Assignment No. 2 — Unit: 3

Q.1 Define what is a transducer ? Explain various types of transducer with example.

A transducer is an electronic device that convert physical force into an electrical signal so that it can be easily handled and transmitted for measurement The process of converting energy from one form to another is known as transduction.

Non-electrical quantity → Sensing Element —(Sensor / Response)→ Transduction element → Electrical signal

Need of Transducer ?

To determine the exact magnitude of Physical forces such as temperature & pressure is difficult. But when these physical forces are converted into electrical signal, then their values can be easily determined using a meter.

Parts of Transducer

① Sensing Element : It is a part of a transducer that responds to the physical sensation . The response of sensing element depends on physical phenomenon.

② Transduction Element

The transduction element of the transducer converts the output of sensing element into an electrical signal.

Types of Transducer are as follows -

1 - On the basis of quantity to be measured.

1- Temperature Transducer

Temp. transducer is a device that convert a thermal quantity into an electrical quantity. for the measurement of temperature Eg: Thermocouple.

2- Heat Transducer

A temperature transducer is an instrument used to convert the thermal energy of the substances into electrical form.

3- Displacement transducer

It measures the movement. Displacement transducer (LVDTs) measuring horizontal (X) and vertical (Y) translations of the BHA during testing, while rotating are fixed to the steel tube at various location along the length of BHA.

2- On the basis of Input

1- Resistive transducer

These are called as variable resistance transducer. The variable resistance transducer are one of the most commonly used types of transducer

2- Inductive Transducer

It work on the principle of inductance change due to any appreciable change in the quantity to be measured

3. Capacitive Transducer

It work on variable capacitance & used for measuring displacement pressure etc. It is passive.

④ Mutual inductance
⑤ Electromagnetic transducer.

On the basis of Output.
① Analog & Digital Transducer
② Active & Passive Transducer
③ Transducer or inverse transducer
④ Primary or Secondry transducer.

Ques-2 What is resistive transducer? Explain the potentiometer type transducer.

Resistive transducer are electronic devices designed to measure different quantities such as force, pressure, temperature and so on.

The potentiometer is a electrical type of transducer or sensor and it is of resistive type bcz it work on the principle of change of resistance of the wire with its length. The resistance of wire directly proportional to the length of the wire.

How it is used as Transducer.

To measure the displacement of the body, this body, which is moving, is connected to the sliding elements of the potentiometer

As the body moves, the position of the slider located on the potentiometer also changes so the resistance b/w the fixed point and slider changes. Due to this the voltage V_o across these points also changes. The change in voltage or the resistance is proportiona

change in the displacement of the body. Thus the voltage change indicates the displacement of the body.

Performance parameter

1) Potentiometer resolution: The smallest increment of the slider that can be recorded ~~as the~~ across the whole length of potentiometer is called as the resolution. Its limiting resolution is measured as the reciprocal of the number of the turn. of the coil. The lower the length higher the resolution of the potentiometer.

2) Potentiometer linearity: The resistance measured b/w the fixed point and the slider point is linear function of the contractor position relative to that end.

In actual cases the change in resistance and the distance b/w fixed & the moving point is never linear.

→

Ques. 3 What is inductive transducer and the variable reluctance transducer.

Inductive Transducer may be either of the self generating or the passive type. The self generating type utilizes the basic electrical generator principle, i.e, a motion b/w a conductor and a magnetic field induces a voltage in the conductor.

It is a device that convert physical motion into a change in inductance

It works on the principle -

1- Variation of self inductance

2- Variation of mutual inductance

It is mainly used to measure the displacement.

on three variables.

1- Number of turns.

