



ZONE TECH
Best Institute For Assistant & Junior Engineer

RPSC-AEn Mains

Work Book Solution

for

Measurement



Visit Our Website
www.zonotech.in



DOWNLOAD NOW

<https://zonotech.in/downloads>

PART - A

2 Marks Questions

1.
Sol. **Precision** : It is defined by repeatability or reproducibility. If multiple readings are taken from an instrument and readings are repeated then instrument will be precise.
Note : If any instrument is accurate then it will be precise and if any instrument is precise then there is no guarantee of being an accurate.

accuracy = precision

precision $\neq$ accuracy

2.
Sol. Probable error is a measure of precision of instrument. It is directly proportional to the Standard deviation (σ) it is given by $r \propto \sigma$

$$r = 0.6745\sigma$$

3.
Sol. Calibration ensures that measurement instruments provide accurate and reliable results by comparing them to a known standard and adjusting or correcting any deviations.

4.
Sol. Accuracy refers to how close a measurement is to the true value, while precision refers to the consistency or repeatability of measurements.

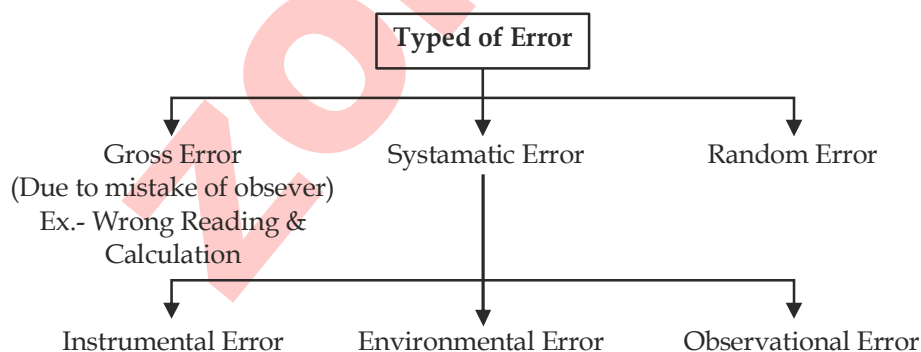
5.
Sol. Analog instruments display measurements on a continuous scale, while digital instruments display measurements in discrete numerical values.

6.
Sol. Sensitivity is the ratio of the output signal to the input signal indicating the instrument's ability to detect small changes in the measured quantity.

7.
Sol. Measurement uncertainty refers to the doubt or uncertainty associated with the result of a measurement, arising from factors such as instrument limitations, environmental conditions and human error.

8.

Sol.



9.
Sol. The deviation between measured value and true value of the quantity under measurement is called Absolute Error. The absolute Error is also known as Limiting or Guarantee Error.

$$S_A = A_m - A_T$$

S_A = Absolute error

A_m = Measured value

A_T = True value



10.

Sol. It can be used as:

1. Ammeter
2. Voltmeter
3. Galvanometer
4. Ohm Meter

11.

Sol. It is providing by spring , It is a Hair thin spring and made of phospher bronze material. when controlling torque is equal to the deflecting torque then pointer stops and gives the measurement.

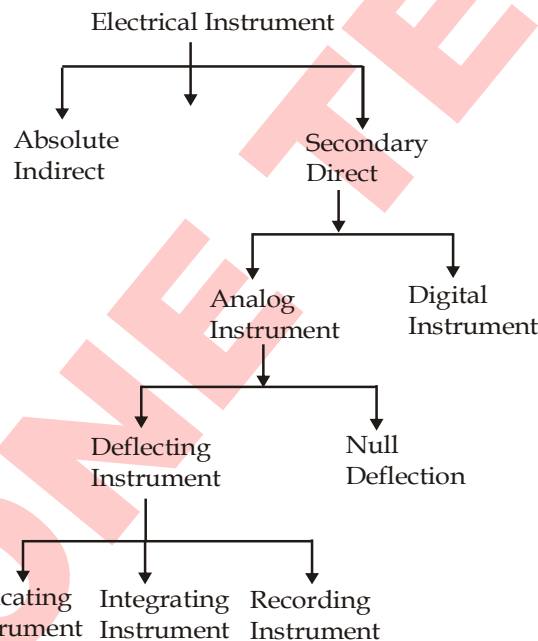
$$T_c = C\theta \quad (C = \text{spring const or stiffness of spring})$$

12.

Sol. The ammeter shunt is the device which provides the low resistance path to the flow of current. It connects in parallel with the ammeter. In some of the ammeter, the shunt is inbuilt inside the instrument while in others it is externally connected to the circuit

13.

Sol.



14.

Sol. There are two purpose of controlling torque:

1. Produce output must be directly proportional to input.
2. To bring back the pointer to its initial positio in the absence of input

15.

Sol. If a voltmeter is connected in series with the circuit, the circuit resistance will become too large and consequently a very small current will flow through it. The instrument will however, read almost the same emf acting in the circuit.

16.

Sol.

1. Consume less power and has great Accuracy.
2. high torque weight Ratio due to high sensivity.
3. It has uniform scale.
4. No losses due to hysteresis.

17.

Sol. An Electrostatic voltmeter draws Negligible current. When connected in the circuit Hence such a voltmeter does not alter the conditions of the Circuit to which it is connected that's why electrostatic Voltmeter gives Accurate Reading.

18.

Sol. Error due to temprature can be eliminated by Connecting a resistance which (10-20) times the Resistance of moving coil, in series with the moving coil. The material of this Resistance is same as that of shunt. This Resistance is called swamping Resistance.

19.

Sol. Those instrument can be calibrated with de and then used for A.C measurement, such instruments are called transfer instruments.

20.

Sol.

1. Low power Consumption.
2. No frequency Error
3. Can be used for measurement of Ae and DC
4. Not affacted by stray magnetic field
5. May be used for high voltage measurement

21.

Sol. When spring of pmmc instrument get damedg then Deflacting torque and controlling torque both are zero on account of pointer Remains to zero position.

22.

Sol. At high frequencies, the reactance of the operating coil/coils may become so high that the instrument does not draw any current. Consequently Readings can not taken.

23.

Sol. Eddy current damping is not provided in moving iron instrument because the presence, of permanent magnet required for the purpose would affect the magnetic field due to the operating coil of the instrument.

24.

Sol. According to this theoram power in polyphase system consisting of 'N' Number of conductors can be Measured with 'N' Number of wattmeter by Connecting Current coil of wattmeter in series with each conductor and pressure coil between a common point and the corresponding conductor. If one of the conductors is taken as Common point then the Number of wattmeter required (N-1).

25.

Sol. It is Loading of energy meter for testing plupose to avoid unnecessary losses of energy during testing In phantom Loading voltage coil is excited with Normal supply voltage and current coil is Supplied from a seprate source having low voltage but supplied rated cyment to the current coil.

26.

Sol. Main Causes of creeping

1. Over Compensation for friction is the main cause
2. Due to mechanical vibration
3. Due to stray magnetic field
4. Due to excessive voltage Across potential coil.

27.

Sol. Energy Meter Disc is rotate without Load This phenomena is known as Creeping error. Main cause of creeping Error is over Compensation.

28.

Sol. % Limiting error = $\frac{\% \text{ Accuracy at full scale} \times \text{full scale reading}}{\text{measured value}}$

$$= \frac{10 \times 2}{5} = 4\%$$



29.

Sol. % Relative error = $\frac{\text{True value} - \text{Measured value}}{\text{True value}} \times 100$

$$= \frac{110 - 100}{110} \times 100$$

$$= 9.09\%$$

30.

Sol. There are the transducers which are in the direct Contact with the quantity under measurement. This output may or may not be electrical signal as like as Bourdon Tubes, Bellows.

31.

Sol. Feed back transducer often called a feedback Sensor, is a device that converts a physical quantity into an electrical signal, and then provides that signal back to a control system to adjust the system behaviour. Example. Encoder, Techometers

32.

Sol. If the cross section of potentiometer wire is not uniform, then potential gradient will not be same at all places on the potentiometer wire. Consequently the measured value of potential difference will not be correct.

33.

Sol. It is because the potential drop under measurement is greater than the potential drop across the Potentiometer wire. In that case, the driver battery of large emf should be used.

34.

Sol. Measurement of Medium Resistances

1. Ammeter Voltmeter Method
2. Substitution method
3. Wheatstone bridge method
4. ohmmeter method.

35.

- Sol.**
1. Error due to Lead Resistances.
 2. Error due to Contact Resistances.
 3. Error due to temprature
 4. Error due to electrothemic effect or thermocouple effect.

36.

Sol. Types of Detectors

1. Vibrational galvenometer → for Low frequency
2. Headphone → Audio frequency range (250Hz to 4KH_z)
3. Tunable Amplifier → for wider frequency range (10Hz to 100KH_z)

37.

- Sol.**
1. Campbell's Bridge
 2. Heaviside Bridge
 3. Campbell's-Heaviside Bridge
 4. Carey-foster bridge.

38.

