National Institute Of Technology Durgapur

ELECTRICAL MEASUREMENT LABORATORY (EES-351)

Group V

Experiment Number: 2

Measurement of Displacement by Using LVDT

Experiment Date: 02nd June 2021

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Aim:

Measurement of displacement using LVDT.

Objective:

Determining the sensitivity of LVDT by plotting Output voltage vs displacement using LVDT sensor.

Apparatus Required:

Serial Number	Instrument Name	Specification	Quantity
1.	Power Supply (Alternating Current)	220 Volt, 50 Hertz	1
2.	Linear Variable Differential Transformer (LVDT)	Soft Iron core (Fe-Ni); Least count of scale =0.1mm	1

Theory:

The linear variable differential transformer (LVDT) is a type of electrical transformer used for measuring linear displacement. The transformer has three solenoidal coils placed end-to-end around a tube. The centre coil is the primary, and the two outer coils are the secondaries. A cylindrical ferromagnetic core, attached to the object whose position is to be measured, slides along the axis of the tube.

An alternating current is driven through the primary, causing a voltage to be induced in each secondary proportional to its mutual inductance with the primary. The frequency is usually in the range 1 to 10 kHz.

As the core moves, these mutual inductances change, causing the voltages induced in the secondaries to change. The coils are connected in reverse series, so that the output voltage is the difference (hence "differential") between the two secondary voltages. When the core is in its central position, equidistant between the two secondaries, equal but opposite voltages are induced in these two coils, so the output voltage is zero.

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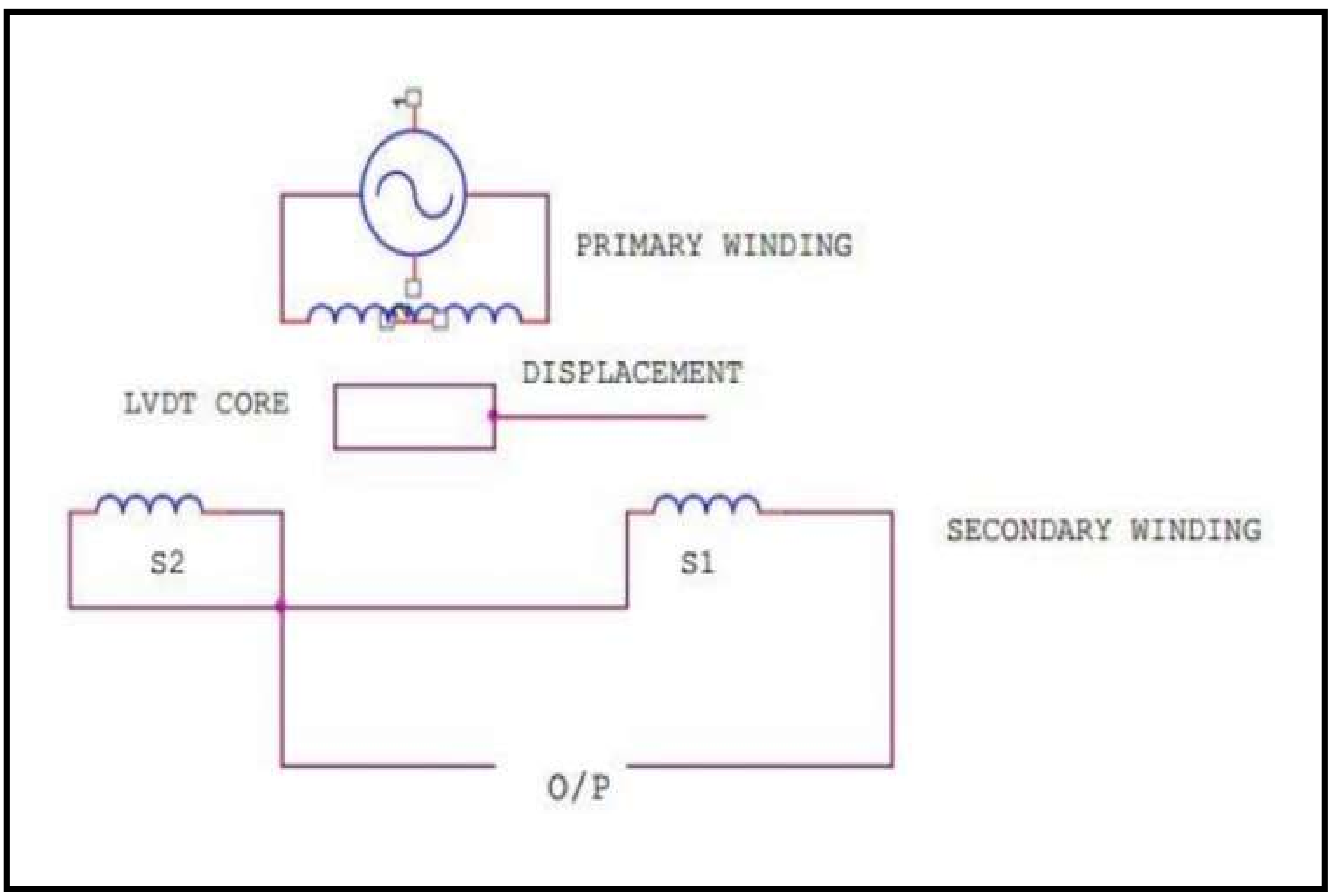
When the core is displaced in one direction, the voltage in one coil increases as the other decreases, causing the output voltage to increase from zero to a maximum. This voltage is in phase with the primary voltage. When the core moves in the other direction, the output voltage also increases from zero to a maximum, but its phase is opposite to that of the primary. The magnitude of the output voltage is proportional to the distance moved by the core (up to its limit of travel), which is why the device is described as "linear". The phase of the voltage indicates the direction of the displacement. Because, the sliding core does not touch the inside of the tube, it can move without friction, making the LVDT a highly reliable device. The absence of any sliding or rotating contacts allows the LVDT to be completely sealed against the environment. LVDTs, are commonly used for position feedback in servomechanisms, and for automated measurement in machine tools and many other industrial and scientific application.

