B.Tech. DEGREE EXAMINATION, JANUARY 2023
Fifth Semester
Electrical and Electronics Engineering
Theory: MEASUREMENT & INSTRUMENTATION
(2013-14 Regulations)

ANSWER KEY
PART A (2X10 = 20 Marks)

1. Distinguish between accuracy & precision?(T1)

Accuracy	Precision
Accuracy is closeness with the true value of the quantity being measured.	Precision is a measure of the reproducibility of the measurement.
Measurement can be accurate but not necessarily precise.	Measurement can be precise but not necessarily accurate.
It can be determined with a single measurement.	It needs serveral measurements to be determined.

2. A thermometer is calibrated 150°C to 200°C. The accuracy is specified ± 0.25% of spam. What is max static error?

Span of the thermometer

$$= 200 - 150 = 50°C$$

∴ Maximum static error

$$= \pm 0.25\% \text{ of } 50°C$$

$$= \pm \frac{0.25}{100} \times 50 = \pm 0.125°C$$

3. What are the precaution taken while using DC voltmeter & DC ammeter?

1. Observe the correct polarity.
2. Wrong polarity causes the meter to deflect against the mechanical stop and this may damage the pointer.
3. When using a multi range voltmeter, always use the highest voltage range and then decrease the range until a good up-scale reading is obtained.
4. Always be aware of the loading effect

4. Define the term a) Ratio error b) creeping.(T2)

(a) Ratio Error : The percentage computed when the numerator is divided by the denominator, rounded up to the nearest hundredth.

(b) Creeping in the induction type energy meter is the phenomenon in which the aluminum disc rotates continuously when only the voltage is supplied to the pressure coil and no current flows through the current coil.

5. Give the significance of Kelvin bridge(T1)

A Kelvin bridge, also called a Kelvin double bridge and in some countries a Thomson bridge, is **a measuring instrument used to measure unknown electrical resistors below 1 ohm**. It is specifically designed to measure resistors that are constructed as four terminal resistors.

Measuring low resistance **helps identify resistance elements that have increased above acceptable values**. The operation of electrical equipment depends on the controlled flow of current within the design parameters of the given piece of equipment.

6. What is mean by seeback effect & how it can be over come

The Seebeck effect is when electricity is created between a thermocouple when the ends are subjected to a temperature difference between them & it can be over come by If the hot and cold junctions are interchanged then the direction of the current will also change

7. Distinguish between LED & LCD(T2)

LED	LCD
• Power Consumption is less • Faster response rate time • Color Accuracy is less • Cannot be extremely slim	• Power Consumption is more • Slower response rate time • Color Accuracy is more • Can be extremely slim

8. Mention the role of data loggers in instrumentation system

Data loggers are electronic devices which automatically monitor and record environmental parameters over time, allowing conditions to be measured, documented, analysed and validated. The data logger contains a sensor to receive the information and a computer chip to store it.

9. What are advantages of electrical transducer?

The advantages of this transducer mainly include the following.

i. Attenuation can be done easily.
ii. Mass inactivity effects can be reduced.
iii. Friction effects can be reduced

10. Define gauge factor of a strain guage

Gauge factor (GF) or strain factor of a strain gauge is the ratio of relative change in electrical resistance R, to the mechanical strain ε.

PART B (5 *11 = 55 Marks)

UNIT-I

11(a). A voltmeter having a sensitivity of 15 kΩ/V reads 80V in its 100V scale when connected across unknown resistance Rx. The current through the resistance is 1.8mA. Determine the %error due to loading effect. (5)

Sensitivity of the voltmeter (S) = $15 k\Omega/V$

Full scale voltage (V_{fsd}) = 100 V

Voltmeter resistance = S × V_{fsd} = 100 × 15 = 1500 kΩ

Voltmeter current $(I_v) = \frac{80}{1500 \times 10^{-3}} = 0.053\, mA$

$I_m = I - I_v$ = 1.8-0.053 = 1.74 mA

Resistance $= \frac{100}{1.74 \times 10^{-3}} = 57.47\, k\Omega$

Meter resistance $R_m = \frac{80}{1.74 \times 10^{-3}} = 45.97 k\Omega$

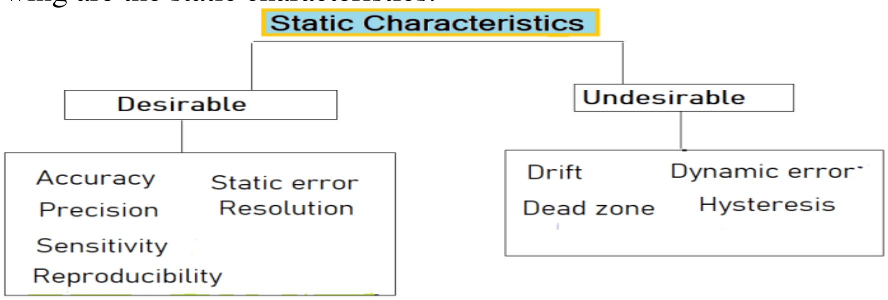
Error due to loading effect $= \frac{45.97-57.47}{57.47} * 100 = -20\%$

(b). Discuss briefly the different type of static errors of a measuring instrument.(6)(T1)

Static Error: The difference between the true value of the measuring quantity to the value shown by the measuring instrument under not varying process conditions. Static error = True value of a measured variable – Instrument reading

Human error, systematic error and random error are the types of static error. The human error occurs because of human mistakes, for example, error in reading or because of instrument measurement, etc.

The following are the static characteristics.

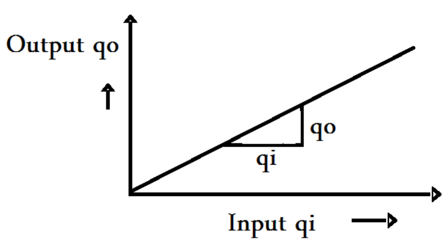


Static Error: The difference between the true value of the measuring quantity to the value shown by the measuring instrument under not varying process conditions.
Static error = True value of a measured variable – Instrument reading.

Accuracy: may be defined as the degree of closeness with which the instrument reading approaching the true value of the quantity to be measured.

Precision: is the degree of exactness for which the instrument is designed.It composed of two characteristics: **conformity** and **significant figures**.

Sensitivity: Sensitivity can be defined as the ratio of a change in output to change in input which causes it, in steady-state conditions.

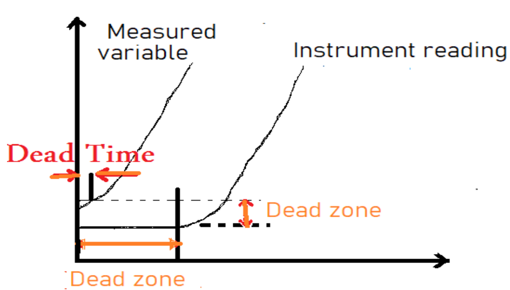


Sensitivity = Change in output **/** Change in input

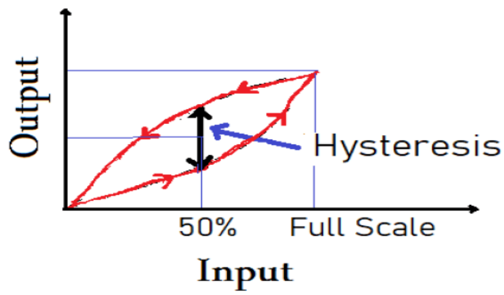
Reproducibility: Under the different measurement conditions, if the successive measurements of the same variable produce agreed results are called Reproducibility.

