[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 behavior 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 Calibration.

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.

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.

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

INTRODUCTION

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.

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.

2. 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

ii) Fluid friction

iii) Eddy current.

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 the rotation is zero.

BASIC METER MOVEMENT OR D’ARSONVAL METER

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, 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.

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' Arsonoval movement.

CONSTRUCTION:

- It consists of a light rectangular coil of many turns of fine wire wound on an aluminum.

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 aluminum 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.

Fig

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.

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:-

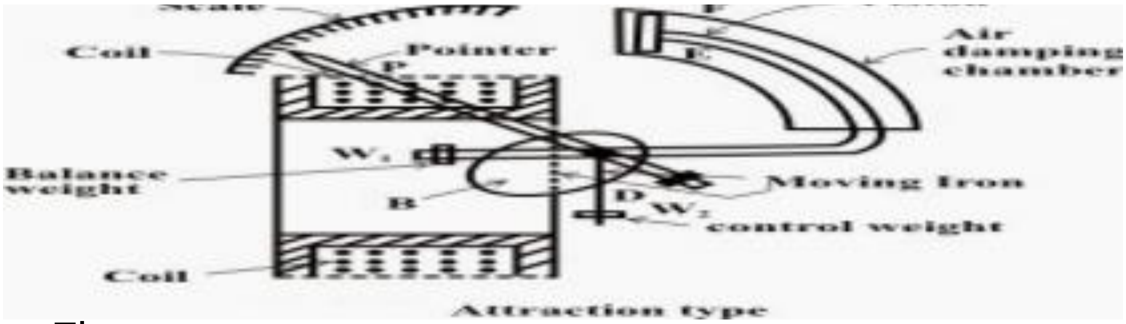
- Let a plate or vane of soft iron or of high permeability steel forms the moving element of the system.
- The iron vane is situated so as, it can move in a magnetic field produced by a stationary coil.
- The coil is excited by the current or voltage under measurement.
- When the coil is excited, it 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

2. <u>REPULSION TYPE:-</u>

➢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.

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 are placed in parallel to give different current ranges.

FIG

Fig.

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 andI_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 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.

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.

<u>SERIES TYPE OHMMETER:</u>

- It consists of basic D'Arsonval movement connected in parallel with a shunting resisto 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.

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.

hence the pointer goes to the top mark.

- When the unknown resistance is inserted at terminal A, B the current through the 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 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 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 $R_x = 0\Omega$, (i.e. A and B are shorted), the meter current is zero.
- If the unknown Resistor $R_x = \infty\Omega$, (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

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

- 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

<u>3rd CHAPTER</u>

<u>DIGITAL INSTRUMENTS</u>

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

- 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.

- 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 characterize 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,

Sensitivity(S) = $(f_s)_{min} * R$

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

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

Fig.

Design and simulation of digital frequency meter : Two type of circuits are 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 be 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.

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 full wave rectifier circuit followed by a ripple reduction filter.

- The resulting D.C fed to ADC and the subsequent display system.

- For 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:

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 pickup for one revolution of the shaft.

- Therefore, in one minute the number of pulses from the pickup is R x P.
- Then, the-frequency of the signal from the pickup 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 (Rx P x 60)/ 60P = R 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.

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.

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.

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

CHAPTER -4

OSCILLOSCOPE

Discuss the basic principle of Oscilloscope.

It is a device that allows the amplitude of electrical signal wheather voltage, current or power to be displayed a function of time.

- It is basically an electron beam voltmeter
- It depends on the movement of an electron beam to impinge on phosphor screen, which produces a visible spot.
- When the electron beam is deflected by some means in two axes (x & y) the visible spot can be used to create a two dimensional graph .
- Oscilloscope is capable of displaying events that take place over periods of microseconds and nanosecond.

Discuss the Block Diagram of Oscilloscope & Simple CRO.

- The block diagram of simple CRO is as shown in figure below.
- Here the Oscilloscopes are used to observe the change of an electrical signal over time, such that voltage and time describe a shape which is continuously graphed against a calibrated scale.
- The observed waveform can be analyzed for such properties as amplitude, frequency, rise time, time interval, distortion and others.
- Modern digital instruments may calculate and display these properties directly.
- Originally, calculation of these values required manually

measuring the waveform against the scales built into the screen of the instrument.

Figure:

- The oscilloscope can be adjusted so that repetitive signals can be observed as a continuous shape on the screen.
- A storage oscilloscope allows single events to be captured by the instrument and displayed for a relatively long time, allowing human observation of events too fast to be directly perceptible.
- Oscilloscopes are used in the sciences, medicine, engineering, and telecommunications industry.
- General-purpose instruments are used for maintenance of electronic equipment and laboratory work.
- Special-purpose oscilloscopes may be used for such purposes as analyzing an automotive ignition system or to display the waveform of the heartbeat as an electrocardiogram.

Dual Trace CRO:

Definition: The oscilloscope which is capable to display two signals at a time on a screen having single election gun is called as dual trace oscilloscope.

Construction:

- It Consists of two attenuator which conditions the input signal.
- It consists of two preamplifier which.
- Amplifies the signal coming from attempt.
- It consists of an electronic switch and vertical amplifier.

WORKING

- In this type of oscilloscope both the input signal are applied simultaneously but it has one election gun.
- Both the signals are fed to the electronic switch through preamplifier.
- The electronic switch connects the signals to the vertical amplifier by two ways.
- One way of connecting the signal to the vertical amplifier expects is alternate made of operation, but it is not suitable for low frequency signals.
- Another way of connecting the signal to the vertical amplifier is chap mode of operation.

Explain the use of Lissajous method for Phase & Frequency Measurement.

Lissajous Pattern :-

- A set of pattern obtained when two sinusoidal wave are applied to the both horizontal and vertical defecting plates (x&y) of CRO simultaneously. Are called as lissajous pattern.
- These patterns are as per the name of scientist. Jauls Antonmene lissajous .
- The shape of the Lissajous pattern depends on the frequency and phase relationship of the two sine wave.

phase measurement :-

Procedure :

- To measure the phase angle between two sinusoidal signal.
- The signal is fed to Y-plate and another signal is feed to the x-plates:
- If two signals are in phase, the display is as shown in the figure :

- If phase angle is 180^0 Then figure is

Figure:

- If phase angle is 90^0 Then the figure is

Figure:

Phase angle in between 0 and 90 or 270 and 360 Then the figure:

Frequency Measurement :-

- Both the signal is applied to X &Y input simultaneously.
- Oscilloscope's internal sweep and sync. Control is switch off.

