SNS COLLEGE OF TECHNOLOGY

Coimbatore-35

An Autonomous Institution

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DEPARTMENT OF ELECTRONICS & COMMUNICATION ENGINEERING

23ECE304-SMART SENSORS AND DEVICES

III ECE / V SEMESTER

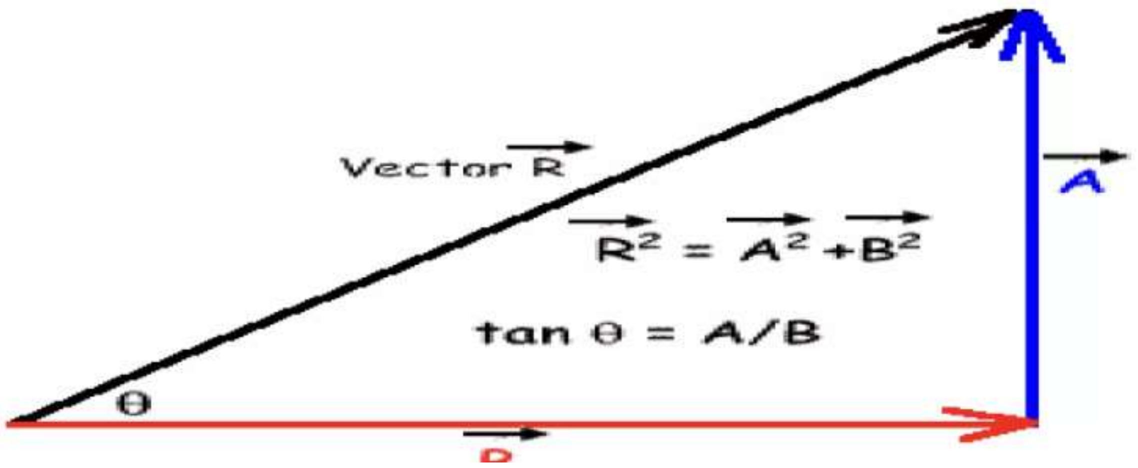
UNIT 1 – OVERVIEW OF MEASUREMENTS AND SENSORS

TOPIC –MEASUREMENT OF DISPLACEMENT USING POTENTIOMETER

DISPLACEMENT

Introduction

- Displacement, a vector quantity
- Represents change in position of a point or body w.r.t reference point
- Difference between coordinates of two points



Need of Measurement

- Used for the measurement of many derived quantities such as force , stress , pressure, velocity and acceleration etc.
- Force, pressure, velocity etc. in terms of displacement

DISPLACEMENT TRANSDUCER

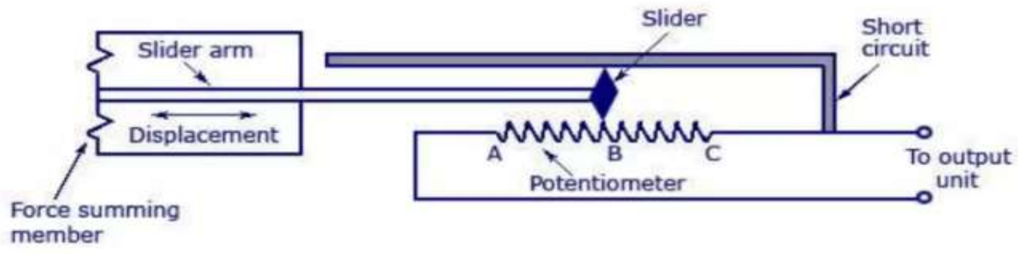
- Converts physical quantity into electrical quantity
- Two main parts

1. Sensing element or primary transducer

2. Transduction element or secondary transducer

Linear Potentiometer

Potentiometers are electrical devices which are a form of variable resistance.



Linear Potentiometer

It consists of a sliding contact which moves over the length of a resistance element.

