies of the order of kHz and above, it is possible to get a resolution of 0.1% of better with a nominal gate time of 1 (sec). But for low frequencies, in order to obtain a resolution of even 0.5%, the gate time has to be considerably larger. For example, consider the case when the input electrical signal frequency is around 50 Hz. In order to obtain a resolution of 0.1 Hz, the gate interval has to be 10 seconds and in order to obtain a resolution of 0.01 Hz, the gate interval has to be 100 s. These gate periods of 10 s and 100 s are too long and in many cases it is desirable to obtain an indication of the frequency in far less time. Hence, direct or ordinary frequency counters are at a great disadvantage when it comes to low frequency measurements.

For the mains frequency monitor, the frequency range of interest is rather narrow, (50 ± 5%) Hz. The technique employed in the measurement of mains frequency, yields only a parabolic calibration curve. But within the narrow frequency range, which in this case is (50 ± 5%) Hz, the calibration is conveniently flat. Hence, the error due to the non-linear calibration is less than 0.2% at a frequency deviation as large as 5% from the centre frequency, which is 50 Hz. The error is 0.02% at a frequency deviation as large as 2% from the centre frequency and as the frequency approaches the centre value of 50 Hz, the error approaches zero.

DIGITAL TACHOMETER

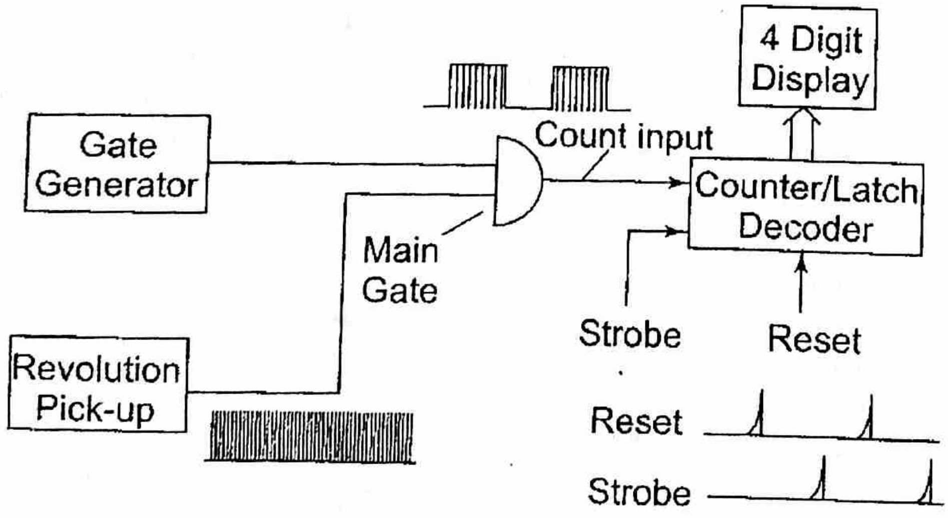
The technique employed in measuring the speed of a rotating shaft is similar to the technique used in a conventional frequency counter, except that the selection of the gate period is in accordance with the rpm calibration.

Let us assume, that the rpm of a rotating shaft is R. Let P be the number of pulses produced by the pick up for one revolution of the shaft. Therefore, in one minute the number of pulses from the pick up is R x P. Then, the-frequency of the signal from the pick up is (R x P)/60. Now, if the gate period is G s the pulses counted are (R x P x G)/60. In order to get the direct reading in rpm, the number of pulses to be counted by the counter is R. So we select the gate period as 60/ P, and the counter counts

$$(R \times P \times 60)/60P = R \text{ pulses}$$

and we can read the rpm of the rotating shaft directly. So, the relation between the gate period and the number of pulses produced by the pickup is G = 60/P. If we fix the gate period as one second (G = 1 s), then the revolution pickup must be capable of producing 60 pulses per revolution.

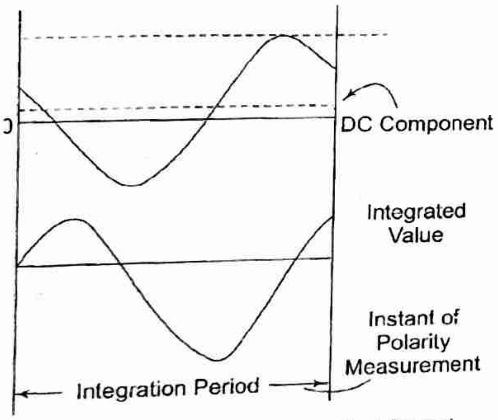
Figure shows a schematic diagram of a digital tachometer.