Sol. The instrument which measures the quality factor of the electrical circuit at radio frequencies, such type of device is known as the Q-meter. The quality factor is one of the parameters of the oscillatory system, which shows the relation between the storage and dissipated energy

39.

Sol. A multimeter, also known as a volt-ohm meter, is a handheld tester used to measure electrical voltage, current (ampere), resistance, and other values. Multimeters come in analog and digital versions and are useful for everything from simple tests, like measuring battery voltage, to detecting faults and complex diagnostics. They are one of the tools preferred by electricians for troubleshooting electrical problems on motors, appliances, circuits, power supplies, and wiring systems.

40.

- Sol.**
1. Low resistance ($R < 1\Omega$)
Armature winding resistance, Ammeter internal resistance etc.
 2. Medium resistance ($1\Omega < R < 100K\Omega$)
Electronic device resistance
 3. High resistance ($R > 100K\Omega$)
Insulation resistance, voltmeter internal resistance

41.

- Sol.**
- | | |
|--|----------------------------|
| $f < 200 \text{ Hz}$ | Vibration Galvanometer |
| $200 \text{ Hz} < f < 10 \text{ KHz}$ | Headphone Detector |
| $10 \text{ KHz} < f < 100 \text{ KHz}$ | Tunable amplifier Detector |
| $f > 100 \text{ KHz}$ | CRO |

42.

- Sol.** **Cathode :** When cathode is heated It emits electron, for continue emission of e^- Barium or Strontium oxide is used on cathode.

43.

- Sol.** **Aquadog Solution**

When electron strike at CRO screen they generate secondary electron. To absorb these secondary electron an aqueous solution of graphite is used which is called Aquadog solution.

44.

- Sol.** It is a Recording type Instrument which is used at ultra high frequency (MHz), it's Input impedance is very high ($M\Omega$) so Very low loading effect (cause very low current)
- Power consumption is very low
 - It reads peak to peak value.
 - It is used for phase angle and frequency measurement.
 - It is voltage operated device.

45.

- Sol.** This transformer are two types

1. Current Transformer
2. Potential Transformer

Instrument Transformer has following points:-

The transformer used for measurement of current is called a Current Transformer.

The transformer used for measurement of voltage is called a Potential Transformer.

CT is always connected in series with the load.

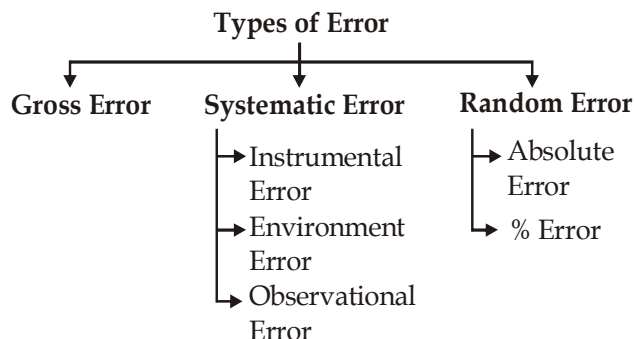
PT is always connected in parallel with the load.

PART - B

5 Marks Questions

46.

Sol.



A. Gross Error

All Human errors comes under the category of gross error.

Like - misreading or miscalculation

To eliminate these errors

1. Multiple reading should be taken from the instrument.
2. Calculator should be used for calculation.

B. Systematic Error**1. Instrumental Error**

These errors are due to short coming in instruments.

Main short coming are ageing effect or magnetic (old magnetic), weak magnetic field, weak spring control.

To reduce this error

- (a) New instrument should be used in place of old instrument. and
- (b) Instrument should repair on time.

2. Environmental Error

Environmental Condition (Temp, vapour, pressure, humidity etc.) effect the instrument reading

To reduce this error Instrument should be used in better suitable condition.

3. Observational Error

This error comes due to lack of human sense.

This error is also called **parallax error** and is present in only analog instrument.

To reduce this error Digital scale should be used in place of analog scale and Proper training should be given to human being.

C. Random Error

There is no proper reason of coming random errors manufacturer always notes random error on instrument.

Random error is represented in two ways

1. Absolute Error

$$\text{Error} = A_M - A_T$$

$$E = \pm \delta A$$

2. Percentage Error

$$\%E = \frac{A_M - A_T}{A_T} \times 100$$

$$\%E = \frac{\delta_A}{A_T} \times 100$$

Note

Percentage error is defined whole true value the value of % error is different whole different reading of scale.

47.

Sol. Electrostatic instruments are essentially voltmeters but they can be used for measurement of current and power with the help of external components. The principle of operation of such instruments is the force of attraction of repulsion between two charged bodies. The use of this force is made to produce deflection, which is a measure of the quantity. There are two types of such instruments namely the quadrature type (which is usually used for measurement up to 20 kV) and the attracted disc type (which is usually used for measurement above 20 kV).

48.

Sol. The moving iron instrument uses the soft iron piece as a rotating element. Whereas the moving coil instrument uses the coil as a rotating element.

The working principle of the moving iron instrument depends on magnetism. Whereas, the working principle of moving coil instrument is similar to the working principle of dc motor.

The MI iron instrument has the non-uniform scale. Whereas the moving coil instrument has the uniform sale.

The moving iron instrument is less accurate as compared to the moving coil instrument.

The moving iron instrument uses the air friction damping while the moving coil instrument uses the eddy current damping system. The damping is the phenomenon through which the amplitude of the oscillations decreases.

The moving iron instrument consumes more power as compared to the moving coil instrument.

The moving iron instrument is used for measuring both the direct and alternating current whereas the moving coil is used for the DC measurement.

In moving iron instruments, the gravity or spring provides the controlling torque to the instrument. Whereas in moving coil instrument the spring provides the controlling torque to the moving coil instrument.

The deflection of the moving iron instrument is proportional to the current. Whereas in moving coil instrument the deflection is proportional to the square of the current.

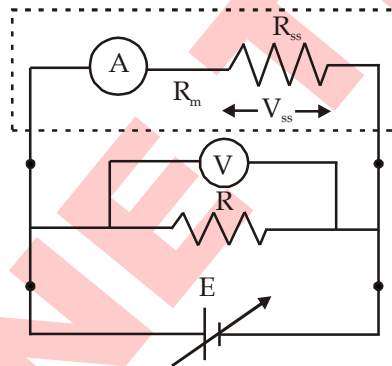
The moving iron instrument is free from the hysteresis loss. Whereas the hysteresis loss occurs in the moving coil instrument.

The instrument which uses the soft iron piece as a moving element such type of instrument is known as the MI instrument.

The moving iron instrument can be used as an ammeter, voltmeter and wattmeter. Whereas the moving coil instrument is used as a voltmeter, ammeter, galvanometer and ammeter.

49.

Sol. Converting an ammeter to a voltmeter involves increasing the resistance of the ammeter. This is done by adding a high resistance in series with the ammeter.



To calculate R_{ss} we note that the voltage drop across the ammeter, showing full scale reading I_0 , is $V_m = I_0 \times R_m$. To make ammeter full-scale to read full-scale voltage V_0 , the remaining voltage $V_{ss} = V_0 - V_m$ should drop across R_{ss} and from

this consideration we calculate series resistance as,

$$\frac{V_{ss}}{R_{ss}} = \frac{V_m}{R_m}$$

$$R_{ss} = R_m \frac{V_{ss}}{V_m}$$

50.

Sol. **Primary/absolute instrument** are those instrument which indicates the quantity to be measured in term of constants of instruments, these instruments are suitable for laboratory use only.

Example:-Tangent galvanometer which gives the measured current in terms of the tangent of the deflected angle, the radius, and the number of turns of the galvanometer

Secondary Instruments -The instruments which measure an electrical quantity on a calibrated scale is termed as a secondary instrument. These instruments measure large values of electrical quantities. Most of the measuring instruments which are used, generally are of secondary type measuring instrument. Secondary instruments are classified into three categories.

Integrating Instrument
Indicating Instrument
Recording Instrument

51.

Sol. Indicating Instrument – The instrument which indicates the magnitude of the measured quantity is known as the indicating instrument. The indicating instrument has the dial which moves on the graduated dial. The voltmeter, ammeter, power factor meter are the examples of the indicating instrument.

Integrating Instrument – The instrument which measures the total energy supplied at a particular interval of time is known as the integrating instrument. The total energy measured by the instrument is the product of the time and the measures electrical quantities. The energy meter, watt-hour meter and the energy meter are the examples of integrating instrument.

52.

Sol.

S.No.	Dynamometer Type Wattmeters	Induction Type Wattmeters
1.	The instrument can be used on both dc and ac systems.	The instrument cannot be used on dc system.
2.	The instrument can have high degree of accuracy if carefully designed.	The instrument is less accurate. It is accurate only at stated frequency and temperature.
3.	Power consumption is comparatively low.	Power consumption is comparatively higher.
4.	Weight of moving system is comparatively low.	Weight of moving system is comparatively higher.
5.	The instrument has uniform scale.	The instrument has uniform and long scale.
6.	The instrument has comparatively weaker working torque.	The instrument has comparatively stronger torque.

