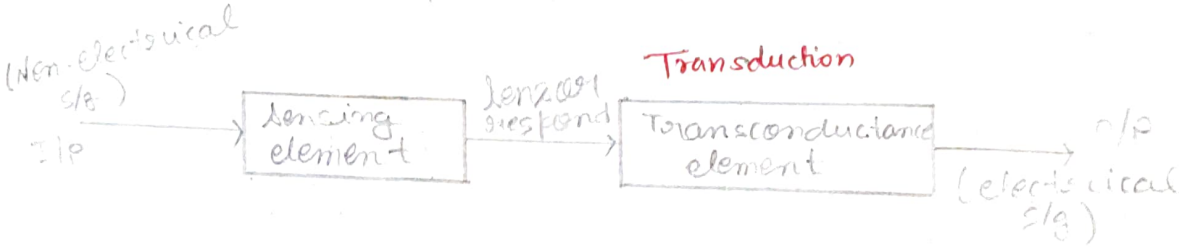
Assignment - 2

Question: - 01

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

Transducer is a device which convert non-electrical quantity into electrical quantity. Transducer convert one form of energy into another form of energy.



Transducer consist two type of element

① Sensing element
② Transconductance element

advantage of Transducer: -

① electrical signal can be control by very small level of Power supply.
② No moving mechanical Part involve.
③ friction effect is minimized
④ easy to fabricate
⑤ It is a low power consuming device

Disadvantages:-

① due to ageing effect it is less used.

② the accuracy and stability in measurement we use feedback system which increase cost and the complexity instruction.

Type of transducer:-

A) On the basis of quantity to be measured.

① Temp. Transducer
② Heat Transducer
③ Displacement Transducer

B) On the basis of input

① resistive transducer
② Inductive transducer
③ Capacitive transducer
④ mutual inductance transducer
⑤ electromagnetic transducer

c) On the basis of output

① analog and digital Transducer
active and Passive Transducer
Transducer and inverse tranducer
Primary and secondary transducer

Question-02

what is resistive transducer? Explain the potentiometer type transducer

Resistive transducer:-

It is the transducer which convert Physical quantity (Heat, Pressure etc.)

into electrical quantity. Known as resistive transducer. It work on the relation of

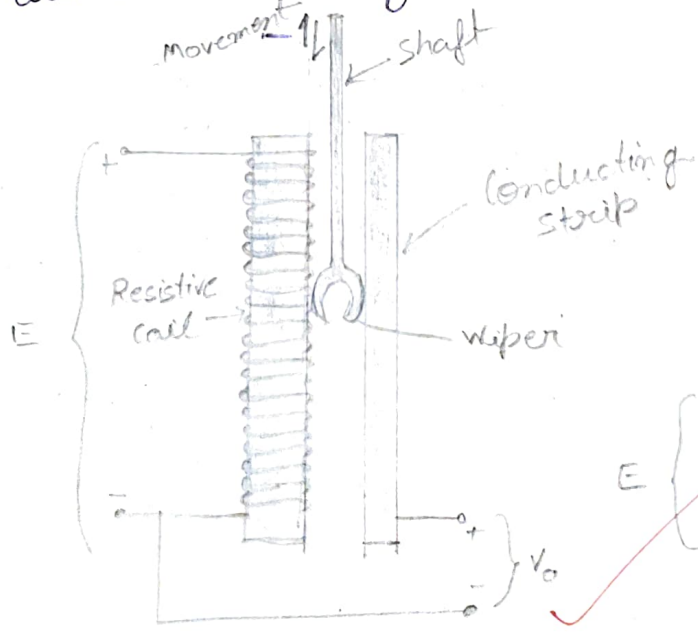
$$R = \rho \frac{l}{A}$$

where,

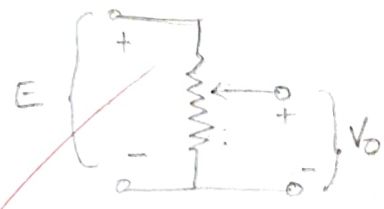
R - resistance of conductor
l - length of conductor
A - Area of crossection
ρ - resistivity of material.