Basic Block Diagram of a Digital Tachometer

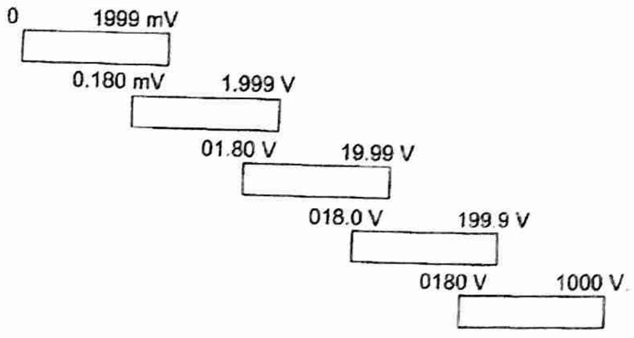
AUTOMATION

1. **Automatic Polarity Indication** :The polarity indication is generally obtained from the information in the ADC. For integrating ADCs, only the polarity of the integrated signal is of importance. The polarity should thus be measured at the very end of the integration period (see Fig. 6.21). As the length of the integration period is determined by counting a number of clock pulses, it is logical to use the last count or some of the last counts to start the polarity measurement. The output of the integrator is then used to set the polarity flip-flop, the output of which is stored in memory until the next measurement is made.



Polarity of Integrated Signal has to be Measured at Very End of Integration Period

2. **Automatic Ranging**: The object of automatic ranging is to get a reading with optimum resolution under all circumstances (e.g. 170 m V should be displayed as 170.0 and not as 0.170). Let us take the example of a 3Yz digit display, i.e. one with a maximum reading of 1999. This maximum means that any higher value must be reduced by a factor of 10 before it can be displayed (e.g. 201 m Vas 0201). On the other hand, any value below 0200 can be displayed with one decade more resolution (e.g. 195 mV as 195.0). In other words, if the display does not reach a value of 0200, the instrument should automatically be switched to a more sensitive range, and if a value of higher than 1999 is offered, the next less sensitive range must be selected.



Example of Overlapping Ranges in Automatic Ranging Instruments

3. Automatic Zeroing

Each user of a voltmeter expects the instrument to indicate zero when the input is short-circuited. In a digital voltmeter with a maximum reading of 1999, a zero error of 0.05% of full scale deflection is sufficient to give a reading of 0001. For this reason, and in the interests of optimum accuracy with low valued readings, a zero adjustment is necessary. To increase the ease of operation, many instruments now contain an automatic zeroing circuit.

In a system used in several multimeters, the zero error is measured just before the real measurement and stored as an analog signal. A simplified circuit diagram of a circuit that can be used for this purpose is given in Fig. 6.24, for a dual slope ADC.

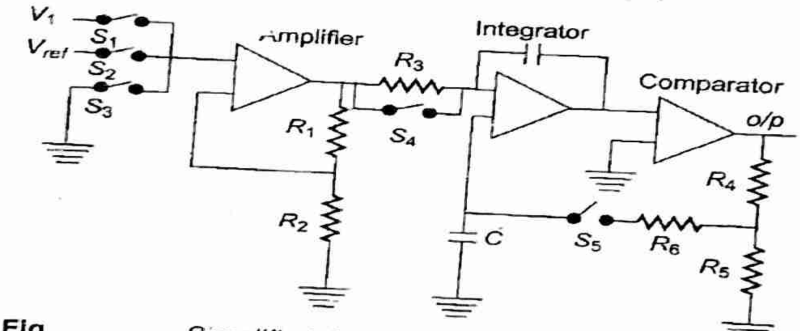


Fig. Simplified Circuit Diagram of Automatic Zeroing Circuit that can be Used With Dual Slope ADC

DIGITAL LCR METER

This type of meter is used to measure the resistance , inductance ,capacitance and dissipation factor. The desired function can be selected by using a rotary switch . The various ranges available are

