DEPT. OF ELECTRICAL & ELECTRONICS ENGINEERING SRM INSTITUTE OF SCIENCE AND TECHNOLOGY, Kattankulathur – 603203.

Title of Experiment	: **9. Displacement measurement using LVDT and pressure measurement using Strain gauge**
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Register Number	:RA2011027010052
Date of Experiment	:25/01/2021
Date of submission	**:27/01/2021**

Sl. No.	Marks Split up	Maximum marks (50)	Marks obtained
1	Pre Lab questions	5	
2	Preparation of observation	15	
3	Execution of experiment	15	
4	Calculation / Evaluation of Result	10	
5	Post Lab questions	5	
Total		**50**	

Staff Signature

Experiment No. 9 a) Date : 25/01/2021	**Displacement measurement using Linear Variable Differential Transformer**

Aim: To measure the displacement and to determine the characteristics of LVDT (Linear Variable Differential Transformer).

Apparatus required: LVDT, Digital displacement indicator, Calibration jig (with micrometre).

THEORY: LVDT (LINEAR VARIABLE DIFFERENTIAL TRANSFORMER)

The most widely used inductive transducer to translate the linear motion into electrical signals is the linear variable differential transformer (LVDT). The basic construction of LVDT is shown in Figure 1.

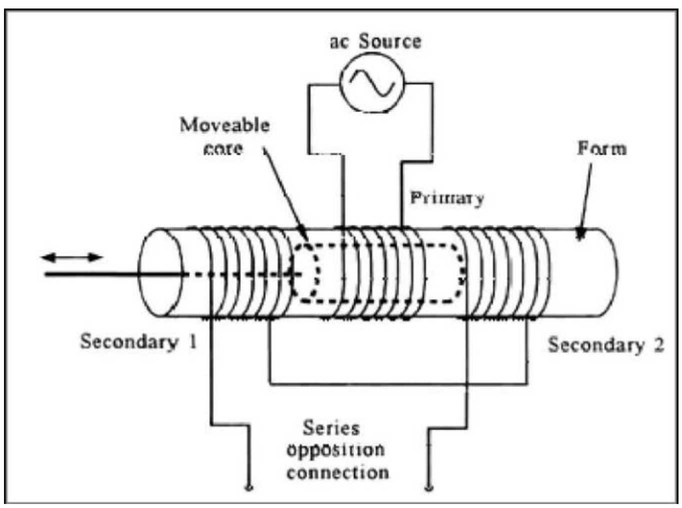


Figure 1. Linear Variable Differential Transformer

The transformer consists of a single primary P and two secondary windings S1 and S2 wound on a cylindrical former. The secondary windings have equal number of turns and are identically placed on either side. A moveable soft iron core is placed inside the transformer. The displacement to be measured is applied to the arm attached to the soft iron core. In practice the arm is made of highly permeability, nickel iron which is hydrogen annealed. This gives low harmonics low null voltage and high sensitivity. This is slotted longitudinally to reduce eddy current losses. The assembly is placed in stainless steel housing and the end leads provides electrostatic and electromagnetic shielding. The frequency of AC applied to primary windings may be between 50 Hz to 20 kHz. Since the primary winding is excited by an alternating source, it produces an alternating magnetic field which in turn induces alternating current voltage in the two secondary windings. Figure 2 depicts a cross-sectional view of an LVDT. The core causes the magnetic field generated by the primary winding to be coupled to the secondary. When the core is centred perfectly between both secondary and the primary as shown, the voltage induced in each secondary is equal in amplitude and 180 degree out of phase. Thus the LVDT output (for the seriesopposed connection shown in this case) is zero because the voltage cancels each other. E0 = Es1 - Es2 = 0.