Resolution: It is the smallest quantity being measured which can be detected with certainty by an instrument.

Dead Zone: for the largest range of values of a measured variable, to which the instrument does not respond.

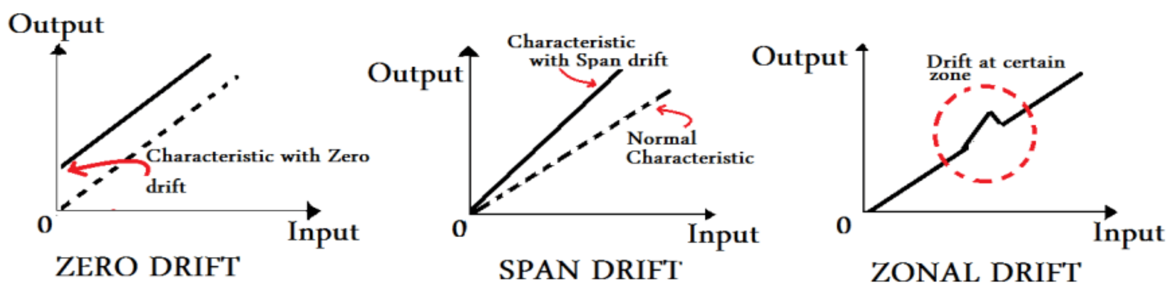


Hysteresis: Hysteresis: Hysteresis is a phenomenon that illustrates the different output effects when loading and unloading.



Drift is an undesired change in the output of a measured variable over a period of time that is unrelated to the changes in output, operating conditions, load.

- Zero Drift
- Span Drift
- Zonal Drift

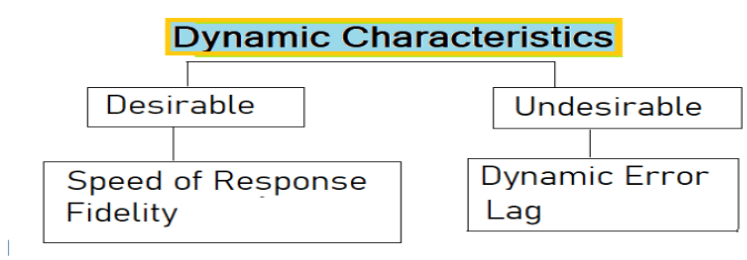


Zero Drift: The zero drift is defined as the deviation in the measured variable starts right from zero in the output with time.

Span Drift:: If there is a proportionate change in its indication right along the upward scale the drift is termed span drift or sensitivity drift.

Zonal Drift: In case if the drift occurs only a certain portion of the span of an instrument. It is called zonal drift.

12(a). Explicate the dynamic characteristics of measuring interment.(5)(T1)



Dynamic Error: The difference between the true value of the measured quantity to the value shown by the measuring instrument under varying conditions.

Speed of response: It is defined as the rapidity of the measurement system that responds to the changes in the measuring variable.
It indicates how active and fast the system is.

Fidelity: It is defined as the degree to which a measuring instrument is capable of faithfully reproducing the changes in input, without any dynamic error.

Lag: Every system takes at least some time to respond, whatever time it may be to the changes in the measured variable.
For Example Lag occurs in temperature measurement by temperature sensors such as Thermocouple or RTD or dial thermometer due to scale formation on thermowell due to process liquid.

Retardation lag: the response of the measurement begins immediately after the change in measured quantity has occurred.

Time delay lag: in this case after the application of input, the response of the measurement system begins with some dead times.

(b).(0-10A) meter with guaranteed accuracy error is ±1% measure true value of 2.5A then calculate the % limiting error (3)

Given- GAE = 1% with full deflection.

Ammeter range = 0-10 A

Maximum current **(I_{fs})** = 10A

Meter reading **(I_m)** = 2.5 A

Limiting error is given by-

$$LE = \frac{I_{fs}}{I_m} \times GAE$$

$$LE = \frac{10}{2.5} \times 1 = 4\%$$

Hence the correct answer is 4%.

(c). 3 resistance 30±3%, 20±2%, 50±4% are connected in series , find the equivalent resistance (3)

The equivalent resistance of series combination is

$R_s = R_1 + R_2 + R3 = 30\ \Omega + 50\ \Omega + 20\,\Omega = 100\ \Omega$

The error in equivalent resistance is given by

$\Delta R = (\Delta R_1 + \Delta R_2 + \Delta R3) = (3 + 4 + 2)\Omega = 9\Omega$

Hence, the equivalent resistance along with error is $(100 \pm 9)\Omega$.

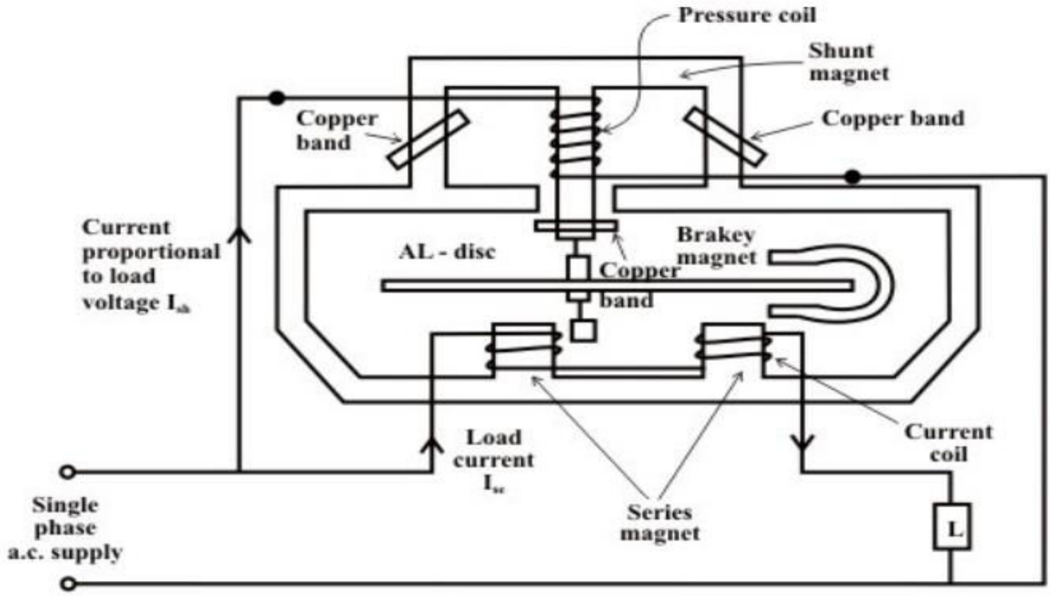
UNIT-II

13. Describe the construction & working of an induction type energy meter Also derive an expression for the Tag which is proportional to P (11)(T2)

Induction instruments operate in alternating-current circuits and they are useful only when the frequency and the supply voltage are approximately constant. The most commonly used technique is the shaded pole induction watt-hour meter, shown in fig

The rotating element is an aluminium disc, and the torque is produced by the interaction of eddy currents generated in the disc with the imposed magnetic fields that are produced by the voltage and current coils of the energy meter.

Let us consider a sinusoidal flux $\phi(t)$ is acting perpendicularly to the plane of the aluminium disc, the direction of eddy current i_e by Lenz's law is indicated in figure Fig. . It is now quite important to investigate whether any torque will develope in aluminium disc by interaction of a sinusoidally varying flux $\phi(t)$ and the eddy currents i_e induced by itself.