1) 200μH/pF/Ω , 2) 2000μH/pF/Ω , 3) 200mH/nF/kΩ , 4) 200mH/nF/kΩ , 5) 2H/μF/MΩ

With the help of this instrument , the following ranges of various measurements can be made

Resistance : From 200 Ω to 20 M Ω;

Inductance : From 2000 μH to 2 H ;

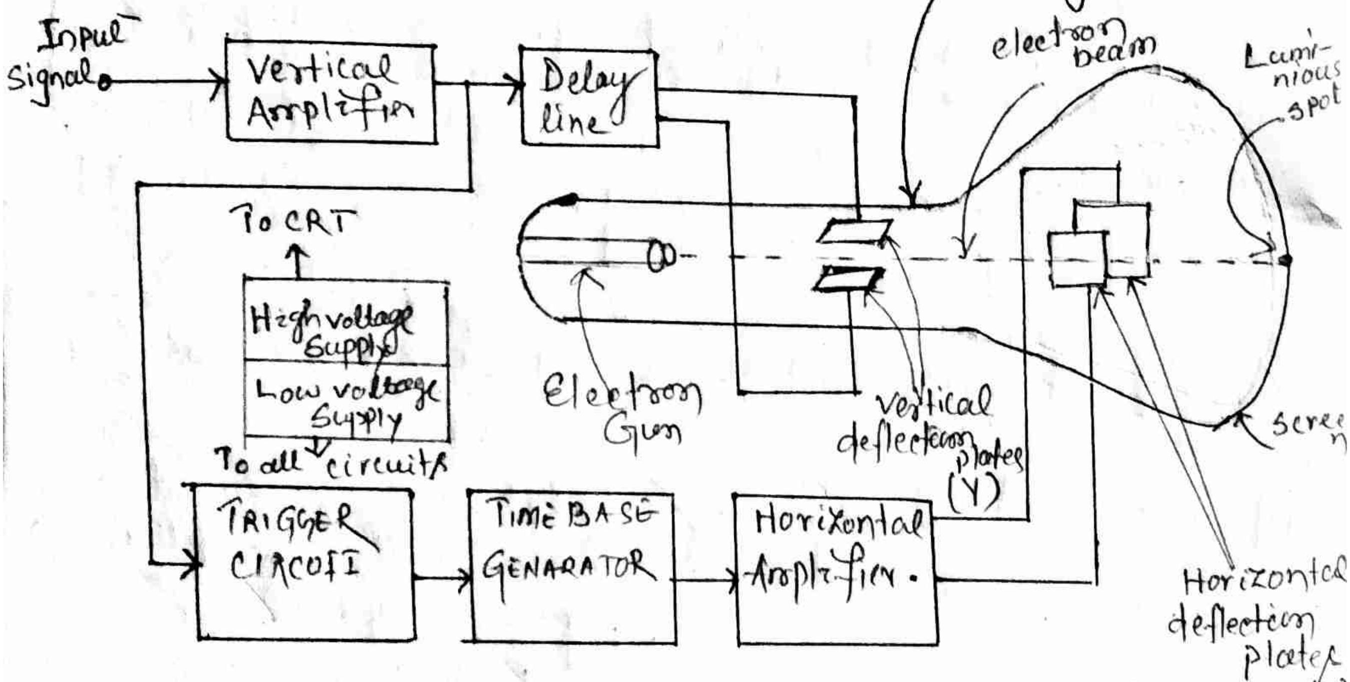
Capacitance : From 2000 pF to 2 μF

CRO

(Cathode Ray oscilloscope)

What is CRO? working of Cathode Ray Oscilloscope (CRO) with block diagram.

CRO (Cathode Ray oscilloscope) -> The Cathode Ray oscilloscope is most versatile instrument used for measurement for display, measurement and analysis of wave form for electronic and electrical circuits. The CRO allows the amplitude of electrical signals whether they are voltage, current or power to be displayed as a function of time or another signal.



CRT -> Cathode Ray Tube -> It is the heart of CRO. It is a vacuum sealed glass envelope that has a source of electrons which emits electrons that are accelerated to pass through two pairs of plates before striking a phosphor coated screen internally to provide a visual display of signal.

Components of CRO

1) Cathode Ray Tube (CRT)
2) Vertical Amplifier
3) Delay line
4) Horizontal Amplifier
5) Time base Generator
6) Triggering circuit
7) Power Supply.