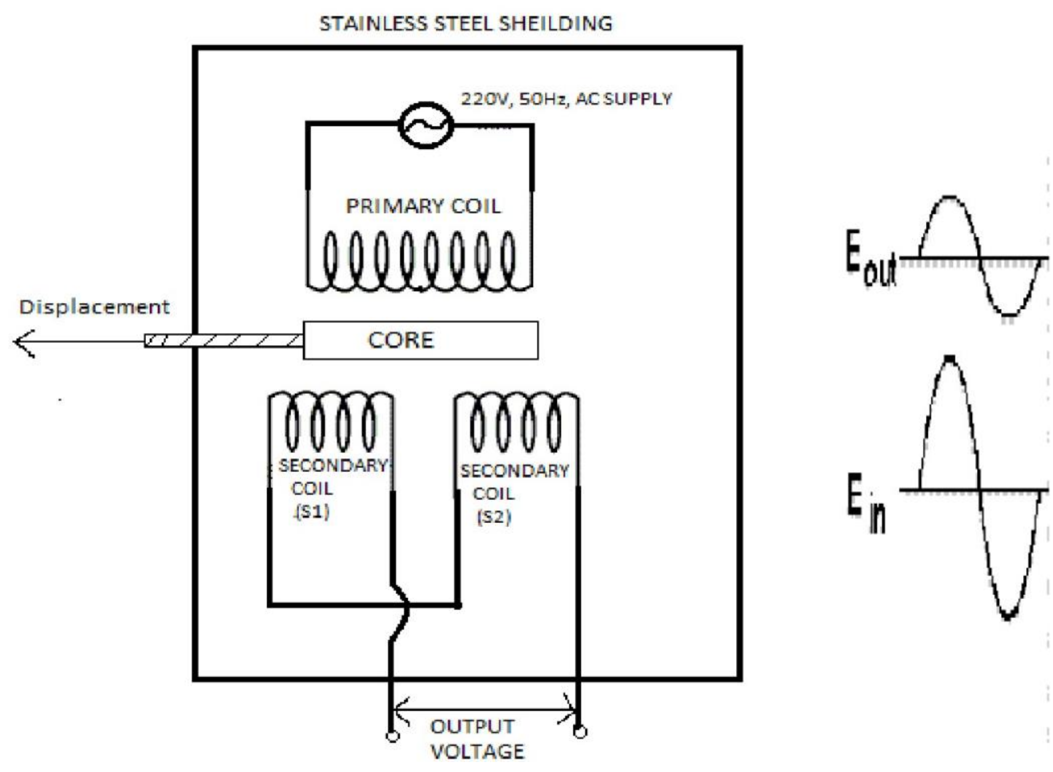


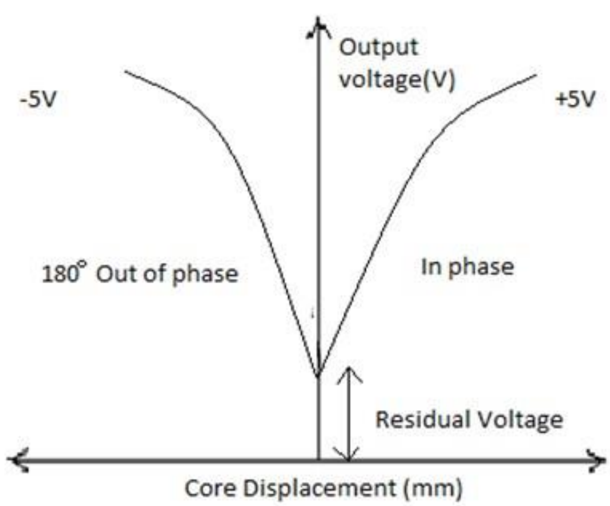
Figure 2. View of LVDT Core and Windings

Displacing the core to the left causes the first secondary to be more strongly coupled to the primary than the second secondary. The resulting higher voltage of the first secondary in relation to the second secondary causes an output voltage that is in phase with the primary voltage. Likewise, displacing the core to the right causes the second secondary to be more strongly coupled to the primary than the first secondary. The greater voltage of the second secondary causes an output voltage to be out of phase with the primary voltage.

