# Measurement and Instrumentation Laboratory (EE3P005)

## EXPERIMENT-3

## Operation of Linearly Variable Differential Transformer

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**AIM OF THE EXPERIMENT:**

To study the operation of linearly variable differential transformer.

**APPARATUS REQUIRED:**

- LVDT experimental module 1 no.
- LVDT jig 1 no.
- Digital Multimeters for AC and DC voltage measurements 2 no.

**THEORY:**

The differential transformer is a passive inductive transformer. It is also known as LINEAR VARIABLE DIFFERENTIAL TRANSFORMER (LVDT). The transformer consists of a single primary winding P1, and two secondary windings S1 and S2, 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 a.c. source. An movable soft iron core slides within the hollow former and therefore affects the magnetic coupling between the primary and the two secondary. The displacement to be measured is applied to an arm attached to the soft iron core.

When the core is in its null (10mm) position, equal voltages are induced in the two secondary windings. The frequency of the a.c. applied to the primary windings is in the range of 3.5 to 4 KHz. The output voltage of the secondary windings S1 is Es1 and that of the secondary winding S2 is Es2.

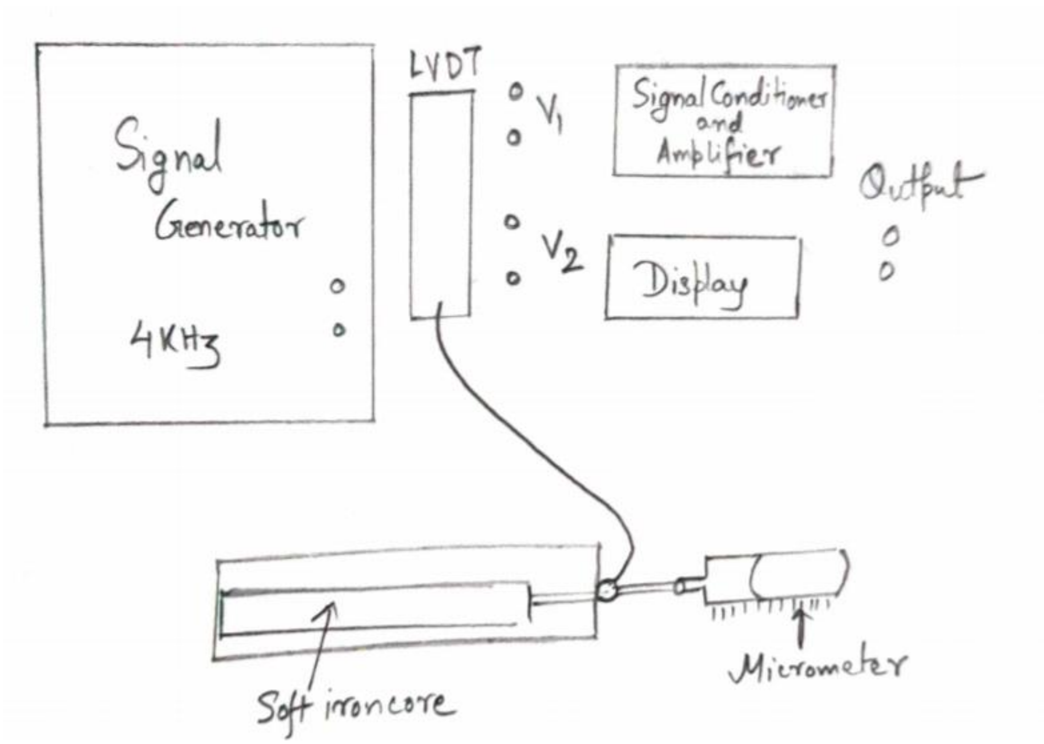
In order to convert the output from S1 to S2 into a single voltage signal, the two secondaries S1 and S2 are connected in series opposition. Hence the output voltage of the transducer is the difference of the two voltages. Therefore the differential output voltage E0 = Es1-Es2. When the core is at its normal position (null position), the flux linking with both secondary windings is equal, and hence equal emfs are induced in them. Hence at null position Es1=Es2. Since the output voltage of the transducer is the difference of the two voltages, the output voltage E0 is Zero at null position.