Electron Gun ⇒ Source of accelerated, energized and focused beam of electrons which strikes the screen.

Screen ⇒ Coated with natural or synthetic phosphor phosphore which emits visible light when the electron beam strikes over it.

Horizontal deflection system ⇒

Triggering circuit ⇒ (I) It is the link between the signal waveform to be observed (vertical input) and the time base (horizontal input)
(II) It synchronizes the horizontal deflection of the electron beam with the vertical input.

Time base Generator ⇒ (I) generates ramp voltage
(II) Also controls the rate which with which the electron beam is scanned across the face of the Screen of CRT.

Horizontal Amplifier ⇒ It's function is just to amplify the horizontal signal and provide to the horizontal deflection plate.

Vertical deflection System ⇒ Amplifies small voltages and is used so that the CRO is able to measure each small changes in the vertical or the y-direction.

Delay Line => (i) It is Connected in Series with amplifier (ii) Introduces a delay in the Vertical input.

(iii) The horizontal time-base triggered by a portion of the input Signal that starts the Sweep generator, the output of which is then fed to the horizontal amplifier.

HV Supply AND LV Supply =>

High voltag Supply (HV) => High voltage is Supplied to CRT. AND

LH Supply (Low voltage) => Low voltage is Supplied to electronic Circuits.

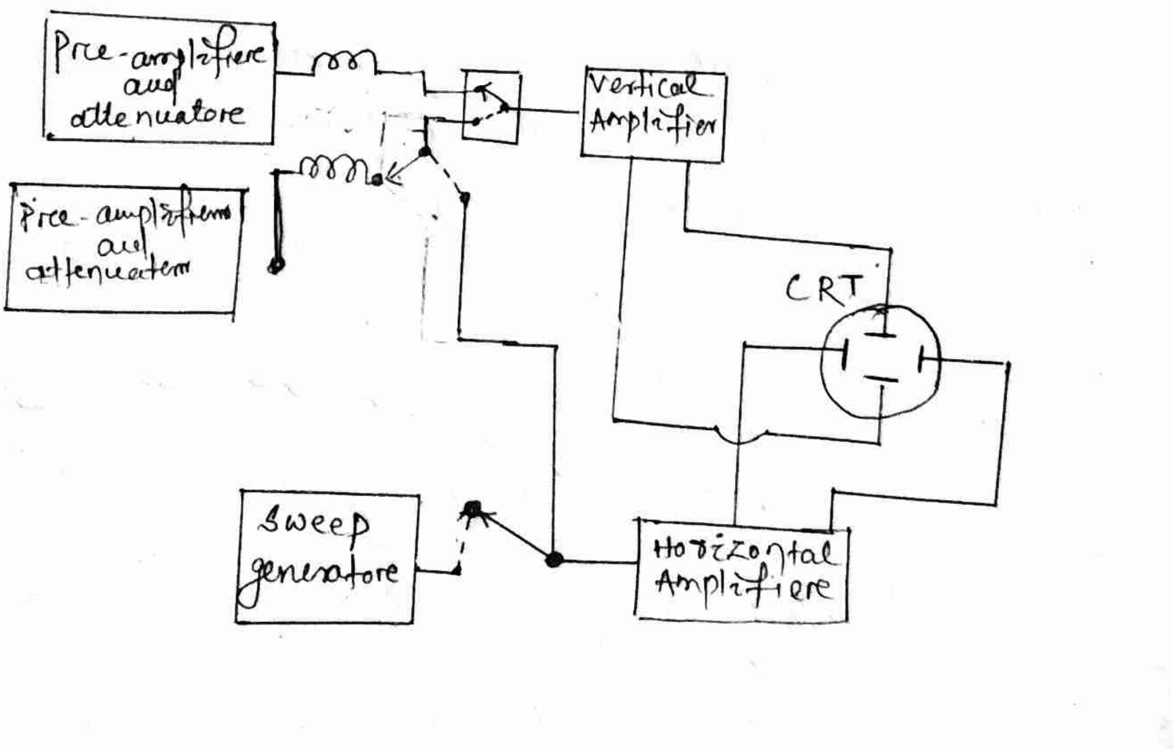
Dual Trace Oscilloscope

Definition => In dual trace oscilloscope, a single electron beam generates 2 traces that undergoes deflection by two independent sources. In order to produce two separate traces, basically 2 methods are used, known as alternate and chopped mode.