Application of CRO:-

1) Tracing of Signal
2) Measurement of amplitude of signal
3) Comparison of phase & frequency of signal.
4) Measurement of capacitance and inductance.
5) In television Radar.
6) For engine pressure analysis.
7) For studying heart beats nervous reactions.

DIGITAL STORAGE OSCILLOSCOPE

Construction

- It consists of Alternator writer amplifier & sample and hold circuit.
- It consists of ADC, trigger CRT and memory.
- It consists control logic unit, DAC and horizontal Amplifier.

Working :-

- The Signal is amplified and attenuated and given to the sample and hold circuit and trigger circuit.
- The output of sample and hold circuit is given to the Analog to-Digital converter which converts our analog signal into digital data.
- This digital data is given to memory which is given to vertical deflection amplifier through D/A.
- The Control logic also gives another signed to CRT through horizontal defection amplifier through D/A.
- By receiving both the signal CRT displays.

ADVANTAGES :-

- Infinite strong time.
- Easy to operate.
- Signature processing is possible.
- A number of traces can be stored.

- Display of work from is possible by retriggering.

Applications

- It can be used to measurement AC& DC.
- It can be used to measure frequency,time period, time interval between two signals.
- It is used to give visual representation for a target of rader.

High Frequency Oscilloscape:-

- The type of oscilloscope which is capable of displaying signal of frequency more than 300 KH_z are called as HF oscilloscope.
- The HF oscilloscope can display up to 500 MH_z signal.
- The HF oscilloscope differ in their internal construction from LF oscilloscope by their special HF CRTS and high frequency amplifiers.
- Electron beam
- The HF oscilloscope consists of series of vertical deflection plates.

CHAPTER -5

BRIDGES:

Types of Bridges

There are two types of bridge (i) Dc bridges.
(ii) Ac bridges.

Wheatstone bridge:

The simplest form of bridge is for the purpose of measuring resistance and is called as wheatstone brodge.

Let R_1, R_2, and R_3 are standard resistors.
R_4 = Unknown resistors .
For a balance bridge condition.
$V_A = V_B$ …………… (1)

$I_1 = I_3$ And $I_2 = I_4$

$I_1 = I_3 = \frac{\mathbf{V}}{R1+R3}$ ....(2)

And $I_2 = I_4 = \frac{\mathbf{V}}{R2+R4}$ ......(3)

From equation (1) $V_A = V_B$

$\Rightarrow I_1R_1 = I_2R_2$

$\Rightarrow \frac{\mathbf{VR1}}{R1+R3} = \frac{\mathbf{VR2}}{R2+R4}$

$\Rightarrow \frac{\mathbf{R1}}{R1+R3} = \frac{R2}{R2+R4}$

$\Rightarrow R_1R_4 = R_2R_4$

Diagram

<u>Measurement of Induction by Maxwell's Bridge</u>

Let C_1, R_1, R_2, R_3 are standard capacitor and resistors.
Let R_4 & L_4 be the unknown resistors and inductor respectively.
The bridge balance equation is

$Z_1Z_4 = Z_2Z_3$

$Z_4 = \frac{Z2Z3}{Z1}$ .... (1)

Where $Z_1 = R_1$

$Z_2 = R_2$

$Z_3 = R_3 + jwL_3$

$Z_4 = R_4 + jwL_4$

Putting all values of in equation (1)
We get
Do your self

Advantages of Maxwell's Bridge

(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.

Disadvantages of Maxwell's Bridge

(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.

Explain the measurement of self inductance by

Hay’s Bridge:

A Hay's bridge is modified Maxwell bridge, now question arises here in our mind that where we need to do modification. In order to understand this, let us consider the connection diagram given below:

Hay's Bridge Circuit

Hay's Bridge Applications

- Before we introduce Hay's bridge let us recall the limitations of Maxwell Bridge, in order to understand what is the necessity of Hay's bridge applications.

- Maxwell bridge is only suitable for measuring medium quality factor coils however it is not suitable for measuring high quality factor (Q > 10). In order to overcome from this limitation we need to do modification in Maxwell bridge so that it will become suitable for measuring Q factor over a wide range.

- This modified Maxwell bridge is known as Hay's bridge.

Advantages of Hay's Bridge

(1) The bridge gives very simple expression for the calculation of unknown inductor of high value. The Hay's bridge requires low value of r_4 while Maxwell bridge requires high value of r_4. Now let us analyze why should put low value of r_4 in this bridge:

Consider the expression of quality factor,

As r_4 presents in the denominator hence for high quality factor, r_4 must be small.

Disadvantages of Hay's Bridge

Hay's bridge is not suitable for measurement of quality factor (Q<10) for Q<10 we should use Maxwell bridge.

Explain the measurement of self inductance by Schering Bridge:

Schering Bridge Theory

This bridge is used to measure to the capacitance of the capacitor, dissipation factor and measurement of relative permittivity.

Let us consider the circuit of Schering bridge as shown

Below:

Here, c_1 is the unknown capacitance whose value is to be determined with series electrical

resistance r_1.

c_2 is a standard capacitor.

c_4 is a variable capacitor.

r_3 is a pure resistor (i.e. non inductive in nature).

And r_4 is a variable non inductive resistor connected in parallel with variable capacitor c_4.

Now the supply is given to the bridge between the points a and c. The detector is connected between b and d. From the theory of ac bridges we have at balance condition,

Substituting the values of z_1, z_2, z_3 and z_4 in the above equation, we get

Equating the real and imaginary parts and the separating we get,

Application:

This bridge is used to measure to the capacitance of the capacitor, dissipation factor and measurement of relative permittivity.

Explain the measurement of Capacitance by Wein's Bridge: Theory of Owen's Bridge

- We have various bridges to measure inductor and thus quality factor, like Hay's bridge is highly suitable for the measurement of quality factor greater than 10.
- Maxwell's bridge is highly suitable for measuring medium quality factor ranging from 1 to 10 and Anderson bridge can be successfully used to measure inductor ranging from few micro Henry to several Henry.
- So what is the need of Owen's bridge?
- The answer to this question is very easy. We need a bridge which can measure inductor over wide range.
- The bridge circuit which can do that, is known as Owen's bridge.
- It is ac bridge just like Hay's bridge and Maxwell bridge which use standard capacitor, inductor and variable resistors connected with ac source for excitation.
- Let us study Owen's bridge circuit in more detail.

