LINEAR VARIABLE DIFFERENTIAL TRANSDUCER (LVDT)

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Principle of LVDT:

- LVDT works under the principle of mutual induction, and the displacement which is a nonelectrical energy is converted into an electrical energy.
- It is also called as **LINEAR VARIABLE DIFFERENTIAL TRANSFORMER**

The differential transformer is a passive inductive transformer.

Construction of LVDT

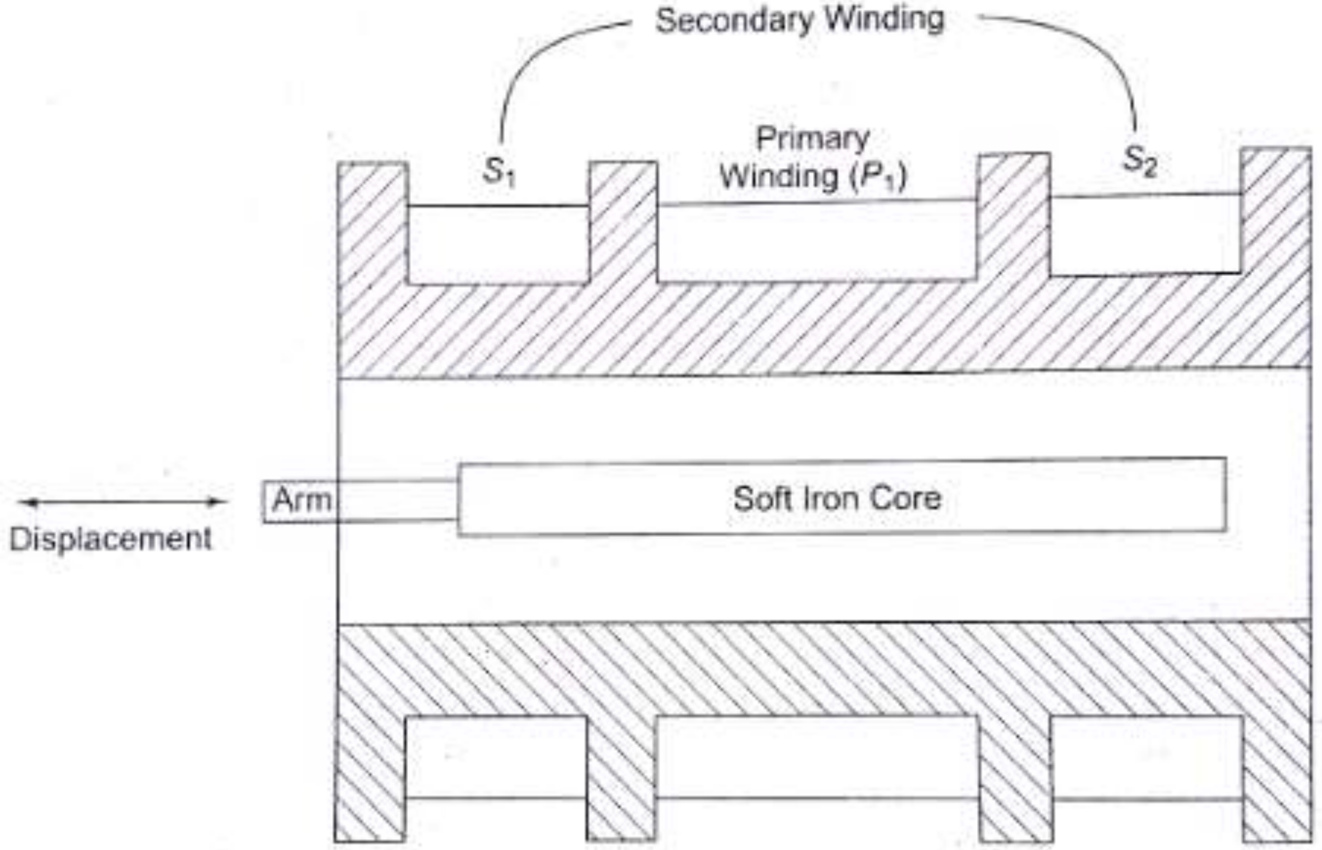


Fig. 13.19 Construction of a Linear Variable Differential Transducer (LVDT)

- LVDT consists of a cylindrical transformer 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.