Need for Dual Trace oscilloscope =>

Comparing voltages in different electronic circuits, one can use multiple oscilloscopes. But simultaneously triggering the sweep of each oscilloscope is a quite difficult task. Thus we have used dual trace oscilloscope provides two traces by making use of a single electron beam.

Block diagram and working of Dual Trace Oscilloscope



TRANSDUCERS

The transducer is a device which ~~energy~~ converts energy from one form to another form.

Ex:- Loud speaker, microphone

Microphone → Sound energy to electrical energy

Loud speaker → Electrical energy to sound energy.

Types :-

(I) primary and secondary
(II) active and passive
(III) Analog and digital
(IV) Transducer and Inverse transducer

~~Active and passive transducers~~ →

Active Transducer ⇒ The transducer which develop their o/p in the form of electrical voltage or current without any auxillary source are called active transducer.

Ex - Thermocouple.

passive Transducer ⇒ The transducer in which electrical parameters (Resistance, Inductance and Capacitance) changes with the change in o/p signal are called passive transducer

Ex - Loud speaker, Microphone, Strain gauge.

SENSOR ⇒ Sensor is a technique used for getting information with the help of electromagnetic energy of an instrument from a distance. Ex - Radar

What is Sensore and types of Sensor?

All these Sensors are used for measuring one of the physical properties like, Temperature, Resistance Capacitance conduction, Heat Transfer etc.

- => Temperature Sensor
- => Pressure Sensor
- => Light Sensor
- => Smoke, Gas and Alcohal Sensor.
- => touch Sensors are frequently used in most electronis applications.

Difference Between Sensor and Transducer =>

One of the significant difference between the Sensor and the transducer is that the Sensor Senses the Physical changes occur in the Surrounding whereas the transducer converts the Physical quantity or non electrical into another Signal or electrical Signal.

The transducer and Sensore both are the physical devices used in electrical and electronic instruments for measuring the physical quantities. The Sensor detects the energy level and changes it into an electrical Signal which is easily measured by the digital meters. The transducer transfers the energy either in the same form or another.

Basic For Comparison	Sensor	Transducer
Definition	Senses the physical changes occurs in the Surrounding and converting it into a readable quantity	The transducer is a device which when actuates transforms the energy from one form to another
Components	→ Sensor itself	→ Sensor and Signal conditioning
Function	→ Detects the Changes and induces the corresponding electrical Signals	→ Conversion of one form of energy into another
Examples	Proximity Sensor, Magnetic Sensor, Light Sensor	→ Thermistor, Potentiometer, Thermocouple etc.

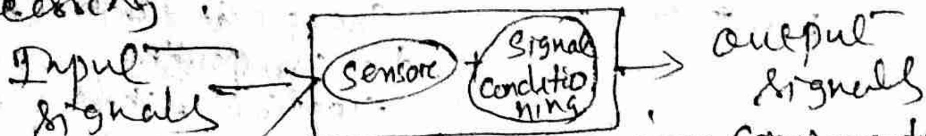
Definition of Sensor => The Sensor is a device that measures the physical quantity (ie Heat, light, Sound, etc) into an easily readable signal (voltage, Current etc) It gives accurate readings after Calibration.

Example - The mercury used in the thermometer converts the measurand temperature into an expansion and contraction of the liquid which is easily measured with the help of a calibrated glass tube. The termocouple also converts the temperature to an output voltage which is measured by the thermometer.

Sensore

The sensore have many applications in the electronic equipment. The few of them are explained below. (1) The motion sensors are used in the home security system and the automation door system.
(2) The accelerometer sensor use in the mobile for detecting the screen rotations.

Definition => The transducer is a device that changes the physical attributes of the non-electrical signal into an electrical signal which is easily measurable. The process of energy conversion in the transducer is known as the transduction. The transduction is completed into two steps. First by sensing the signal and then strengthening it for further processing.



The transducere has three major components they are the input device, signal conditioning or processing device and an output device

The input devices receive the measurand quantity and transfer the proportional analogue signal to the conditioning device. The conditioning device modified, filtered or attenuates the signal which is easily acceptable by the output devices.

EMI

1. a) what is Lissajous pattern?