53.

Sol. Error Due to Inductance of Pressure Coil. Inductance of pressure coil may cause an error in the wattmeter reading. The instrument gives high reading on lagging pf and low reading on leading power factor and true power is given by the equation

$$\text{True Power} = \frac{\cos \phi}{\cos \theta \cos(\phi - \theta)} \times \text{actual reading of wattmeter}$$

where $\cos \phi$ is the power factor of the load and $\theta = \tan^{-1} \frac{\omega L_p}{r_p + R}$; r_p, L_p and R being the resistance of pressure coil, inductance of pressure coil and resistance connected in series with the pressure coil respectively.

54.

Sol. The loading effect is the degree to which a measurement instrument impacts electrical properties (voltage, current, resistance) of a circuit

Loading effect of voltmeters

A voltmeter always connects in parallel to electronic components for measuring the voltage. Practical voltmeters are designed to possess very high internal resistance (usually 10 or 20 Mohm). There are two cases which might result in fault measurements.

When voltmeter connects to a very high external resistance the overall resistance of circuit changes. When internal resistance of voltmeter is small and it connects to external resistance. The overall resistance will be changed.

Both above cases change the working of the circuit and thus lead to inappropriate readings.



55.

Sol. Rosettes- In addition to single element gauges, clusters of strain gauges called the rosettes are available in different configurations for specific stress analysis or transducer applications. Measurement of strain in more than one direction can be accomplished by placing single element gauges at the proper locations but the task becomes simple and more accurate with multi-element or rosette gauges.

56.

Sol. Strain Gauges- The strain gauge is basically a device used for measuring mechanical surface strain and is one of the most extensively used electrical transducers. Its popularity stems from the fact that it can detect and convert force or small mechanical displacements into electrical signals. Many other quantities such as torque, pressure, weight, and tension etc., which involve effects of force or displacement, can also be measured by strain gauges. Furthermore, if the mechanical displacements under measurement have a time-varying form, such as vibrational motion, signals with frequencies of up to 100 kHz can be detected or measured.

57.

Sol. Capacitive Transducers- The variable capacitance transducer comprises of a capacitor, the capacitance of which is varied by the non-electrical quantity being measured. The capacitance of a parallel plate capacitor, C is given by an equation

$$C = \frac{\epsilon_0 \epsilon_r A}{d} \text{ farads}$$

where ϵ_0 is the permittivity of free space and is equal to $8.854 \times 10^{-12} \text{ F/m}$; ϵ_r is the relative permittivity of the dielectric, A is the area of plates in m^2 and d is the distance between the two plates in metre. As the capacitance of a capacitor depends upon the area of its electrodes, the distance between them and the relative permittivity of the dielectric material, hence such transducers can be used for measurement of non-electrical quantities by affecting any one of the above mentioned parameters. Capacitive transducers are analog passive transducers. In such transducers capacitance of the capacitor is varied by any of the following three methods.

1. By varying overlapping area of plates, A.
2. By varying distance between plates, d.
3. By varying relative permittivity of dielectric material between two plates.

58.

Sol. Hall Effect Transducers- When a conductor is kept perpendicular to the magnetic field and a direct current is passed through it, it results in an electric field perpendicular to the directions of both the magnetic field and current with a magnitude proportional to the product of the magnetic field strength and current. The voltage so developed is very small and it is difficult to detect it. But in some semiconductors such as germanium, this voltage is enough for measurement with a sensitive moving coil instrument. This phenomenon is called the Hall effect.

Commercial Hall effect transducers are made from germanium or other semiconductor materials. They find applications in instruments that measure magnetic field with small flux densities. Hall effect element can be used for measurement of current by the magnetic field produced due to flow of current. Hall effect element may be used for measuring a linear displacement or location of a structural element in cases where it is possible to change the magnetic field strength by variation in the geometry of a magnetic structure..

The main advantage of Hall effect transducers is that they are non-contact devices with small size and high resolution. The main drawbacks of such transducers are high sensitivity to temperature variations and variation of Hall coefficient from plate to plate, thereby requiring individual calibration in each case.

59.

Sol. Pressure Measurement- The electronic devices, used in pressure measurement, usually depend upon some physical change, that can be detected, indicated or recorded electronically.

For measurement of force or pressure, the applied force or pressure is first converted into a displacement by means of some elastic element (such as a diaphragm, capsule, bellows or bourdon tube) and then displacement is converted into an electrical signal which can be indicated or recorded by some electrical or electronic device.



The conversion of mechanical phenomenon into an equivalent electrical signal is achieved by a variety of linkage mechanisms. The transducers, used in measurement of pressure as secondary transducers, are potentiometric, bonded and unbonded strain gauges, piezoresistive, inductive, LVDT, capacitive, piezoelectric, photoelectric types.

The main advantages of the bellows are the moderate cost, capability of providing high force and wide pressure range. The drawbacks of the bellows are that (i) ambient temperature compensation is required and (ii) unsuitable for measurement of very high pressure.

60.

Sol.



1. Cur

- It is an Intermediate device.
- It change one form of energy into another form of energy.

There are two types :

1. **Active Transducer :**

- These are self generating type transducers they generate Operating Quantity by itself. These transducers do not required external supply.

Ex. Pizzo electric transducers, Thermocouple transducer

2. **Passive Transducer :**

- These transducer are not self generating types. They required external supply to operate.

Ex.Potentiometer, strain gauge, LVDT, RTD, Thermister etc.

61.

Sol. The smallest change in input that can change the output also is called sensitivity of Instrument.

$$S = \frac{\text{Change of output}}{\text{Change in input}}$$

Sensitivity is also defined by Torque upon weight ratio.

$$S = \frac{\text{Torque} \uparrow}{\text{weight} \downarrow}$$

For Better sensitivity instrument.

$$\frac{\text{Torque}}{\text{weight}} > 1$$

Note:- If sensitivity is high then loading effect low.

62.

Sol. Ohmmeter- The ohmmeter is a direct reading device for the measurement of resistance. Though this method of measuring resistance is very simple, convenient and fast but its accuracy is rather of low degree.

An ohmmeter is widely employed for the approximate measurement and sorting of resistances used in electronic circuits, measurement of resistance of heater elements, field coils of motors etc. It is also used for checking circuit continuity. In the precision measurement of resistance, it is used along with bridge circuit and saves the time in bridge balancing as an approximate value of the resistance under test is obtained first by an ohmmeter.

Series Type Ohmmeter- This instrument essentially consists of a sensitive dc instrument connected in series with a resistance and a battery to a pair of terminals to which the resistance under test is connected. So the indication of the instrument depends on the magnitude of current flowing through the meter which ultimately depends on the value of resistance under test, provided the instrument is properly calibrated. Circuit diagram of a simple series type ohmmeter is shown in Fig.

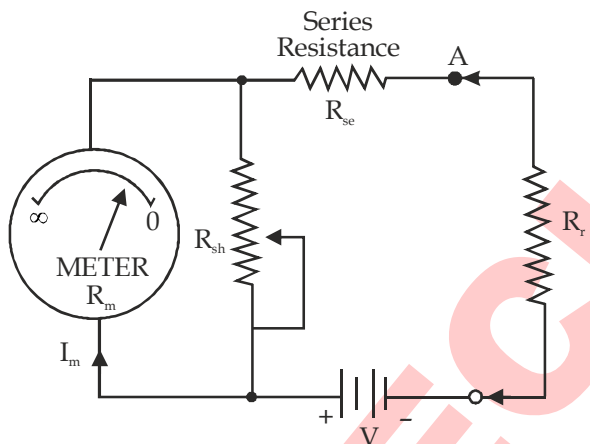


Fig.:- Simple Series Type Ohmmeter

Shunt Type Ohmmeter- Circuit diagram of a shunt type ohmmeter is shown in Fig. In this instrument a battery is connected in series with a D'Arsonval galvanometer and an adjustable resistor R . The resistance under test is connected across the terminals A and B in parallel to the meter. In this circuit it is necessary to provide a on-off switch in order to keep battery from running down when the instrument is not in use.