An Owen's bridge circuit is given below.

DIAGRAM

Advantages of Owen's Bridge

(1)The for inductor l_1 that we have derived above is quite simple and is independent of frequency component.

(2)This bridge is useful for the measurement of inductor over wide range.

Disadvantages of Owen's Bridge

(1) In this bridge we have used variable standard capacitor which is quite expensive item and also the accuracy of this is about only one percent.

(2) As the measuring quality factor increases the value of standard capacitor required increases thus expenditure in making this bridge increases.

Discuss the working principle of Q Meter.

Working Principle of Qmeter, Its Circuit Diagram & Measurement:-

Def :-The instrument which is designed to measure electrical properties of coils and captions is called as Q-met.

Principle :- The Principle of the Q-meter is based on series resonance, the voltage drop areas the coil or cap

Construction:

- It consists of a wide range of oscillator which is used as power supply of the circuit.
- It also consist of a shunt resister R_{sh} inductor L , resonating capacitor C_R .
- It consists of electronic voltmeter calibrated in Q-value & thermocouple voltmeter.

Working:

- Quality factor is nothing the ratio of reactance to resistance.(X_L/R).
- When a fixed is applied to the circuit, voltmeter across the capacitor can be calibrated to read directly.
- Where X_L= Inductive reactance.
  X_c=capacitive reactance
  R = Coil resistance.
  I= circuit current.
  V_L=Inductive voltage
  V_c=Capacitor voltage

At resonance $X_L=X_C$

$V_L=IX_L$

$V_C=IX_C$

V= IR

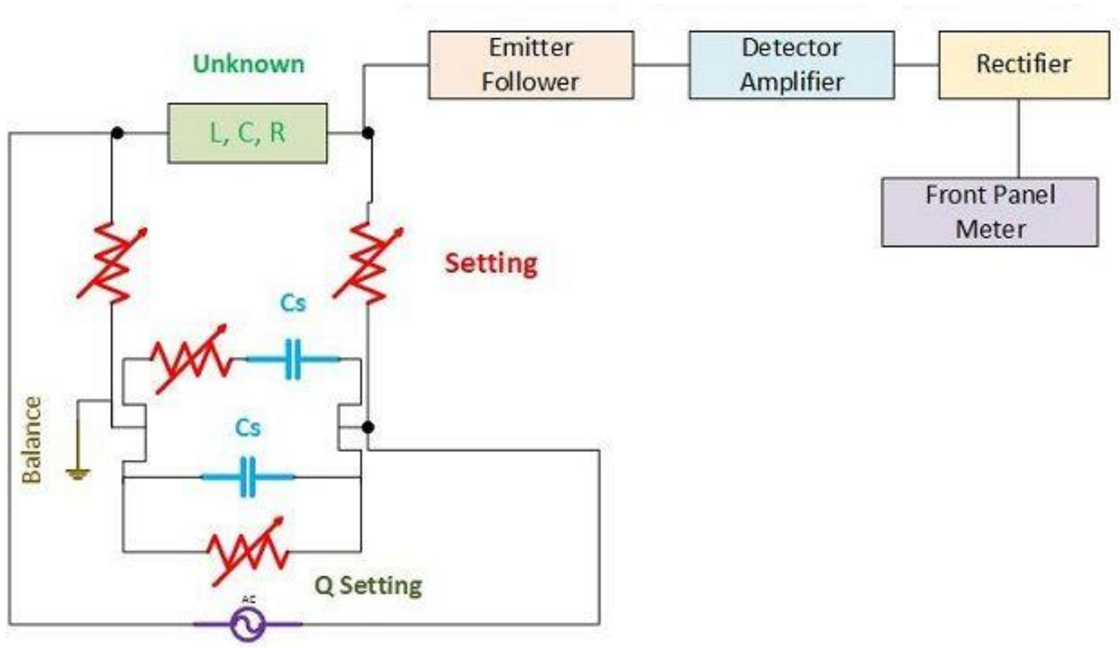
Therefore Q= $X_L/R = X_C/R = 1/\omega cR = V_C/V$…….(1)

➢ In the above equation if V is kept constant, the voltage across the capacitor can be measured by voltmeter calibrated to read directly in terms of Q.

LCR Meter & it is measurements

Def:- It is defined as the electronic measuring instrument which can measures values of inductances (L), Capacitance (c) & Resistance (R) directly.

CKT Diagram



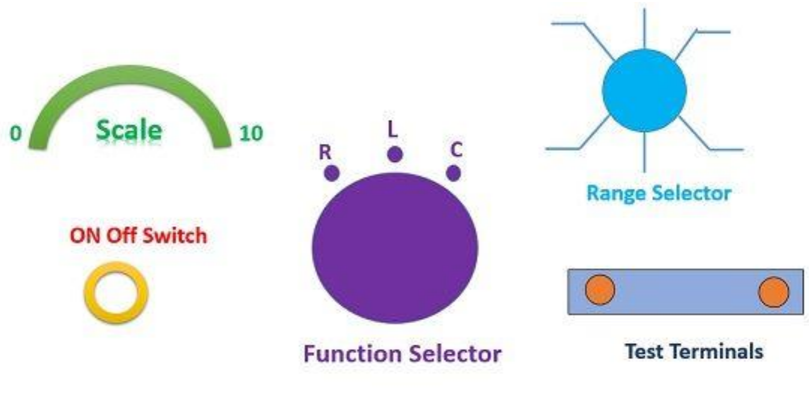
Construction:-

➢ It consists of a permanent magnet moving coil instrument.
➢ The scale of the meter is calibrated in terms of R, L, C.
➢ It consists of an emitter follower circuits.
➢ It consists of a detector amplifier.
➢ It consists of a rectifier.
➢ It also consists of wheatstone bridge.

WORKING

➢ When the test component is set at the test terminal the current passes through it.
➢ The bridge is adjusted in null position in order to balance it completely.
➢ The output from the bridge is fed to emitter follower circuit.

- The output from emitter follower circuit is given as an input to detector amplifier.
- The detector amplifier is used in order to prevent the fall of voltage level during measurement process.
- The **rectifier** is used in the circuit to convert the AC signal into DC signal.
- At last the DC signal is converted to digital data which is shown in the display device.