Now, if the core is moved to the left of the null position, more flux links with windings S1 and less with winding S2. Hence, output voltage Es1 of the secondary windings S1 is greater than Es2. The magnitude of the output voltage of the secondary is then Es1- Es2, in phase with Es1 (the output voltage of secondary winding S1).

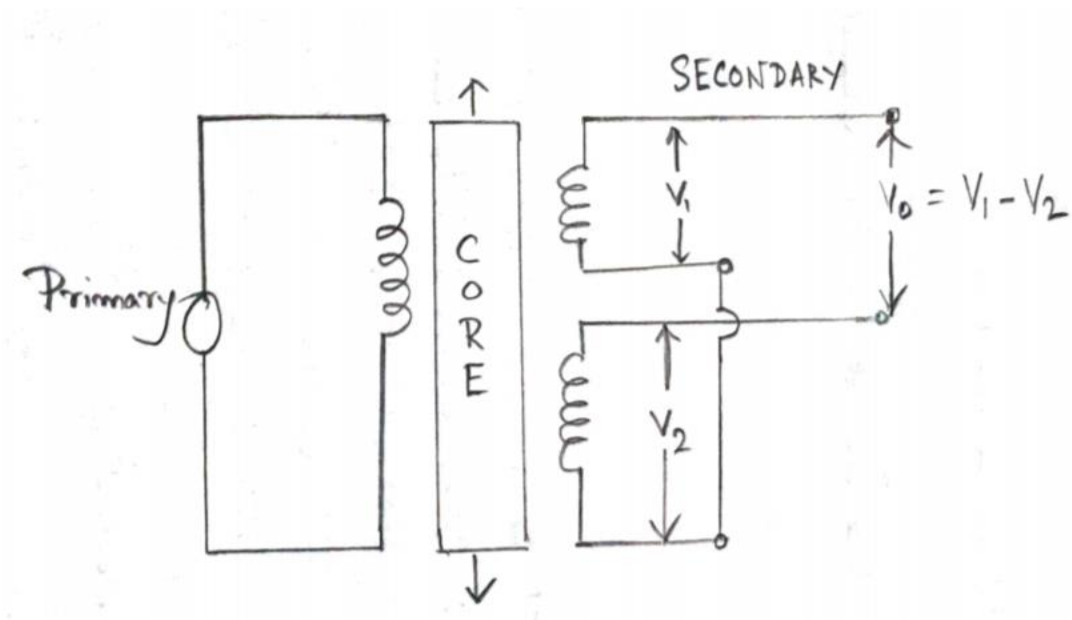
Similarly, if the core is moved ot the right of the null position, the flux linking with winding S2 becomes greater than that linked with windings S1. This results in Es2 becoming larger than Es1. The output voltage in this case is E0 = Es2-Es1 and is in phase with Es2.