Circuit Diagram:



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Experiment Results:

At null condition **displacement** = 0mm and **voltage** = 0mV

Serial Number	Clockwise Direction		Anticlockwise Direction	
	Displacement(mm)	Voltage(mV)	Displacement(mm)	Voltage(mV)
1	0	0.8	0	0.8
2	0.5	1.7	0.5	1.7
3	1	2.6	1	2.6
4	1.5	3.5	1.5	3.5
5	2	4.4	2	4.4
6	2.5	5.3	2.5	5.3
7	3	6.2	3	6.2
8	3.5	7.1	3.5	7.1
9	4	8	4	8
10	4.5	8.9	4.5	8.9
11	5	9.8	5	9.8
12	5.5	10.7	5.5	10.7
13	6	11.26	6	11.26
14	6.5	12.5	6.5	12.5
15	7	13.4	7	13.4

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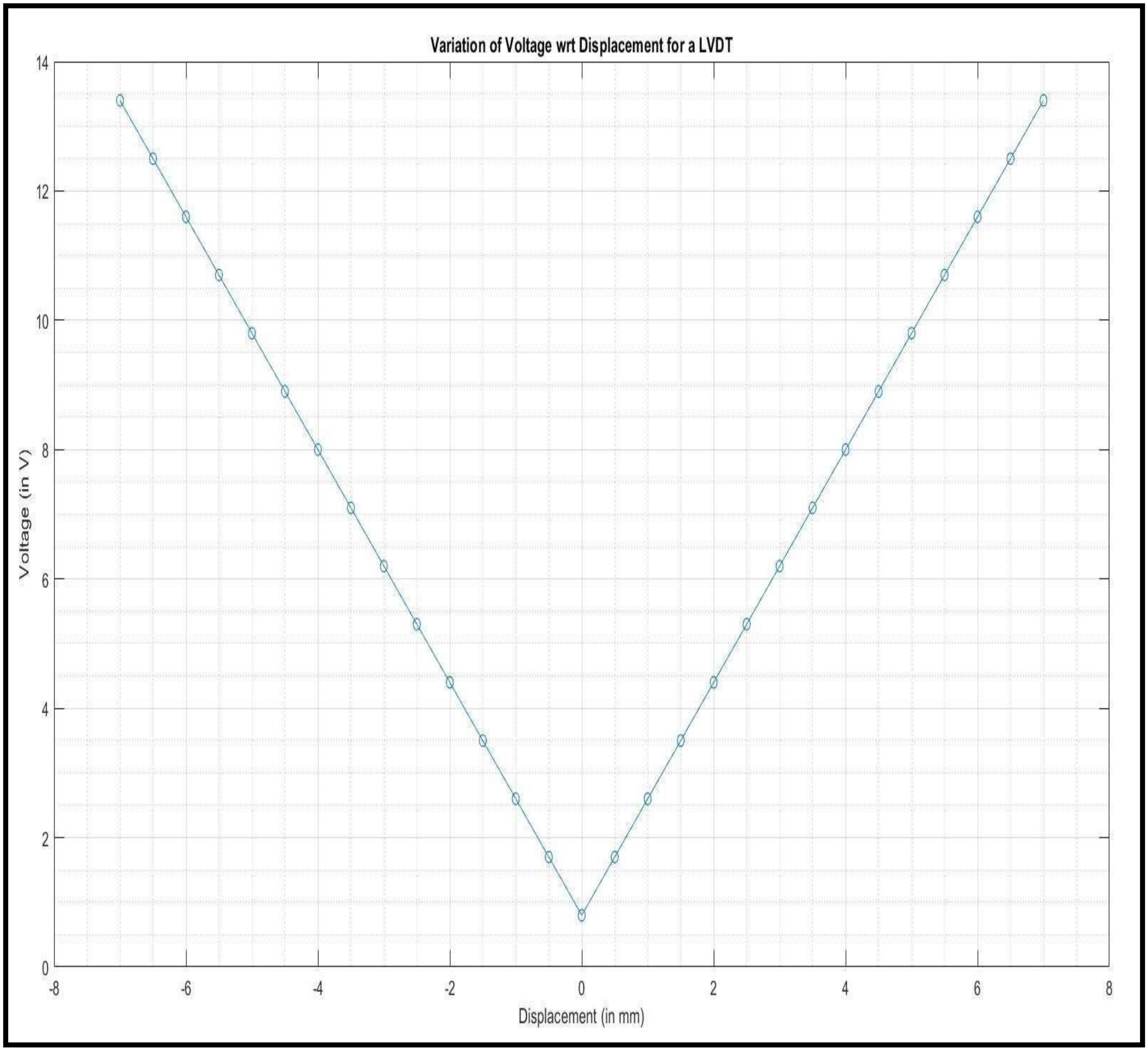
Graph:



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Calculations and Rough Work:

A graph is drawn by plotting output voltage vs displacement. From the graph, residual voltage and sensitivity of LVDT can be found.

$$\textbf{Sensitivity of LVDT} = \frac{Output\ Voltage}{Displacement} = \frac{\Delta y}{\Delta x} = \frac{8 - 7.1}{4 - 3.5} = \mathbf{1.8}\ \boldsymbol{mV/mm}$$

$$\textbf{Residual Voltage} = \mathbf{0.8}\ \boldsymbol{mV}$$

Conclusion:

- At the null position, the voltages induced in both the secondary windings S1 and S2 are equal i.e., $E_{(S1)} = E_{(S2)}$. From theory, we know that the differential voltage should be equal to zero. From the experiment, we observe that at NULL, the differential voltage $E_0 = E_{S1} - E_{S2} = 0.8\ mV \approx 0\ V$, i.e., there is a minimal residual voltage of 0.8 mV, which is almost equal to zero. The appearance of residual voltage is due to the presence of harmonics in supply voltage, presence of stray capacitance in primary and secondary winding, mismatch between two secondary windings, and the presence of a ferromagnetic core.
- When the LVDT core moves in the anticlockwise direction, more flux links with S1 and less with winding S2. Accordingly, $E_{S1} > E_{S2}$ and $E_0 = E_{S1} - E_{S2}$ and it is phase with primary voltage.
- When moved clockwise, $E_{S2} > E_{S1}$ and here E_0 will be 180^0 out of phase with primary voltage.
- The amount of voltage change in either of the secondary windings is proportional to the amount of movement of the core. Hence, we have an indication of the amount of Linear motion.
- The sensitivity of the LVDT transducer is found to be 1.8 mV/mm.
- The residual voltage of the LVDT transducer is found to be 0.8 mV.
- For a good transducer, it must have linearity, ruggedness, reliability and stability along with high output signal quantity. LVDT has all these properties with good linearity (proven from graph), good resolution and sensitivity and consumes low power.

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