## 4.1 DISPLACEMENT MEASUREMENT

- A displacement measurement implies the measurement of the movement of point from one position to another.
- The measurement of displacement is made frequently to relate some other measurement and hence displacement measurement instrument is fundamental components of measurement system.
- The displacement can be measured by both mechanical and electrical methods, however only e electrical methods which are usually used in indust1ial measurement.
- The resistance strain gauge and LVDT are most common instruments to measure the displacement.

## 4.2 RESISTANCE POTENTIOMETER

- As we know that resistance (R) of metal conductor depends on the resistivity of conductor (p), length of conductor (l) and cross sectional area of conductor (A) as mathematically expressed by

$$R = \frac{\rho}{l}$$

- Any method of varying one of these quantities can be design basis of an electrical transducer.
- The translational and rotational potentiometers which work on the basis of change me value of resistance with change in length of the conductor can be used for measurement of translational and rotary displacements.
- This transducer converts mechanical displacement into an elect1ical output (resistance change). This is accomplished by changing the effective length of conductor across which output measured.
- The simplest fo1m of resistance translational potentiometers as shown in Fig. 4.1 consists of a stretched resistance element and a slider.
- The resistance element in common use is wire wound because that gives sufficiently high resistance value in small space.
- The slider is called wiper which maintains an electrical contact with wire and moves upon it. Any displacement of shaft wiIl change the resistance of wire (conductor) and this change in resistance is measured with electrical circuit.
- The effective resistance existing between either end of the wire and the slider becomes the measure of mechanical displacement.
- This type of device is normally used for large displacements. It can also be used to measure pressure, acceleration, force, torque, liquid level, etc.

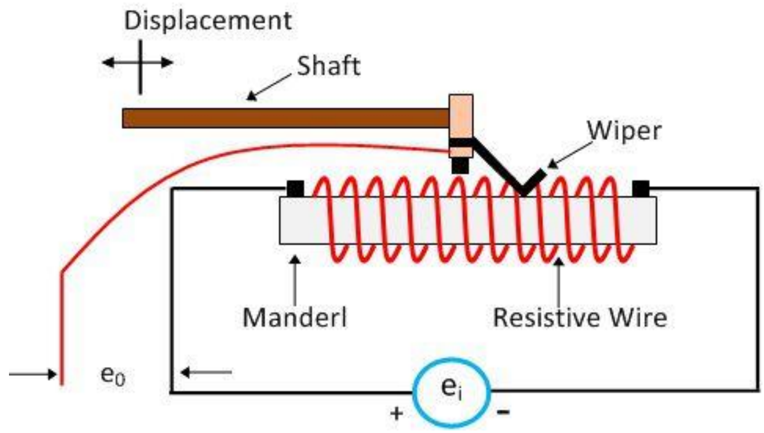


*Figure 4.1 Resistance translational potentiometers*

## 4.3 LINEAR VARIABLE DIFFERENTIAL TRANSFORMER

- An LVDT provides an alternating current (AC) voltage output proportional to the relative displacement of a transformer core with respect to a pair of electrical windings.
- It provides a high degree of amplification and is very popular because of its ease of use. Moreover, it is a non-contact-type device, where there is no physical contact between the plunger and the sensing element.
- As a consequence, friction is avoided, resulting in better accuracy and long life for the comparator. It can be conveniently packaged in a small cartridge. Figure illustrates the construction of an LVDT.
- An LVDT produces an output proportional to the displacement of a movable core within the field of several coils. As the core moves from its 'null' position, the voltage induced by the coils change, producing an output representing the difference in induced voltage.
- It works on the mutual inductance principle. A primary coil and two secondary coils, identical to each other, are wound on an insulating form, as shown in Fig.4.2
- An external AC power source is applied to the primary coil and the two secondary coils are connected together in phase opposition. In order to protect the device from humidity, dust, and magnetic influences, a shield of ferromagnetic material is spun over the metallic end washers.
- The magnetic core is made of an alloy of nickel and iron. The motion of the core varies the mutual inductance of secondary coils. This change in inductance determines the electrical voltage induced from the primary coil to the secondary coil.
- Since the secondary coils are in series, a net differential output results for any given position of the core. Figure 6.14 illustrates the characteristic curve of an LVDT.
- This curve shows the relationship between the differential output voltage and the position of the core with respect to the coils. It can be seen from this graph that if the core is centered in the middle of the two secondary windings, then the voltage induced in both the secondary coils will be equal in magnitude but opposite in phase, and the net output will be zero.

- An output voltage is generated when the core moves on either side of the null position. Theoretically, output voltage magnitudes are the same for equal core displacements on either side of the null balance.
- However, the phase relation existing between power source and output changes 180° through the null.

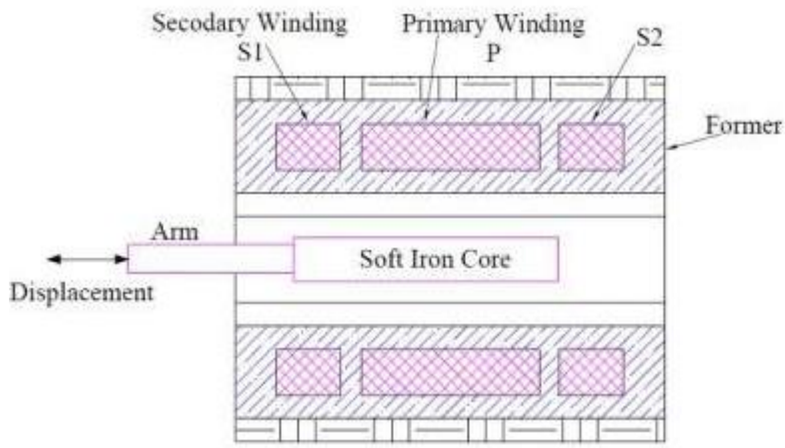


*Figure 4.2 LVDT*

- Therefore, it is easy, through phase determination, to distinguish between outputs resulting from displacements on either side of the null.
- For such displacements, which are within the linear range of the instrument, output voltage is a linear function of core displacement. However, as Fig. indicates, the linear range of the instrument is limited.
- Care should be taken to ensure that the actual measurement ranges are limited to the linear range of the LVDT.
- Sensitivity of an LVDT is stated in terms of millivolts output per volt input per 1 mm core displacement. The per-volt input voltage refers to the exciting voltage that is applied to the circuit.
- Sensitivity varies from 0.1 to 1.5 mV for a range varying from 0.01 to 10 mm of core displacement. Sensitivity is directly proportional to excitation voltage, frequency of input power, and number of turns on the coils.
- An LVDT enjoys several distinct advantages compared to other comparators.

**Advantages of LVDT**

1. It directly converts mechanical displacement into a proportional electrical voltage. This is unlike an electrical strain gauge, which requires the assistance of some form of elastic member.
2. It cannot be overloaded mechanically. This is because the core is completely separated from the remainder of the device.
3. It is highly sensitive and provides good magnification.
4. It is relatively insensitive to temperature changes.
5. It is reusable and economical to use.