Controls on face panel of LCR meter

CH-6: TRANSDUCERS AND SENSORS

Definition of transducers: The device which transforms the energy of the process variable to an output of some other type of energy which is able to operate some control device is called as ttransducer.

Definition of Sensor: the device which sense the condition , state or value of the process variable and produce an output which reflects this condition , state or variable.

Method of Selecting transducers:

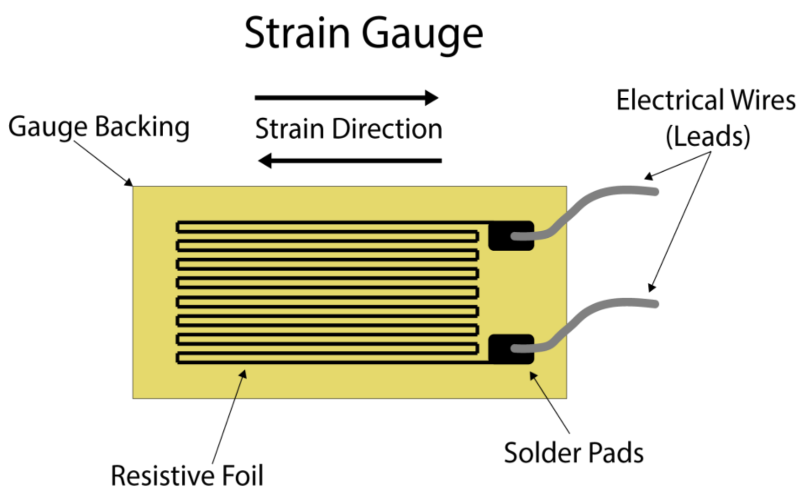
- There are many ways for measurement of a physical quantity. While *selection of transducers*.
- How to select a transducer for a particular application, following points should be kept in the mind.
- Unfortunately most transducers are not sensitive to just one quantity. If measurements are to be made under conditions where there is likelihood of two or more input quantities influencing the transducer.
- it is desirable to select a transducer which is sensitive to the desirable quantity and insensitive to the unwanted quantity.
- If this is not possible, ways and means should be found to eliminate or compensate for the effects of the unwanted input quantity.
- **Operating Principle**. The transducers are many times selected on the basis of operating principle used by them. The operating principles used may be resistive, inductive, capacitive, optoelectronic, piezoelectric etc.
- **Sensitivity**. The transducer must be sensitive enough to produce detectable output.
- **Operating Range**. The transducer should maintain the range requirements and have a good resolution over its entire range. The rating of the transducer should be sufficient so that it does not breakdown while working in its specified operating range.
- **Accuracy**. High degree of accuracy is assured if the transducer does not require frequent calibration and has a small value for repeatability. It may be emphasized that in most industrial applications, repeatability is of considerably more importance than absolute accuracy.
- **Cross sensitivity**. Cross sensitivity is a further factor to be taken into account when measuring mechanical quantities. There are situations where the actual quantity is being measured is in one plane and the transducer is subjected to variations in another plane. More than one promising transducer design has had to be abandoned because the sensitivity to variations of the measured quantity in a plane perpendicular to the required plane has been such as to give completely erroneous results when the transducer has been used in practice.

Advantages of transducers:

- Attenuation can be done easily.
- Mass inactivity effects can be reduced.
- Friction effects can be reduced.
- The o/p can be specified & recorded remotely at a distance from the sensing medium.
- The signal can be mixed to get any permutation with outputs of related transducers otherwise control signals.

Working principle of Strain Gauges, define Strain Gauge.

- A strain gauge is a type of electrical sensor.
- A strain gauge is a sensor whose measured electrical resistance varies with changes in strain.
- Strain is the deformation or displacement of material that results from an applied stress.
- Stress is the force applied to a material, divided by the material's cross-sectional area.
- Strain gauges convert the applied force, pressure, torque, etc. into an electrical signal which can be measured.
- Force causes strain, which is then measured with the strain gauge by way of a change in electrical resistance.
- Then the voltage measurement is done by electrical instruments.



LINEAR VARIABLE DIFFERENTIAL TRANSFORMER (LVDT)

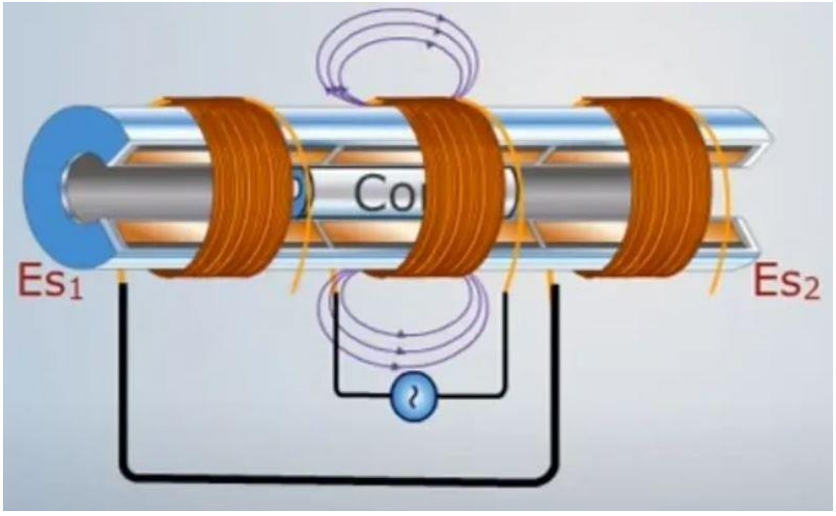
Working principle of LVDT

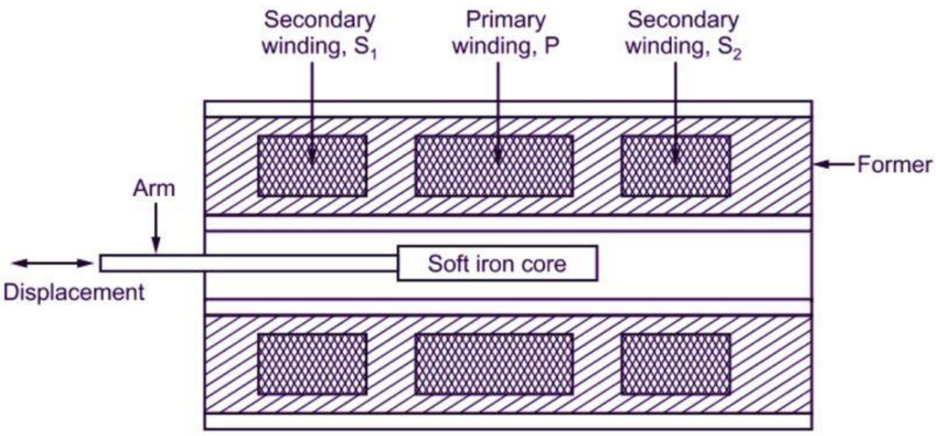
Principle:

- The working of LVDT is based on the principle of Faraday's law of electromagnetic induction that states that "the net induced emf in the circuit is directly proportional to the rate of change of magnetic flux across the circuit, and the magnetic flux of the coil wounded with wires can be changed by moving a bar magnet through the coil.

