BEE Eæperiments Record

9. DISPLACEMENT MEASUREMENT USING LVDT & PRESSURE MEASUREMENT USING STRAIN GAUGE.

☆ PRE - LAB QUESTIONS (LVDT) ⟹

① Eddy currents can be used to find out both cracks in material and thickness of non-conductive coating.

② The heat generated in transformer is dissipated to the surroundings mainly by convection.

③ Basic source of magnetism is movement of charged particles.

④ The magnetic field of a magnet weakens as the distance from the magnet increases.

⑤ LVDT means Linear Variable Differential Transformer.

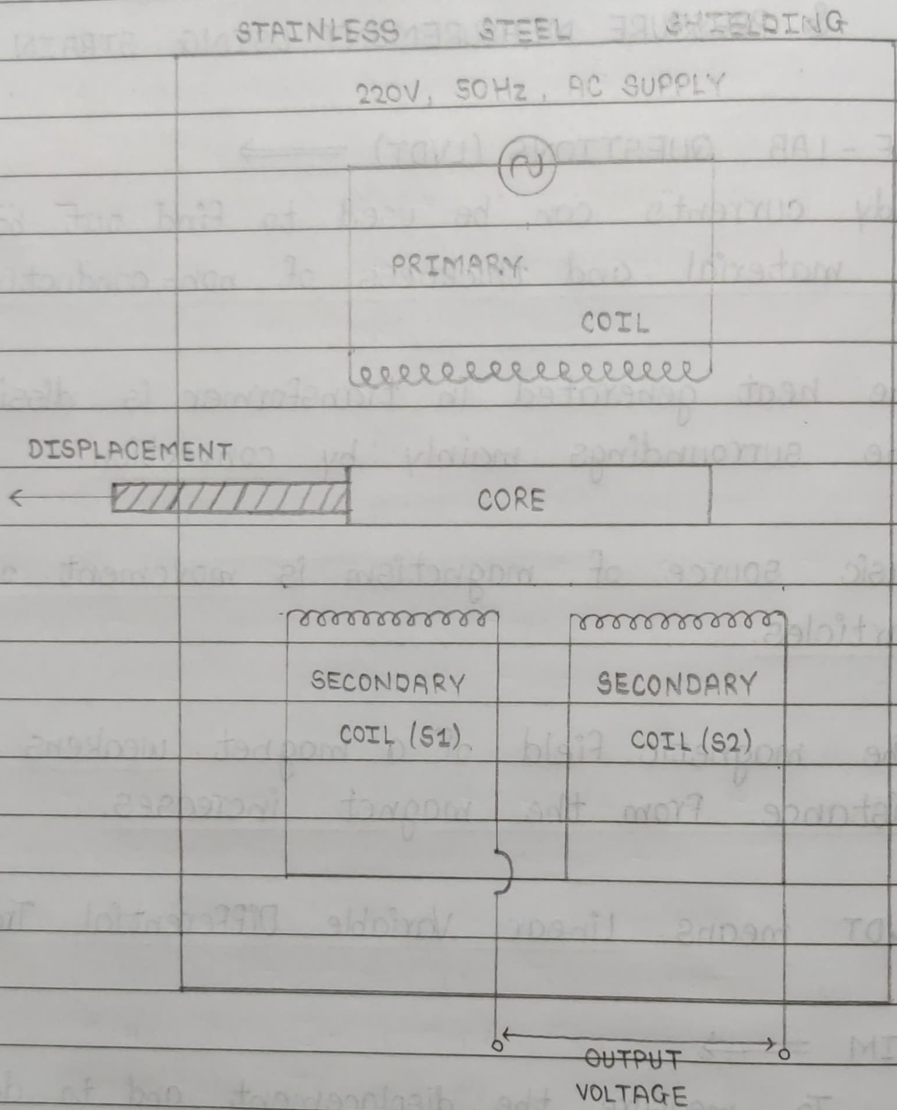
☆ AIM ⟹

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

☆ APPARATUS REQUIRED ⟹

LVDT, Digital displacement indicator, Calibration jig (with micrometer).