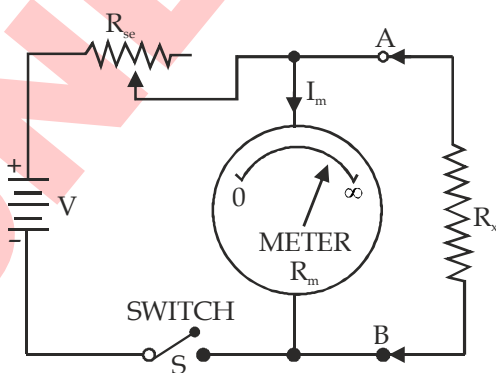


Fig.:- Shunt Type Ohmmeter

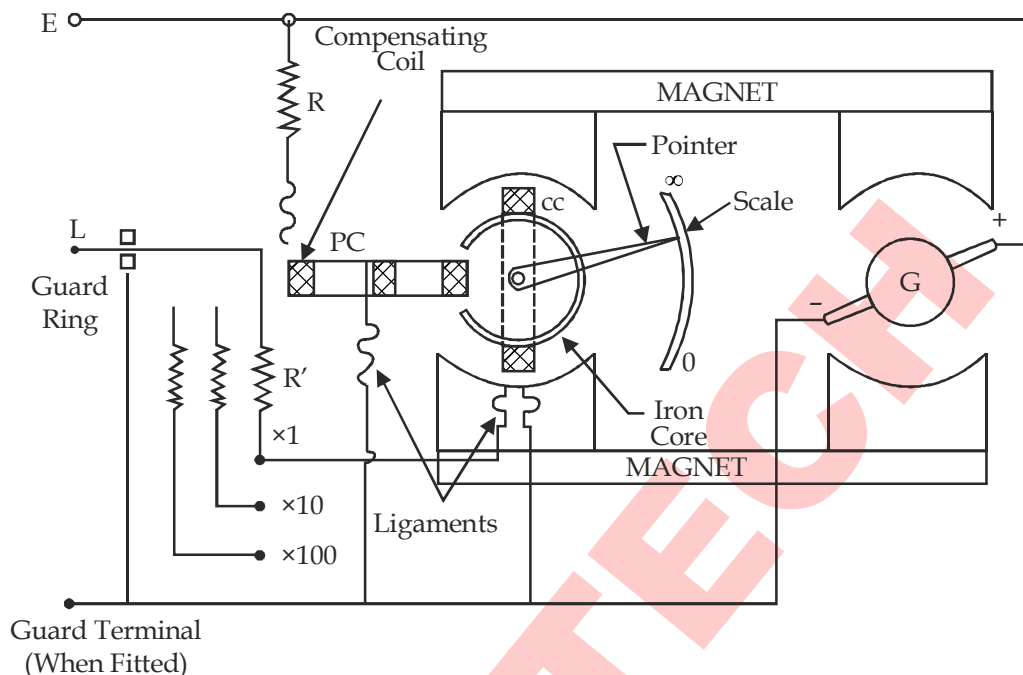
This type of ohmmeter is particularly suited for the measurement of low-value resistors.

63.

- Sol. Megger-** The megger is an instrument used for the measurement of high resistance and insulation resistance. Essentially the megger insulation tester consists of a hand driven dc generator and a direct reading true ohmmeter. A simplified diagram of electrical connections of the instrument is shown in Fig. 11.38. Permanent magnets provide the field for both the generator and the ohmmeter. The moving element of the ohmmeter consists of three coils, known as current (or deflecting) coil, pressure (or control) coil and compensating coil, which, are mounted rigidly to a pivoted central shaft and which are free to rotate over a stationary C-shaped iron core. The coils are connected to the circuit by means of flexible leads (or ligaments) that exert no restoring torque on the moving



element. Hence the moving element may take up any position over the scale when the generator handle is stationary.

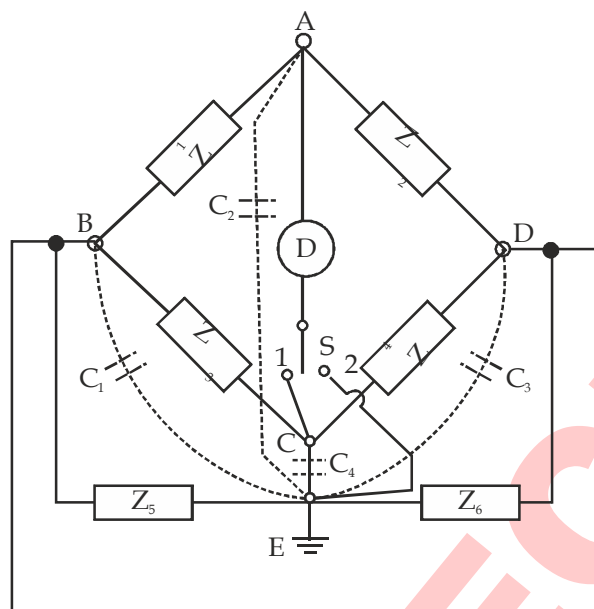


The current (or deflecting) coil is connected in series with the resistance R' between one generator terminal and the test terminal marked 'L'. The series resistance R' protects the current (or deflecting) coil in case the test terminals are short-circuited and also controls the range of the instrument. The pressure (or control) coil in series with a compensating coil and protection resistance R is connected across the generator terminals. Compensating coil is provided to obtain better scale proportions and to make the instrument astatic.

64.

Sol. Wagner's Earthing Device- If each component in a bridge has a defining screen connected to one end, a very high accuracy in measurement can be achieved by using Wagner's earthing device in the bridge circuit. This device removes all the earth capacitances from the bridge network.

This device consists of two auxiliary adjustable bridge arms Z_5 and Z_6 , as shown in Fig. The nature of these arms should be respectively of the same nature as Z_3 , and Z_4 i.e., if Z_3 is resistance in series with inductance then Z_5 should also have resistance in series with inductance. The junction point of these two impedances is earthed. These two impedances should be capable of forming a balanced bridge with Z_1 and Z_2 or Z_3 , and Z_4 and can be a duplicate of either of these pairs of arms. C_1 , C_2 , C_3 and C_4 are the stray earth capacitances appearing at the apexes of the bridge. D is the detector.



65.

Sol. The bridge which is used for measuring the unknown impedance of the circuit is known as the Wheatstone bridge. The DC bridge is used for measuring the unknown resistance of the circuit.

The AC bridge uses the AC supply. The DC bridge uses the DC supply for measuring the resistance. In AC bridge the current is detected by using the AC detector. While in DC bridge the current is detected by using the DC detector.

The resistive and reactive components are used in the AC bridge circuit while in the DC circuit only resistive components are used.

The AC bridge circuit uses the Wagner earth device for removing the earth capacitance from the circuit. It also reduces the harmonics and the error which occurs because of the stray magnetic field. The Wagner earthing device is not used in the DC bridge circuit.

The AC bridges take less time to come in balance condition while the DC bridge uses comparatively more time to come in the balanced condition.

Wheatstone Bridge and the Kelvin bridge are the types of the DC bridge. The AC bridges are classified into seven types. These are capacitance comparison bridge, inductance comparison bridge, Maxwell's bridge, Hay's bridge, Anderson Bridge, Schering bridge, Wein bridge.

66.

Sol. Oscilloscope Specificatin-

1.Sensitivity- It refers to smallest deflection factor $G = \frac{1}{s}$ and is expressed in mV/division.

2.Bandwidth- Bandwidth is the range of frequencies that lies between ± 3 dB of centre frequency.

3.Rise Time- The rise time in terms of bandwidth is given as

$$t_r = \frac{0.35}{\text{Bandwidth}}$$



67.

Sol. Voltage measurement : CRO is a voltage controlled device it measures peak to peak value & voltage.
Current measurement : Current measurement is not possible from CRO because CRO is voltage controlled device. To measure current from CRO current is pass through a resistance and potential drop across the resistance is measured by CRO then by the help of this potential drop & resistance value, current is calculated.

Phase angle & frequency measurement :

When sinusoidal input are applied on both of the plates of CRO then a different pattern is achieved on RO screen this pattern is called Lissajous pattern.

By the help of Lissajous pattern phase angle & frequency are measured.

68.

Sol.

1. CRT

- CRT is called heart of CRO.
- The main parts of CRT are as follow.

(i) **Electron gun & accelerating section**

(a) **Heater :** Heater is used to rise the temperature of cathode.

(b) **Cathode :** When cathode is heated It emits electron, for continue emission of e^- Barium or Strontium oxide is used on cathode.

(c) **Grid :** The e^- which are emitted from cathod are passed through the grid. Grid controls the emitted e^- so it is also called control grid.

Grid is made of Nickel Material & It is cylindrical in shape.

It has a hole in center.

(d) **Pre & Post accelerating anode :** These are positively charged electrods which are used to increase the velocity of e^- beam.

A voltage of 1500 is applied on these anodes.

(e) **Focusing anode :** This anode is used to focus the electron beam on CRO screen.

Electrostatic focusing is used in CRT. Which is given by two concave lens.

2. **Deflection section :**

(1) **Vertical Deflection plate :**

- This plate is used to deflect the e^- beam in vertical direction.
- Input signal is applied on vertical deflection plate.
- Vertical deflection plate is kept in horizontal position.

(2) **Horizontal Deflection Plate :**

- This plate is used to deflect the e^- beam in horizontal direction.
- For continuous motion of e^- beam sweep signal is applied on horizontal plate.
- The signal is generated by waveform generator or UJT. UJT is inbuilt in CRT.
- Horizontal Deflection Plate is kept vertically.

3. **Display Section :**

- CRO Display is mode of optical fiber.
- Phosphorous coating is used on screen of CRO. This Phosphorous change electrical energy into light energy.

This Principle is called **Fulorocent**.

- On non viewing side of CRO screen a thin layer of Aluminium layer is present.