2- Geometric Configuration

3- Permeability of the magnetic material.

$$\phi = \frac{Ni}{R}$$

$$\frac{d\phi}{dt} = \frac{N}{2} \times \frac{di}{dt} - \frac{Ni}{R^2} \times \frac{dR}{dt}$$

If current varies vary rapidly.

$$\frac{d\phi}{dt} = \frac{N}{2} \times \frac{di}{dt}$$

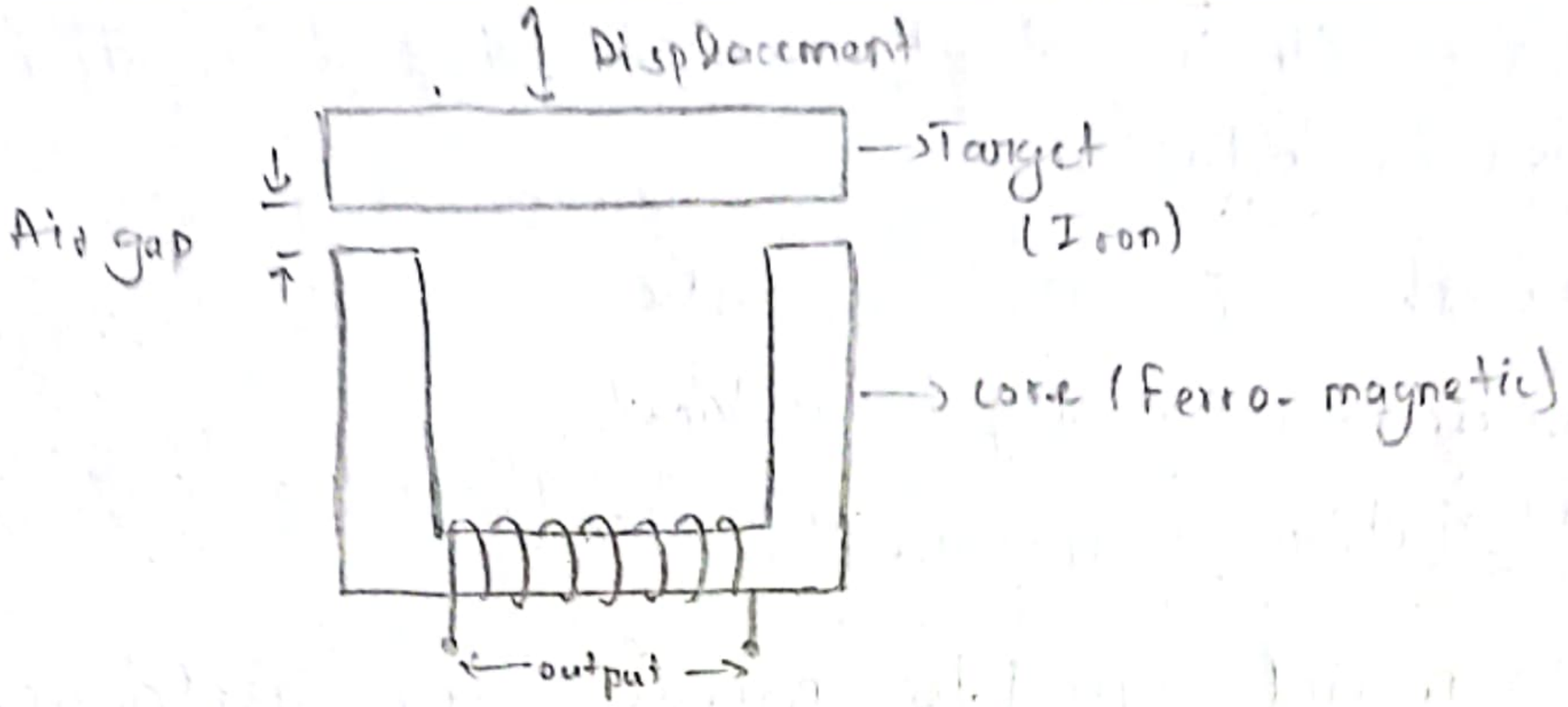
$$\therefore \quad e = N \times d\phi dt$$

$$e = N \times \frac{N}{2} \times \frac{di}{dt} = \frac{N^2}{R} \times \frac{di}{dt}$$

$$L = \frac{e}{di/dt} = \frac{N^2}{R}$$

→ Variable Reluctance Type Transducer.

A transducer of the variable type consists of a coil wound on a ferromagnetic core.. The displacement which is to be measured is applied to a ferromagnetic target. The core & target are seperated by air gap.