Ans => Lissajous pattern produced by the intersection of two Sinusoidal curves the axes of which are at right angles to each other.

b) Define the accuracy and sensitivity?

Accuracy => It is defind as the ability of a device or a system to respond to a true value of a measure variable under condition

Sensitivity => Sensitivity can be defind as a ratio of a change output to the change input at steady state condition.

c) Write down the application of digital tachometer
i) It is used to measure rotational speed.
ii) It can measure the flow of liquid.
iii) measure the blood flow rate of the patients.
iv) measure the rate of engine crank shaft
IV) It is used in vachicles to display the rotation.

d) State the difference beteen transducer and sensor?

Transducer	Sensor
The transducer is a device which acturates transforms the energy from one form to another	It senses the physical changes accurs in the surroundings and converting it into a readable quantity
Ex - Thermistor, Potentiometers Thermocouple.	Ex - proximity sensors magnetic sensors Light sensors.

e) Define static and dynamic characteristics

Ans => static charachonstics where the performance criteria for the measurement of quantities that remain constant. Dynamic characteristics on the other hand, shows the relationship between the system input and output when the measured quantity is varying rapidly.

f) State the advantage and Disadvantages of MI instrument.

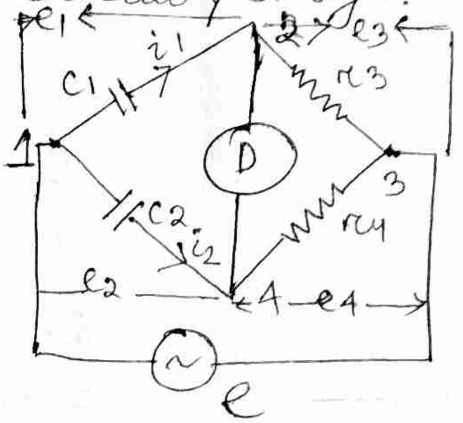
Advantage
i) It is used for the measurement of AC and DC quantities.
ii) It has a very high torque to weight ratio.
iii) It consumes low power
iv) It is very cheap due to simple constructeion.
(v) It has a very high accuracy.

Disadvantage
1) These instruments suffer from error due to hysteresis, frequency change and stray losses.
2) It has non-uniform scale, accurate readings not possible at lower range
3) It is suitable for low frequency application.

1) g) What is DSO? A digital Storage oscilloscope (DSO) is an oscilloscope which stores and analyses the input signal digitally.

h) Define Q-factor?
It is defind as the ratio of the initial energy stored in the resonator to the energy lost in one radian of the cycle of oscillation. Q-factor is alternatively defind as the ratio of a resonator's centree frequency to its bandwidth when subject to an oscillating driving force.

(i) Draw the diagream of De-Sauty bridge.



(j) What is a signal generatore and classify it?
A signal generatore is a piece of test equipment that produces an electrical signal in the form of a wave. Signal generator classifies the signal source into a mixed signal source and a logical signal source.

Quality Factore, Q definition =>

For electronic circuits, Q is defind as the ratio of the energy stored in the resonatore to the energy supplied by to it, per cycle, to keep signal amplitude constant, at a frequency where the stored energy is constant with time.

(or)