69.

Sol. Digital Voltmeters- The digital voltmeter (DVM) displays measurements of ac or de voltages as discrete numerals instead of a pointer deflection on a continuous scale as in analog instruments. It is a versatile and accurate instrument that is em- ployed in many laboratory measurement applications. Because of development and perfection of IC modules, the size, power requirements, and cost of the digital voltmeter has been drasti- cally reduced and, therefore, DVMs can actively compete with conventional analog instruments, both in price and portability.



The block diagram of a simple digital voltmeter is shown in Fig. The unknown voltage signal is fed to the pulse generator which generates a pulse whose width is directly proportional to the input unknown voltage. The output of the pulse generator is applied to one leg of an AND gate. The input signal to the other leg of the AND gate is a train of pulses. The output of the AND gate is, thus, a positive trigger train of duration t seconds and the inverter converts it into a negative trigger train. The counter, counts the number of triggers in t seconds which is proportional to the voltage under measurement. Thus, the counter can be calibrated to indicate voltage in volts directly.

Thus, we see that the DVM described above is an ADC which converts an analog signal into a train of pulses, the number of which is proportional to the input voltage. So a digital voltmeter can be made by using any one of the A/D conversion methods and can be represented by a block diagram shown in Fig. 11.66. Thus the DVMs can be classified on the basis of ADCs used.

The input range of the DVM may vary from ± 1.00000 V to $+1,000.00$ V and its limiting accuracy is as high as ± 0.005 per cent of the reading. Its resolution may be 1 part in 10, giving $1 \mu\text{V}$ reading of the 1-V input range. It has a high input resistance of the order of $10 \text{ MS}\Omega$ and input capacitance of the order of 40 pF .

70.

Sol. The working of this instrument is based on the induction motor principle. When a disc or drum of a non-magnetic conducting material is placed in a rotating magnetic field, eddy current is induced in it. The reaction between the rotating flux and the eddy current produced by is, results in a torque which is responsible for the rotation of the disc or drum.

Such instruments are suitable for ac measurements only. In these instruments the deflecting torque is produced by the eddy currents induced in an aluminium or copper disc or drum by the flux created by an electromagnet.

The main advantages of such instruments are that (i) a full scale deflection of some 300° can be obtained giving long and open scale (ii) the effect of stray magnetic field is small and (iii) damping is easier and effective.

These instruments have got some serious disadvantages which for most purposes outweigh their advantages. The greater deflection causes more stresses in the control springs. Variation in supply frequency and temperature may cause serious errors unless compensation device is employed. These instruments are costlier and consume more power as compared to other instruments.

PART - C

20 Marks Questions

71.

Sol. **Linear Variable Differential Transformer LVDT)**- LVDT is the most widely used inductive transducer for translating the linear motion into an electrical signal. LVDT is a differential transformer consisting of one primary winding P and two identical secondary windings S_1 , and S_2 , wound over a hollow bobbin of non-magnetic and insulating material.

The displacement to be measured is applied to the arm attached to the soft iron core. When the core is in the centre, called the reference position, the induced voltages E_1 and E_2 are equal and opposite. Hence they cancel out and the output is zero. As the core is moved toward left from its voltage V_{out} null position, the voltage induced in secondary winding S_1 increases whereas the voltage induced in secondary winding S_2 decreases. The movement of the core toward right will have opposite effect. Secondary windings S_1 and S_2 are connected in series opposition so that the difference of the voltages induced in the secondary windings S_1 and S_2 provides the measurement of displacement.

Difference of induced voltages in secondary windings gives the amount of displacement following a linear law within a limited range of motion. In either direction of movement of the core, difference of induced voltages increases or decreases giving the idea of direction of movement.



Sensitivity of LVDT is given by expression

$$\text{Sensitivity} = \frac{\text{Output voltage}}{\text{Displacement}} \text{ in volts/mm}$$

In commercially available LVDTs, normally range for displacement varies from ± 0.01 mm to ± 25 mm.

Primary winding is connected to an ac source of voltage varying from 5 to 25 V and of frequency ranging from 50 Hz to 20 kHz.

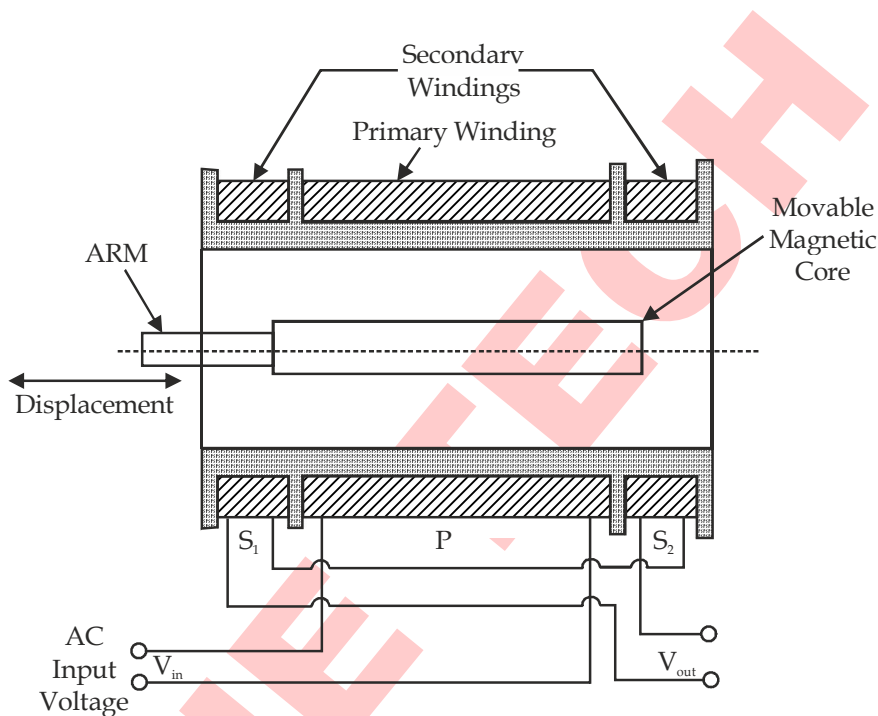


Fig.:- LVDT

LVDTs are suitable for use in applications where the displacements are too large for strain gauges to handle. For example, LVDTs can be employed for measurement of displacements that range from a fraction of a mm to a few cm.

Since the LVDTs can also be connected to other transducers, whose outputs are mechanical displacements, these are often employed together with other transducers for measurement of force, weight, pressure etc.

72.

Sol. Piezoelectric Transducers- In some crystalline or ceramic materials, a potential difference appears across the opposite faces of the material as a result of dimensional changes when a mechanical force is applied to it. This is called the piezoelectric effect and such materials are called the piezoelectric materials. This effect is reversible also i.e., when a potential difference is applied across the opposite faces of the material, it changes its physical dimensions. This principle of electromechanical energy conversion is utilized in construction of both mechanical to electrical and electrical to mechanical energy conversion transducers. The mechanical-input / electrical-output transducers are widely employed for measurement of dynamic pressure, force, and shock or vibratory motion. It can also be used as a means of generating high-voltage, low-current electric power, such as is used in spark-ignition engines and electrostatic dust filters. The electrical-input/mechanical-output transducers are employed in small vibration shakers, sonar systems for acoustic ranging and direction detection, industrial ultrasonic non-destructive test equipment, pumps for inkjet printers, ultrasonic flow-



meters, and micromotion actuators. In a piezo- electric pressure transducer, the crystal elements form an elastic structure which functions to transfer the displacement produced by the force into an electrical signal proportional to the pressure applied. Pressure acting on a flush diaphragm produces the force.

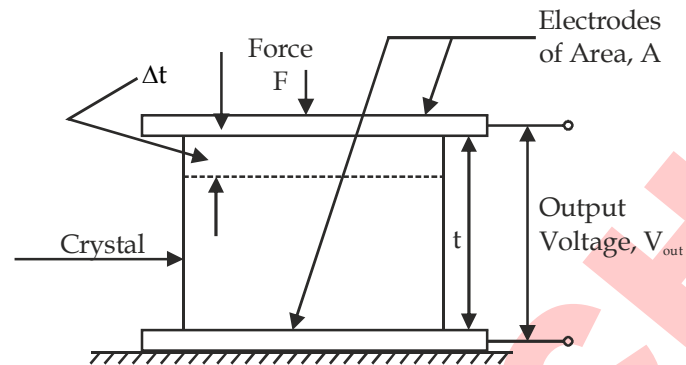


Fig.- Piezoelectric Transducer

The charge at the electrodes gives rise to an output voltage V_{out} and is given by the expression

$$V_{out} = \frac{Q}{C} = \frac{d.F}{\epsilon_0 \epsilon_r A / t} = \frac{d}{\epsilon_0 \epsilon_r} \times \frac{F \times t}{A} = gPT$$

where $g = \frac{d}{\epsilon_0 \epsilon_r}$ and it is the crystal sensitivity in Vm/N and is constant for a given crystal, $P = \frac{F}{A}$ is the pressure in pascals on the crystal and t is the thickness of crystal.