- 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:

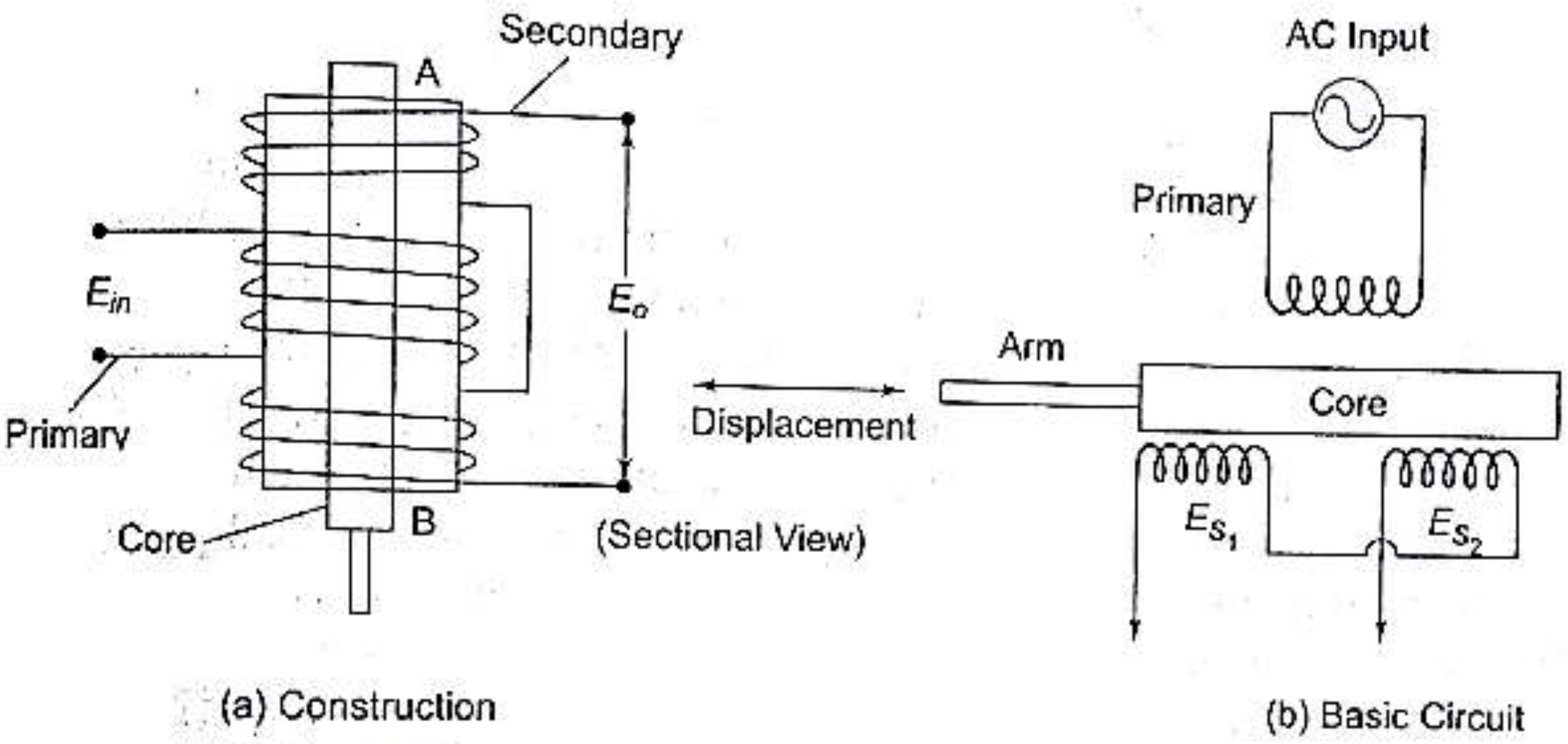
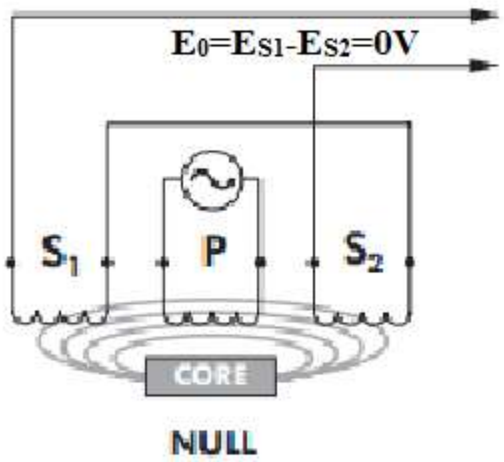