. The reluctance of the magnetic path is determined by the size of the air gap. The inductance of the coil depends upon the reluctance of the magnetic circuits.

$$L = \frac{N^2}{R_i + R_g}$$

The reluctance of iron part is neglible.

$$L = N^2/R_g$$

But reluctance of air gap.

$$R_g = \frac{l_g}{\mu_0 + A_g}$$

$l_g \rightarrow$ length of the air gap.

Hence l is proportional to 1/g i.e the self inductance of the coil is inversly proportional to the length of the air gap.

Ques 4 Strain guage wire length is 40 cm, diameter is 25 um, it has resistence of 250 Ω and guage factor 2.5. Calculate the change in length & diameter when resistive change is measured as 0.5 Ω.

Ans- $\Delta l/l = \frac{\Delta R/R}{GF} = \frac{0.5/250\,\Omega}{2.5}$

$= 8 \times 10^{-4}$

$\Delta l = 8 \times 10^{-4} \times 40cm$

$= 0.32\,mm.$

$\mu = \frac{GF-1}{2} = \frac{2.5-1}{2}$

$= 0.75$

$\frac{\Delta d}{d} = \mu \times \frac{\Delta l}{l} = 0.75 \times 8 \times 10^{-4}$

$\Delta d = d \times 6 \times 10^{-4}$

$= 25\,\mu m \times 6 \times 10^{-4}$

$= 1.5 \times 10^{-4}\,\mu m$

Qu.5 A parallel plate capacitive transducer has a plate area of 15 mm × 15 mm & a plate spacing of 0.2 mm Calculate

a) Device capacitance

b) Displacement that causes the capacitance to decrease by 2pF.

As we know that $C = \frac{\varepsilon_r \varepsilon_0 A}{d}$

$= \frac{8.84 \times 10^{-4} \times (15 \times 15 \times 10^{-6})\,m^2}{0.2\,mm}$