Potentiometer transducer :-

It works on the principle of change of resistance of the wire with its length. The resistance of the wire is directly proportional to the length of the wire, thus as the length of the wire changes the resistance of the wire also changes.



Transducer Construction



Circuit diagram

The potentiometer has a supply voltage (E), and so the position of the wiper determines the output voltage (V_o). The shaft displacement can be measured electrically, and the measurement can be displayed for further Processing.

An advantage of this type of transducer is that it can be as large or as small as required.

Question :- 3

what is inductive transducer and the variable reluctance transducer?

Inductive transducer :-

Inductive transducer may be either of the self generating or the Passive type. The self generating ~~or the Passive~~ utilizes the basic electrical generator Principle i.e a motion between a conductor and magnetic field induces a voltage in the conductor.

An inductive transducer is a device that converts physical motion into change in inductance.

These are of two types.

① Variable reluctance transducer
② Linear Variable Differential transducer

Variable Reluctance Transducer:-

A variable reluctance transducer uses the change in reluctance of an air gap in a magnetic Path to measure displacement.

This type of transducer which consists of an iron target piece and a u-shaped iron core with a coil. Two air gaps are maintained between the target and iron core, and the target displacement varies the length of the air gaps, and thus changes the reluctance of the magnetic circuit.

The equation for magnetic Path reluctance is

$$R_m = \frac{l}{\mu_0 A}$$

l - total air gap length
μ_0 - the permeability of free space
A - air gap cross-sectional area

The inductance at the coil terminals is inversely proportional to the reluctance.

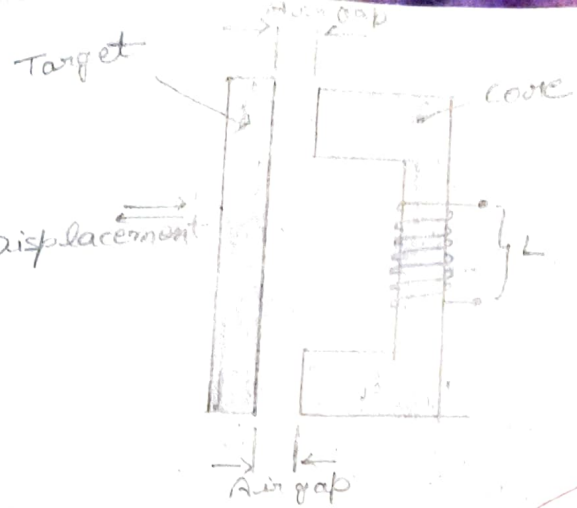
$$L = \frac{N^2}{R_m} = \frac{N^2 \mu_0 A}{l}$$

$N \rightarrow$ number of turns of the coil.

N, μ_0, A are constant

$$L = \frac{K}{l}$$

where K is constant.



Question no:- 04

A strain gauge wire length is 40cm, diameter is 25 μm, it has resistance of 250Ω and gauge factor 2.5. Calculate the change in length & diameter when resistive change is measured as 0.5Ω.

$$G.f = \frac{\Delta R/R}{\Delta l/l}$$

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

$$= \frac{0.5/250}{2.5}$$

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

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

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

$$= 320\,cm \times 10^{-4}$$

$$\boxed{\Delta l = 0.32\,mm}$$

$$\mu = \frac{GF - 1}{2} \quad \{GF = 1 + 2\mu\}$$

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

$$\mu = 0.75$$

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

$$\Delta d/d = \mu \times \Delta l/l$$

$$= 0.75 \times 0.5 \times 10^{-4}$$

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

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

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

$$= 150\,\mu m \times 10^{-4}$$

$$\boxed{\Delta d = 1.5 \times 10^{-2}\,\mu m}$$

Question no:-05

A Parallel Plate capacitive transducer has a plate area of 15 mm × 15 mm and a plate spacing of 0.2 mm. Calculate –