## CIRCUIT DIAGRAM:

- **Schematic Diagram:**




- **Equivalent Electrical Circuit Diagram:**



## PROCEDURE:

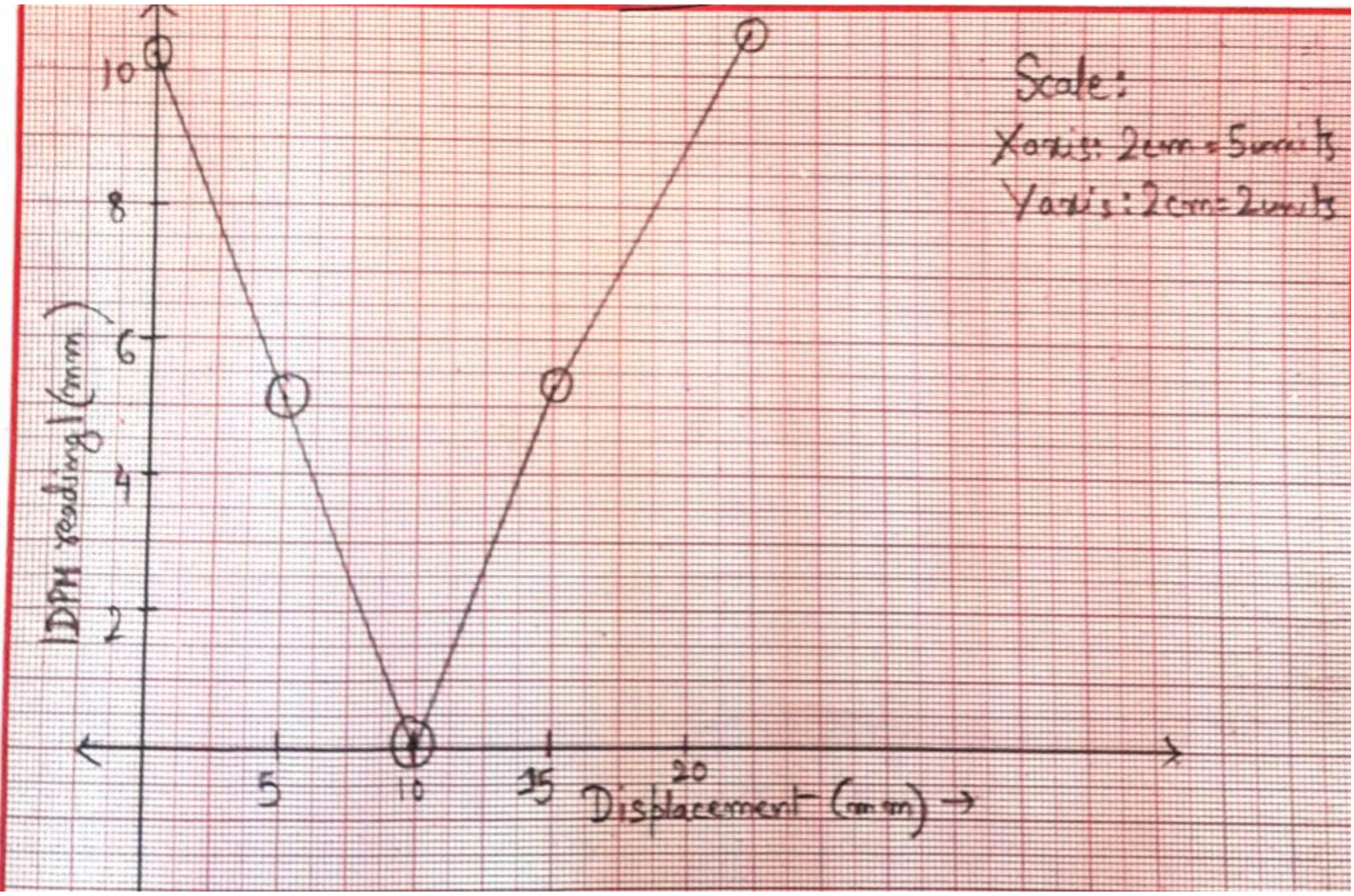
1. Connect LVDT Jig to the experimental module and switch on the instruments
2. Adjust micrometer to 10mm. This is center position. Here display should be **'0'**
3. If display is not **'0'** then note down the error. This is system error. Note that the error may be in micrometers. Even a small misalignment may cause this. This error may carry to the all readings.
4. Now adjust the micrometer to 0mm. Note down the displayed reading. This should be approximately **'-10mm'**.
5. Adjust DMM to 2V AC range measure Sec-1 and Sec-2 outputs.
6. Connect another DMM at O/P voltage and measure voltage in DC.
7. Tabulate all measurements.
8. Now adjust micrometer upto 20mm and tabulate measurements at steps of 1mm. at 20mm displayed value should be **'+10mm'**.
9. You can also observe the sec-1 and sec-2 outputs using CRO.