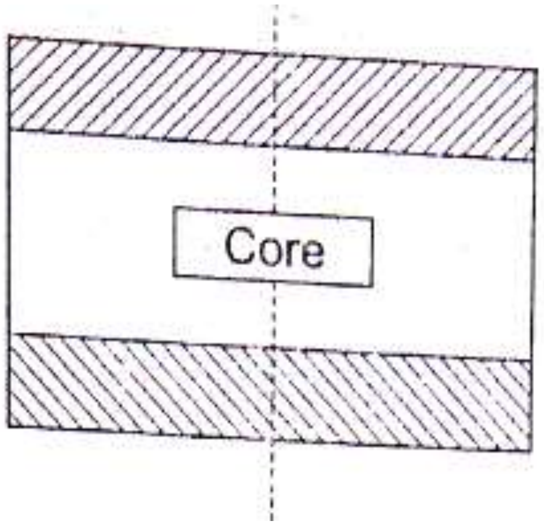
Fig. 13.20 Secondary Winding Connected for Differential Output

- The Displacement to be Measured is applied to an arm attached to the Soft iron core

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

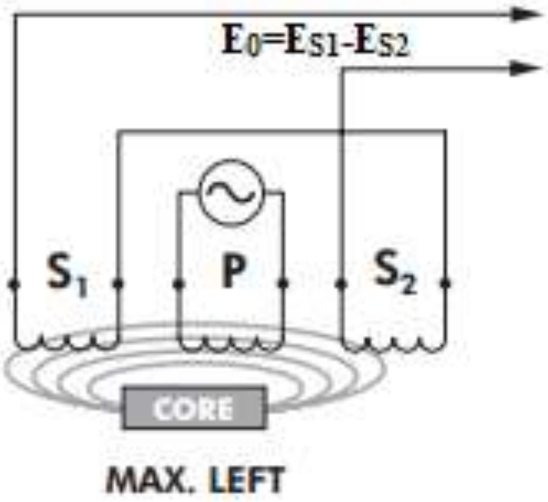
- Equal Voltages induced in the two secondary windings
- The Output Voltage of secondary winding S_1 is E_{s1} and secondary winding S_2 is E_{s2}
- The Differential output Voltage $E_0 = E_{S1} \sim E_{S2}$
- At Normal Position $E_0 = 0$,because The Flux linking with both secondary windings is equal , hence equal emf are induced in them. (i.e $E_{S1} = E_{S2}$)