a) Device capacitance

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

a) $$C = \frac{\varepsilon_r \varepsilon_0 A}{d} = \frac{8.84 \times 10^{-12} \times (15 \times 15 \times 10^{-6})\,m^2}{0.2 \times 10^{-3}\,m}$$

$$C = 9945 \times 10^{-15}\,F = 9.94\,pF$$

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

b) $$d + \Delta d = \frac{\varepsilon_r \varepsilon_0 A}{C - \Delta C} = \frac{8.84 \times 10^{-12} \times 225 \times 10^{-6}\,m^2}{9.94 - 2\,pF}$$

$$= \frac{1989 \times 10^{-18}}{7.94 \times 10^{-12}} = 250 \times 10^{-6}\,m = 0.25\,mm$$

$$\Delta d = (d + \Delta d) - d = 0.25\,mm - 0.2\,mm$$

$$\boxed{\Delta d = 0.05\,mm}$$

Sensitivity, $$\frac{\Delta C}{\Delta d} = \frac{2\,pF}{0.05\,mm} = \frac{2 \times 10^{-12}}{0.05 \times 10^{-3}}$$

$$= 40\,pF/mm$$

a) Device capacitance.

$$C = 9.94\ pF$$

b) Displacement :-

$$\Delta d = 0.05\ mm$$

Sensitivity :-

$$= 40\ pF/mm.$$

Question no:- 06

What is Photoelectric transducer ? explain how does a Photo electric transducer work.

Photoelectric transducer :-

The Photoelectric transducer can be defined as, a transducer which changes the energy from the light to electrical. it can be designed with the semiconductor material. This transducer utilizes an element like Photosensitive which can be used for ejecting the electrons as the light beam soak ups through it.

~~Photoelectron~~

Photoelectric transducer classification :-

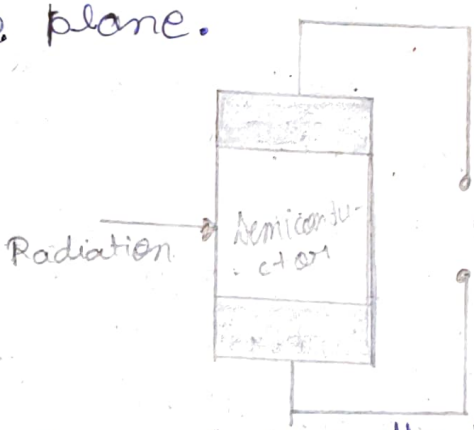
These transducer are classified into five types which include the following -

① Photo emissive cell
② Photodiode
③ Phototransistar
④ Photo - valtaic cell
⑤ Photoconductive cell

Working Principle :-

The working Principle of Photoelectric Transducer can be classified like Photoemissive, Photovoltaic otherwise Photoconductive.

In Photoemissive type devices, once the radiation drops over a cathode can cause emission of electrons from the cathode plane.



(Photoelectric Transducer)

The output of the PV cells can generate a voltage which is relative to the intensity of radiation. The occurrence of radiation can be IR (infrared), UV (ultraviolet), X-rays, gamma rays, and visible light. In Photo-conductive devices, the material's resistance can be changed once it is light up.

Applications :-

① - These transducer are used in biomedical applications
② - Pickups of pulse
③ - Measure blood pulsative volume changes.
④ - Recods body movements.