## OBSERVATION:

| Displacement (mm) | Expected o/p (mm) | Sec-1 Voltage ($V_1$) (V) (AC) | Sec-2 Voltage ($V_2$) (V) (AC) | $V_o$ (output) $= V_1 - V_2$ (V) | DPM reading (mm) | Output voltage (mV) (AC) | Error % | DC o/p (mV) |
|---|---|---|---|---|---|---|---|---|
| 10 | 0 | 0.152 | 0.176 | −0.024 | −0.003 | 7.7 | ≈ 0% | −4.4 |
| 15 | 5 | 0.133 | 0.195 | −0.062 | 5.11 | 55.9 | −2.2% | 46.8 |
| 20 | 10 | 0.114 | 0.214 | −0.100 | 10.33 | 61 | −3.3% | 101 |
| 5 | −5 | 0.174 | 0.155 | 0.19 | −5.04 | 22.6 | −0.8% | −54.8 |
| 0 | −10 | 0.189 | 0.139 | 0.60 | −10.14 | 22.8 | −1.4% | −101.6 |

$$\text{Error} = \left(\frac{\text{Expected o/p} - \text{DPM reading}}{\text{Expected output}}\right) \times 100$$

**aph:**




# CONCLUSIONS

Thus, we have successfully verified for the linearity of LVDT while measuring the change in voltage of secondary windings while moving the core.

# DISCUSSION

**Q. What is the objective of this experiment?**

The main objective of the experiment is:

- To measure the linear displacement in the form of electrical voltage by associating a specific signal value for any given position of the core.
- To prove the linearity of LVDT
- To know the working principle of LVDT.

**Q. Briefly explain the operation of an LVDT identifying some of its applications?**

LVDTs operate on the principle of a transformer. The transformer has three coils placed in it. The centre coil is the primary, and the other two coils are the secondaries. As the core moves, these mutual inductances change, causing the voltages induced in the secondaries to change. When the core is in its centre position, the core is equidistant between two secondaries, the voltage induced in both secondaries is same so the output voltage is zero. When the core is displaced in upward direction, the voltage in first coil increases as the other decreases, causing the output voltage to be positive. When the core is displaced in downward direction, the voltage in first coil decrease and the other increases, causing the output voltage to be negative. This difference is shown in the DPM.

**Q. What is the use of the micrometer in the experiment?**

The micrometer is used to change the position of the core accurately and it is also used to calibrate the LVDT setup.

**Q. What is frequency of the output at the secondary?**

LVDT is a transformer. Since in transformer the frequency of the primary and secondary will be same. The frequency of the primary is 4kHz.So, the frequency of the secondary also 4kHz.

**Q. Say at any given instant the ac output from each of the secondaries is 125 mV and 100 mV. What is the corresponding dc output of the secondaries? (not the dc at the final output)**

Since the given ac Voltages are rms Values

$V_{peak} = \sqrt{2} V_{rms}$

$V_{P.sec1} = \sqrt{2} \cdot 125 \text{ mV}$ $\qquad$ $V_{P.sec2} = \sqrt{2} \cdot 100 \text{ mV}$

$= 176.77 \text{ mV}$ $\qquad$ $= 141.42 \text{ mV}$

$V_{avg} = \frac{2V_P}{\pi}$ [ for a sine or cos wave)

$V_{avg.sec1} = \frac{2 \cdot 176.77}{\pi}$, $\qquad$ $V_{avg.sec2} = \frac{2}{\pi} \cdot 141.42$

$= 112.6 \text{ mV}$ $\qquad$ $= 90 \text{ mV}$

$\therefore$ The corresponding DC Voltages of Secondaries are 112.6 mV and 90 mV.

Difference $= 112.6 - 90$

$= 22.6 \text{ mV}$