☆ CIRCUIT DIAGRAM ⟹



★ OBSERVATIONS ⟹

1) Number of Turns = 1000
2) Supply Voltage (Vrms) = 10
3) Supply Frequency (Hz) = 1000

★ TABULAR COLUMN ⟹

Core Displacement (mm)	Secondary Output Voltage (mV)
-5	84·62
-4	68·48
-3	51·82
-2	34·77
-1	17·45
+1	17·45
+2	34·77
+3	51·82
+4	~~3~~68·48
+5	84·62

☆ RESULT ⟹

Thus, the displacement is measured and the characteristics of LVDT (Linear Variable Differential Transformer) is determined.

☆ POST - LAB QUESTIONS ⟹

① What are the three principles of inductive transducers?

→ The inductive transducers uses three working principles which include the following:

1) Change of self-inductance.
2) Change of mutual-inductance.
3) Production of eddy currents.

② What are the limitations of LVDT?

→ There are some disadvantages of Linear Variable Differential Transformer (LVDT) which are given below:

1) It has large primary voltage produce distortion in output.
2) Temperature affects the performance.
3) Sensitive to stray magnetic field.
4) Dynamic response is limited.

③ Where LVDT is used?

→ LVDTs have been widely used in applications such as power turbines, hydraulics, automation, aircraft, satellites, nuclear reactors, servo mechanics, process and control, materials testing, etc.

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

→ The different types of transducers used are:
1) Linear Potentiometer Transducer.
2) Proximity Inductance Transducer.
3) Capacitive Transducer.
4) Piezoelectric Transducer.
5) Photo-electric Transducer.
6) Linear Variable Differential Transformer (LVDT).
7) Linear Motion Variable Inductance Transducer.

★ PRE-LAB QUESTIONS (Strain Gauge) ⟹

① How does a Strain Gauge work?

→ 1) In general, a strain gauge makes use of very fine wire or metallic foil arranged in grid pattern.
2) The electrical resistance of the strain gauge's metallic grid changes in proportion to the

amount of strain experienced by the object, offering the operator a clear, accurate measurement of strain.

eg. How much the item is stretched or twisted.

3) Strain gauges come in many different shapes, and patterns depending on the parameter being measured.

② What is 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 piezo-relectric effect, it cannot be used to generate a voltage across the device.

③ What are the types of strain gauges?

→ The types of strain gauges are:

1) Quarter - Bridge Strain gauge.
2) Half - Bridge Strain gauge.
3) Full - Bridge Strain gauge.

④ Define gauge factor.

→ Gauge Factor (GF) or strain factor of a strain gauge is the ratio of relative change in electrical resistance (R) to the mechanical strain (ε). The gauge factor is defined as:

$$GF = \frac{\Delta R / R}{\Delta L / L} = \frac{\Delta R / R}{\varepsilon} = 1 + 2\nu + \frac{\Delta P / P}{\varepsilon}$$

where, ε = strain = $\Delta L / L_0$

ΔL = absolute change in length

L_o = original length
v = Poisson's ratio
P = resistivity
R = unstrained resistance of strain gauge
ΔR = change in strain gauge resistance due to axial strain and lateral strain.

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.

★ AIM ⟹

To measure the strain using strain gauge.

★ APPARATUS REQUIRED ⟹

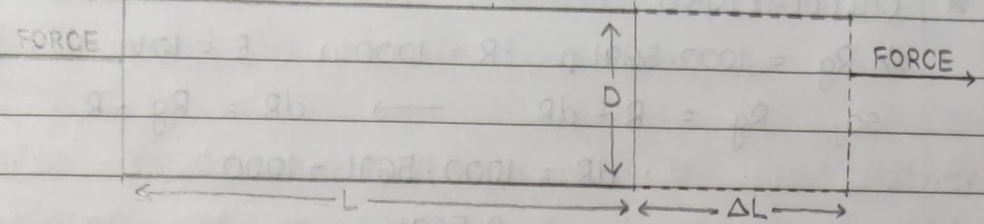
Strain gauge, weight, LABVIEW software.