- LVDT stands for Linear Variable Differential Transformer.

DIAGRAM:





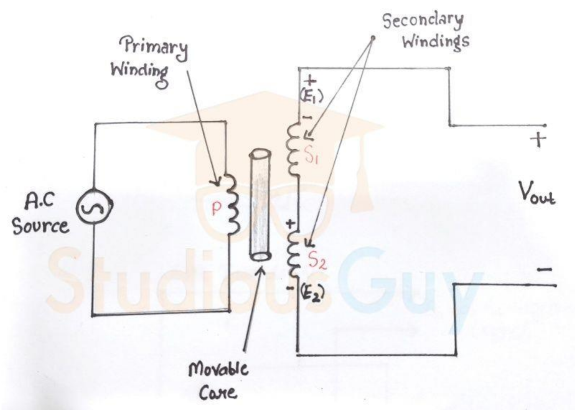
CONSTRUCTION:

- The structure of LVDT is similar to the transformer.
- It consists of one primary winding, i.e., P and two secondary windings, i.e., S1 and S2.
- The primary and secondary windings are wounded on a hollow cylindrical shaped structure, called former.
- The former is usually made of glass-reinforced polymer wrapped in a highly permeable material and then covered with cylindrical steel.
- The primary winding is at the centre of the cylindrical former and the secondary windings are present on both sides of the primary winding at an equal distance from the centre.
- Both the secondary windings consist of an equal number of turns, and they are linked with each other in series opposition.

- The movable part of LVDT is a separate arm that is made up of a magnetic material.
- It is usually a soft iron core, which is laminated to reduce the losses due to eddy current.
- The core can freely move within the hollow coil (former), and the object whose displacement is to be measured is attached to the core through a non-magnetic rod.

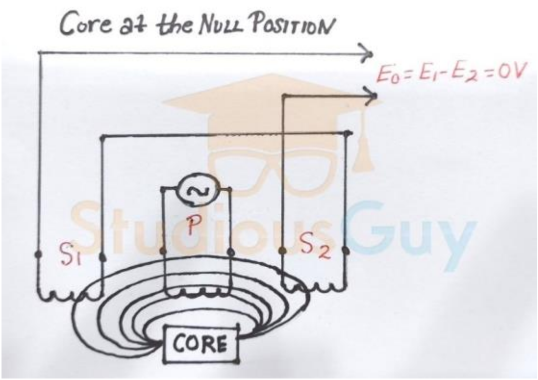
Working of LVDT:

- When current flows through the primary winding it induces voltage across the secondary coils.
- Let the induced voltage be E_1 and E_2 across the secondary coils S_1 & S_2 respectively.
- Since the secondary windings are connected in series and opposite phases their net induced voltage will be $E=E_1 \sim E_2$.
- The net emf induced in the circuit depends upon the position of the movable core; let us discuss the three different cases according to the position of the core.

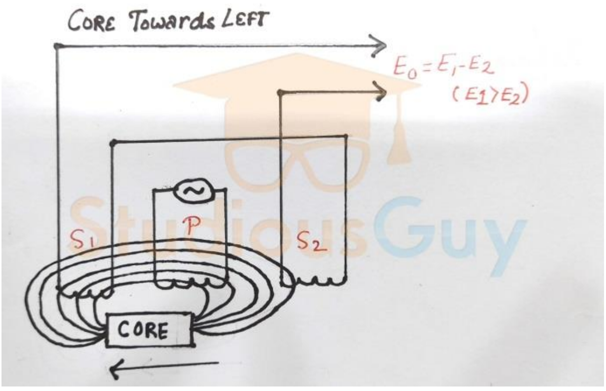


- **CASE 1: Core at the Null Position**

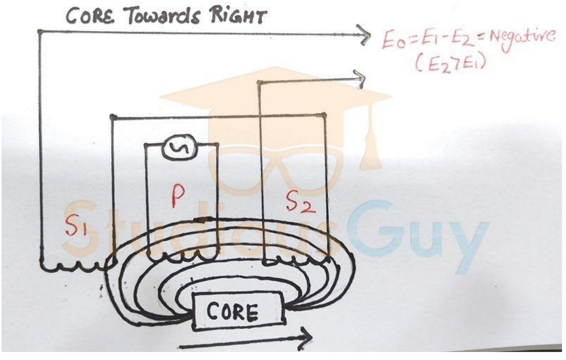
- when the core is placed at the centre, the induced emf's E1 and E2 in the secondary windings S1 and S2 respectively will be the same, i.e., E1=E2.
- Hence, the net induced emf (Eo) in the circuit at the normal position of the core is zero (E1-E2=0).
- The normal position of the soft iron core at which the net induced emf is zero is called the 'Null Position' of the LVDT.As shown in the figure.



- CASE 2: Core at the Left of Null Position
- If the core is moved towards the left from the null position, the induced emf in coil S_1 will be larger than the induced emf in coil S_2.
- Hence, the tool output voltage (E_{output}) of LVDT is given by, $E_{output} = E_1 - E_2$ = Positive ($E_1 > E_2$)



- CASE 3: Core at the Right of Null Position
- If the core is displaced from the null position and moved towards the right, the induced emf in winding S_2 will become more than the emf induced in winding S_1.
- Hence, the tool output voltage (E_{output}) of LVDT is given by, $E_{output} = E_1 - E_2$ = Negative ($E_2 > E_1$).



- From all the three cases discussed above, it can be concluded that the displacement of the body is directly proportional to the output voltage.
- Hence, the direction of the movement of the body attached to the core of the LVDT can be find out with the help of net output voltage obtained across the output terminal of the LVDT.