$= 9.94\,pF$

$C - \Delta C = \frac{\varepsilon_r \varepsilon_0 A}{d + \Delta d}$

$d + \Delta d = \frac{\varepsilon_r \varepsilon_0 A}{C - \Delta C}$

$$= \frac{8.84 \times 10^{-12} \times 225 \times 10^{-6}\ m}{9.94 - 2}$$

$$= 0.25\ mm$$

$$\Delta d = (d + \Delta d) - d$$

$$= 0.25 - 0.2$$

$$= 0.05\ mm$$

for sensitivity

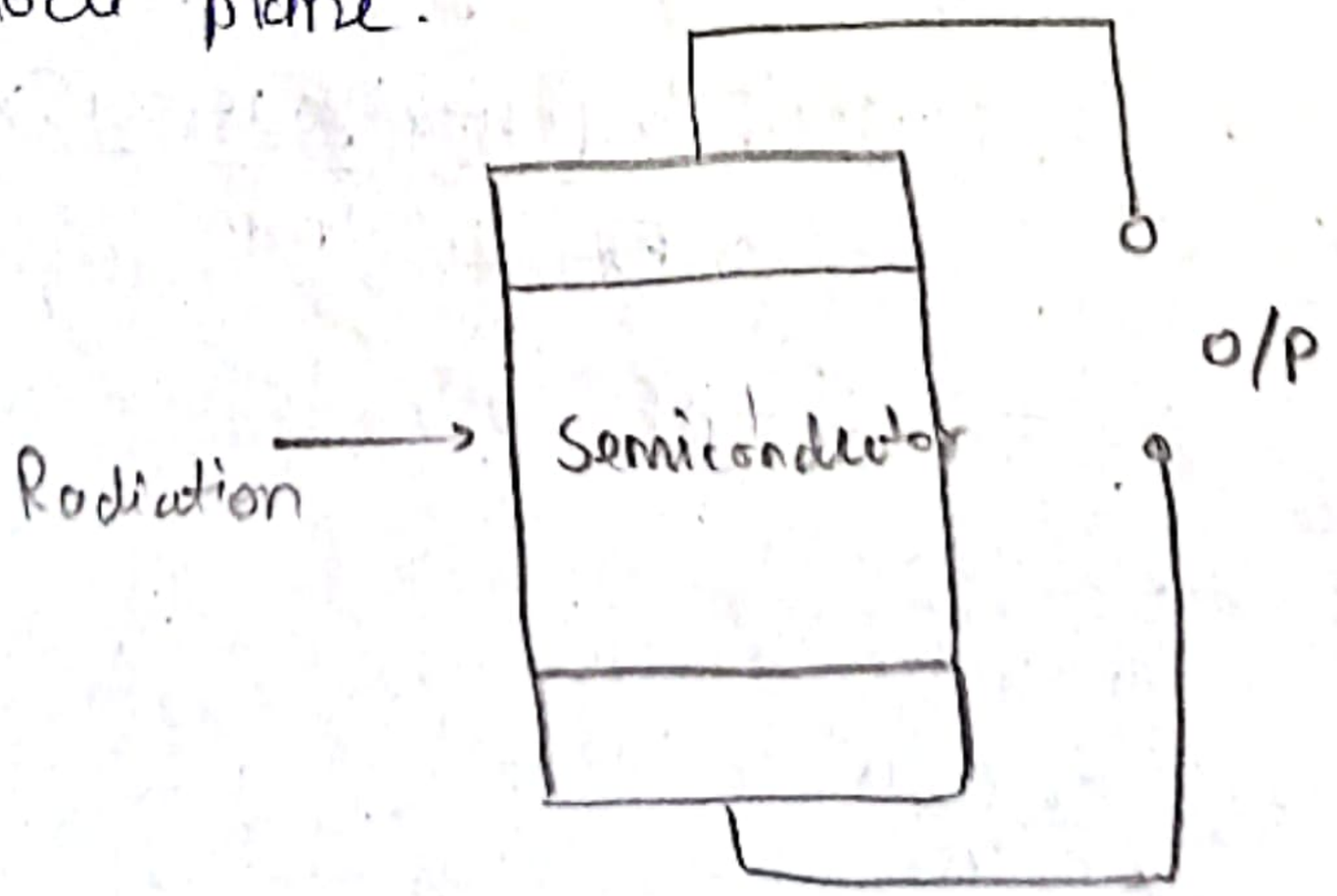
$\frac{\Delta C}{\Delta d}$ = sensiti.

Que.6 What is photo electric transducer ? Explain how does a photoelectric transducer work.