★ FORMULAE ⟹

1) Resistance of strain gauge : $R_g = R + dR$
where, R = resistance of strain gauge

2) Output voltage in Quarter Bridge : $e = 1/4 \times (dR/R) \times E$
Output voltage in Half Bridge : $e = 1/2 \times (dR/R) \times E$
Output voltage in Full Bridge : $e = (dR/R) \times E$
where, E = voltage applied

★ CIRCUIT DIAGRAM ⟹



$$\varepsilon = \Delta L / L$$

☆ OBSERVATIONS ⟹

1) Material = Titanium
2) Input Voltage = 10 V
3) Resistance = 1000 Ω
4) Gauge Factor = 2
5) Configuration = Full-Bridge.

☆ TABULAR COLUMN ⟹

Weight in Pan (kg)	Voltage measured (mV)	Calculated Value (mV)
1	5.69	5.691
2	11.38	11.383
3	17.07	17.074
4	22.77	22.765
5	28.46	28.456
6	34.15	34.148
7	39.84	39.839
8	45.53	45.530
9	51.22	51.222
10	56.91	56.913
MEAN ⟶	31.302	31.3021

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☆ CALCULATIONS ⟹

1) $R_g = 1000.5691\,\Omega$, $R = 1000\,\Omega$, $E = 10V$, $W = 1kg$.

so, $R_g = R + dR \longrightarrow dR = R_g - R$

$\therefore dR = 1000.5691 - 1000$

$= 0.5691$

now, $e = (dR/R) \times E$

$= \frac{0.5691}{1000} \times 10 = 0.005691\ V$

$\therefore$ converting V to mV $\longrightarrow e = 5.691\ mV$.

2) $R_g = 1002.8456\,\Omega$, $R = 1000\,\Omega$, $E = 10V$, $W = 5kg$

so, $R_g = R + dR \longrightarrow dR = R_g - R$

$\therefore dR = 1002.8456 - 1000$

$= 2.8456$

now, $e = (dR/R) \times E$

$= \frac{2.8456}{1000} \times 10 = 0.028456\ V$

$\therefore$ converting V to mV $\longrightarrow e = 28.456\ mV$

3) $R_g = 1005.6913\,\Omega$, $R = 1000\,\Omega$, $E = 10V$, $W = 10\,kg$

so, $R_g = R + dR \longrightarrow dR = R_g - R$

$\therefore dR = 1005.6913 - 1000$

$= 5.6913$

now, $e = (dR/R) \times E$

$= \frac{5.6913}{1000} \times 100 = 0.056913\ V$

$\therefore$ converting V to mV $\longrightarrow e = 56.913\ mV$

☆ RESULT ⟹

Thus, the strain using strain gauge is measured with output voltage as 31.302 mV (mean).

☆ POST - LAB QUESTIONS ⟹

① 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.

② What is a micro-strain?

→ 1) Strain is calculated by dividing the total deformation of the original length by the original length.

$\therefore$ Strain $(\varepsilon) = \frac{\Delta L}{L}$

2) Typical values of strain are less than 0.005 inch/inch and are often eæpressed in microstrain units.

$\therefore$ Micro-strain = Strain $\times 10^{6}$

③ What is sensitivity of strain gauge?

→ 1) A fundamental parameter of the strain gauge is its sensitivity to strain, eæpressed quantitatively as the gauge factor (GF).

2) GF is the ratio of the fractional change in electrical resistance to the fractional change in length (strain).

3) The GF for metallic strain gauges is usually around 2.

④ What are the limitations of a strain gauge?