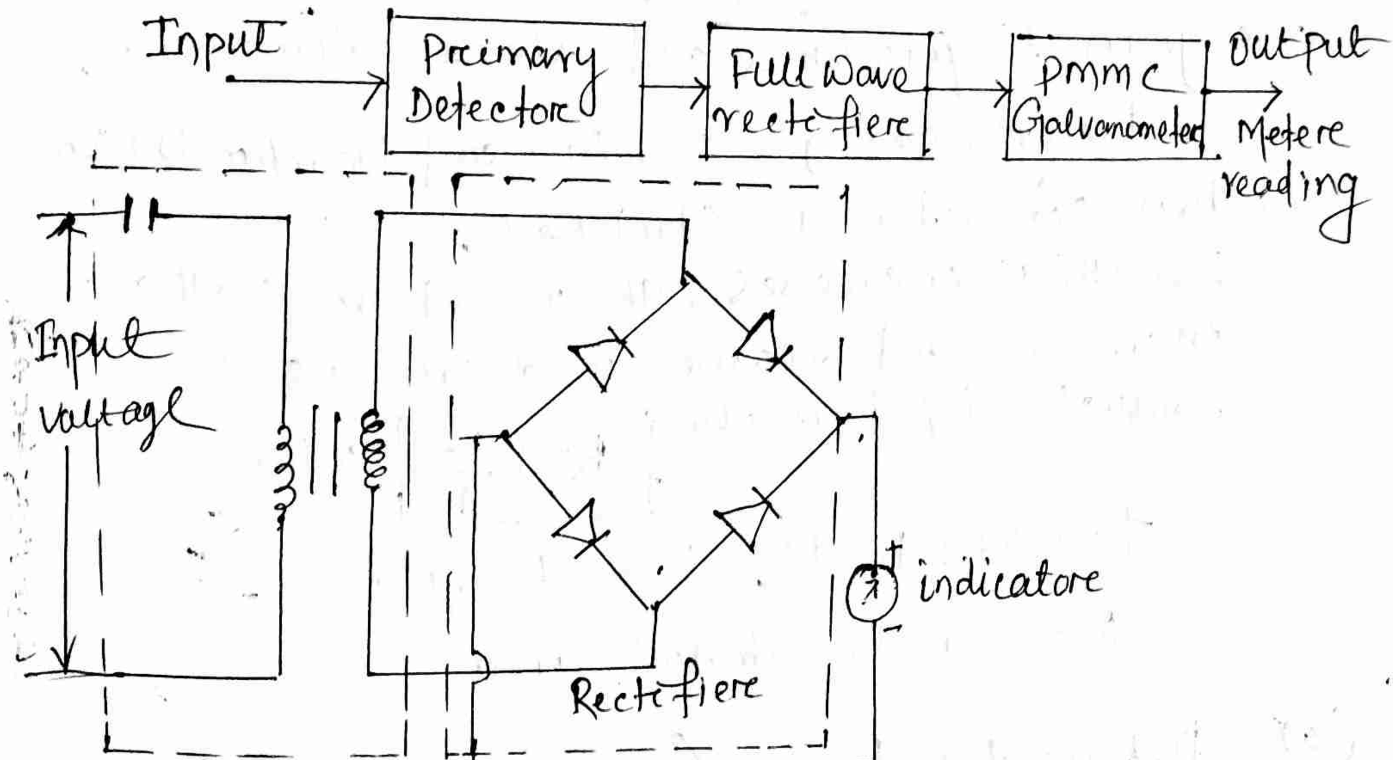
Q-factor of a series resonant circuit is defined as the ratio of the voltage across a coil or capacitor to the applied voltage,

$$Q = \frac{\text{Voltage across L or C}}{\text{Applied voltage}}$$

1 a) Draw the block diagrom of basic wave analysere.

Ans => Wave Analysere => An electronic instrument that analyses the signal ore wave by measuring the amplitude of the frequency components or harmonics is called a Wave Analysere

The wave analyser Block diagram contains a Primary detectore, fullwave rectifiere and pmmc galvanometere



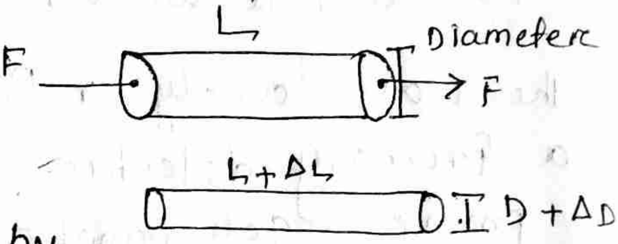
Wave Analysere Block diagram

b) Why the defectores are used in the bridge circuits?

Ans => To know all the voltage or current of the Source will be displayed at the detectore.

Preinciple of Strain Gause

Considere conductore of Length 'L' and diametere 'D'. This conductore Stretched by force 'F'.



Due to applied of force 'F', there will be change in longitudinal and lateral dimension.

∴ Length changes L + ΔL and Diametere D+ΔD when conductore is Stretched, Length is increases, the resistance will also increases and diametere decreases of Conductor by formula $R = \rho \frac{L}{A}$ where

$\rho \rightarrow$ Resistivity, $L \rightarrow$ Length

$A \rightarrow$ Cross-sectional area.

c) Define the term Gause factor of a Strain Gause.