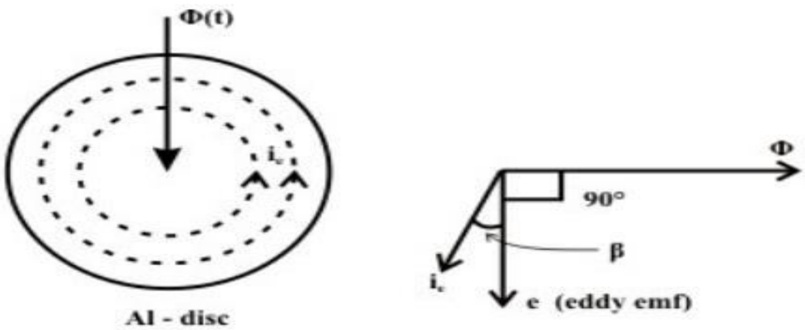


Fig. : Eddy currents in aluminium disc due to time-varying flux.

$$T_{d(av.)} \propto \phi\, I_e \cos(\angle \phi, I_e) = \phi\, I_e \cos(90^0 + \beta)$$
$$\propto \phi\, I_e \sin(\beta) = 0$$

where ϕ and I_e are expressed in r.m.s and $\beta = 0$ (because the reactance of the aluminium disc is nearly equal to zero). Therefore, the interaction of a sinusoidally varying flux $\phi(t)$ and its own eddy current i_e (induced) cannot produce torque any on the disc.

So in all induction instruments we have two fluxes produce by currents flowing in the windings of the instrument. These fluxes are alternating in nature and so they induce emfs in a aluminium disc or a drum provided for the purpose. These emfs in turn circulate eddy currents in the disc.

As in an energy meter instrument, we have two fluxes and two eddy currents and therefore two torques are produced by

i) first flux(ϕ_1) interacting with the eddy currents (I_{e2}) generated by the second flux (ϕ_2), and

ii) second flux (ϕ_2) interacting with the eddy currents (I_{e1}) induced by the first flux (ϕ_1).

In the induction type single phase energy meter, the flux produced by shunt magnet (pressure or voltage coil current) Φ_{sh} lags behind the applied voltage V by almost 90°. The flux ϕ_{se} is produced by the load current I and Φ_{se} is in the direction of I (see Fig.44.3).

Let the supply voltage $v(t) = V_{max} \sin(\omega t)$ and load current $i(t) = I_{max} \sin(\omega t - \theta)$. So, the fluxes are :

(i) Flux generated by current coil

$$\Phi_{se} = k\, I_{\max} \sin(\omega t - \theta) = \Phi_{\max(se)} \sin(\omega t - \theta)$$

(ii) Flux generated by voltage coil

$$\Phi_{sh} = k' \int v(t) dt$$

$$= -k' \frac{V_{\max}}{\omega} \cos(\omega t) = \Phi_{\max(sh)} \sin(\omega t - 90^0)$$

(note: $v(t) = \frac{1}{k'} \frac{d(\Phi_{sh})}{dt}$ and k and k' are constants.)

The eddy e.m.f , induced by flux Φ_{se} is

$$e_{se} \infty -\frac{\mathrm{d}}{\mathrm{dt}}(\Phi_{se}) = -k\, I_{\max}\, \omega \cos(\omega t)$$

Eddy current generated in disc by the current coil

$$i_{se} \infty -\frac{k}{Z} I_{\max}\, \omega \cos(\omega t - \theta - \alpha) = \frac{k}{Z} I_{\max}\, \omega \sin(\omega t - (\theta + \alpha + 90^0)),$$

where Z is the eddy current path impedance and α is the phase angle. In general, the angle $\alpha = \tan^{-1}\frac{X}{R}$ is negligible because $X = 0$.

Also, note that

$$e_{sh} \infty -\frac{\mathrm{d}}{\mathrm{dt}}(\phi_{sh}) = -k' \frac{V_{\max}}{\omega}\, \omega \sin(\omega t)$$

Eddy current generated in disc by the voltage coil

$$i_{sh} \infty -k' \frac{V_{\max}}{Z} \sin(\omega t - \alpha) = k' \frac{V_{\max}}{Z} \sin(\omega t + (180^0 - \alpha))$$

The instantaneous torque on the disc is then proportional to

$$(\Phi_{sh}\, i_{se} - \Phi_{se}\, i_{sh}) = \frac{k\,k'}{Z} V_{\max}\, I_{\max} \left(\cos(\omega t) \cos(\omega t - \theta - \alpha) - \sin(\omega t - \theta) \sin(\omega t - \alpha)\right)$$

where Φ_{sh} is the flux generated by the voltage coil, Φ_{se} is flux generated by the current coil, i_{sh} is the eddy current produced in the disc by the voltage coil, and i_{se} is the eddy current produced in the disc by the current coil. The relative phases of these quantities are shown in fig.

The flux generated by the current coil is in phase with the current and flux generated by the voltage coil is adjusted to be exactly in quadrature with the applied voltage by means of the copper shading ring on the voltage or shunt magnet. Theory of shaded pole is discussed in Appendix. The average torque acting upon the disc

$$T_{d(av)} \infty \frac{k\,k'}{Z} V_{\max}\, I_{\max} \frac{1}{2}\left(\cos(\theta + \alpha) + \cos(\theta - \alpha)\right)$$

$$\infty \frac{k\,k'}{Z} V_{\max}\, I_{\max} \cos\alpha \cos\theta = \left(\frac{2\,k\,k'}{Z} \cos\alpha\right) VI \cos\theta$$

$$\infty\ VI\cos\theta = \text{power in the circuit}$$

One can write average torque expression directly from the phasor diagram shown in fig.44.3

$$T_{d(av)} \infty \left[\Phi_{sh(rms)}\, I_{se} \cos(\angle \Phi_{sh(rms)}, I_{se}) - \Phi_{se(rms)}\, I_{sh} \cos(\angle \Phi_{se(rms)}, I_{sh})\right]$$

$$\infty \left[\Phi_{sh(rms)}\, I_{se} \cos(\theta + \alpha) - \Phi_{se(rms)}\, I_{sh} \cos(180 + \alpha - \theta)\right]$$

$$\infty \left[k' V\, k \frac{I}{Z} \cos(\theta + \alpha) + k\, I\, k' \frac{V}{Z} \cos(\theta - \alpha)\right]$$

$$\infty \left(\frac{2\,k\,k'}{Z} \cos\alpha\right) VI \cos\theta$$

$$\infty\ VI\cos\theta = \text{power in the circuit}$$

where $\Phi_{sh}, \Phi_{se}, I_{sh}, I_{se}, V,$ *and* I are all expressed as r.m.s.

14(a) Explain with neat sketch any one of the instrumentation transformation (6)(T2)

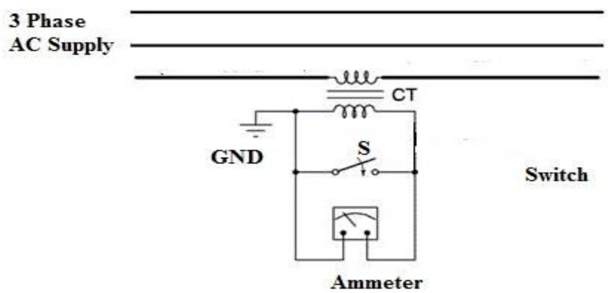
Types of Instrument Transformers

Instrument transformers are classified into two types such as

- Current Transformer
- Potential Transformer

Current Transformer

This type of transformer can be used in power systems to step down the voltage from a high level to a low level with the help of a 5A ammeter. This transformer includes two windings like primary and secondary. The current in the secondary winding is proportional to the current in the primary winding as it generates current in the secondary winding. The circuit diagram of a typical current transformer is demonstrated in the following figure.