The photoelectric transducer is a light sensitive device used to convert light energy into electrical energy. It is made up of semiconductor material that emits electrons when a beam of light falls on it.

Working:

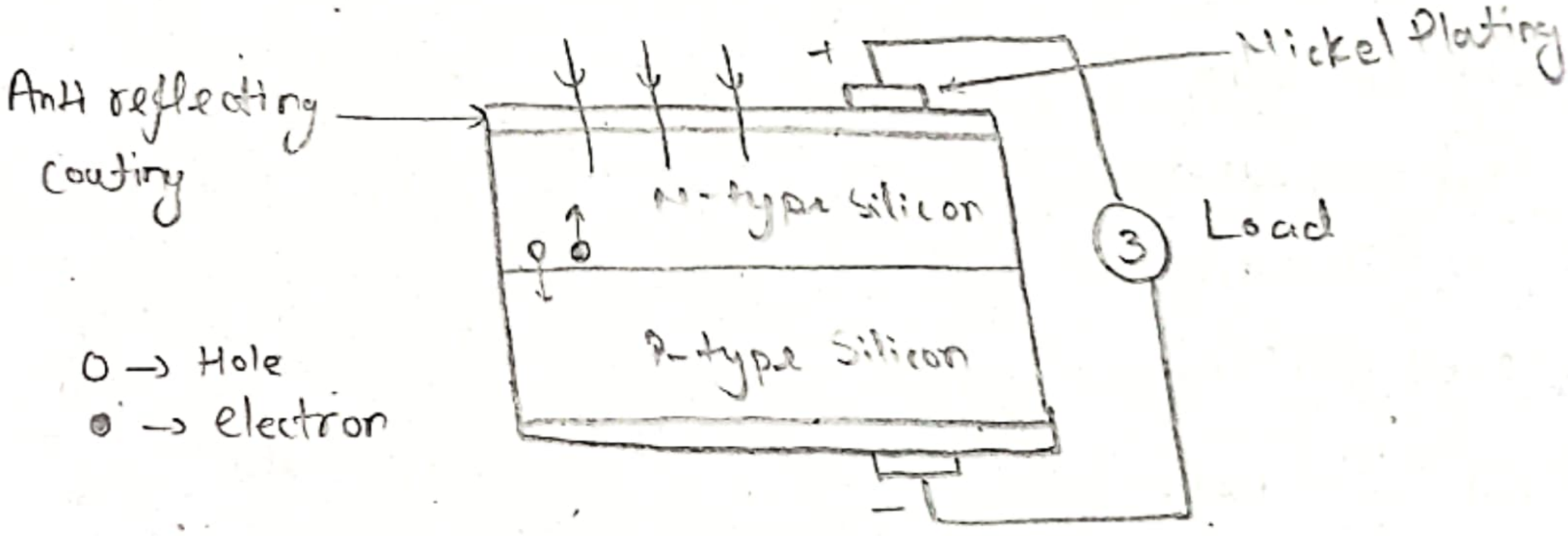
The working principle of photoelectric Transducer can be classified like photoemissive, photovoltic et. otherwise photoconductive. In photoemissive type devices, once the radiation drops over a cathode can cause emission of electrons from the cathode plane.