CAPACITIVE TRANSDUCERS (PRESSURE)

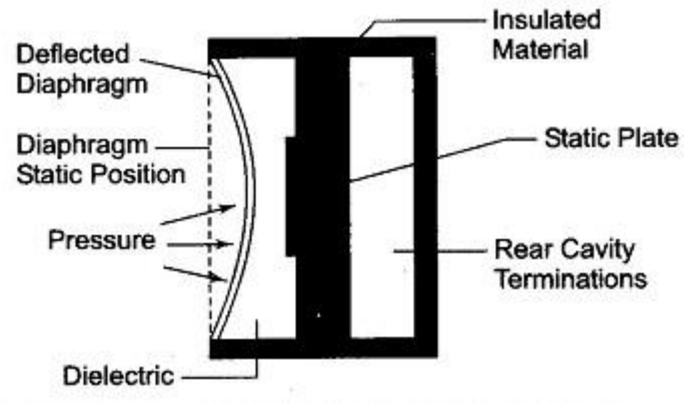
Working principle of capacitive transducers (pressure)

- A linear change in capacitance with changes in the physical position of the moving element is used to provide an electrical indication of the element's position.
- The capacitance is given by

$C= k\frac{A}{D}$

where

- K = the dielectric constant
- A = the total area of the capacitor surfaces
- D = distance between two capacitive surfaces
- C = the resultant capacitance.
- From the above equation, it is seen that capacitance increases (i) if the effective area of the plate is increased, and (ii) if the material has a high dielectric con-stmt.
- The capacitance is reduced if the spacing between the plates is increased.
- Transducers which make use of these three methods of varying capacitance have been developed.
- With proper calibration, each type yields a high degree of accuracy in measurement.



LOAD CELL (PRESSURE CELL)

- Load cell is a sensor or a transducer that converts a load or force acting on it into an electrical signal.
- This electrical signal can be a voltage change, current change or frequency change depending on the type of load cell and circuitry used.

Working principle of Load Cell (Pressure Cell)

- **Resistive load cells** work on the principle of piezo-resistivity. When a load/force/stress is applied to the sensor, it changes its resistance. This change in resistance leads to a change in output voltage when a input voltage is applied.
- **Capacitive load cells** work on the principle of change of capacitance which is the ability of a system to hold a certain amount of charge when a voltage is applied to it. For common parallel plate capacitors, the capacitance is directly proportional to the amount of overlap of the plates and the dielectric between the plates and inversely proportional to the gap between the plates.
- A load cell consists of an elastic member as the primary transducer and strain gauges as secondary transducer.
- When combination of the strain gauge and elastic member is used for weighing, it is called as load cell.

Load cells one various types
(i) Hydraulic load cells.
(ii)Pneumatic load cell.
(iii) Strain-gauge load cell.

WORKING PRINCIPLE OF TEMPERATURE TRANSDUCER (RTD,OPTICAL PYROMETER, THERMOCOUPLE , THERMISTER)

- A Temperature Transducer is a device that converts the thermal quantity into any physical quantity such as mechanical energy, pressure and electrical signals etc.
- Temperature transducers consist of sensing element, metal enclose, and external output terminal.
- Sensing elements are categorized into two types.

(i) Contact sensor device.

Direct contact with the substances and the heat transfer occurs to the sensing element in the form of conduction. These type of preferable for high temperature measurement, typically 50 to 2500 + deg.

Example: Thermocouple

(ii)Noncontact sensor device.

It does not have direct contact with the substances. There is a metal enclose is used to protect the sensing element.

Example: Thermister.

RTD (Resistance Temperature Detector) :-

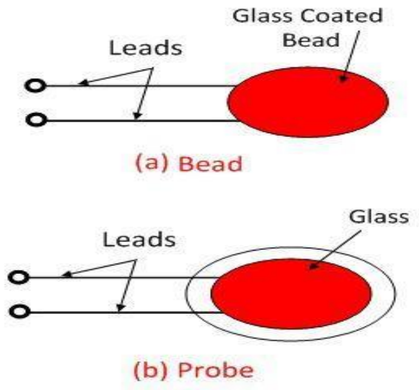
- RTD is also called as Resistance Themometer.
- RTD works on the principle of change in temperature of a conductor changes the resistance of that conductor.
- The variation of resistance R with temperature T (ºk) can be represented by the allowing relationship.
- $R=R_0(1+\alpha_1 T+ \alpha_2 T^2+ \alpha_3 T^3+\ldots\ldots+)$.

Where R_0= Resistance of the conductor at temperature $T=o^0K$.
α= Temperature coefficient.

- Generally platinum wire is used for RTD.

<u>THERMISTORS :-</u>

- Thermistor is a contraction of a thermal resistors.
- Thermistors are generally composed of mixture of metallic oxides.
- Thermistors works on the principle of change in resistance of conductor with the change in temperature of that conductor.
- Generally most of the thermistors have –ve temperature coefficient.
- They are usually called the ideal temperature transducer.



Thermistor

Properties of Thermistors

- They have Negative Thermal Coefficient i.e. resistance of the thermistor decreases with increase in temperature.
- They are made up of the semiconductor materials.
- They are more sensitive than RTD (Resistance Thermometres) and Thermocouples.
- There resistance lies between 0.5Ω to 0.75 MΩ.
- They are generally used in applications where measurement range of temperature -60• °C to 15• °C.

Thermocouples

- Thermocouple works on the seeback effect, which states that when two metals having different work functions are placed together a voltage difference is generate at Junction which is nearly proportional to the temperature difference between these two junction.
- Thermocouples are temperature transducers that are basically consists of two junctions of dissimilar metals, such as copper and constantan that are welded.
- One junction is kept at a constant temperature called the reference (Cold) junction, while the other the measuring (Hot) junction.
- When the two junctions are at different temperatures, a voltage is developed across the junction which is used to measure the temperature.

Principle of Thermocouple

- When the junctions of two metals such as copper and constantan are connected together the potential difference is produced is between them.
- The phenomenon is called as the seebbeck effect as a temperature gradient is generated along the conducting wires producing an emf.
- Then the output voltage from a thermocouple is a function of the temperature changes.

Main Features of Thermocouples

- Thermocouples have good sensitivity.
- Extreme temperatures of range between -200^{o}C to over +2000^{o}C can be measured with thermocouples which is an advantage over both RTD and Thermistor.
- They are the Active Transducers so they don't require any external source for measuring of temperature as like RTD's and Thermistors.
- They are the cheaper than both RTD's and Thermistors.
- These have small accuracy as compared to RTD's and Thermistors so generally they are not used for high precision work.
- It is suitable for very high frequency measurement.
- Its accuracy is very high.