Procedure:

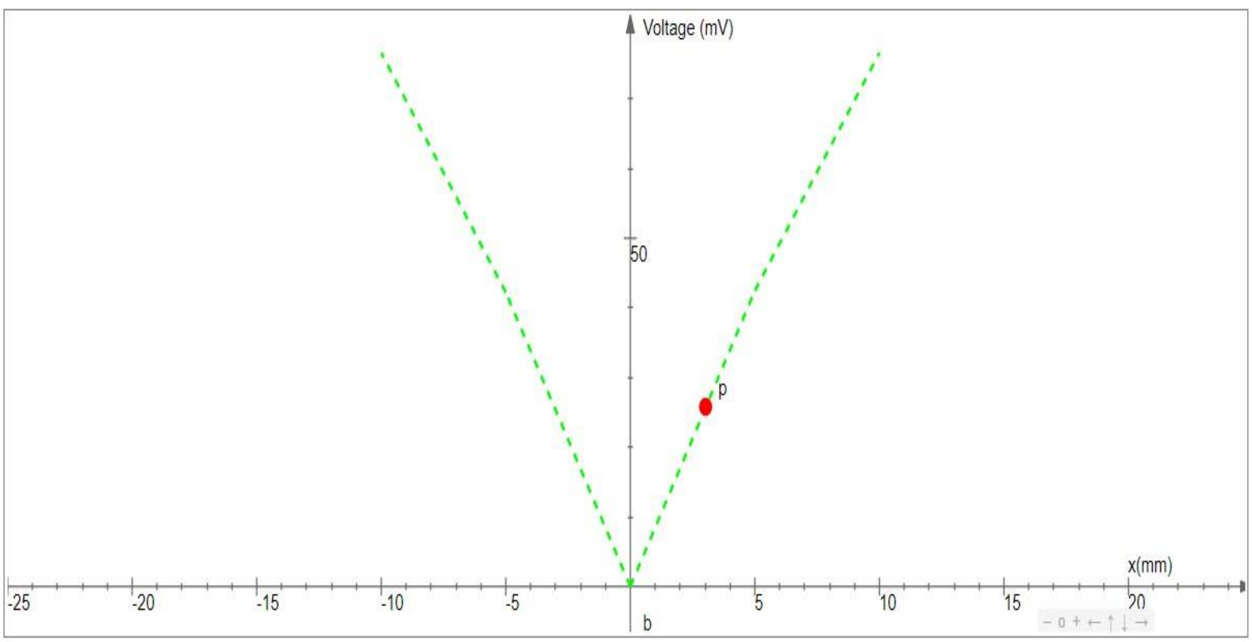
1. Plug power cord to AC mains 230 V, 50 Hz and switch on the instrument.
2. Place the READ/CAL switch at READ position.
3. Balance the amplifier with the help of zero knob so that the display should read zero without connecting the LVDT to the instrument.
4. Replace the READ/CAL switch at CAL position.
5. Adjust the calibration point by rotating the CAL knob so the display should read 10.00 i.e., maximum calibration range.
6. Again keep the READ/CAL switch at READ position and connect the LVDT cable to instrument.
7. Make mechanical zero by rotating the micrometre. Display will read (00.00) this is null balancing.
8. Give displacement with micrometre and observe the digital readings.
9. Plot the graph of micrometre reading v/s digital reading.

Model Graph:



Tabulations:

CORE DISPLACEMENT (mm)	SECONDARY OUTPUT VOLTAGE(mV)
-3	25.91
-2	17.38
-1	8.72
1	8.72
2	17.38
3	25.91



Result: Hence , we measured the displacement and determined the characteristics of LVDT (Linear Variable Differential Transformer)

POST LAB QUESTIONS:

1. What are the three principles of Inductive transducers?

- Self Inductance Change.
- Mutual Inductance Change.
- Eddy Current Production.

2. What are the limitations of LVDT?

- It has a large primary voltage and produces distortion in output.
- Temperature affects the performance.
- Sensitive to stray magnetic field.

3. Where LVDT is used?

LVDTs have been widely used in applications such as power turbines, hydraulics, automation, aircraft, satellites, nuclear reactors, and many others.

4. What are the different types of transducers used for displacement measurement?

- Linear Potentiometer Transducer.
- Linear Motion Variable Inductance Transducer.
- Proximity Inductance Transducer.
- Capacitive Transducer.
- Linear Voltage Differential Transformer (LVDT) ● Piezoelectric Transducer.
- Photo-Electric Transducers.

5. **What is the difference between variable resistance & variable inductance displacement transducer?**

The variable resistance transducer elements work on the principle that the resistance of the conductor is directly proportional to the length of the conductor and inversely proportional to the area of the conductor.

