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Internal Assessment Test 1 – Oct. 2018

Sub:	Electronic Instrumentation					Sub Code:	17EC32	Branch:	ECE
Date:	17/ 10/ 2018	Duration:	90 minutes	Max Marks:	50	Sem & Sec	3rd Semester D	OBE	

Answer any FIVE FULL Questions

		MARKS	CO	RBT
1 (a)	Write notes on statistical analysis of measurement data.	[05]	CO1	L1
(b)	Write notes on error classification.	[05]	CO1	L1
2	Design an Ayrton shunt to provide an ammeter with a current range of 1mA, 10mA, and 100mA. Given a D'Arsonval movement with an internal resistance of 100Ω and full scale current of 50µA. List its advantages over a simple multi range ammeter.	[10]	CO2	L3
3 (a)	How to convert a basic Galvano meter to an AC voltmeter? Explain two types of rectifier type AC voltmeter and derive an expression for the multiplier resistor in each case.	[06]	CO2	L2
(b)	Convert a Galvano with Im = 100µA and Rm = 100Ω to an AC voltmeter. Calculate the value of multiplier resistor required for a full wave rectifier type AC voltmeter with range of 100V RMS.	[04]	CO2	L2
4	How to convert a basic Galvano to a multi-range voltmeter. Give example.	[10]	CO2	L2
5 (a)	Explain the working of a resistive position transducer.	[06]	CO5	L1
(b)	If a resistive position transducer uses a stoke of 5 inch and the total resistance of potentiometer is 5k Ω. Calculate the output voltage when the wiper is 1.5 inch from the extreme end and the applied voltage is 5V.	[04]	CO5	L2
6	A component manufacturer constructs certain resistances to be anywhere between $1.14\ k\Omega$ and $1.26\ k\Omega$ and classifies them to be $1.2\ k\Omega$ resistors. What tolerance should be stated? If the resistance values are specified at $25°C$ and the resistors have a temperature coefficient of $+500\ ppm/°C$.Calculate the maximum resistance that one of these components might have at $60°C$.	[10]	CO2	L3
7 (a)	Explain construction, principle of operation and working of LVDT.	[06]	CO5	L1
(b)	List the factors to be considered while selecting a transducer	[04]	CO5	L1

1 (a) Write notes on statistical analysis of measurement data.

Statistical Analysis:

The statistical analysis of measurement data is important because it allows an analytical determination of the uncertainty of the final test result. To make statistical analysis meaningful, a large number of measurements is usually required. Systematic errors should be small compared to random errors, because statistical analysis of data cannot remove a fixed bias contained in all measurements.

Arithmetic Mean

The most probable value of a measured variable is the arithmetic mean of the number of readings taken. The best approximation is possible when the number of readings of the same quantity is very large. The arithmetic mean of n measurements at a specific count of the variable x is given by the expression

$$\bar{x} = \frac{x_1 + x_2 + x_3 + \cdots + x_n}{n} = \frac{\sum_{n=1}^{n} x_n}{n}$$

where $\bar{x}$ = Arithmetic mean

x_n = nth reading taken

n = total number of readings

Deviation from the Mean

This is the departure of a given reading from the arithmetic mean of the group of readings. If the deviation of the first reading, x_1, is called d_1 and that of the second reading x_2 is called d_2, and so on,

The deviations from the mean can be expressed as

$d_1 = x_1 - \bar{x}$, $d_2 = x_2 - \bar{x}$ ..., similarly $d_n = x_n - \bar{x}$

The deviation may be positive or negative. The algebraic sum of all the deviations must be zero.

Average Deviations

The average deviation is an indication of the precision of the instrument used in measurement. Average deviation is defined as the sum of the absolute values of the deviation divided by the number of readings. The absolute value of the deviation is the value without respect to the sign.

Average deviation may be expressed as

$$D_{av} = \frac{|d_1| + |d_2| + |d_3| + \cdots + |d_n|}{n}$$

or $$D_{av} = \frac{\sum |d_n|}{n}$$

where D_{av} = average deviation

$|d_1|, |d_2|, \ldots, |d_n|$ = Absolute value of deviations

and n = total number of readings

Highly precise instruments yield a low average deviation between readings.