OPTICAL PYROMETER

- The noncontact type temperature measurement in which operation of the device happen on the visible radiation from the measurand and is called optical pyrometer.
- Optical pyrometer makes use of the variations in color of a hot body and interprets this phenomena in terms of temperature.
- When a body is heated, it initially becomes dark red turns to orange, and finally becomes white.
- The actual measurement of temperature is based upon the determination of the changes in color of the hot body, and comparing it with known values produced with a heated filament.

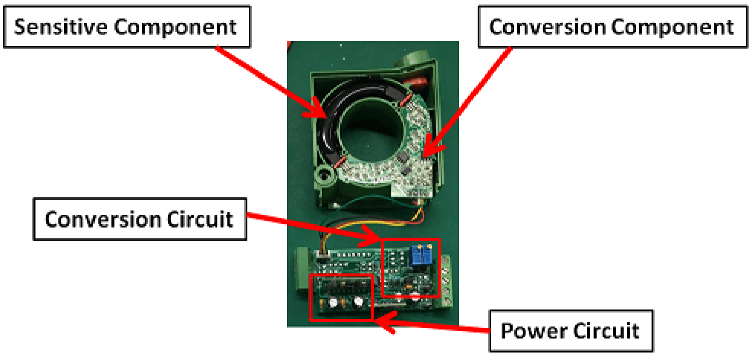
Working principle of Current transducer

- A current transducer is a device that converts alternating or direct electrical signals into a proportional industrial standard electrical signal.

Construction

- Current transducer consists of sensitive component.
- It also consists of a conversion component.
- It consists of a conversion circuit.
- It consists of a power circuit.

Diagram



WORKING

- First of all the sensitive component will detect the incoming electrical signal and give a signal.
- After that the signal will be passed to conversion component, which can convert the signal to a small current signal.
- Then it will be passed to conversion circuit, which process the small current signal and provide an industrial standard electrical signal, usually is 0-5V, 4-20mA, RS485.
- At the end the output signal goes to terminal equipment, such as display, PLC, alarm unit, automation control, etc.
- Current transducer usually has a power circuit, which provide the power to conversion component and conversion circuit.

KW Transducer.

- A watt or power transducer measures true electrical power delivered to a load and converts that measurement to a DC voltage or current signal proportional to the power measured.
- To measure power, the watt transducer must monitor both the voltage and current in a circuit.
- Further, it must be able to accurately determine the phase relationship between the voltage and current.
- This is the angle by which the current leads or lags the voltage.

- This measurement is very important to accurately determine true power.
- The watt transducer must also measure the power in each of the branches of the circuit.
- Your house, apartment, or small office is wired in what is often referred to as the Edison System.
- This is a three-wire, single phase system with two power lines in a neutral. The watt transducer must measure the power in each of the power lines or mains.
- This circuit requires a two-element watt transducer.
- A two-element watt transducer has two-watt transducers in the same case.
- The outputs of the two transducers or multipliers are summed so that the out put signal of the entire watt transducer represents total power.

CH7: SIGNAL GENERATOR, WAVE ANALYZER & DAS

General aspect & classification of Signal generators

Defination of Signal generator: A Signal generator is an instrument that provides a controlled output waveform or signal for use in testing or aligning, or in measurements on other circuits or equipments.

Classification of Signal Generator:

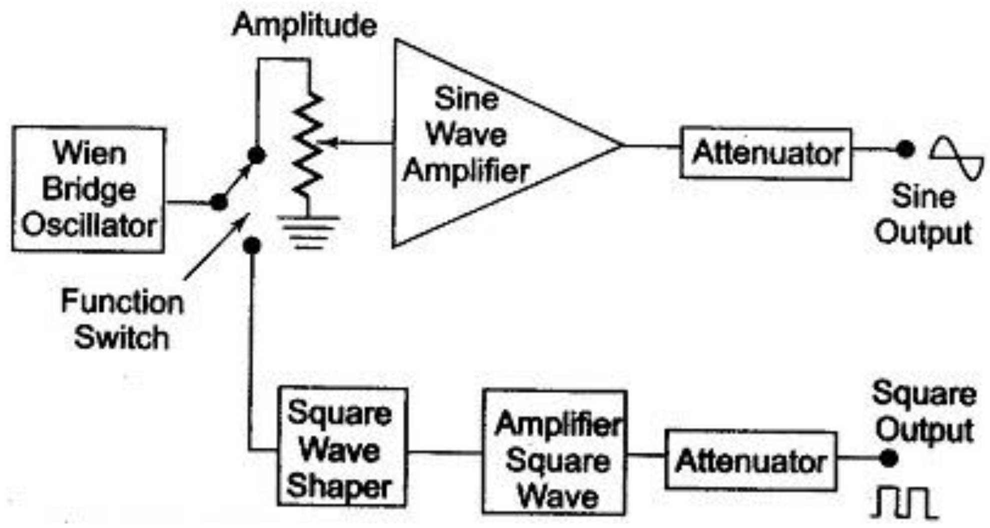
The Signal generator can be classified into the following categories:

1. Audio generators
2. Functions
3. Pulse
4. RF

5. Frequency synthesizer.

Working principle of AF since & square wave generator.

BLOCK DIAGRAM:



Construction

- It consist a wein bridge oscillator which provide signals of audio frequency range.
- It consists of function switch, amplitude control resistors.
- It consists of sine wave amplifier, square wave amplifier.
- It also consists of attenuator and square wave shaper circuit.