Question no:- 07

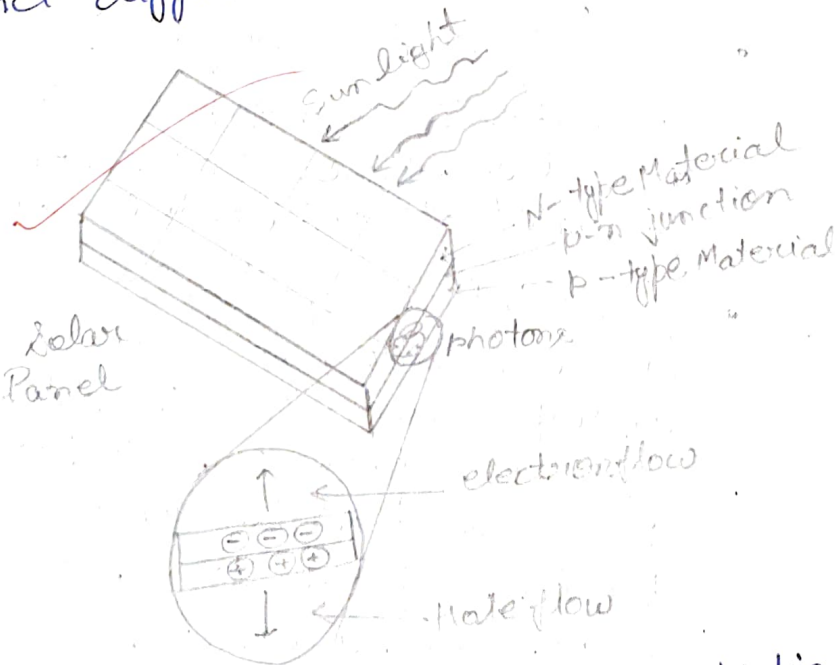
What is a photovaltaic cell? explain its working principle and type of Photovaltaic cell.

Photovaltaic Cell:-

A Photovaltaic cell harnesses energy It converts salar energy to electrical energy by the principle of photovaltaic effect.

It consists of a specially treated semiconductor layer for converting salar energy into electrical energy.

A Photovaltaic cell is a type of PN junction diode which harnesses light energy into electricity. They generally work in a reverse bias condition. it is analogous to a salar cell since they belong to similar working Principles but have distinct differences.



The diagram above is a cross-section of a photovaltaic cell taken from a salar panel which is also a type of photovaltaic cell.

Photovoltaic cell working :-

- A photovoltaic cell works on the same principle as that of the diode, which is to allow the flow of electric current to flow in a single direction and resist the reversal of the same current, i.e. causing only forward bias current.
- when light is incident on the surface of a cell, it consists of photons which are absorbed by the semiconductor and electron-hole pairs are liberated to produce an external DC supply.
- In a solar cell, the junction area is much bigger than the photovoltaic cell because it's main interest is the generation of Power but for a photovoltaic cell the main purpose is the generation of electricity.
- If the incident energy ($h\nu$) is greater than the energy gap of that semiconductor material, these electron-hole pairs are generated at the depletion region of a diode.
- when this photon from external radiation hits the diode, these electron-hole pairs disrupt the neutrality of the conductor. if an external current path has been provided then the electrons flowing through the p-side travel towards the n-side, eventually generating a DC current and the magnitude of this electromotive force generated is directly proportional to the intensity of the incident radiation.

The main types of Photovaltaic cells are the following:-

- monocrystalline silicon cells (made of a single silicon crystal with a uniform structure that is highly efficient)
- Polycrystalline silicon cells (made of many silicon crystals and have lower performance.)
- Thin-film cells. (obtained by depositing several layers of PV material on a base)

Question no:-08

what is meant by digital transducer? classify digital transducer.

Digital transducer:-

A transducer measures physical quantities and transmits the information as coded digital signals rather than as continuously varying currents or valtages.

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.

The transducer which converts input quantity into output having digital pulses is called digital transducer.

Most transducers used in digital systems are primarily analogue in nature and incorporate some form of conversion to provide the digital output.