Voltage sensitivity of the crystal can also be expressed as

$$g = \frac{V_{out} / t}{P} = \frac{\text{Electric field}}{\text{Stress applied to the crystal}}$$

and charge sensitivity is given by the expression

$$d = \epsilon_0 \epsilon_r g \text{ Coulombs per newton}$$

Merits. 1- Piezoelectric transducers are generally small in size, light in weight and very rugged in construction.

2. These are self generating transducers as they do not need external power.
3. These transducers can operate over a wide range of temperature without appreciable temperature induced errors. Quartz devices can be employed over a temperature range of -200° to $+300^\circ\text{C}$; whereas ceramic devices are limited to $+100^\circ\text{C}$.
4. These transducers have very good high frequency response. They provide flat frequency response from 1 Hz to 20 kHz, the natural frequency being of the order of 50 kHz.
5. Their outputs are quite large; for example, a quartz crystal 2.5 mm thick has a sensitivity of 125 mV/kPa and for a crystal area of 1,000 mm², sensitivity is 125 V/KN.

Demerits. 1- On application of a constant deflection to the transducer, it develops voltage across its terminals and the charge leaks off slowly through the leakage resistance of the transducer but this decay of charge is very slow on account of very high leakage resistance (of the order of 10¹¹ ohms) of the transducer. However, when a voltmeter or any other voltage measuring device is connected across the terminals of the transducer the charge leaks off very rapidly. This prevents the measurement of static displacement. Some commercially available systems employing quartz elements of very high leakage resistance and input amplifiers of very high input impedance achieve an effective total resistance of 10¹⁴ ohms, which gives reasonably slow leakage to allow static measurements.

2. The output voltage is affected by temperature variations of the crystal.

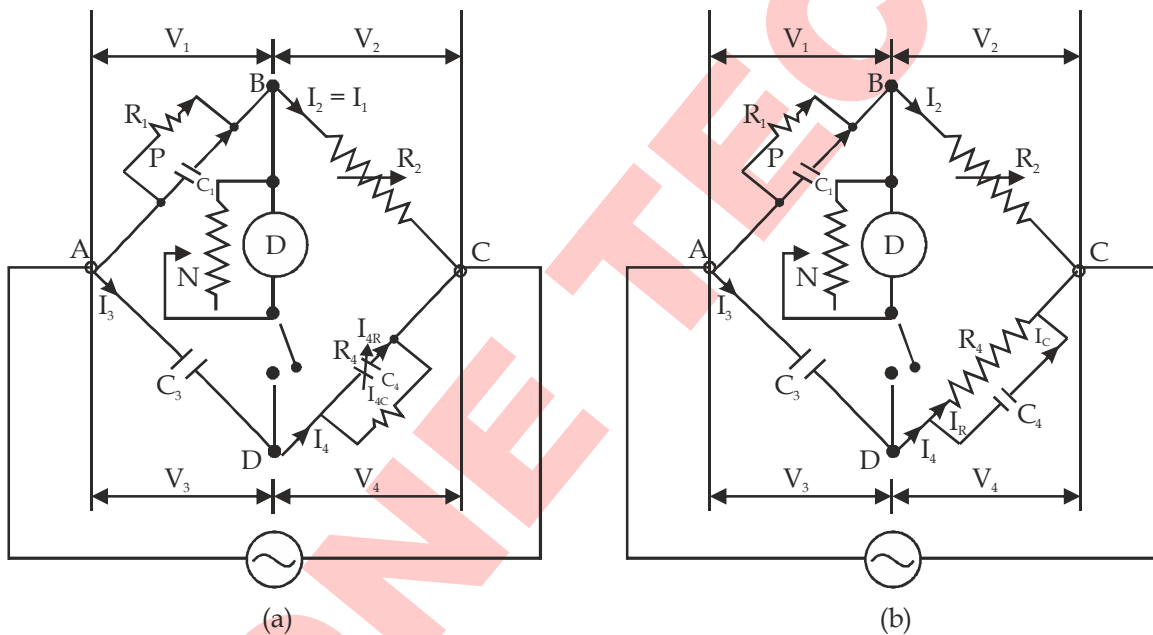
73.

- Sol.** The circuit is shown in Fig. (a) in which C_1 is the capacitor under test, R_1 is an imaginary resistance representing its dielectric loss component; C_3 is a standard capacitor, C_4 is a variable capacitor and R_2 and R_4 are known non-inductive resistors. The resistance R_2 is variable. Under balance conditions

$$C_1 = \frac{C_3 R_4 \cos^2 \delta}{R_2}$$

where δ is known as a loss angle of capacitor and $\sin \delta$ is known as pf of the capacitor.

Imperfect Capacitor as a Series Circuit. An alternative method to that of representing an imperfect capacitor diagrammatically as a perfect capacitor C_1 , in parallel with a resistance R_1 , is to represent it as a perfect capacitor C_s , in series with resistance R_s as illustrated in Fig.



Under balance conditions $R_s = \frac{C_4}{C_3} R_2$ and $C_s = \frac{R_4}{R_2} C_3$. Generally C_4 and R_4 are chosen as the variable elements in order to get both of the balance equations independently.

The Schering bridge circuit is also used for the measurement of relative permittivity of the specimens of dielectric materials. This involves measuring the capacitance of a small capacitor with the specimen as dielectric. The electrode configuration normally used is either parallel-plate or concentric-cylinder, guard circuits being used to make the plate area definite.

74.

- Sol. Digital Multimeters-** Digital multimeter (DMM) is basically a digital voltmeter and may be used for the measurement of voltage, current (dc or ac) and resistance. All quantities other than dc voltage are first converted into an equivalent dc voltage by some device.

The block diagram of a basic digital multimeter is given in Fig. For measurement of ac voltage the input voltage is converted into a dc voltage by means of a rectifier. A compensated attenuator is employed. Many manufacturers provide the same attenuator for both dc and ac measurements.

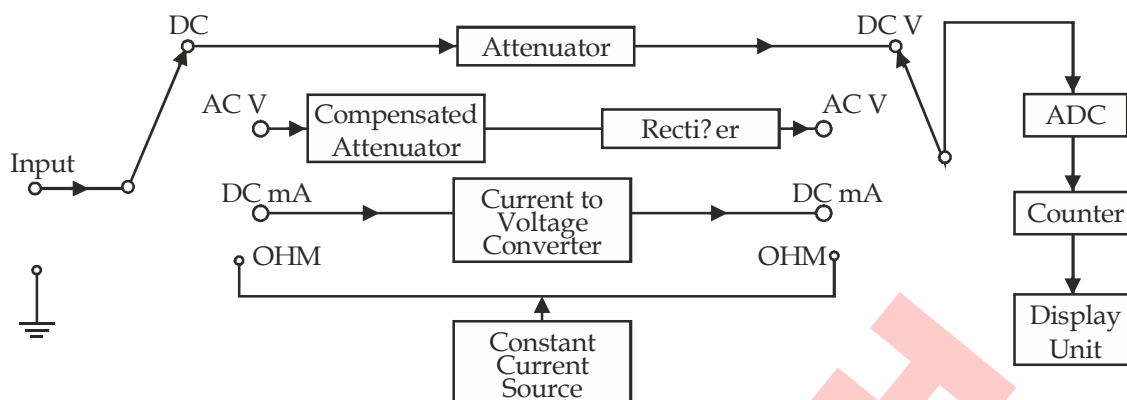


Fig.:- Block Diagram of Digital Multimeter

For measurement of resistance a constant current, depending on the range, supplied from a battery or a constant current source is passed through the resistance under measurement and the voltage developed across it is measured. The resistance value is displayed in ohms.

For measurement of current, the unknown current is passed through a precision resistor in many commercial digital multimeters and the voltage developed across the precision resistor is measured. The current value is displayed in mA.

For measurement of current, a current-to-voltage converter may also be used, as illustrated by block diagram in Fig.

The current under measurement is applied to the summing junction at the input of the op-amp. The current in the feedback resistor I_p is equal to the input current I because of very high input impedance of the op-amp. The current I_p causes a voltage drop across one of the resistors, which is proportional to the input current I_N . Different resistors are employed for different ranges.