Working

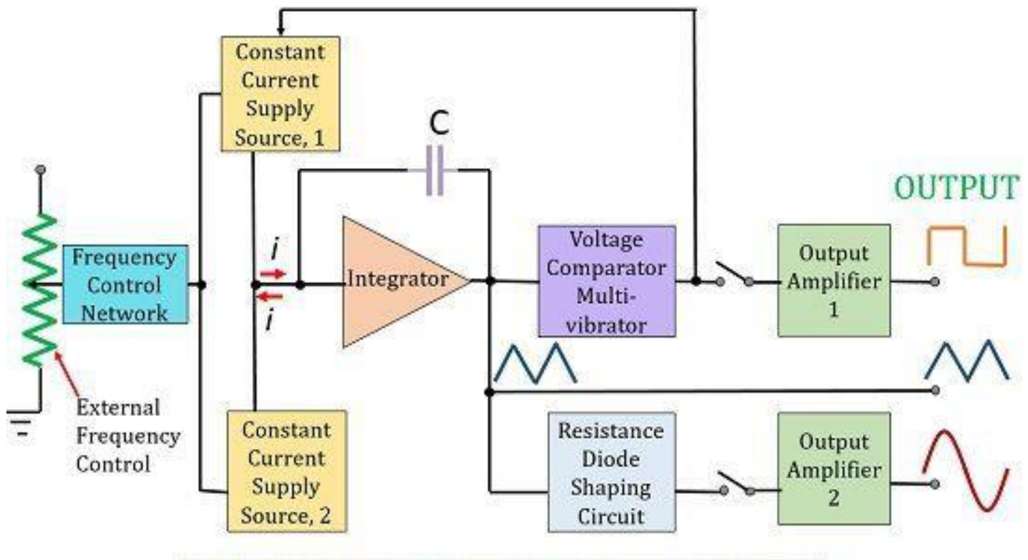
- First of all function switch is placed as per our requirement of sine wave or square wave amplifier.
- When sine wave section is activated by function switch, the signal from oscillator reaches at sine wave amplifier through amplitude control resistor.
- The sine wave amplifier increases the strength of the signal and gives it to attenuator.
- The attenuator decreases the strength of the spikes present in the amplified signal and its output sine wave output.

- When sequence wave section in activated by function switch the signal form oscillator reaches at sequence wave shaper circuit
- The output of square wave shaper circuit is given to the sequence would amplifier in order to amplify the strength of the signal.
- Then the amplified signal is given is given to the attenuator for cutting of the spikes present in the amplified signal and the final square wave signal is found.
- Then the amplified signal is given to the attenuator the cutting of the spikes present in the amplified signed and the final sequence wave signal is found.

Function Generator

Principle:

- It is defined as the instrument that has the capability of producing different types of wave from as its output signal.
- Function Generator is basically a signal generator that produces different types of waveforms at the output.
- Function Generator is a versatile instrument as an extensive variety of frequencies and waveforms are produced by it.



Construction:

- The function generator consists of an integrator and a frequency control switch.
- It consists of a frequency range selection switch and a submit trigger.
- It consists of a sine wall convertor and a function switch.
- It also consists of a attenuator for giving a smooth signal.

Working:

- First of all- the frequency range selection and frequency control switch is adjusted as per the requirement.
- Then the integrator gives its output which is a triangular wave as per the frequency control switch to the sine wave generator and Schmitt trigger.
- If the function switch is connected directly to the integrator than the output of the function generator is a triangular wave from.
- If the function switch is connected to the submit trigger than the output of the generator is a square wave.
- If the function switch is connected to the sine wave converter then the output of the generator is sine wave.
- In this way the function generator works.

Basic concept of Data acquisition system (DAS)

- It is defined as a system used for data processing, data conversion data transmission & data various types
- Data acquisition system one of various types

i) Analog data acquisition system.
ii) Digital data acquisition system.

- An analog data acquisition system consists of following elements

i) Transducers
ii) Signal conditioners.
iii) Calibrating equipments
iv) Integrating equipment
v) Visual devices.
vi) Graphic recording instrument.
vii) Magnetic tape instrumentation.
viii) Analog computers.
ix) High speed camera & TV equipments.

- A digital data acquisition system consist of following elements.

i) Transfer
ii) Signal conditioner
iii) Scanner or multiplexer
iv) Signal convertor
v) ADC
vi) System Programer
vii) Digital recorder
viii) Digital Printer

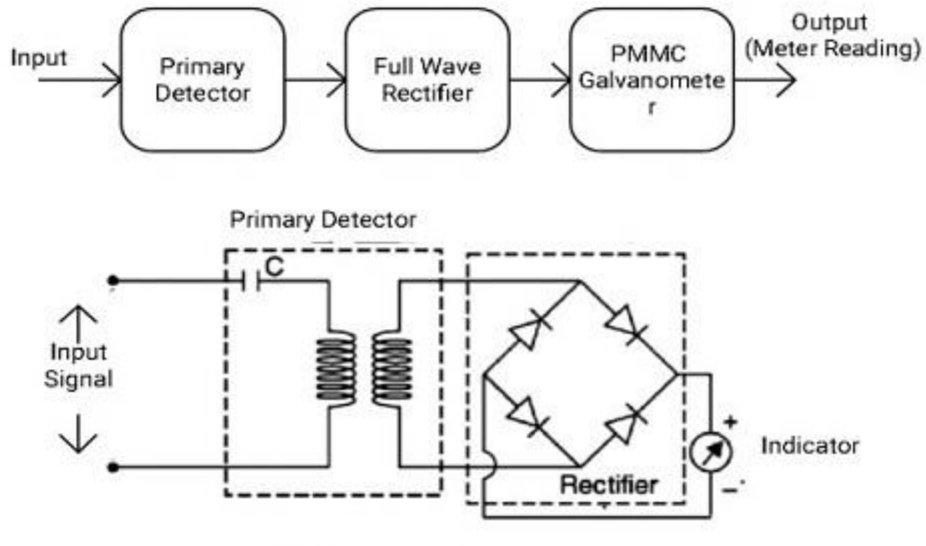
Function of basic wave analysis & spectrum Analyse

<u>Wave analyser</u>

➢ It is an instrument which measures relative amplitude of single frequency components in a complex waveform.
➢ Wave analyser are of two types basing upon frequency range.
(i)Basic wave analysis

a) Frequency selective wave analyzer (20-20KHZ)
b) Heterodyne wave analyzer (10KHZ to 18 MHZ

Basic wave analyser :-
It is the simplest form of wave analyzer which measures relative amplitudes of single frequency components in a complex or distorted wave from.



Wave Analyzer

Construction :-
➢ It consists of a primary detector.
➢ It consists of a full wave rectifier.
➢ It consists of an indicating instrument.
Working :-
➢ The primary detector detector the single frequency component and rejects all the frequencies.
➢ The detected signals average value is provided by the full wave rectifier.
➢ The indicating device shows the value of single frequency component wave/signal.

Wave analyzer based upon frequency range:- Wave analyzer based upon frequency range is of two types
(i) Frequency selective wave analysis (20HZ-20KHZ).

(ii)Heterodyne wave analysis (10KHZ-18MHZ).