Whereas ,the inductive transducers work on the principle of the electromagnetic induction. Just as the resistance of the electric conductor depends on number of factors, the induction of the magnetic material depends on a number of variables like the number of turns of the coil on the material, the size of the magnetic material, and the permeability of the flux path

PRE LAB QUESTIONS (Strain gauge):

1. How does a strain gauge work?

A strain gauge is a sensor whose measured electrical resistance varies with changes in strain. Strain is the deformation or displacement of material that results from an applied stress. Stress is the force applied to a material, divided by the material's cross-sectional area. Load cells are designed to focus stress through beam elements where strain gauges are located. Strain gauges convert the applied force, pressure, torque, ect., into an electrical signal which can be measured.

2. What is the piezo-resistive effect?

The piezo-resistive effect describes the change in electrical resistance that occurs when an external force is applied to a semiconductor. This change only affects the material's electrical resistivity. Unlike the piezoelectric effect, it cannot be used to generate a voltage across the device.

3. What are the types of strain gauge?

- Linear strain gauges
- Membrane Rosette strain gauges
- Double linear strain gauges
- Full bridge strain gauges
- Shear strain gauges

4. Define gauge factor

Gauge Factor is defined as the ratio of per unit change in resistance to the per unit change in length.

5. Mention some practical applications of strain gauge

Strain gauges are used to measure the torque applied by a motor, turbine, or engine to fans, generators, wheels, or propellers. This equipment is found in power plants, ships, refineries, automobiles and industry at large.

Experiment No. 9 b) Date : 25/01/2021	**Strain measurement using Strain gauge**

Aim: To measure the strain using strain gauge.

Apparatus Required: Strain gauge, weight, LABVIEW software.

Theory: Strain is the amount of deformation of a body due to an applied force. More specifically, strain (e) is defined as the fractional change in length, Strain can be positive (tensile) or negative (compressive). Although dimensionless, strain is sometimes expressed in units such as in./in. or mm/mm. In practice, the magnitude of measured strain is very small. Therefore, strain is often expressed as microstrain (me), which is e x 10-6. When a bar is strained with a uniaxial force, as in Figure 1, a phenomenon known as Poisson Strain causes the girth of the bar, D, to contract in the transverse, or perpendicular, direction. The magnitude of this transverse contraction is a material property indicated by its Poisson's Ratio. The Poisson's Ratio n of a material is defined as the negative ratio of the strain in the transverse direction (perpendicular to the force) to the strain in the axial direction (parallel to the force), or n = eT/e. The most widely used gage is the bonded metallic strain gage. The metallic strain gauge consists of a very fine wire or, more commonly, metallic foil arranged in a grid pattern. The grid pattern maximizes the amount of metallic wire or foil subject to strain in the parallel direction (Figure 2). The cross-sectional area of the grid is minimized to reduce the effect of shear strain and Poisson Strain. The grid is bonded to a thin backing, called the carrier, which is attached directly to the test specimen.