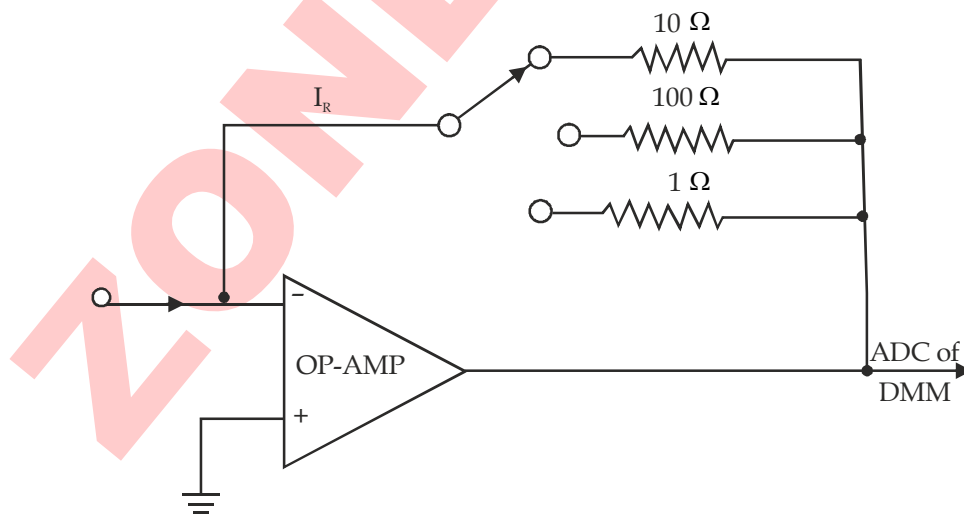


Fig.:- Block Diagram of Current-To-voltage Converter

Characteristics of Digital Meters- Resolution, sensitivity and accuracy are the few specifications which characterise digital meters. These are explained as below.

Resolution- It is defined as the number of digit positions or simply the number of digits used in a meter. Hence a three-digit display on the digital meter for 0-1 V range will be able to indicate from 000 to 999 mV, with smallest increment (resolution) of 1 mV.

If the number of full digits is n , then resolution



$$R = \frac{1}{10^n}$$

For $n=4$, $R = \frac{1}{10^4} = 0.0001$ or 0.01%

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. Sensitivity is given as

$$S = (fs)_{\min} \times R$$

where $(fs)_{\min}$ is the lowest full-scale value of digital meter, and R is the resolution in decimal.

75.

Sol. Measurement of Medium Resistances- The methods of measuring medium resistances are (a) ammeter-voltmeter method (already described in previous article) (b) Wheatstone bridge method, (c) substitution method and (d) Carey Foster bridge method.

Wheatstone Bridge Method- This is one of the most widely used methods for the measurement of resistances of medium values. As shown in Fig. it is composed of known adjustable resistances P , Q and S . The unknown resistance R is connected between A and D . The resistances are arranged in two parallel circuits through which the current from the battery can flow. A sensitive galvanometer G , shunted by a variable resistance N to avoid deflection of the galvanometer, when the bridge is out of balance, is bridged through switch S , across the two circuits between B and D .

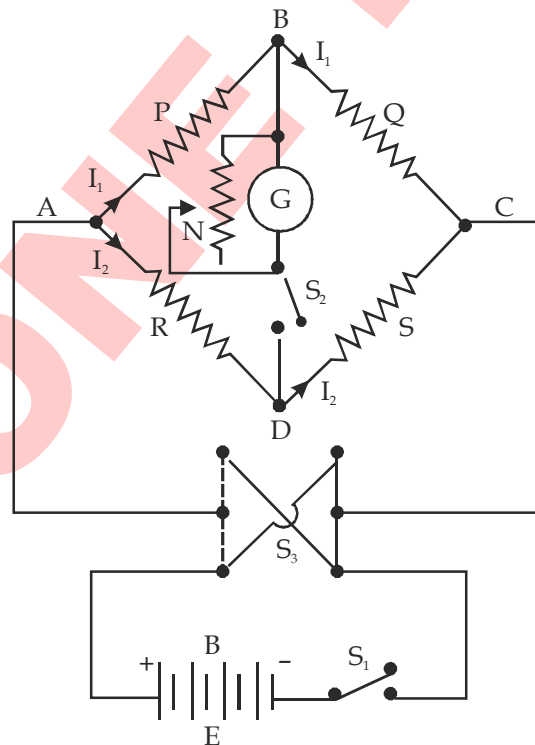


Fig.:- Wheatstone Bridge

While balancing the bridge, the switch S , is closed, the values of resistances P , Q and S are so adjusted that the deflection of galvanometer is nil when switch S_2 is closed.

- (c) **Substitution Method-** Connection diagram is shown in Fig. In the process of measurement first unknown resistance X is put in the circuit by putting switch S_1 on stud 1, switch S_2 is closed and reading of ammeter is noted. Then switch S_1 is transferred to stud 2 and the known variable resistance R is adjusted until the ammeter gives same deflection as before. The value of known variable resistance, producing the same deflection, gives the value of unknown resistance directly.

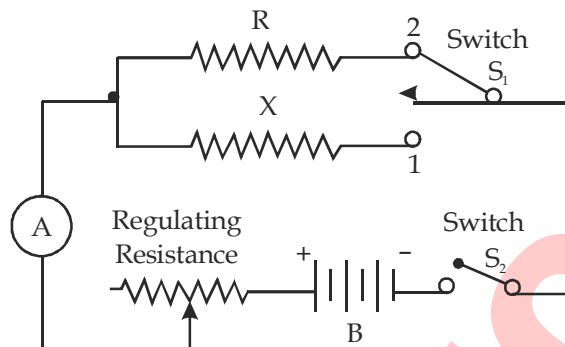


Fig.:- Substitution Method of Measurement of Resistance

The accuracy of the measurement obviously depends upon the constancy of the supply voltage, of the resistance of the circuit excluding X and R and upon the sensitivity of the ammeter, as well as upon the accuracy with which the resistance R is known.

- (d) **Carey Foster Bridge Method-** This bridge circuit is an elaboration of the Wheatstone bridge and is specially suited for comparing two nearly equal resistances. All high-accuracy bridges are liable to errors owing to thermoelectric emfs particularly if the arm resistances are low. To minimise this trouble, Carey Foster bridges often incorporate a special switch, which enables the connections to R and S to be interchanged without the necessity for handling the coils.

76.

Sol. Instrument transformers are employed for ac measurements (current, voltage, power and energy) in conjunction with the relevant instruments. Such transformers are of two types-current (or series) transformers and potential (or parallel) transformers.

Current transformer is employed whenever the current of an ac circuit exceeds the safe current of the measuring instrument (e.g., ammeter or wattmeter or energy meter).

Potential transformer is employed whenever and wherever the voltage of an ac circuit exceeds the voltage of 750 volts as it is not easy to provide adequate insulation on measuring instruments for voltage above 750 volts.

Instrument transformers have the following advantages:

1. They enable the single range instrument to cover a large current or volt range.
2. They provide isolation to measuring circuits and protection circuits from the high voltage power circuit.
3. Low power consumption in metering circuit.
4. Several instruments can be operated from a single instrument transformer.
5. They produce practically same multiplication regardless of load.

Instrument transformers have a major drawback that these cannot be used for dc measurements.

- (a) **Current Transformers (CTs).** The primary of the CT, which consists of only one or a few turns, is connected in series

with the load circuit and so carries the load current to be measured. The secondary winding consists of many more turns than the primary and have the instrument (an ammeter or ammeter and current coil of wattmeter) directly connected across it. The current transformer in operation slightly differs



from that power transformer. In case of current transformer as the load impedance or 'burden' on the secondary is very small, so the current transformer operates on short-circuit conditions. Also the current in secondary winding is not governed by the load impedance on the secondary but depends upon the current flowing in the primary winding (i.e., main circuit current).

The amount of power which the CT handles is small. The product of voltage and current on the secondary side when the CT is supplying the instrument with its maximum rated value of current, is known as rated burden and is measured in volt-amperes (VA). The usual rating of a CT is very small (e.g., 15 VA and in no case exceeds 30 VA).

There are two types of errors introduced by CT into a circuit. These are

(i) ratio error (ii) phase angle error.

CT ratio and phase angle errors are given by equations

$$\begin{aligned}\text{Ratio error} &= \frac{K_n - K_c}{K_c} = \frac{K_T - K_c}{K_c} \\ &= \frac{K_T I_s - (K_T I_s + I_m \sin \theta + I_e \cos \theta)}{K_T I_s + I_m \sin \theta + I_e \cos \theta} \\ &= -\frac{I_m \cos \theta - I_e \cos \theta}{K_T I_s}\end{aligned}$$

Phase angle error,

$$\beta = \frac{I_m \cos \theta - I_e \cos \theta}{K_T I_s} \text{ radians}$$

Ratio error is taken as +ve when the actual ratio of current transformer is less than nominal ratio. In the above equation of ratio error -ve sign indicates that actual ratio of CT is more than nominal ratio. The ratio error determines the amount of turns compensation to reduce the error to minimum.

In power measurement; when CC of a wattmeter is supplied by a CT secondary, then it is necessary that secondary current of CT should be displaced by exactly 180° from the primary current but this condition is not fulfilled and the CT has a phase angle error and so it introduces an appreciable error in power measurement.

Current Transformer Secondary on Open Circuit. An exceedingly important precaution that is to be taken while using a CT is to maintain at all times a closed circuit on the secondary side. If the instrument is to be taken out of the circuit, then secondary terminals must first be short-circuited by a low resistance not greater than 0.5 ohm. The reason for the precaution is given below.