In this transformer, the primary winding consists of few turns and it is connected with the power circuit in series. So it is called a series transformer. Likewise, the secondary winding includes a number of turns and it is connected to an ammeter directly because the ammeter includes small resistance.

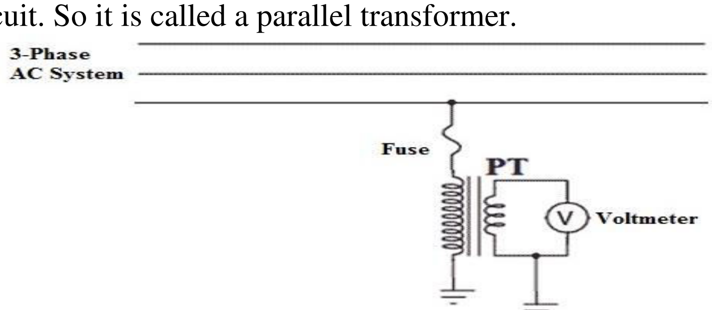
Thus, the secondary winding of this transformer works almost in the condition of a short circuit. This winding includes two terminals where one of its terminals is connected to ground to evade the huge current. So insulation breakdown chances will be reduced to guard the operator from huge voltage.

The secondary winding of this transformer in the above circuit is short-circuited before disconnecting the ammeter with the help of a switch to avoid the high voltage across the winding.

Potential Transformer

This type of transformer can be used in power systems to step down the voltage from a high level to a lower level with the help of a small rating voltmeter which ranges from 110 Volts to 120 Volts. A potential transformer typical circuit diagram is illustrated below.

This transformer includes two windings like a normal transformer like primary & secondary. The primary winding of the transformer includes a number of turns and it is connected in parallel with the circuit. So it is called a parallel transformer.



Similar to the primary winding, the secondary winding includes fewer turns and that is connected to a voltmeter directly because it includes huge resistance. Therefore the secondary winding works approximately in open circuit condition. One terminal of this winding is connected to the earth to maintain the voltage with respect to the earth to protect the operator from a huge voltage

(b) Prove that for lagging power factor an electrodynamometer reads more than the true power .(5)(MODEL)

Pressure coil inductance: In an ideal dynamo-meter type watt meter the current in pressure coil in phase with the applied voltage. But in practically the pressure coil of watt meter has an inductance and current in it will lag behind the applied voltage. If there is no inductance the current in pressure coil will be in phase with the applied voltage. In the absence of inductance in pressure coil of wattmeter, it will read correctly in all power factors and frequency. The wattmeter will read high when the load power factor is lagging ,as in that case the effect of pressure coil inductance is to reduce the phase angle between load current and pressure coil current . Hence the wattmeter will read high. This is very serious error. The wattmeter will read low when the load power factor is leading as in that case the effect of pressure coil inductance is to increase the phase angle between load current and pressure coil current. Hence the wattmeter will read low. Compensation for inductance of pressure coil. Inductance of pressure coil can be reduced by means of capacitor connected in parallel with a portion of multiplier (series resistance).

Instantaneous Torque Expression (neglecting inductance of voltage coil or moving coil):-

$$T_{inst} = \frac{V_m \sin\omega t}{R} I_m \sin(\omega t - \phi)\frac{dM}{d\theta}$$

$$T_{av} = \frac{1}{RT}\left[\int_0^T \frac{V_m I_m}{2} 2\sin\omega t \sin(\omega t - \phi)dt\right]\frac{dM}{d\theta}$$

$$= \frac{1}{RT} VI\left[\int_0^T [\cos(\phi) - \cos(2\omega t - \phi)dt]\right]\frac{dM}{d\theta}$$

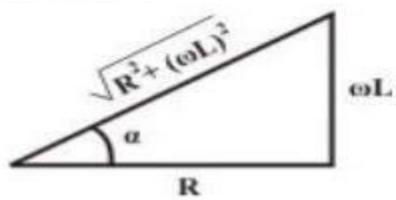
$$= \frac{VI}{RT}[\cos\phi]_0^T = \frac{VI}{R}\cos\phi\frac{dM}{d\theta} \qquad \boxed{1}$$

In practice, the voltage–coil must posses some inductances; at a given frequency, let the resulting reactance be $X_L = \omega L$.

The instantaneous current through the voltage

$$i'(t) = \frac{V_m \sin(\omega t - \alpha)}{\sqrt{R^2 + (\omega L)^2}} \qquad \text{where } \alpha = \tan^{-1}\frac{\omega L}{R}$$

where $v(t) = V_m \sin\omega t$ = voltage across the load.



$$T_{instantaneous}(t) = I_m \sin(\omega t - \phi)\frac{V_m \sin(\omega t - \alpha)}{\sqrt{R^2 + (\omega L)^2}}\frac{dM}{d\theta}$$

$$= \frac{V_m I_m}{\sqrt{R^2 + (\omega L)^2}}\sin(\omega t - \phi)\sin(\omega t - \alpha)\frac{dM}{d\theta}$$

$$T_{av} = \frac{1}{T}\int_0^T \frac{V_m I_m}{\sqrt{R^2 + (\omega L)^2}}\sin(\omega t - \phi)\sin(\omega t - \alpha)\frac{dM}{d\theta}dt$$

$$= \frac{VI}{\sqrt{R^2 + (\omega L)^2}}\cos(\phi - \alpha)\frac{dM}{d\theta} \qquad \boxed{2}$$

$$= \frac{VI}{R}\cos\alpha\cos(\phi - \alpha)\frac{dM}{d\theta}$$

$\boxed{1 \ \& \ 2}$

Comparison of equations (43.15) and (43.16) shows that the correction factor by which the deflection must be multiplied is $\dfrac{\cos\phi}{\cos\alpha\cos(\phi - \alpha)}$.

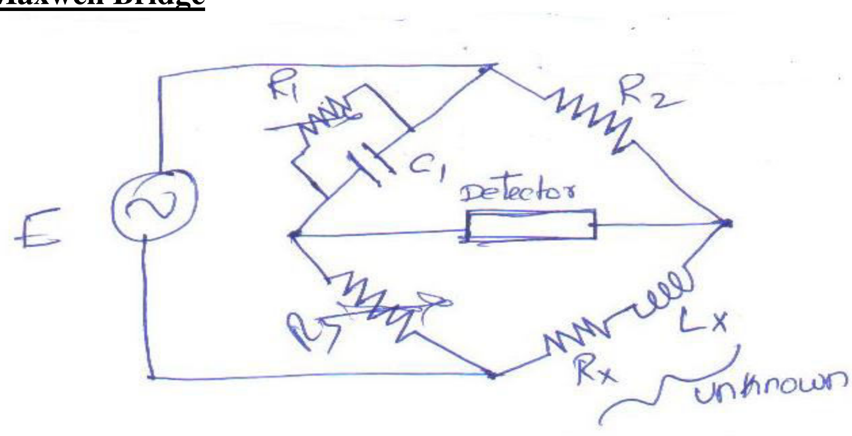
Remarks:

- As α is very small, it is usually sufficiently accurate to take the correction factor as (i) $\dfrac{\cos\phi}{\cos(\phi-\alpha)}$ for lagging power factor of the load. (ii) $\dfrac{\cos\phi}{\cos(\phi+\alpha)}$ for leading power factor of the load.
- The effect of inductance in the moving coil circuit is to cause the wattmeter to read high on **lagging power factor**
- For **leading power factor** the wattmeter will read low.
- Correction factor is zero at load of unity power factor.