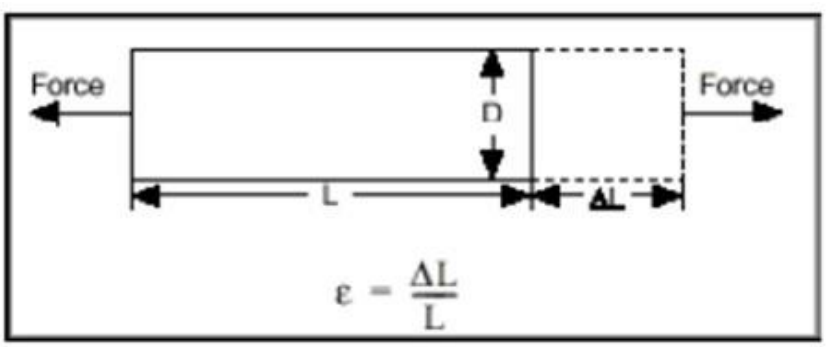


Figure 1. Strain measurement

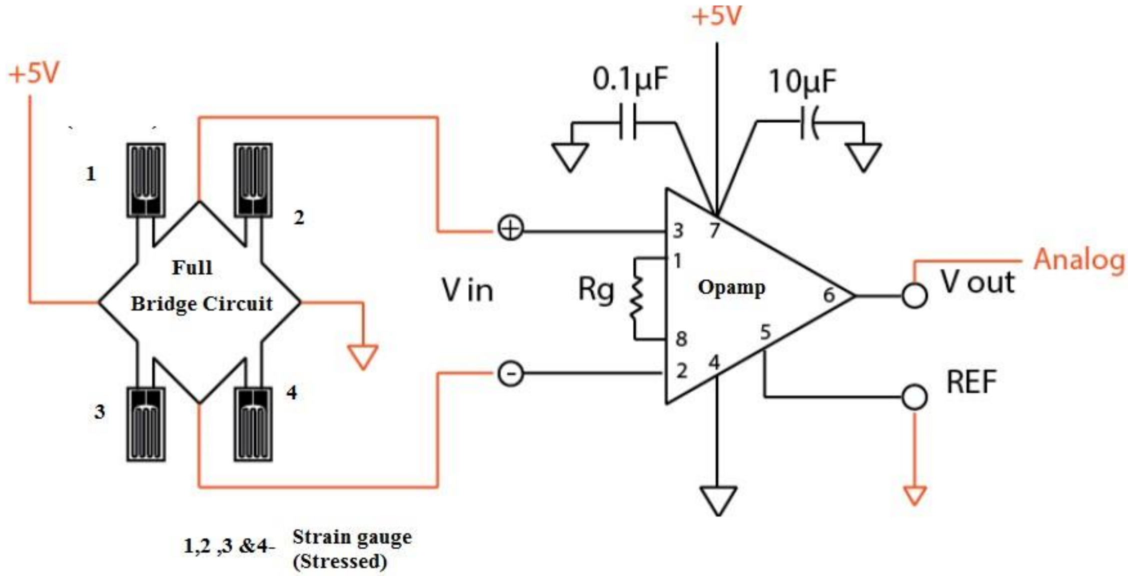


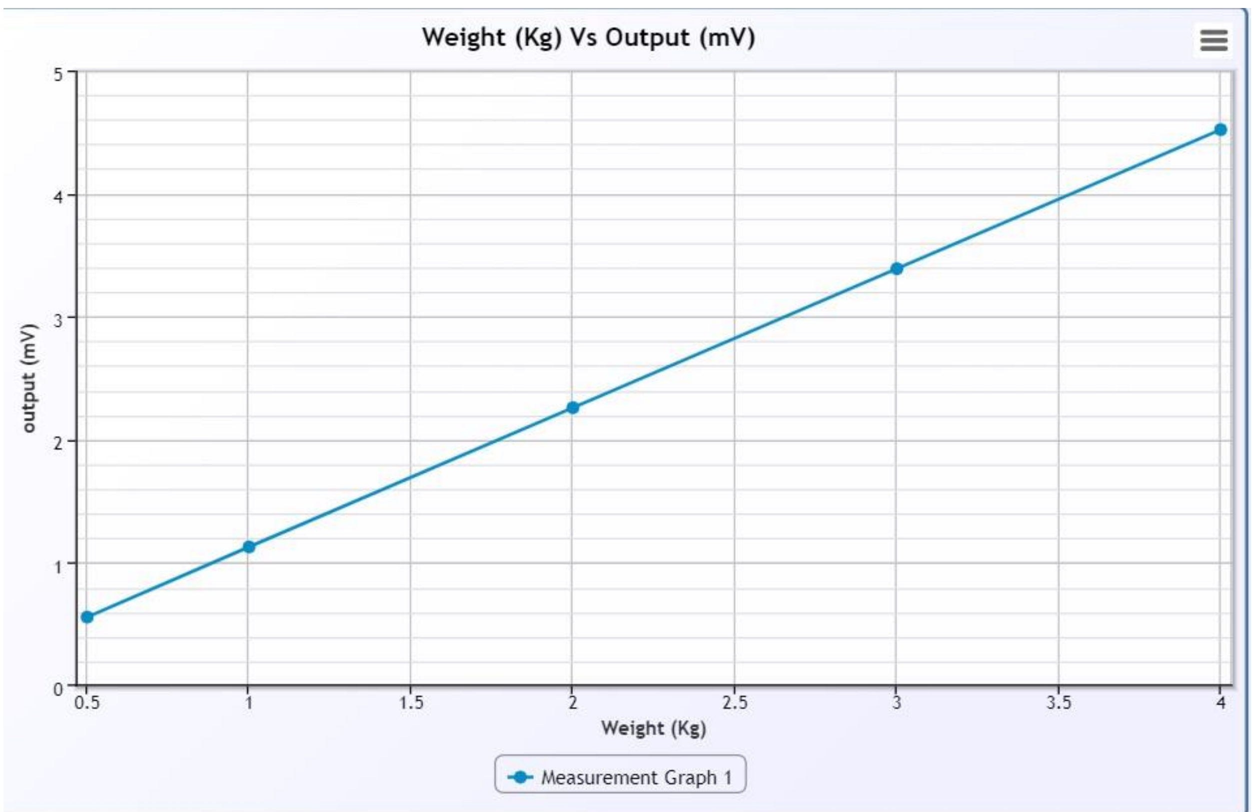
Figure 2. Full- Bridge Strain gauge circuit