Standard Deviation

The standard deviation of an infinite number of data is the Square root of the sum of all the individual deviations squared, divided by the number of readings. It may be expressed as

$$\sigma = \sqrt{\frac{d_1^2 + d_2^2 + d_3^2 + \cdots + d_n^2}{n}}$$

$$\sigma = \sqrt{\frac{d_n^2}{n}}$$

where σ = standard deviation

The standard deviation is also known as root mean square deviation, and is the most important factor in the statistical analysis of measurement data. Reduction in this quantity effectively means improvement in measurement.

For small readings (n < 30), the denominator is frequently expressed as (n — 1) to obtain a more accurate value for the standard deviation.

Limiting Errors

Most manufacturers of measuring instruments specify accuracy within a certain % of a full scale reading. For example, the manufacturer of a certain voltmeter may specify the instrument to be accurate within ± 2% with full scale deflection. This specification is called the limiting error. This means that a full scale deflection reading is guaranteed to be within the limits of 2% of a perfectly accurate reading; however, with a reading less than full scale, the limiting error increases.

(b) Write notes on error classification.

Classification of Errors:

Errors are classified in two types – **Systemic (Determinate)** and **Random (Indeterminate)** errors

Systemic (Determinate) errors:

Errors which can be avoided or whose magnitude can be determined is called as systemic errors. It can be determinable and presumably can be either avoided or corrected. Systemic errors further classified as

- Operational and personal error
- Instrumental error
- Errors of method
- Additive or proportional error

Operational and personal error:
Errors for which the individual analyst is responsible and are not connected with the method or procedure is called as personal errors e.g. unable to judge color change

When errors occur during operation is called as operational error e.g. transfers of solution, effervescence, incomplete drying, underweighting of precipitates, overweighing of precipitates, and insufficient cooling of precipitates. These errors are physical in nature and occur when sound analytical techniques is not followed

Instrumental and Reagent errors:
Errors occur due to faulty instrument or reagent containing impurities e.g. un-calibrated weights, un-calibrated burette, pipette and measuring flasks.

Errors of Method:
When errors occur due to method, it is difficult to correct. In gravimetric analysis, error occurs due to Insolubility of precipitates, co-precipitates, post-precipitates, decomposition, and volatilization.

In titrimetric analysis errors occur due to failure of reaction, side reaction, reaction of substance other than the constituent being determined, difference between observed end point and the stoichiometric equivalence point of a reaction.

Additive or proportional errors:
Additive error does not depend on constituent present in the determination e.g. loss in weight of a crucible in which a precipitate is ignited.

Proportional error depends on the amount of the constituent e.g. impurities in standard compound.

Random Errors:
It occurs accidentally or randomly so called as indeterminate or accidental or random error. Analyst has no control in this error. It follows a random distribution and a mathematical law of probability can be applied.

2. ***Design an Ayrton shunt to provide an ammeter with a current range of 1mA, 10mA, and 100mA. Given a D'Arsonval movement with an internal resistance of 100Ω and full scale current of 50μA. List its advantages over a simple multi range ammeter.***
$I_m = 50\mu A$ $R_m = 100\ \Omega$
0-1mA Range:

I=1mA
Ish =I-Im =950μA
R1+R2+R3 = ImRm/Ish
R1+R2+R3 = 5.26 Ω ……………….. (1)
0-10mA Range:
I=10mA
Ish =I-Im =9950μA
R2+R3 = Im(Rm+R1)/Ish .... (2)