UNIT-III

15. Explain how the induction is measured in term of known capacitor using Maxwell's bridge. Derive the condition for balance (11)(T2)

<u>Maxwell Bridge</u>



One arm has a resistance R1 in parallel with C1 and hence it is easier to write the balance equation using the admittance of arm 1 instead of the equation.

The general equation for bridge balance is

$$\bar{Z}_1 \bar{Z}_x = \bar{Z}_2 \bar{Z}_3$$

$$\bar{Z}_x = \frac{\bar{Z}_2 \bar{Z}_3}{\bar{Z}_1}$$

$$\bar{Z}_x = \bar{Z}_2 \bar{Z}_3 \bar{Y}_1 \quad \left(1/\bar{Z}\right) \text{ — } (1)$$

$$\bar{Z}_1 = R_1$$

R_1 in parallel with C_1

$$\bar{Y}_1 = \frac{1}{\bar{Z}_1}$$

$$\bar{Y}_1 = 1/R_1 + j\omega C_1$$

$\bar{Z}_2 = R_2$

$\bar{Z}_3 = R_3$

$\bar{Z}_x = R_x$ in series with L_x $(R_x + j\omega L_x)$

Subs $\bar{Z}_2$, $\bar{Z}_3$ $\bar{Y}_1$ in eqn ①

$$\bar{Z}_x = \bar{Z}_2 \bar{Z}_3 \bar{Y}_1$$

$$R_x + j\omega L_x = R_2 R_3 \left(\frac{1}{R_1} + j\omega C_1\right)$$

$$R_x + j\omega L_x = \frac{R_2 R_3}{R_1} + j\omega C_1 R_2 R_3$$

equating real terms & imaginary terms

$$\boxed{R_x = \frac{R_2 R_3}{R_1}}$$

$$\boxed{L_x = C_1 R_2 R_3}$$

To obtain the bridge balance, first R_3 is adjusted for inductive balance & R_1 is adjusted for resistive balance.

The quality factor of the coil is

$$Q = \frac{\omega L_x}{R_x} = \frac{\omega C_1 R_2 R_3}{\frac{R_2 R_3}{R_1}}$$

$$Q = \frac{\omega C_1 \cancel{R_2} \cancel{R_3} R_1}{\cancel{R_2} \cancel{R_3}}$$

$$\boxed{Q = \omega C_1 R_1}$$

Advantages

1. Limited to the measurement of low Q values.
2. The balance equation is independent of losses associated with inductance.
3. The measurement is independent of the excitation frequency
4. The scale of the resistance can be calibrated to read inductance directly
5. A wide range of inductance at power and audio frequency can be measured.

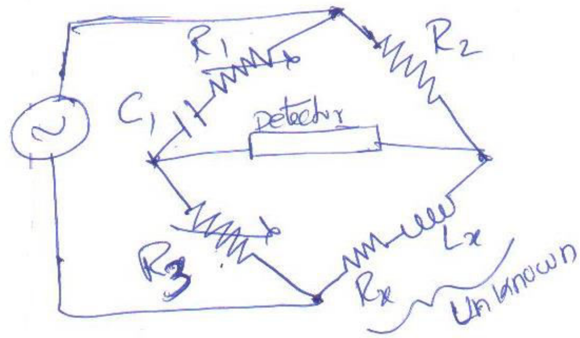
Disadvantages

1. High Q values cannot be measured
2. It cannot be used for measurement of very low Q values because of balance coverage problem.

16. What is hay's bridge? Derive the condition for balance (11)

HAY'S BRIDGE

R1 in series with standard capacitor C1 instead of in parallel This bridge is ,thus convenient for measuring high Q coils.



The general equation for bridge balance is

$$\bar{Z_1}\,\bar{Z_x} = \bar{Z_2}\,\bar{Z_3} \quad \text{——} (1)$$

$$\bar{Z_1} = R_1 - \frac{j}{\omega C_1}$$

$$\bar{Z_2} = R_2$$

$$\bar{Z_3} = R_3$$

$$\bar{Z_x} = R_x + j\omega L_x$$

Subs these values in eqn (1)

$$\left(R_1 - \frac{j}{\omega C_1}\right)\left(R_x + j\omega L_x\right) = R_2 R_3$$

$$R_1 R_x + j\omega L_x R_1 - \frac{j R_x}{\omega C_1} + \frac{L_x}{C_1} = R_2 R_3$$

equating the real & imaginary terms

$$R_1 R_x + \frac{L_x}{C_1} = R_2 R_3 \quad \text{——} (2)$$

$$\frac{R_x}{\omega C_1} = \omega L_x R_1 \quad \text{——} (3)$$

$$R_x = \omega^2 C_1 L_x R_1 \quad \text{——} (4)$$

Subs (4) in eqn (2)

$$R_1\left(\omega^2 C_1 L_x R_1\right) + \frac{L_x}{C_1} = R_2 R_3$$

$$\omega^2 R_1^2 C_1 L_x + \frac{L_x}{C_1} = R_2 R_3$$

× by both sides by "C"

$$\omega^2 R_1^2 C_1^2 L_x + L_x \cdot \frac{C_1}{C_1} = R_2 R_3 C_1$$

$$L_x \left(1 + \omega^2 R_1^2 C_1^2 L_x\right) = R_2 R_3 C_1$$

$$L_x = \frac{R_2 R_3 C_1}{1 + \omega^2 R_1^2 C_1^2}$$

subs for L_x in eqn. ⓐ

$$R_x = \omega^2 C_1 R_1 \times \frac{R_2 R_3 C_1}{1 + \omega^2 R_1^2 C_1^2}$$

$$\boxed{R_x = \frac{\omega^2 C_1^2 R_1 R_2 R_3}{1 + \omega^2 R_1^2 C_1^2}}$$

→ Bridge is frequency sensitive.

→ Bridge is not suited for measurement of coils having Q < 10.

→ A commercial bridge measures from 1 μH – 100 H with ± 2% error.

Bridge is frequency sensitive. Bridge is not suited for measurement of coils having Q less than 10.A commercial bridge measures from 1µH – 100H with ±2% error.

UNIT-IV

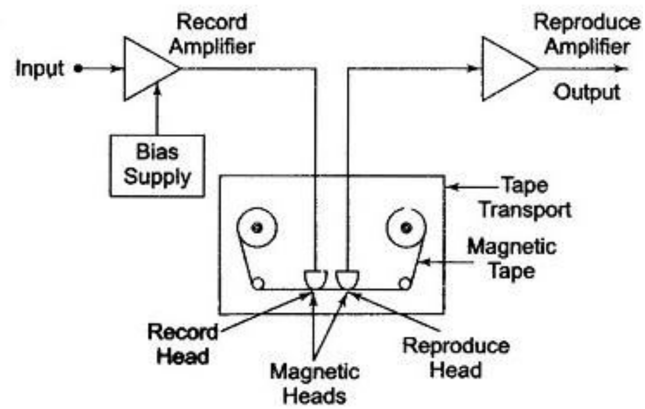
17(a) Explain the construction & working principle of magnetic tape recorder (6)(model)

A magnetic tape recorder consists of the following basic components.

1. Recording Head
2. Magnetic Head
3. Reproducing Head
4. Tape transport mechanism
5. Conditioning devices

Magnetic Recording:

The basic elements of a simple Magnetic Tape Recorder Working Principle system are illustrated in Fig.