The output of PV cells can generate a voltage which is relatively to the intensity of radiation. The occurance of radiation can be IR (ifrared). UV, x-rays, gamma & visible light.

Ques.7 What is a photovaltic cell? Explain its working principle and types of photovoltic cell.

The photovoltic cell is the semiconductor device that converts the light into electrical energy. The voltage induces by the PV cell depends on the intensity of light incident on it.



Working:

The light incident on the semiconductor material may be pass or reflected throughl it. ~~The PV~~ When the semiconductor material absorbs the lights the electrons of the material start emitting. This happens becz light consists of small energise particle called photons. When the e- absorbs the photons, they become energised and start moving into the material. Becz of the effect of an electric field, the particle moves

only in the one direction and develop current. The semiconductor material having metallic electrode through which the current goes out of it. Monocrystalline silicon (M-Si), Polycristaline (P-Si)

Ques-8 What is meant by digital transducer? Classify digital transducer.

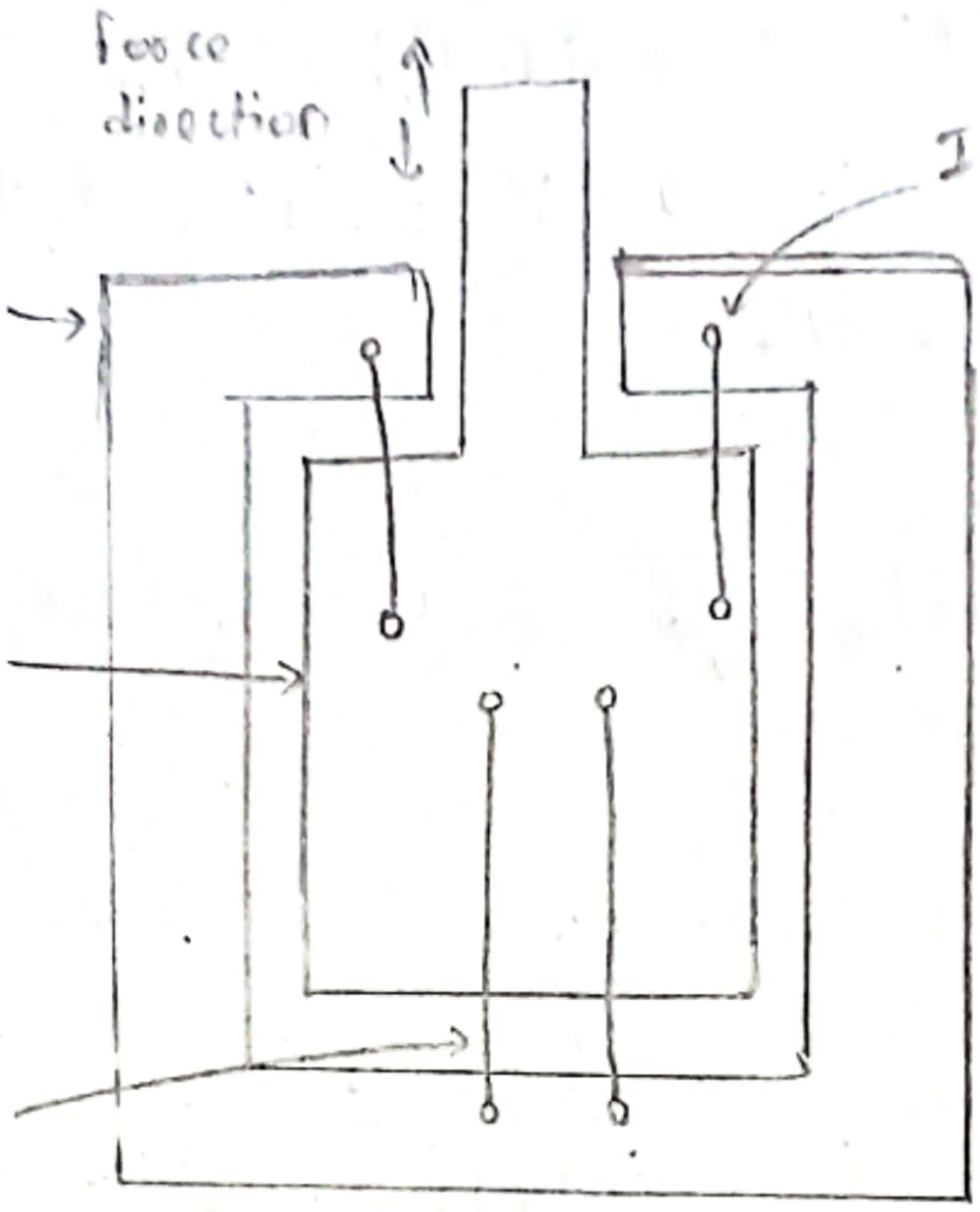
Any transducer that presents information as discrete samples and that does not introduce a quantization error when the reading is represented in the digital form may be classified as a digital transducer.

1. Shaft Encoder
2. Digital Resolvers
3. Digital Tachmeters
4. Hall Effect Sensors
5. Limit Switches.

Ques9 Explain strain guage transducer. Derive its expression Define the relation of gauge factor and poisson ratio.

A strain guage type transducer converts physical quality such as load, pressure or displacement into mechanical strain is converted into electrical output using strain gauges mounted on the elastic body.

Straing gauges are classified as bonded and unbonded



The equation for the resistance of the wire

$$R = \frac{\rho l}{A}$$

where ρ is the specific resistance of the wire in Ωm, l is the length in m, and A is the wire cross-sectional area in m^2

$$R = \frac{\rho l}{\pi d^2/4}$$

d = diameter

new length $(l + \Delta l)$

new diameter $(d - \Delta d)$

new resistance $(R + \Delta R)$

Any strain gauge, the ratio of ΔR to R divided by the ratio of Δl to l is known as the guage factor (GF)

$$GF = \frac{\Delta R/R}{\Delta l/l}$$

The ratio of Δd to d divided by the ratio of Δl to l is referred to as the Poisson's ratio (μ)

$$\mu = \frac{\Delta d/d}{\Delta l/l}$$

The relationship b/w of S μ can be.

$$GF = 1 + 2\mu$$

Now - final expression.

$$R + \Delta R = \frac{\rho(l + \Delta l)}{(\pi/4)(d - \Delta d)^2}$$ //

Ques. 10 What is an LVDT? How does an LVDT work? Define its advantages and disadvantages.