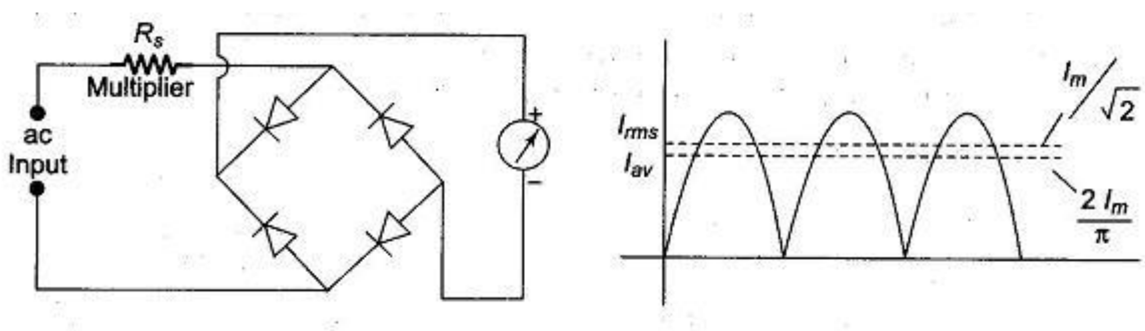
0-100mA Range:
I=100mA
Ish =I-Im =99950μA
R3 = Im(Rm+R1+ R2)/Ish .... (4)

Solving equations (1),(2),(3) and (4)
R1 =4.74 Ω
R2 = 0.4573 Ω
R3= 0.05263 Ω

3 (a) How to convert a basic Galvano meter to an AC voltmeter? Explain two types of rectifier type AC voltmeter and derive an expression for the multiplier resistor in each case.

AC Voltmeter using Rectifiers:

AC Voltmeter using Rectifiers – Rectifier type instruments generally use a PMMC movement along with a rectifier arrangement. Silicon diodes are preferred because of their low reverse current and high forward current ratings. Figure below gives an ac voltmeter circuit consisting of a multiplier, a bridge rectifier and a PMMC movement.



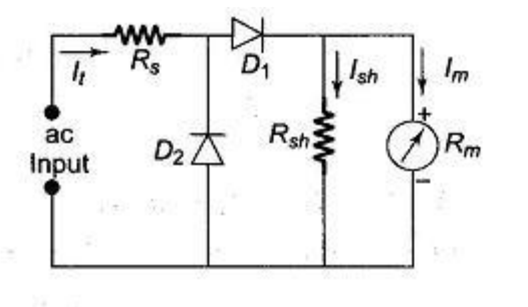
The bridge rectifier provides a full wave pulsating dc. Due to the inertia of the movable coil, the meter indicates a steady deflection proportional to the average value of the current. The meter scale is usually calibrated to give the RMS value of an alternating sine wave input.

$R_s = (V*0.9/I_m) - R_m$

Practical rectifiers are non-linear devices particularly at low values of forward current. Hence the meter scale is non-linear and is generally crowded at the lower end of a low range voltmeter. In this part the meter has low sensitivity because of the high forward resistance of the diode. Also, the diode resistance depends on the temperature.

The rectifier exhibits capacitance properties when reverse biased, and tends to bypass higher frequencies. The meter reading may be in error by as much as 0.5% decrease for every 1 kHz rise in frequency.

A general rectifier type ac voltmeter arrangement is given below



Diode D_1 conducts during the positive half of the input cycle and causes the meter to deflect according to the average value of this half cycle. The meter movement is shunted by a resistor, R_{sh} in order to draw more current through the diode D_1 and move the operating point into the linear portion of the characteristic curve, In the negative half cycle, diode D_2 conducts and the current through the measuring circuit, which is in an opposite direction, bypasses the meter movement.

$Rs = (V*0.45/I_m) - R_m$

(b) Convert a Galvano with Im = 100µA and Rm = 100Ω to an AC voltmeter. Calculate the value of multiplier resistor required for a full wave rectifier type AC voltmeter with range of 100V RMS.

$Rs = (V*0.9/I_m) - R_m$

$= (100*0.9/100\mu) - 100 = 900k - 100 = 899.9\ k\Omega$

4 How to convert a basic Galvano to a multi-range voltmeter. Give example.

Basic Meter as a DC Voltmeter

To use the basic meter as a dc voltmeter, it is necessary to know the amount of current required to deflect the basic meter to full scale. This current is known as full scale deflection current (I_{fsd}). For example, suppose a 50 µA current is required for full scale deflection.

This full scale value will produce a voltmeter with a sensitivity of 20,000 Ω per V.