Elementary Magnetic Tape Recorder

The Magnetic Tape Recorder Working Principle is made of a thin sheet of tough, dimensionally stable plastic, one side of which is coated with a magnetic material.

Some form of finely powdered iron oxide is usually cemented on the plastic tape with a suitable binder. As the tape is transferred from one reel, it passes across a magnetising head that impresses a residual magnetic pattern upon it in response to an amplified input signal.

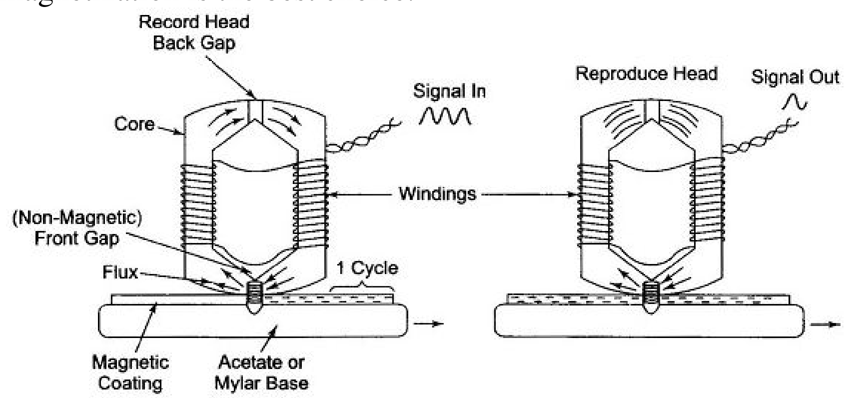
The methods employed in recording data on to the magnetic tape include direct recording, frequency modulation (FM) and pulse code modulation (PCM).

Modulation of the current in the recording head by the signal to be recorded linearly modulates the magnetic flux in the recording gap. As the tape moves under the recording head, the magnetic particles retain a state of permanent magnetization proportional to the flux in the gap. The input signal is thus converted to a spatial variation of the magnetization of the particles on the tape. The reproduce head detects these changes as changes in the reluctance of its magnetic circuit which induce a voltage in its winding. This voltage is proportional to the rate of change of flux. The reproduce head amplifier integrates the signal to provide a flat frequency characteristics.

Since the reproduce head generates a signal which is proportional to the rate of change of flux, the direct recording method cannot be used down to dc. The lower limit is around 100 Hz and the upper limit for direct recording, around 2 MHz. The upper frequency limit occurs when the induced variation in magnetization varies over a distance smaller than the gap in the reproduce head.

The signal on an exposed tape can be retrieved and played out at any time by pulling the tape across the magnetic head, in which a voltage is induced.

It is possible to magnetize the tape longitudinally or along either of the other two main axis, but longitudinal magnetization is the best choice.

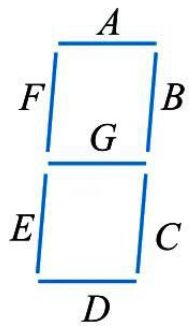


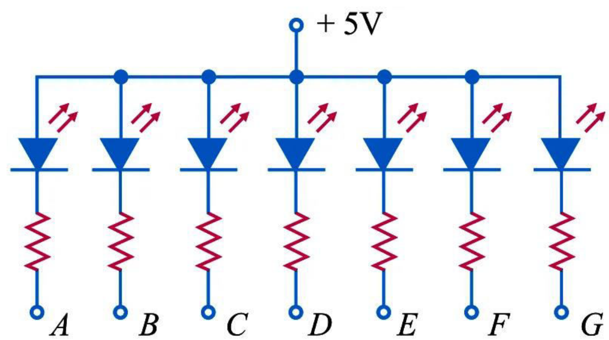
Magnetisation of Tape

shows simply how the tape is magnetized. If a magnetic field is applied to any one of the iron oxide particles in a tape and removed, a residual flux remains. The relationship between the residual flux and the recording field is determined by the previous state of magnetization and by the magnetization curves of the particular magnetic recording medium.

(b)Explain the theory of 7 segment LED display. Draw the circuit diagram of common anode display.(5)(MODEL)

LEDs are often grouped to form seven-segment display. The below Fig. shows the front of a seven segment display. It contains seven LEDs (*A, B, C, D, E, F* and *G*) shaped in a figure of 8. Each LED is called a segment. If a particular LED is forward biased, that LED or segment will light and produces a bar of light. By forward biasing various combinations of seven LEDs, it is possible to display any number from 0 to 9. For example, if LEDs *A, B, C, D* and *G* are lit (by forward biasing them), the display will show the number 3. Similarly, if LEDs *C, D, E, F, A* and *G* are lit, the display will show the number *6*.





The emission of photons from a 7-segment display occurs when the diode junction of each segment is forward biased by an external voltage allowing current to flow across its junction, and in Electronics we call this process electroluminescence.

The actual colour of the visible light emitted by an LED, ranging from blue to red to orange, is decided by the spectral wavelength of the emitted light which itself is dependent upon the mixture of the various impurities added to the semiconductor materials used to produce it.

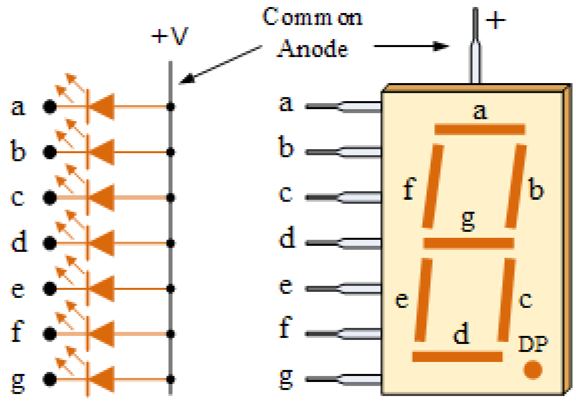
Light emitting diodes have many advantages over traditional bulbs and lamps, with the main ones being their small size, long life, various colours, cheapness and are readily available, as well as being easy to interface with various other electronic components and digital circuits.

But the main advantage of light emitting diodes is that because of their small die size, several of them can be connected together within one small and compact package producing what is generally called a **7-segment Display**.

The *7-segment display*, also written as "seven segment display", consists of seven LEDs (hence its name) arranged in a rectangular fashion as shown. Each of the seven LEDs is called a segment because when illuminated the segment forms part of a numerical digit (both Decimal and Hex) to be displayed.

An additional 8th LED is sometimes used within the same package thus allowing the indication of a decimal point, (DP) when two or more 7-segment displays are connected together to display numbers greater than ten.

Common Anode Configuration



In general, common anode displays are more popular as many logic circuits can sink more current than they can source. Also note that a common cathode display is not a direct replacement in a circuit for a common anode display and vice versa, as it is the same as connecting the LEDs in reverse, and hence light emission will not take place.

Depending upon the decimal digit to be displayed, the particular set of LEDs is forward biased. For instance, to display the numerical digit 0, we will need to light up six of the LED segments corresponding to a, b, c, d, e and f. Thus the various digits from 0 through 9 can be displayed using a 7-segment display as shown.