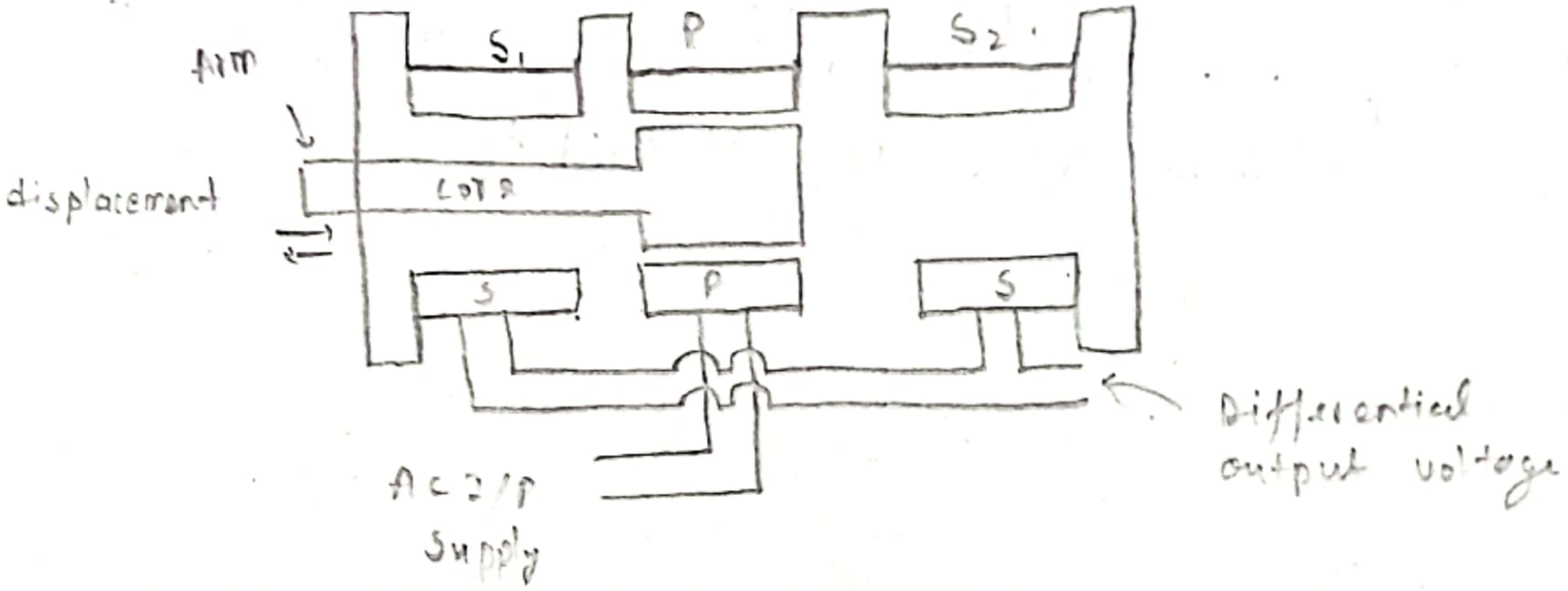
Linear Variable Differential Transformer (LVDT) is an Electromechanical type Inductive Transducer that converts rectilinear displacement into the AC Electrical Signal.

Since LVDT is a secondry transducer, hence physical quantities such as force, weight, Tension, Pressure, etc are first converted into displacement by a primary transducer and then LVDT is used to measure it in terms of the corresponding Electrical Signal.

Construction

LVDT consists of one primary winding P and two secondry windings S_1 & S_2 mounted on a

cylindrical former. Both the secondry winding (S_1 & S_2) has an equal numbers of turns and P is placed identically on either side of the primary winding in such a way that the net output will be the difference of the voltage of both scondry windings



LVDT Working principle

The working principle of LVDT is based on the mutual Induction principle.

Case1: When the core moves towards S_1 (Max Left)

When the core th of LVDT moves towards secondry winding S_1.

