LINEAR VARIABLE DIFFERENTIAL TRANSDUCER (LVDT) 13.11

The differential transformer is a passive inductive transformer. It is also known as a Linear Variable Differential Transformer (LVDT). The basic construction is as shown in Fig. 13.19.

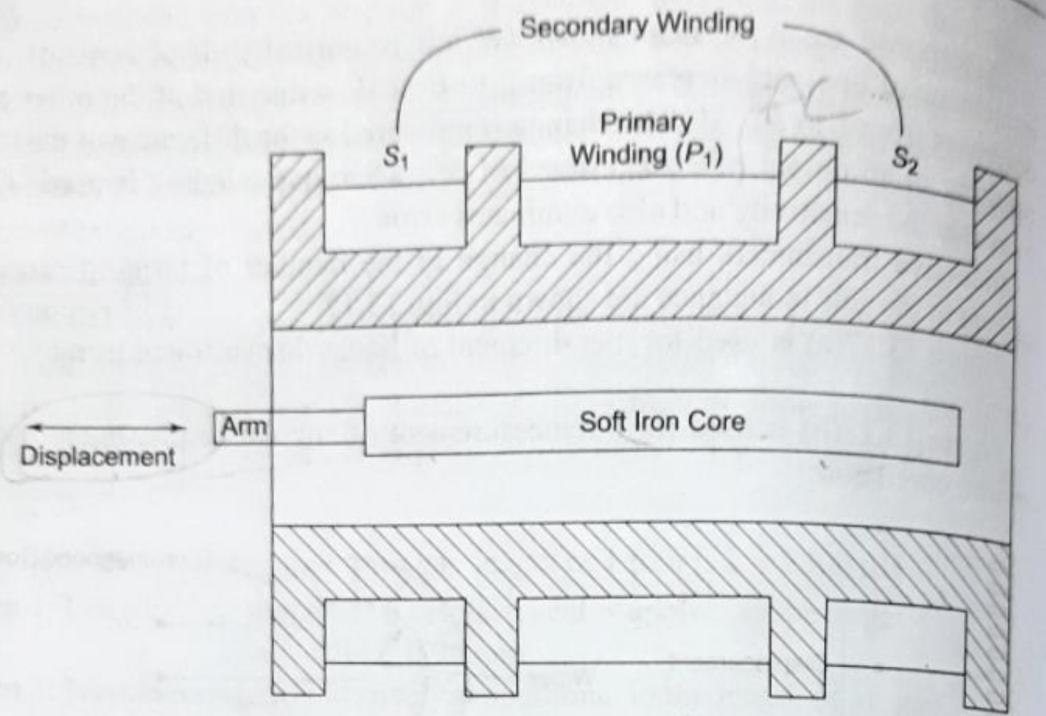


Fig. 13.19 Construction of a linear variable differential transducer (LVDT)

The transformer consists of a single primary winding P_1 and two secondary windings S_1 and S_2 wound on a hollow cylindrical former. The secondary windings have an equal number of turns and are identically placed on either side of the primary windings. 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.

The displacement to be measured is applied to an arm attached to the soft iron core.

(In practice, the core is made up of a nickel-iron alloy which is slotted longitudinally to reduce eddy current losses.)

When the core is in its normal (null) position, equal voltages are induced in the two secondary windings. The frequency of the ac applied to the primary winding ranges from 50 Hz to 20 kHz.

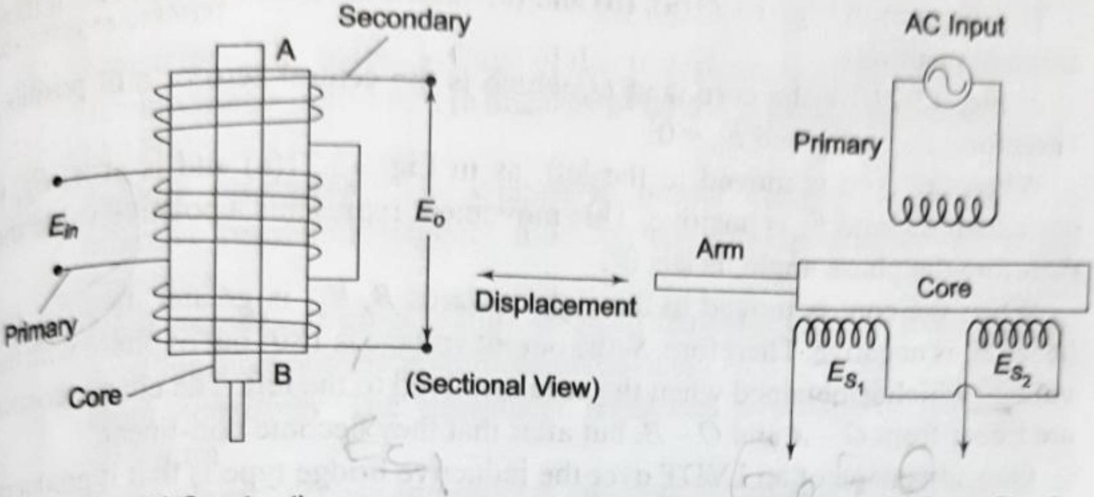
The output voltage of the secondary windings S_1 is E_{S1} and that of secondary winding S_2 is E_{S2}.

In order to convert the output from S_1 to S_2 into a single voltage signal, the two secondaries S_1 and S_2 are connected in series opposition, as shown in Fig. 13.20.

Hence the output voltage of the transducer is the difference of the two voltages. Therefore the differential output voltage $E_o = E_{S1} \sim E_{S2}$.

When the core is at its normal position, the flux linking with both secondary windings is equal, and hence equal emfs are induced in them. Hence, at null position $E_{S1} = E_{S2}$. Since the output voltage of the transducer is the difference of the two voltages, the output voltage E_o is zero at 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_{S1} of the secondary winding S_1 is greater than E_{S2}. The magnitude of the output voltage of the secondary is then $E_{S1} - E_{S2}$, in phase with E_{S1} (the output voltage of secondary winding S_1).



(a) Construction (b) Basic Circuit

Fig. 13.20 Secondary winding connected for differential output

Similarly, 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_{S2} becoming larger than E_{S1}. The output voltage in this case is $E_o = E_{S2} - E_{S1}$ and is in phase with E_{S2}.

The amount of voltage change in either secondary winding is proportional to the amount of movement of the core. Hence, we have an indication of the amount of linear motion. By noting which output is increasing or decreasing, the direction of motion can be determined. The output ac voltage inverts as the core passes the centre position. The farther the core moves from the centre, the greater the difference in value between E_{S1} and E_{S2} and consequently the greater the value of E_o. Hence, the amplitude is function of the distance the core has moved, and the polarity or phase indicates the direction of motion, as shown in Fig. 13.21.

As the core is moved in one direction from the null position, the difference voltage, i.e. the difference of the two secondary voltages increases, while maintaining an in-phase relation with the voltage from the input source. In the other direction from the null position, the difference voltage increases but is 180° out of phase with the voltage from the source.

By comparing the magnitude and phase of the difference output voltage with that of the source, the amount and direction of the movement of the core and hence of the displacement may be determined.

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).

Applications of LVDT

Some of the principle applications of LVDT are as follows,

(i) LVDT is used to measure linear displacements ranging from a fraction of mm to cm. In this case, the LVDT converts the applied displacement into its proportional electrical output.

(ii) It can be used for measurement of force and vibrations.

(iii) LVDT can be used to measure weight and pressure exerted by liquid in a tank.

(iv) It can be used to measure and control of thickness of a metal steel being rolled.

(v) It can be used to measure tension in a cord.