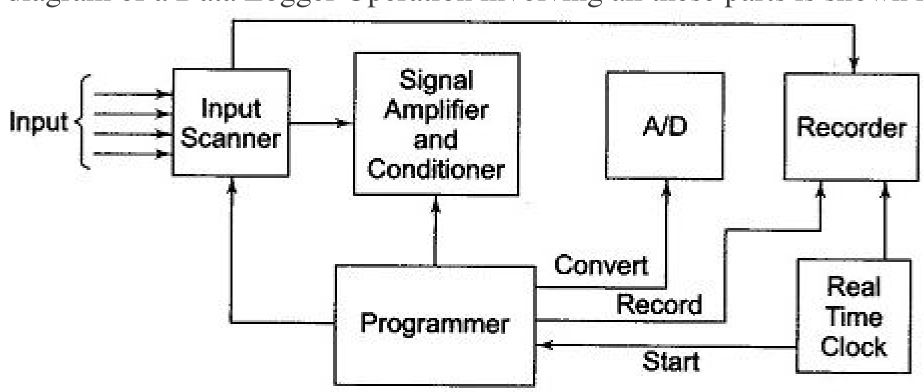
18. What is data logger? What is the basic component of data logger? What are the functions of data logger?(11)

Data Logger Operation – For proper understanding of a Data Logger Operation, it is essential to understand the difference between analog and digital signals. For example, measurement of temperature by a milli voltmeter, whose needle shows a reading directly proportional to the emf generated by the thermocouple, is an analog signal.

Basic parts of a Data Logger Operation

1. **Input scanner**
2. **Signal conditioner**
3. **A/D converter**
4. **Recording equipment**
5. **Programmer**

The block diagram of a Data Logger Operation involving all these parts is shown in Fig.



Block Diagram of a Data Logger

The input scanner is an automatic sequence switch which selects each signal in turn. Low level signals, if any, are multiplied to bring them up to a level of 5 V. If the signals are not linearly proportional to the measured parameter, these signals are linearised by the signal conditioner.

The analog signals are then converted to digital signals suitable for driving the recording equipment (printer or punched paper tape).

The programmer (serialiser) is used to control the sequence operation of the various items of the logger. It tells the scanner when to step to a new channel, and receives information from the scanner, converter and recorder. The real time clock is incorporated to automatic the system. The clock commands the programmer to sequence one set of measurements at the intervals selected by the user.

Input Signals

The input signals fed to the input scanner of the Data Logger Operation can be of the following types.

1. **High level signals from pressure transducers**
2. **Low level signals from thermocouples**
3. **ac signals**
4. **Pneumatic signals from pneumatic transducers**
5. **On/off signals from switches, relays, etc.**
6. **Pulse train from tachometer**
7. **Digital quantities**

Input Scanners

Because the scanner select each input signal in turn, the Data Logger Operation requires only one signal amplifier and conditioner, one A/D converter and a single recorder.

Modern scanners have input scanners which can scan at the rate of 150 inputs/s, but the rate of scanning has to be matched with the rate of change of input data, and the time required by the recorder and the output devices to print one output.

Sometimes it is desirable to scan certain parameters at a faster rate and some others at a longer intervals. For such mixed scan rates, the scanning equipment is designed for an interlaced scan operation, in which it is possible to log some parameters at 30 — 60 minutes interval, some every 5 minutes, and others every few seconds.

A scanner, in effect, is a multiway switch which is operated by a scanner drive unit for selecting the circuits. As the switch contacts have to continuously (24 hours/day) deal with low level signals at very, high frequencies,

Scanner Drive

The most common arrangement for selecting individual input one after another, is to use a matrix, (Signal) Input Conditioning

Since Data Logger Operation give their readout in the units of measurements concerned, there are two requirements:

Scaling linear transducers

Correcting the curvature of a non-linear transducer, such as a thermocouple

The simplest is to provide individual resistance attenuation on each input in order to reduce the transducer output level, where the scale factor is an integral power of ten. For example, if a particular transducer has a full scale of 10 mV for a pressure of 500 kg/cm^2, we can reduce the value to one half by the use of an attenuator, such that 500 kg/cm^2 may be represented by 5 mV. If the system is to have a resolution of 1 kg/cm^2, the A/D converter must have a resolution of 10 pV. This technique is limited only by the sensitivity of the A/D converter.

Recorders

The output from the Data Logger Operation can be printed on any of the following.

1. **Typewriter**
2. **Strip printer and/or digitally recorded on punched tape or magnetic tape for further analysis in a digital computer.**

The typewriter provides a conventional log sheet with tabulated results, and prints in two colours.

The signals obtained from the A/D converters are applied to the electro- magnetic operated levers of a typewriter. Plus, Minus, characters which can be printed one at a time, decimal point shift, line shift, type colour and spacing are controlled by the EM solenoids which are energised from the programmer unit. Punched paper tape or magnetic tape is used when the recorded data is to be further analysed or where the rate of data acquisition is too great for a printer.

Programmer

This can be considered as an automatic sequence switch which controls the operation of all other units of the data logger. The sequential operations performed by a programmer are as follows.

1. Set amplifier gain for individual input, i.e. gain of the amplifier has to be so adjusted that for a maximum value of input signal, the A/D converter records a full scale reading.
2. Set linearization factor so that the adjusted output from the signal amplifier is directly proportional to the measured quantity.
3. Set high and low alarm limit
4. Initiate alarm for abnormal condition
5. Select input signal scanner switching is set normally by a timing pulse to select the reset input.
6. Start A/D conversion
7. Record reading channel identify and time (in order that the readings may be identified at a later stage, a number identifying that the input has been normally recorded, with the actual reading and the time during the beginning of each complete scan).
8. Display reading
9. Reset logger. (At the end of cycle the A/D converter sections of the logger are reset to their initial conditions and the cycle' starts again.)

UNIT-V

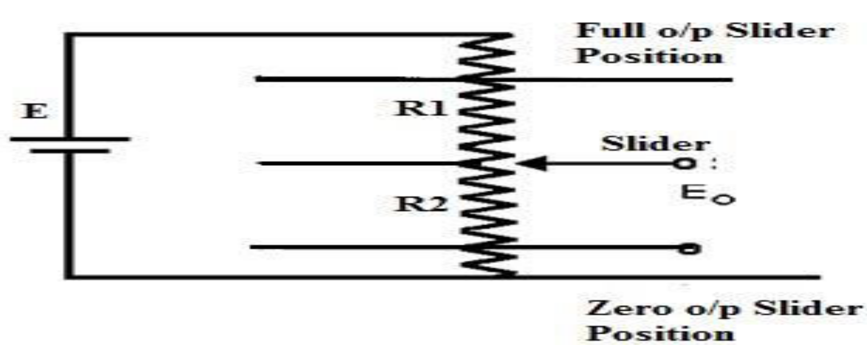
19(a). Give 2 example for resistive transducer & explain any one(5)(MODEL)

The applications of resistive transducer include **potentiometer, resistance thermometer, strain gauges, thermistor**, etc

A resistive transducer is an electronic device that is capable of measuring various physical quantities like temperature, pressure, vibration, force, etc. These physical quantities are otherwise extremely difficult to measure as they can change easily. However, using this transducer, you can easily calculate the values of these quantities. The resistance of this transducer changes concerning the change in the physical quantities.

potentiometer

The best example of this circuit is the sliding contact device. The circuit diagram of this is shown below. The sliding contact of this transducer mainly includes a long conductor whose length can be changed. One side of the conductor is connected whereas another side of the conductor can be connected to a brush/slider which moves through the conductor's full-length.



The displacement of the object can be calculated by connecting it to the slider. Whenever energy is given to the object for moving them from its first position, then the slider moves with the conductor's length. So the length of the conductor will change to reflect on modify within the resistance of the conductor. A transducer like a potentiometer works on the sliding contact type principle which is used to calculate linear & angular displacement.