The sensitivity is based on the fact that the full scale current of 50 µA results whenever 20,000 Ω of resistance is present in the meter circuit for each voltage applied.

$$\textbf{Sensitivity} = 1/I_{fsd} = 1/50\mu A = 20k\Omega/V$$

Hence, a 0 – 1 mA would have a sensitivity of 1 V/1 mA = 1 kΩ/V or 1000 Ω.

DC Voltmeter

A basic D' Arsonval movement can be converted into a dc voltmeter by adding a series resistor known as multiplier, as shown in Fig. 4.1. The function of the multiplier is to limit the current through the movement so that the current does not exceed the full scale deflection value. A dc voltmeter measures the potential difference between two points in a dc circuit or a circuit component.

To measure the potential difference between two points in a dc circuit or a circuit component, a dc voltmeter is always connected across them with the proper polarity.

The value of the multiplier required is calculated as follows. Referring to Fig. 4.1,

I_m = full scale deflection current of the movement (I_{fsd})

R_m = internal resistance of movement

R_s = multiplier resistance

V = full range voltage of the instrument

From the circuit of Fig. 4.1

$$V = I_m (R_s + R_m)$$

$$R_s = \frac{V - I_m R_m}{I_m} = \frac{V}{I_m} - R_m$$

$$R_s = \frac{V}{I_m} - R_m$$

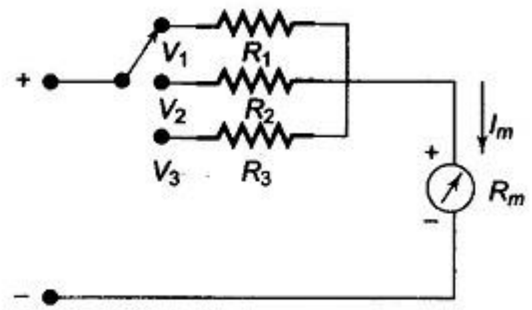
The multiplier limits the current through the movement, so as to not exceed the value of the full scale deflection I_{fsd}. The above equation is also used to further extend the range in DC voltmeter.

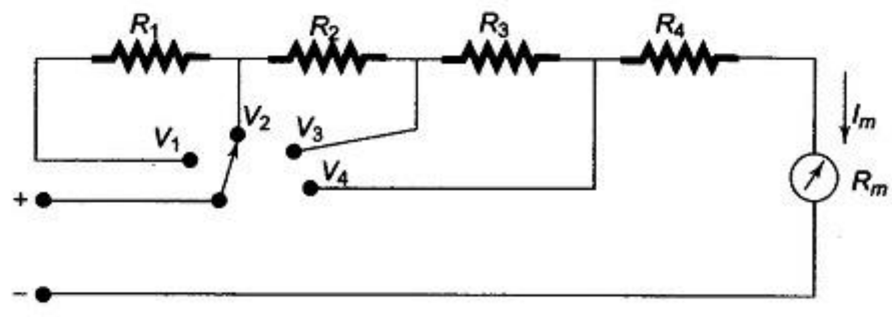
<u>Multirange Voltmeter</u>

As in the case of an ammeter, to obtain a multirange ammeter, a number of shunts are connected across the movement with a multi-position switch. Similarly, a dc voltmeter can be converted into a multirange voltmeter by connecting a number of resistors (multipliers) along with a range switch to provide a greater number of workable ranges.

Figure 4.1 shows a multirange voltmeter using a three position switch and three multipliers R_1, R_2, and R_3 for voltage values V_1, V_2, and V_3. Figure 4.1 can be further modified to Fig. 4.2, which is a more practical arrangement of the multiplier resistors of a multirange voltmeter.

In this arrangement, the multipliers are connected in a series string, and the range selector selects the appropriate amount of resistance required in series with the movement.





This arrangement is advantageous compared to the previous one, because all multiplier resistances except the first have the standard resistance value and are also easily available in precision tolerances:

The first resistor or low range multiplier, R_4, is the only special resistor which has to be specially manufactured to meet the circuit requirements.