Ans => Gause factor is defined as the ratio of per unit change in resistance to the Per unit change in Length. This can be mathematically written as $G_f = \frac{\Delta R}{R} / \frac{\Delta L}{L}$

Where $\frac{\Delta R}{R}$ → Per Unit change in resistance

$\frac{\Delta L}{L}$ → Per unit change in Length

Gf → Gause Factor

As strain is an elastic material is defind as the per unit length change in length

therefore ε = change in length/original length

$= \frac{\Delta L}{L}$

Hence Gause factor, $Gf = \frac{\Delta R/R}{\varepsilon}$

(d) What is current treansducere? where it is used?

Ans ⇒ Current treansducere provedes a DC current or voltage at the output directly proportional to the AC input current.
AC current treansducers typically have a transformer input to isolate the treansducer from the current input.

AC current Treansducer

0-100A ac INPUT = 4-20mAdc OUTPUT

Where it is used? (i) Treansduceres aree used in Ultrea Sound Machine.
(ii) Treansducer in a Speakere Convert Electrical Signal to Sound.
(iii) Treansducers aree used in antenna convert electromagnetic waves into an electrical signal.

(e) Write application of Multimeter

Ans -> (I) AC/DC voltage Measurement
(II) AC/DC Current Measurement
(III) Measurement of capacitance
(IV) Measurement of frequency
(V) To test batteries.

(f) Define the terms: Precision and Resolution

Ans -> Precision => It is the measurements of successive readings in an instrument which should not differ in reading.

Resolution => The smallest increment an instrument can detect and display hundredths, thousands.

Range :- The upper and lower limits an instrument can measure a value or signal such as amps, volts and ohms.

(g) List the types of moving iron instrument

Ans -> There are two types of moving iron (MI) instruments. They are attraction type and repulsion type moving iron instruments.

(h) What is an LVDT ?

Ans => The term LVDT Stands for the Linear variable Differential Transformer. It is the most widely used inductive transducer that converts the linear motion into the electrical Signal. The output across secondary of this transformer is the differential thus it is called so.

(i) Define load cell ?

Ans => Load cells are Sensors that detect force (mass, torque, etc). When a force is applied to a load cell, it converts the force into an electrical Signal. Load cells are also known as load transducer which converts the force into electrical signals.

(j) Define the Strain Gauge.

Ans => Definition :- Strain Gauge is a device where force is applied any material, there is a change in resistance. The change in resistance is measured in terms of either load or displacement. It is basically measures Strain on the application of Stress. Strain gause directly is used for the measurement of load and indirectly it is used for the measurement displacement.

(7)

(K) What is a function generatore?

Ans => A function generatore is usually a piece of electronic test equipment used to generate different types of electrical waveforms over a wide range of frequencies. Common waveforms produced by the function generator are the sine wave, square wave, triangular wave and sawtooth shapes.

(L) What is thermistor?

Ans => Thermistor is a special type of resister whose resistance changes with the change in temperature. If temperature increases and resistance decreases, it is called Negative temperature co-efficient. If temperature increases and resistance also increases, it is called positive temperature co-efficient.

Thermistor can be used for the temperature range $-60°C$ to $15°C$

(m) Why triggering is used in CRO?

Ans => Triggering is used to observe the wave form at any time for analysis by switching on the horizontal sweep generator.

(n) What is the time base signal in CRO?

Ans ⇒ The time base signal in CRO is a Saw tooth signal. A saw tooth wave increases linearly with time and has a sudden decrease. This is also called as a Time base signal.

(o) Give two application of CRO.

(I) CRO is used to measure the voltage, current frequency, inductance, admittance, resistance and power factor.

(II). The device is used to monitor the signal properties as well as characteristics and also controls the analog signals.

(P) Name different types of Strain gauses.

Ans → (I) Linear strain gauses.
(II) Full bridge Strain gauses.
(III) Shear strain gauses.
(IV) Column strain gauses.

(q) Can you use moving coil meters measurement of A.C? Why?

Ans ⇒ 'NO' we can not use moving coil meters measurement of A.C because $\theta \propto I$ which means the painter will deflect in the direction only. Which has a lineare scale.

(r) Which type of damping is used in moving iron instruments AND which type of damping used in moving coil instrument?

Ans ⇒ In moving iron instrument Air friction type damping and In moving coil instrument eddy current damping is used.