(b). Discuss in detail any one of inductive type transducer(6)

D**efinition:** A transducer that works on the principle of electromagnetic induction or transduction mechanism is called an inductive transducer. A self-inductance or mutual inductance is varied to measure required physical quantities like displacement (rotary or linear), force, pressure, velocity, torque, acceleration, etc. These physical quantities are noted as measurands. Linear Variable Differential Transducer (LVDT) is an example of an inductive transducer. Using LVDT, displacement is measured in terms of the voltage induced in the winding by moving the core in one direction.

Rest is explained in Question 20

20. Explain in detail about construction detail & working of LVDT (11)(T2)

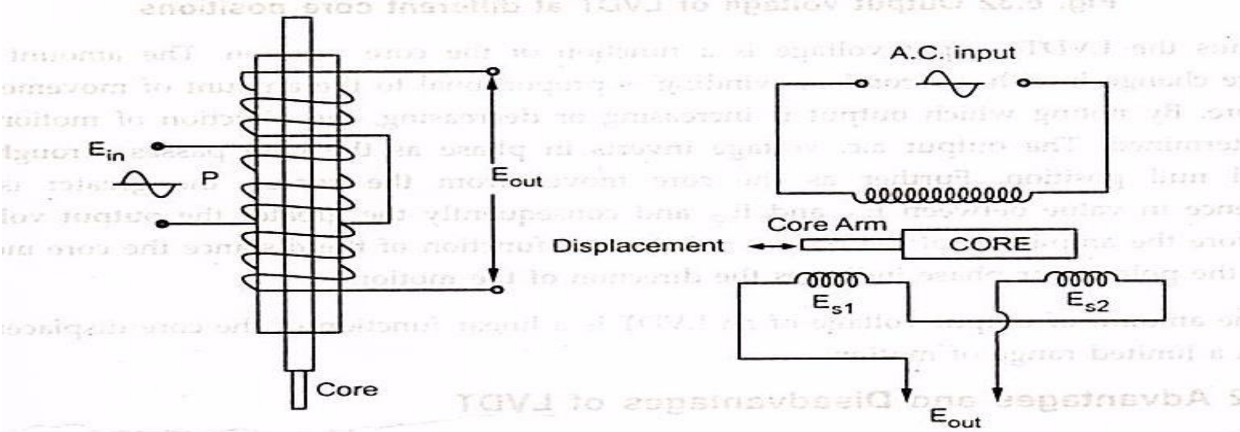
LVDT -Definition

Used to translate linear motion to electrical signals

Construction

The linear variable differential transformer consists of a single primary winding P1 and two secondary windings S1 and S2 wound on a hollow cylindrical former. The secondaries have an equal number of turns but they are connected in series opposition so that the e.m.f.s induced in the coils oppose each other. The primary winding is connected to an a.c. source, whose frequency may range from 50 Hz to 20 kHz. A movable soft iron core slides inside the hollow former.

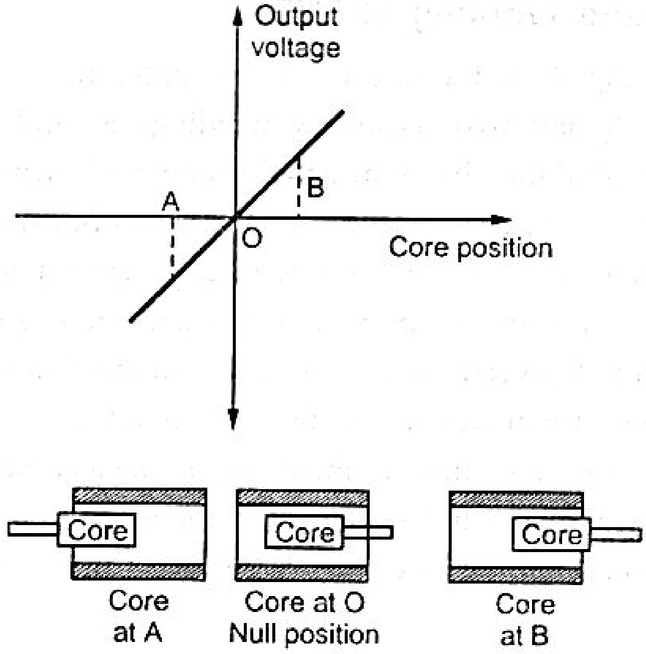
The position of the movable core determines the flux linkage between the a.c. excited primary winding and each of the two secondary windings. The core made up of nickel-iron alloy is slotted longitudinally to reduce eddy current losses. The displacement to be measured is applied to an arm attached to the core. With the core in the center, or reference, position, the induced e.m.f.s in the secondaries are equal, and since they oppose each other, the output voltage will be zero volt.



When an externally applied force moves the core to the lefthand position, more magnetic flux links the left-hand coil than the right-hand coil. The e.m.f. induced in the left-hand coil, Es1, is therefore larger than the induced e.m.f. of the right-hand coil, Es2. the magnitude of the output voltage is then equal to the difference between the two secondary voltages and it is in phase with the voltage of the left-hand coil.

Similarly, when the core is forced to move to the right, more flux links the right-hand

Coil than the left-hand coil and the resulting output voltage, which is the difference Between Es2 and Es2, is now in phase with the e.m.f. of the right hand coil.



Thus the LVDT output voltage is a function of the core position. The amount of a voltage change in either secondary winding is proportional to the amount of movement of the core. By noting which output is increasing or decreasing, the direction of motion can be determined. The output a.c. voltage inverts in phase as the core passes through the central null position. Further as the core moves from the center, the greater is the difference in value between Es2, and Es1 and consequently the greater the output voltage. Therefore the amplitude of the output voltage is a function of the distance the core moves while the polarity or phase indicates the direction of the motion.
The amount of output voltage of an LVDT is a linear function of the core displacement within a limited range of motion.

Advantages

1. Linearity: The output voltage of LVDT is almost linear for displacement upto 5 mm.
2. Infinite Resolution: The change in output voltage is continuous, stepless. The effective resolution depends more on the equipment used for the measurement rather than on the LVDT.
3. High Output: LVDT gives reasonably high output, and hence requires less amplification afterwards.
4. High Sensitivity: LVDT has high sensitivity of about 300 mV/mm; i.e., 1 mm displacement of the core produces a output voltage of 300 mV,
5. Ruggedness : LVDT is mechanically rugged and can withstand mechanical shock and vibrations.
6. Less Friction: Since Lhere are no sliding contacts, the friction is very less.
7. Low Hysteresis: LVDT has a low hysteresis, hence its repeatability is extremely good under all conditions.
8. Low Power Consumption: Most LVDTs consume less than 1 W of power.
9. The LVDT transducers are small, simple, and light in weight. They are stable and easy to align and maintain.

Disadvantages

1. Comparatively large displacements are necessary for appreciable differential Output.

2. They are sensitive to stray magnetic fields. However, this interference can be reduced by shielding.
3. The dynamic response is limited by the mass of the core.
4. Temperature affects the transducer.

Application of LVDT

1. The LVDT can be used in all applications where displacement ranging from fractions of a few mm to a few cm have to be measured.
2. Acting as a secondary transducer, LVDT can be used as a device to measure force, weight, and pressure etc. The force or pressure to be measured is first converted into a displacement using primary transducers. Then this displacement is applied to an LVDT, that acts as a secondary transducer, and converts the displacement into proportional output voltage. In these applications the high sensitivity of LVDT is a major attraction.