Example:

Let I_m = 500µA, V (range)= 50V and R_m =1kΩ
Design equation for multiplier resistance,

$$R_m = \frac{V}{I_m} - R_m$$

$$R_m = \frac{50}{500\mu} - 1k$$

$$R_m = 99k\Omega$$

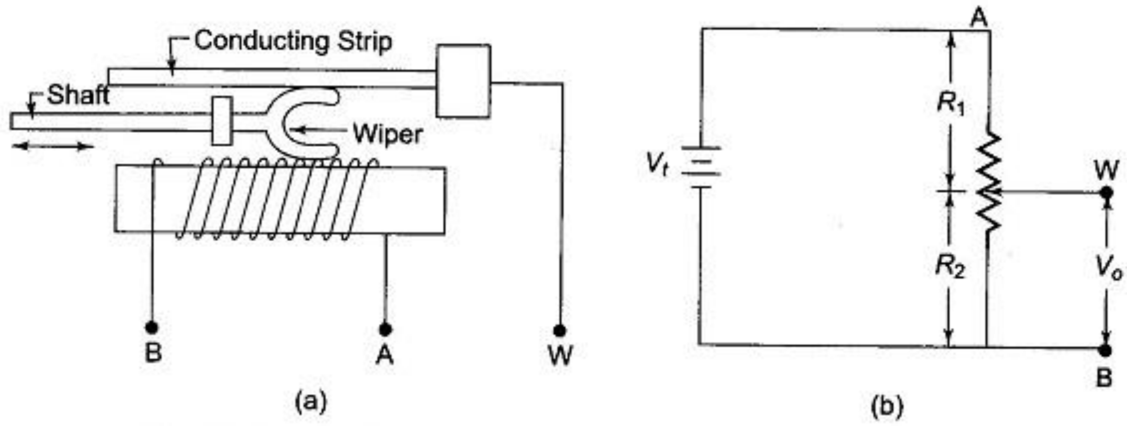
5 (a) Explain the working of a resistive position transducer.

Resistive Position Transducer:

The principle of the Resistive Position Transducer is that the physical variable under measurement causes a resistance change in the sensing element. (A common requirement in industrial measurement and control work is to be able to sense the position of an object, or the distance it has moved).

One type of displacement transducer uses a resistive element with a sliding contact or wiper linked to the object being monitored or measured. Thus the resistance between the slider and one end of the resistance element depends on the position of the object. Figure a gives the construction of this type of transducer.

Figure a shows a typical method of use. The output voltage depends on the wiper position and is therefore a function of the shaft position. This voltage may be applied to a voltmeter calibrated in cms for visual display.



(Typical commercial units provide a choice of maximum shaft strokes, from an inch or less to 5 ft or more.) Deviation from linearity of the resistance versus distance specifications can be as low as 0.1 — 1.0%.

Considering Figure b, if the circuit is unloaded, the output voltage V_o is a certain fraction of V_t, depending upon the position of the wiper.

$$\frac{V_o}{V_t} = \frac{R_2}{R_1 + R_2}$$

Therefore,

When applied to resistive position sensors, this equation shows that output voltage is proportional to R_2, i.e. the position of the wiper of the potentiometer. If the resistance of the transducer is distributed uniformly along the length of travel of the wiper, the resistance is perfectly linear.

5 (b) If a resistive position transducer uses a stoke of 5 inch and the total resistance of potentiometer is 5k Ω. Calculate the output voltage when the wiper is 1.5 inch from the extreme end and the applied voltage is 5V.

Resistance per 1inch stroke = 5 kΩ /5 = 1kΩ

Length of the stroke involved = 5 -1.5= 3.5 inch

Resistance per 3.5 inch = 3.5 kΩ

Voltage output = (5V*3.5k)/5k = 3.5V

6. A component manufacturer constructs certain resistances to be anywhere between $\mathbf{1.14}\ \boldsymbol{k}\Omega$ and $\mathbf{1.26}\ \boldsymbol{k}\Omega$ and classifies them to be $\mathbf{1.2}\ \boldsymbol{k}\Omega$ resistors. What tolerance should be stated? If the resistance values are specified at $\mathbf{25}°\boldsymbol{C}$ and the resistors have a temperature coefficient of $+\mathbf{500}\ \boldsymbol{ppm}/°\boldsymbol{C}$.Calculate the maximum resistance that one of these components might have at $\mathbf{75}°\boldsymbol{C}$.