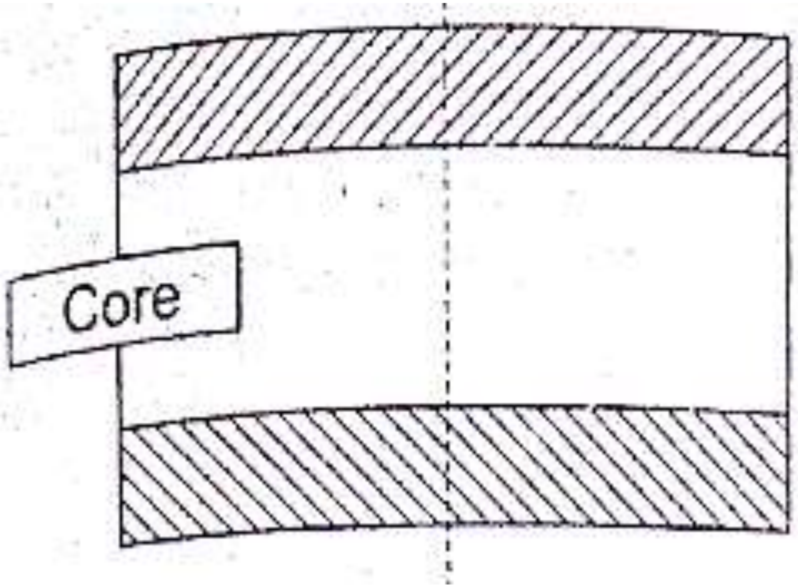




Case 2: When the Core is moved to the left of null position

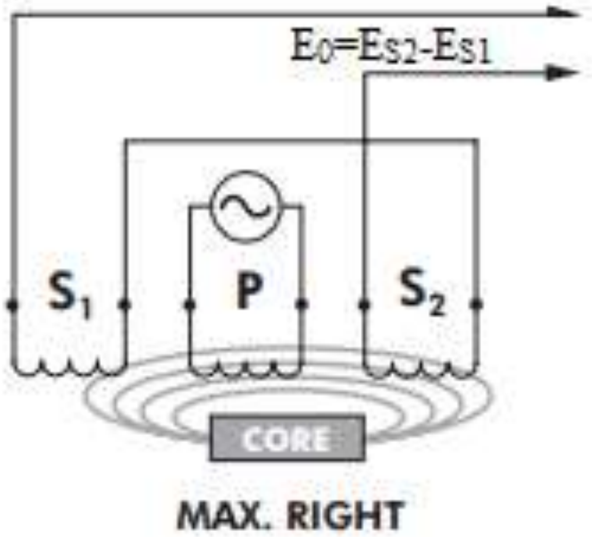
Now, if the core is moved to the left of the null position, more flux links with winding S_1 and less with winding S_2. Hence, output voltage E_{S_1} of the secondary winding S_1 is greater than E_{S_2}. The magnitude of the output voltage of the secondary is then $E_{S_1} - E_{S_2}$, in phase with E_{S_1}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

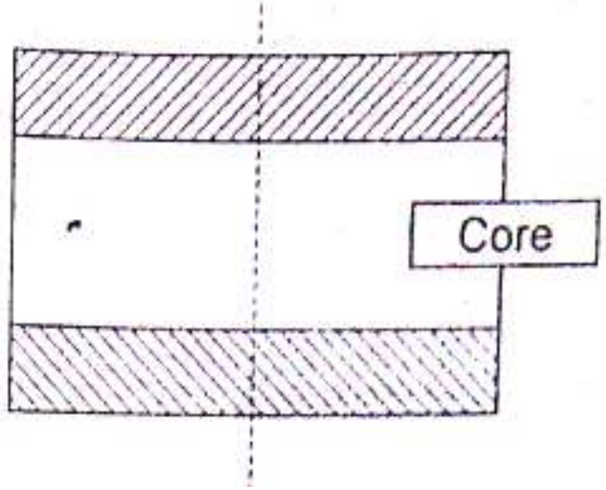




Case 3: When the Core is moved to the right of null position

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. This 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}.





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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).