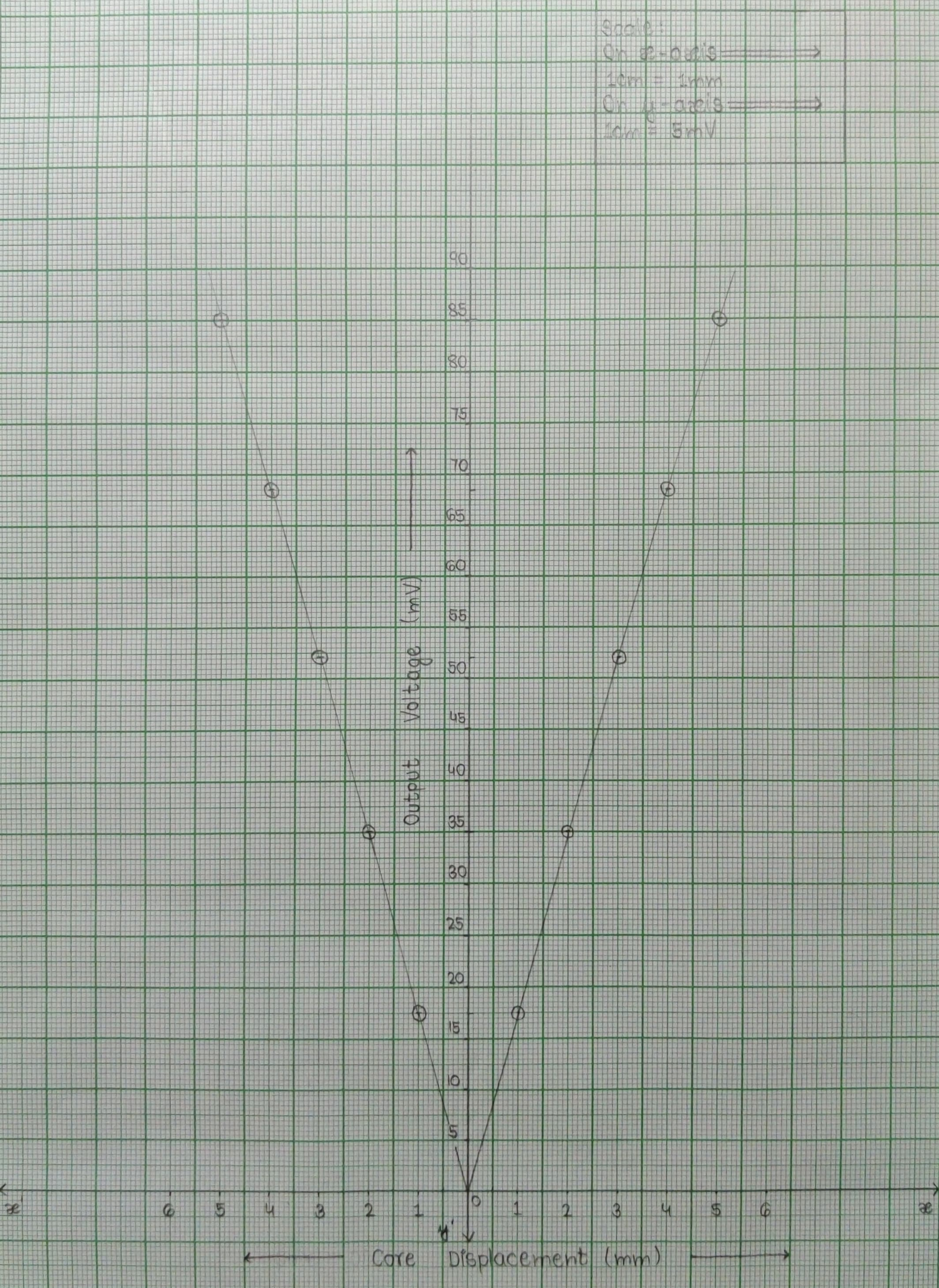
→ Each strain gauge has its limitations in terms of temperature, fatigue, the amount of strain, and the measurement in environment. These limitations must be examined before a strain gauge is used.

⑤ How can you apply the principle of strain gauge?

→ 1) A strain gauge works on the principle of electrical conductance and its dependance on the conductor's geometry. Whenever a conductor is stretched within the limits of its elasticity, it doesn't break but, gets narrower and longer. Similarily, when it is compressed, it gets shorter and broader, ultimately changing its resistance.

2) APPLICATION OF PRINCIPLE :

The gauge is attached to the object under stress using an adhesive. The deformation in the object causes the foil to get distorted which ultimately changes the electrical resistivity of the foil. This change in resistivity is measured by a Wheatstone Bridge which is related to strain by a quantity called, Gauge Factor.


Scale:
On x-axis →
1cm = 1mm
On y-axis →
1cm = 5mV
Output Voltage (mV) →
Core Displacement (mm)
x
x'
y
y'
0
1
2
3
4
5
6
5
10
15
20
25
30
35
40
45
50
55
60
65
70
75
80
85
90