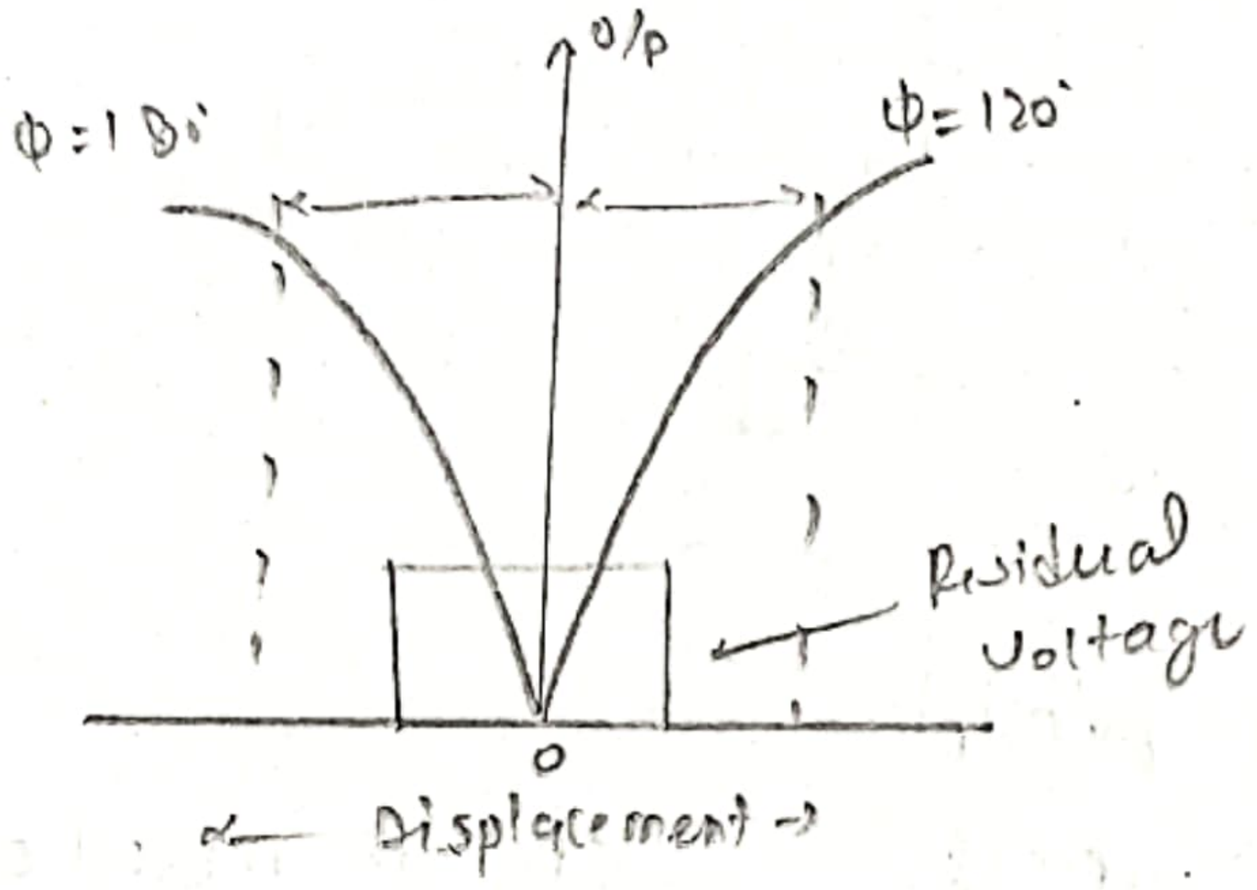
∴ Then in this case, the flux linkage with S_1 will be more as compared to S_2. This means the emf induced in S_1 will be more than the induced emf in S_2. Hence $E_1 > E_2$ and Net differential output voltage $E_o = E_1 - E_2$ will be positive.

Case2: When the core is at Null position

When the core is at null position then the flux linkage with both the secondry windings will be the same.

So the induced emf (E_1 & E_2) in both the windings will be the same. Hence the Net differential output voltage $E_o = E_1 - E_2$ will be zero.

Case3: When core moves towards S_2 (Max Right)
When the core of LVDT moves towards Secondry winding S2. Then in this case, the flux linkage with S_2 will be more as compared to S_1.



Variation of output wrt ~~per~~ displacement

Advantage
1) Smooth and wide Range operation
2) High Sensitivity
3) Low Hysteresis Losses.
4) Low friction Losses
5) Rugged Operation
6) Low power Consumption
7) Direct Conversion to Electrical Signal
8) Fast dynamic Response.

Disadvantages
1) Since LVDT is Inductive, so it is sensitive to Stray Magnetic field.
2) It is affected by vibration & temp. Variation.