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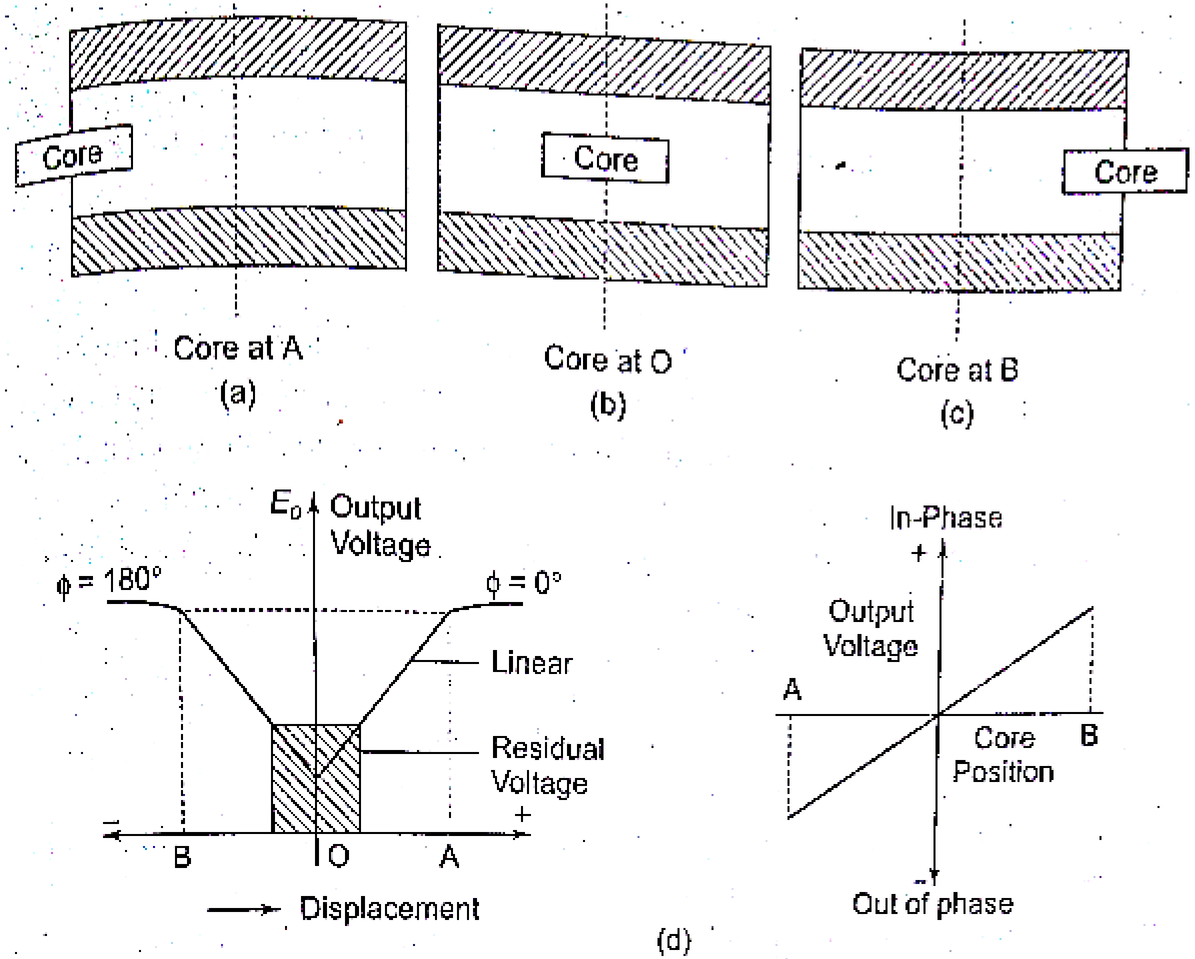

Fig. 13.21 (a), (b), (c) Various Core Position of LVDT
(d) Variation of Output Voltage vs Displacement

- The Characteristics are linear from O-A and O-B , But after that they become non-linear.

LVDTs are available with ranges as low as ± 0.05 in. to as high as ± 25 in. and are sensitive enough to be used to measure displacements of well below 0.001 in. They can be obtained for operation at temperatures as low as – 265°C and as high as + 600°C and are also available in radiation resistance designs for nuclear operations.

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.

Advantages of LVDT

7. ***Low hysteresis*** This transducer has a low hysteresis, hence repeatability is excellent under all conditions.
8. ***Low power consumption*** Most LVDTs consume less than 1 W of power.

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 measure 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.

Example 13.5 An ac LVDT has the following data.

Input = 6.3 V, Output = 5.2 V, range ± 0.5 in. Determine

(i) Calculate the output voltage vs core position for a core movement going from + 0.45 in. to – 0.30 in.

(ii) The output voltage when the core is – 0.25 in. from the centre.

Solution

(i) 0.5 in. core displacement produces 5.2 V, therefore a 0.45 in. core movement produces $(0.45 \times 5.2)/0.5 = 4.68$ V.

Similarly a – 0.30 in. core movement produces

$$(-0.30 \times -5.2)/(-0.5) = -3.12 \text{ V}$$

(ii) – 0.25 in. core movement produces

$$(-0.25 \times -5.2)/(-0.5) = -2.6 \text{ V}$$