Under normal operating condition the secondary ampere-turns of a CT almost balances the primary ampere-turns and flux set up is only due to small number of ampere turns $I_T p$. If by chance the secondary is open-circuited and there is no change in the primary current, then primary ampere-turns remain the same and opposing ampere turns set up by the secondary becomes zero, consequently the entire primary turns T_{p1} are used in creating the flux. This causes an extraordinary large magnetic flux and flux density in the iron circuit.

The large flux leads to dangerously high emfs for both the operator and the transformer insulation. The high flux density results in increase of iron loss in the core.

- (b) **Potential Transformers (PTs)** The potential transformers are used for measurement of high voltages by means of low range voltmeters or for energising the potential coils of wattmeters and energy meters. These are also used for energising relays and other protective equipment. The voltage being measured acts across the primary winding, which has a large number of turns and connected across the circuit. The secondary winding, which has a much smaller number of turns is coupled magnetically through the magnetic circuit to the primary winding. The turn ratio is so adjusted that secondary voltage is 110 volts when full rated primary voltage is applied to the primary.

The errors introduced by PT are less pronounced than those introduced by CTs. The theory of operation of a PT is essentially the same as that of the power transformer. The main difference between the PT and power transformer is due to the fact that the load current of the former is of the order of exciting current and the secondary impedance of the PT is mostly resistive being made of the potential coil (PC) of the instrument.

$$\text{Ratio error} = \frac{K_N V_s - V_p}{V_p}$$

where $K_N = \text{Nominal ratio} = \frac{\text{Rated primary voltage}}{\text{Rated secondary voltage}}$

Phase angle error,

$$\beta = \frac{\frac{I_s}{K_T} (R_p \sin \phi - X_p \cos \phi) - I_e X_p + I_m R_p}{K_T V_s}$$

From the above equations it is obvious that a potential transformer also introduces both the ratio and phase angle errors. The "ratio error" only is of importance in measurement of voltage but "phase angle error" is of importance only when power is to be measured.

The ratio error can be compensated by increasing the turns on secondary winding by the appropriate small amount. The increased secondary turns compensate the voltage drop in the PT. Since the impedance drop in the PT is of constant magnitude and there is no change in secondary current of PT, the turn compensation is, therefore, better suited for a PT than for a CT

77.

Sol. There are various methods of measuring frequency of a local supply, other than that of the controlled grid system.

The frequency of supply from a local alternator can be determined by measuring the speed of the machine and knowing the number of poles on the machine. This is a simple and very accurate method of determination of frequency. If the speed of an alternator is N rpm and the number of poles on it are P , then frequency of supply taken from it will be equal to

$$f = \frac{NP}{120} \text{ Hz}$$

Certain ac circuits of the bridge type are also used for measurement of frequency over a wide range but most of them are used when the source of alternating supply is not accessible or where the frequency is in the audible range.

For measurement of commercial frequency i.e., frequency of order of 50-100 Hz, portable commercial instruments, known as frequency meters or indicators, are used. These instruments indicate the supply frequency directly and are convenient in practical use. Though the accuracy of such instruments is somewhat less than that of above methods but sufficient for normal uses.

Frequency meters may be classified into two general types viz. vibrating reed type (or mechanical resonance type) and deflection types. Deflection type frequency meters are further subdivided into two categories: those depending on electrical resonance, and those depending on the frequency variation of current distribution between an inductive circuit and a parallel resistive circuit.

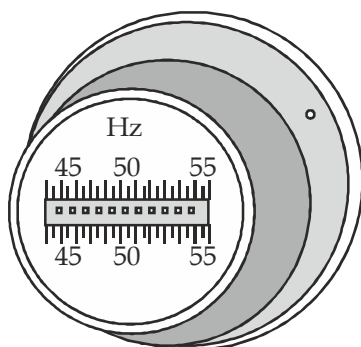


Fig.- General View of Vibrating Reed Frequency Meter



Vibrating Reed Frequency Meter- In this instrument use is made of phenomenon of mechanical resonance. It is a simple instrument and has got advantage of giving reading free from errors due to change in temperature, waveform and magnitude of applied voltage provided the voltage is not too low to give appreciable amplitude of the vibrations. For normal variation of supply voltage, say within $\pm 5\%$, the performance of this type of meter will not be affected.

Weston Frequency Meter- This is a moving iron instrument which operates on the principle of variation of impedance in an inductive circuit with the variation in supply frequency.

The construction and internal connections of the instrument are shown in Fig.

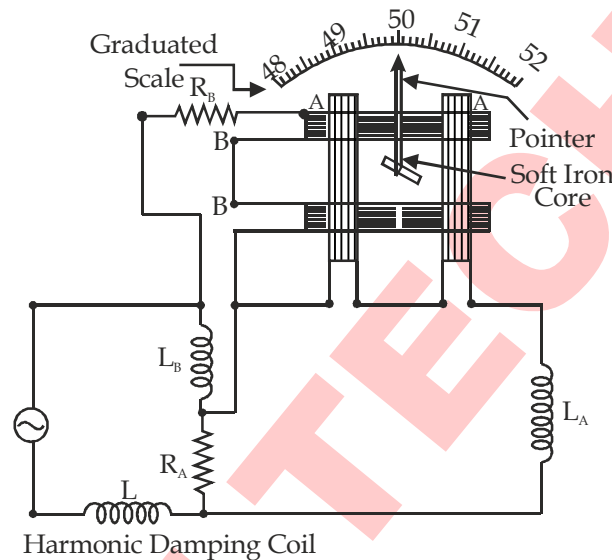


Fig.- Weston Frequency Meter

Range- General range is 6 Hz (from 47 to 53 Hz)

Advantage- The scale can be extended over 300° in the short range as well as long range instruments.

78.

Sol. In the simpler measurement applications in which we monitor, control, or perform experimental engineering analysis with only a few channels of data and/or do only minor data processing, often a system "casually" assembled from available sensors, amplifiers, filters, recorders etc., is adequate. However, when requirements become more comprehensive and stringent, data acquisition and processing systems of various types are commercially available and may be necessary. Such systems vary with respect to several factors:

1. Is data processing mainly analog or digital ?
2. Is there one amplifier per channel, or is a single amplifier time-shared by multiplexing?
3. If the system is digital-computer-based, is it self-contained (includes the computer) or just a "front end" that can be interfaced with different computers ?
4. Is the system a general purpose type that can be ordered off the shelf, ready for immediate use, or will it be tailored to the specific application and thus need some system engineering before delivery and some debugging after delivery?
5. Are the signals changing relatively slowly, or is fast dynamic response required?

A typical data acquisition system (DAS) consists of individual sensors with necessary signal conditioning, multiplexing, data conversion, data processing, data handling and associated transmission, storage, and display systems. In order to optimize the characteristics of a system in terms of performance, handling capability, and cost, the relevant sub-systems may often be combined together. The analog data is usually acquired and converted into digital form for the purpose of processing, transmission, display, and storage.

Processing may consist of a large variety of operations, from simple comparison to complicated mathematical manipulations. It may be for such purposes as information (averages, statistics etc.) collection, data conversion into a useful form (e.g., calculations of efficiency of motor from speed, power input and torque developed), using data for controlling a process, performing repeated calculations for separating out signals buried in noise, information generation for displays, and other various purposes.

Data may be transmitted over long distances (from one location to another one) or short distances (from a test centre to a nearby computer).

The data may be displayed on a digital panel meter or as a part of CRT presentation. The same may be stored temporarily (in either raw or processed form) for immediate use or permanently for ready reference later.

Data acquisition generally relates to the process of collecting the input data in digital form, as rapidly, accurately, completely and economically as required. The basic instrumentation used may be a standard digital panel meter with digital outputs, a shaft digitizer or a sophisticated high-speed high-resolution device. For matching the input requirement of the converter with the output available from the sensor, some form of scaling and offsetting is required and is performed with an amplifier/attenuator. For conversion of analog information from more than one source, either additional converters or a multiplexer may be used. To increase the speed with which information is to be accurately converted, a sample and hold (S/H) circuit may be desirable or a necessity. In some cases, for analog signals with extra-wide range, logarithmic conversion is used.

Applications of Data Acquisition Systems- Data acquisition systems are being used in ever increasing, large and wide fields in a variety of industrial and scientific areas, including the aerospace, biomedical and telemetry industries. The type of data acquisition system to be used depends upon the application and the intended use of recorded input data.

In general, analog data acquisition systems are used when wide bandwidth is required or when lower accuracy can be tolerated.

Digital data acquisition systems are used when the physical quantity being monitored has a narrow bandwidth (ie., when the quantity varies slowly). Digital systems are also used when high accuracy and low per channel cost is required.

Digital data acquisition systems are in general, more complex than analog systems, both in terms of instrumentation involved and the volume and complexity of input data they can handle.

Data acquisition systems often make use of magnetic tape recorders. Digital systems need converters to convert analog voltages into discrete digital quantities or numbers. Conversely, digital information may have to be converted back into analog form, such as voltage or current, which can be used as a feedback quantity controlling an industrial process.