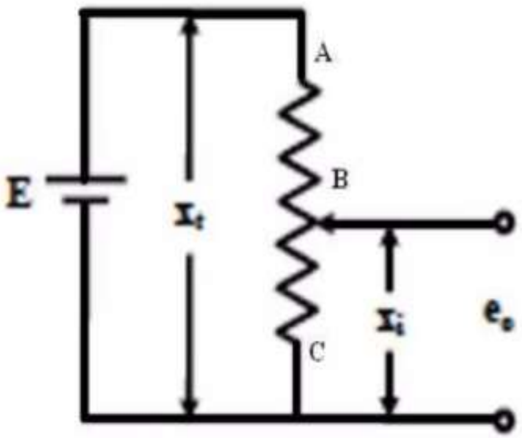
This sliding contact connects to a plunger, which links to the object whose displacement is to be measured.

Referring to the electrical circuit shown here,

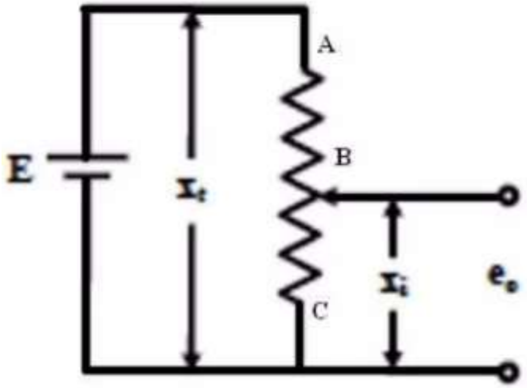
an input voltage X_t is applied across the whole resistance element, at points A and C.

The output voltage, X_i , is measured between the sliding contact at point B and the end of the resistance element at point C.

A linear relationship exists between the input voltage X_t, output voltage X_i and the distance BC.



Mathematical Expression for Potentiometer

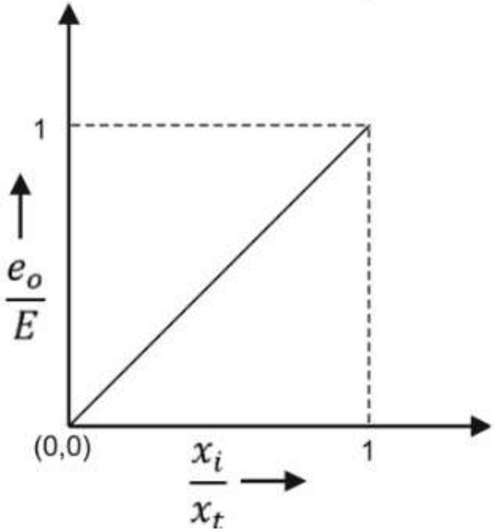


Since resistance of potentiometer is linearly distributed along its length.

Voltage per unit length = E/x_t

Output $Voltage(e_o) = \frac{x_i}{x_t}E$

so there is a linear relationship between input displacement and output voltage.



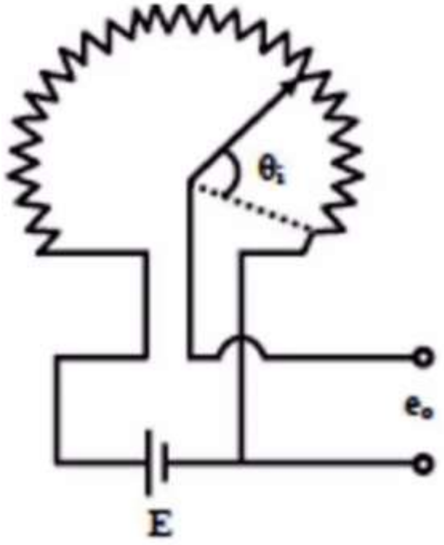
Resistive Transducer

Angular Potentiometer

Angular Displacement

Rotational motion measured from a few seconds to 360^o

Rotary or angular potentiometers measure angular displacement .



Linear Variable Displacement Transducer

A very basic transducer which is always useful in the field of instrumentation

Principle 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.

And the way how the energy is getting converted is described in working of LVDT in a detailed manner.