Absolute error = $1.26\,k\Omega - 1.2\,k\Omega = +0.06\,k\Omega$

or $1.2\,k\Omega - 1.14\,k\Omega = -0.06\,k\Omega$

hence Absolute error = $\pm 0.06\,k\Omega$

$$\text{Tolerance} = \frac{\pm 0.06\,k\Omega}{1.2\,k\Omega} \times 100\,\%$$

$$= \pm 5\,\%$$

largest possible resistance at 25°C

$$R = 1.26\,k\Omega$$

Resistance change / °C = 500 ppm of R

$$= \frac{500}{1000000} \times 1.26\,k\Omega$$

$$= 0.63\,\Omega / °C$$

Temp increase = 75°C − 25°C

$$= 50°C$$

Total resistance increase = ~~50°C × 0.63 Ω/°C~~

$$= 50°C \times 0.63\,\Omega/°C$$

$$= 31.5\,\Omega$$

maximum Resistance at 75 °C

$$R + \Delta R = 1.26\,k\Omega + 31.5\,\Omega$$

$$= 1.2915\,k\Omega$$

→ Ans.

7 (a) Explain construction, principle of operation and working of LVDT.

LVDT-Linear Variable Differential Transformer
Principle and Construction of LVDT:
LVDT works under the principle of mutual induction, and the displacement which is a non-electrical energy is converted into an electrical energy
LVDT consists of a cylindrical former where it is surrounded by one primary winding in the centre of the former and the two secondary windings at the sides. The number of turns in both the secondary windings are equal, but they are opposite to each other, i.e., if the left secondary windings is in the clockwise direction, the right secondary windings will be in the anti-clockwise direction, hence the net output voltages will be the difference in voltages between the two secondary coil. The two secondary coil is represented as S1 and S2. Esteem iron core is placed in the centre of the cylindrical former which can move in to and fro motion as shown in the figure. The AC excitation voltage is 5 to 12V and the operating frequency is given by 50 to 400 HZ.