Procedure:

1. Connect the cantilever strain measurement assembly to the main trainer and switch ON the trainer
2. Connect the multimeter at the Instrument output with the multimeter in DC VOLTAGE mode and 20 V Range.
3. Connect this STRAIN output also to display the section marked Vout.
4. Now without any strain or load in the cantilever beam. So adjust the OFFSET CONTROL to 0 volts at the output.
5. Now place 500 grams weights on the pan suspended on the beam and adjust the gain or call control to read 0.5 volt by multimeter at the strain output terminal.
6. Now remove the weight from the pan and the output must be 0 volt. IF not then readjust OFFSET Control
7. Table the readings for different weights or strains on the load cell as well as display readings.

Tabulation:

S.no	Weight in Pan (Kg)	Display reading (mV)	Calculated value (mV)
1	0.5	0.56	0.566
2	1	1.13	1.129
3	2	2.26	2.258
4	3	3.39	3.39
5	4	4.52	4.52



Calculations.

$R_g = R + dR$

Full Bridge, $e = (dR/R) * E$

For 0.5kg

$R = 120\,\Omega$

$R_g = 120.0136\,\Omega$

$dR = 0.0136\,\Omega$

$$e = \left(\frac{0.0136}{120}\right) * 5$$

$= 0.566\,mV$

For 1 kg

$R_g = 120.0271$

$dR = 0.0271$

$$e = \left(\frac{0.0271}{120}\right) * 5$$

$= 1.129\,mV$

For 2 kg

$R_g = 120.0542$

$dR = 0.0542$

$e = 2.258\,mV \quad \left[\because \frac{0.0542}{120} \times 5\right]$

For 4kg

$R_g = 120.1085$

$dR = 0.1085$

$$e = \left(\frac{0.1085}{120}\right) * 5$$

$= 4.52\,mV$

for 3 kg

$R_g = 120.0814$

$dR = 0.0814$

$$e = \left(\frac{0.0814}{120}\right) * 5$$

$= 3.39\,mV$

Result: Hence , we measured using Strain gauge.

POST-LAB QUESTIONS:

1. How can you apply the principle of strain gauge?

A strain gauge is a resistor used to measure strain on an object. When an external force is applied on an object, due to which there is a deformation occurring in the shape of the object. This deformation in the shape is both compressive or tensile is called strain, and it is measured by the strain gauge. When an object deforms within the limit of elasticity, either it becomes narrower and longer or it becomes shorter and broadens. As a result of it, there is a change in resistance end-to-end

2. What is meant by passive transducer?

The passive transducer produces a change in some passive electrical quantity, such as capacitance, resistance, or inductance, as a result of stimulation. Passive transducers usually require additional electrical energy.

3. What is sensitivity of strain gauge?

A fundamental parameter of the strain gage is its sensitivity to strain, expressed quantitatively as the gauge factor. GF is the ratio of the fractional change in electrical resistance to the fractional change in length, or strain

4. What is a macrostrain?

Usually, strain is in the order of um/m, i.e. 10^{-6}, and therefore, the unit 'με' (macrostrain) is most commonly used.

5. What are the limitations of a strain gauge?

Strain gauges biggest disadvantage is that they are non-linear.It needs regularcalibration in order to use perfectly and take perfect reading.

Once the strain gauge is installed, it could only be used for a particular specimen. It cannot be removed or reused.

Each strain gauge has its limitations in terms of temperature, fatigue, the amount of strain, and the measurement environment.