LVDT

Construction of LVDT

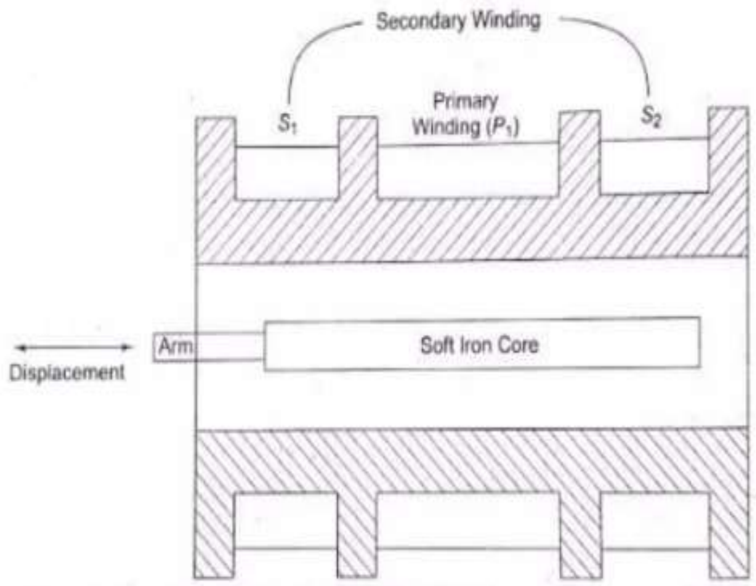


Fig. 13.19 Construction of a Linear Variable Differential Transducer (LVDT)

- LVDT consists of a cylind transformer where it surrounded by one pri 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.
- The Primary Winding is Connected to an ac source

An movable soft iron core slides within the hollow former and therefore affects the magnetic coupling between the primary and the two secondaries.

Working of LVDT

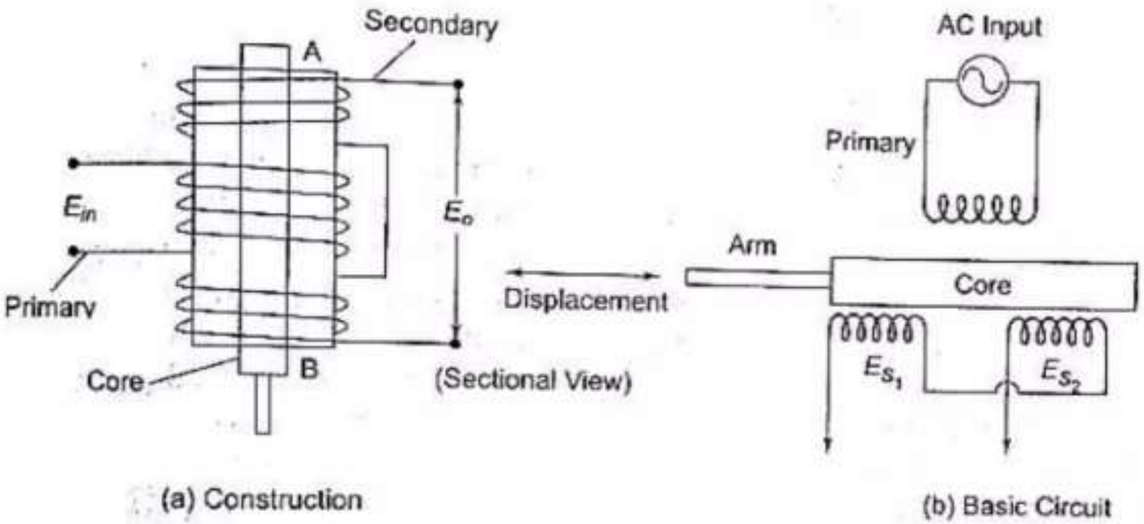
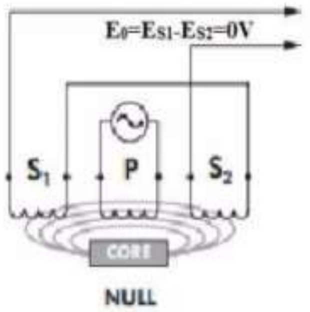


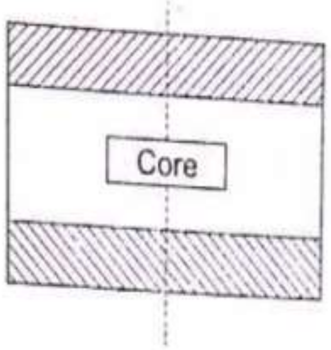
Fig. 13.20 Secondary Winding Connected for Differential Output

Working of LVDT

Case 1: When the Core is in its normal position.