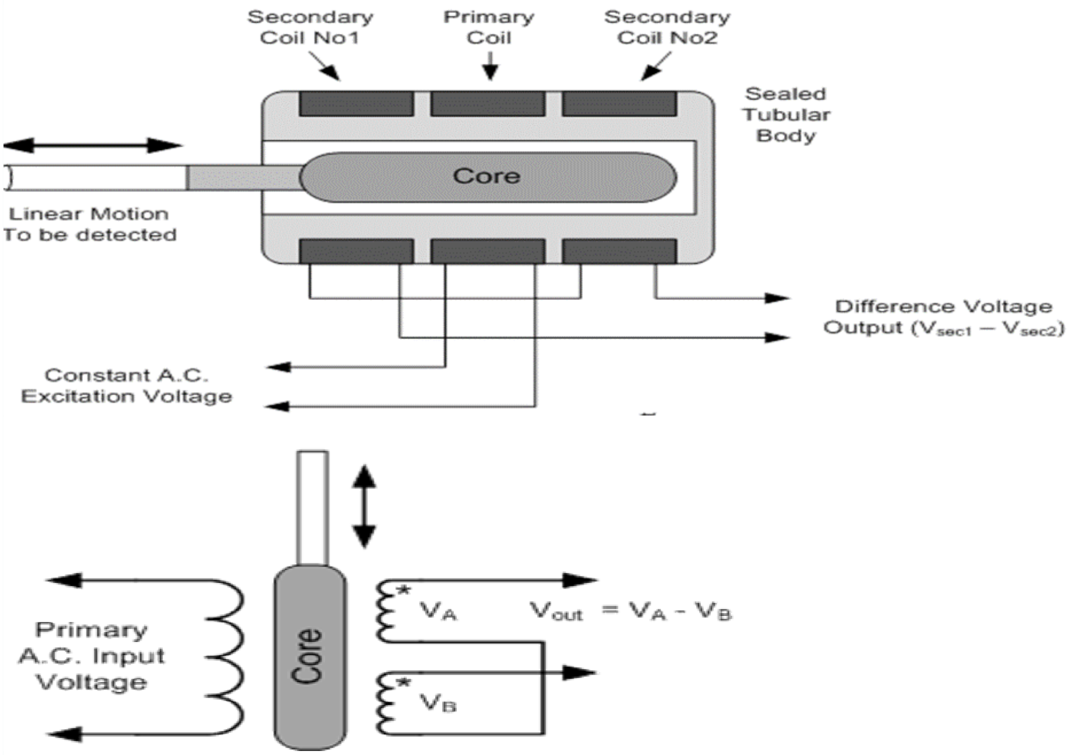


Fig 7.1 Construction of LVDT

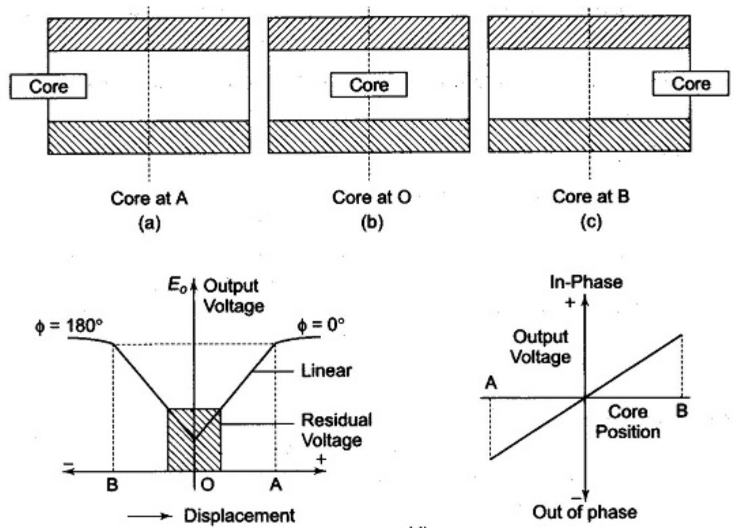


Fig 7.2 Output voltage and phase as a function of displacement

Working:

Case 1: On applying an external force which is the displacement, if the core remains in the null position itself without providing any movement then the voltage induced in both the secondary windings are equal which results in net output is equal to zero
i.e., Va-Vb=0
Case 2: When an external force is applied and if thel iron core tends to move in the left hand side direction then the emf voltage induced in the secondary coil is greater when compared to the emf induced in the secondary coil 2.
Therefore the net output will be Va-Vb
Case 3: When an external force is applied and if the steel iron core moves in the right hand side direction then the emf induced in the secondary coil 2 is greater when compared to the emf voltage induced in the secondary coil 1. Therefore the net output voltage will be Vb-Va

Advantages of LVDT:
* Infinite resolution is present in LVDT
* High output
* High sensitivity
* Very good linearity
* Ruggedness
* Less friction
* Low hysteresis
* Low power consumption.

Disadvantages of LVDT:
* Very high displacement is required for generating high voltages.
* Shielding is required since it is sensitive to magnetic field.
* The performance of the transducer gets affected by vibrations
* It is greatly affected by temperature changes.

Applications of LVDT:

- LVDT is used to measure displacement ranging from fraction milli-metre to centimetre
- Acting as a secondary transducer
- LVDT can be used as a device to measure force, weight and pressure etc.

7 (b)List the factors to be considered while selecting a transducer

Electrical transducer: An electrical transducer is a sensing device by which the physical, mechanical or optical quantity to be measured is transformed directly by a suitable mechanism into an electrical voltage/current proportional to the input measurand. The transducer or sensor has to be physically compatible with its intended application. The following factors need to be considered while selecting a transducer.

- Operating range: Chosen to maintain range requirements and good
- Sensitivity: Chosen to allow sufficient output.
- Frequency response and resonant frequency: Flat over the entire desired range.
- Environmental compatibility: Temperature range, corrosive fluids, pressure, shocks, interaction, size and mounting restrictions.
- Minimum sensitivity: To expected stimulus, other than the measurand.
- Accuracy: Repeatability and calibration errors as well as errors expected due to sensitivity to other stimuli.
- Usage and ruggedness: Ruggedness, both of mechanical and electrical intensities versus size and weight.
- Electrical parameters: Length and type of cable required, signal to noise ratio when combined with amplifiers, and frequency response limitations.