- Equal Voltages induced in the two secondary windings
- The Output Voltage of secondary winding S_1 is E_{s1} and secondary winding S_2 is E
- The Differential output Voltage $E_0=E_{S1}\sim E_{S2}$
- At Normal Position $E_0=0$,because The Flux linking with both secondary windings is equal , hence equal emf are induced in them. (i.e $E_{S1}=E_{S2}$)

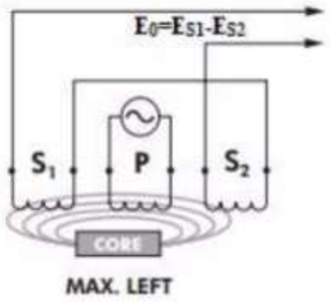


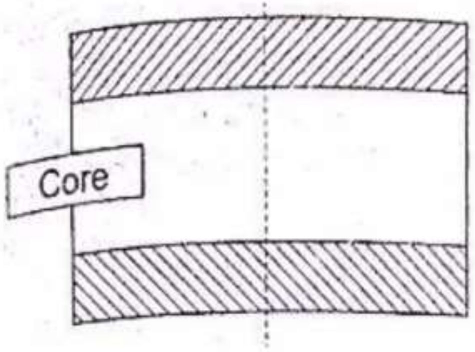


Working of LVDT

Case 2: When the Core is moved to the left of null position

Now, if the core is moved to the left of the null position, more flux links with winding S_1 and less with winding S_2. Hence, output voltage E_{S_1} of the secondary winding S_1 is greater than E_{S_2}. The magnitude of the output voltage of the secondary is then $E_{S_1} - E_{S_2}$, in phase with E_{S_1} (the output voltage of secondary winding S_1).

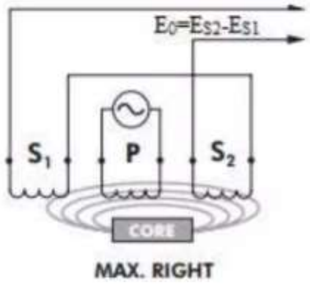


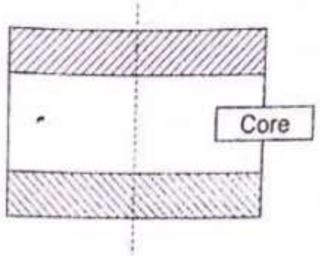


Working of LVDT

Case 3: When the Core is moved to the right of null position

if the core is moved to the right of the null position, the flux linking with winding S_2 becomes greater than that linked with winding S_1. Thi results in E_{S_2} becoming larger than E_{S_1}. The output voltage in this case is E_o = $E_{S_2} - E_{S_1}$ and is in phase with E_{S_2}.





The amount of voltage change in either secondary winding is proportional to the amount of movement of the core.

The amount of output voltage may be measured to determine the displacement. The output signal may also be applied to a recorder or to a controller that can restore the moving system to its normal position.

The output voltage of an LVDT is a linear function of the core displacement within a limited range of motion (say 5 mm from the null position).

Advantages of LVDT

1. ***Linearity*** The output voltage of this transducer is practically linear for displacements upto 5 mm (a linearity of 0.05% is available in commercial LVDTs).
2. ***Infinite resolution*** The change in output voltage is stepless. The effective resolution depends more on the test equipment than on the transducer.
3. ***High output*** It gives a high output (therefore there is frequently no need for intermediate amplification devices).
4. ***High sensitivity*** The transducer possesses a sensitivity as high as 40 V/mm.
5. ***Ruggedness*** These transducers can usually tolerate a high degree of vibration and shock.
6. ***Less friction*** There are no sliding contacts.

Disadvantages of LVDT

1. Large displacements are required for appreciable differential output.
2. They are sensitive to stray magnetic fields (but shielding is possible).
3. The receiving instrument must be selected to operate on ac signals, or a demodulator network must be used if a dc output is required.
4. The dynamic response is limited mechanically by the mass of the core and electrically by the applied voltage.
5. Temperature also affects the transducer.

Applications of LVDT

1. Acting as a secondary transducer, LVDT can be used as a device to mea force, weight and pressure, etc..
2. Testing of soil strength
3. PILL making Machine
4. “Brain Probing” medical device
5. Robotic Cleaner
6. Dollar bill thickness in ATM Machine.
7. Hydraulic cylinder Displacement.