Type of Digital transducers :-

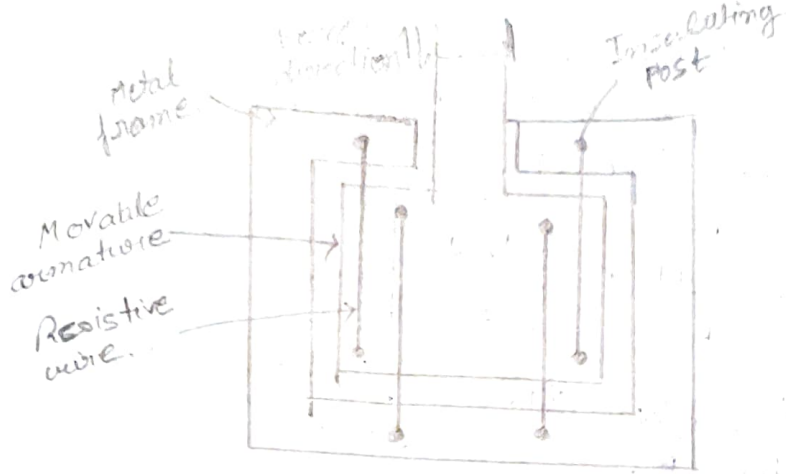
1. Shaft Encoders
   i) Absolute encoders
   ii) Incremental encoders
2. Digital Resolvers
3. Digital Tachometers
4. Half effect sensors
5. Limit switches.

Question no:- 09 :-

Explain strain gauge transducer. Derive its expression. Define the relation of gauge factor and Possion ration.

Strain gauge transducer:-

A strain gauge transducer uses the resistance change in a wire when it is strained to measure the physical change that produces the strain. Strain gauges are classified as bonded and unbonded. The bonded type is bonded (glued) on to the physical quantity under investigation. An unbonded strain gauge is normally part of an individual transducer used to investigate an applied force.



Unbonded strain gauge

The equation for the resistance of the wire is

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

ρ = specific resistance of the wire
l = total length in meter
A = wire cross-sectional area.

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

d = wire diameter

when the resistance wire is strained positively, its length is increased and diameter is decreased. and the wire resistance increased. new length is $(l + \Delta l)$, diameter $(d - \Delta d)$ and the increased resistance is $(R + \Delta R)$.

For any strain gauge, the ratio of ΔR to R divided by the ratio of Δl to l is known as the gauge 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 known as the Poisson ratio (μ).

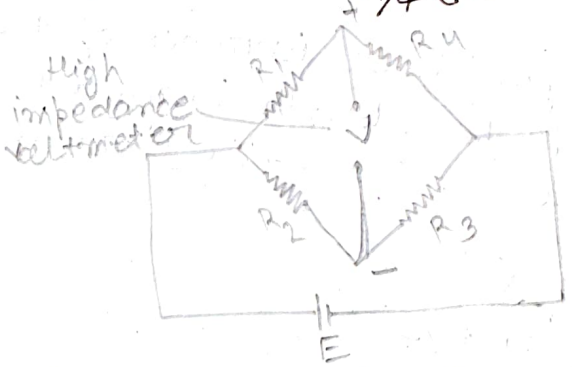
$$\mu = \frac{\Delta d/d}{\Delta l/l}$$

relation b/w GF and μ can be shown to be.

$$GF = 1 + 2\mu$$

and

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



Case 1: when no strain is applied

$F/A = 0$

un strained resistance:

$R_1 = R_2 = R_3 = R_4 = R$

$V = 0\ V$

Case 2: when we apply strain on R_2

$F/A \neq 0$

$R_1 = R_3 = R_4 = R$

$R_2 = R + \Delta R$

$$V_{bridge} = V_+ - V_-$$

$$= \frac{VR_2}{R_1 + R_2} - \frac{VR_4}{R_3 + R_4}$$

$$= \frac{V(R + \Delta R)}{R + R + \Delta R} - \frac{VR}{R + R}$$

$$= \frac{VR\Delta R}{2R(2R + \Delta R)}$$

$$= \frac{V\Delta R}{4R+2\Delta R} \qquad \because R >> \Delta R$$

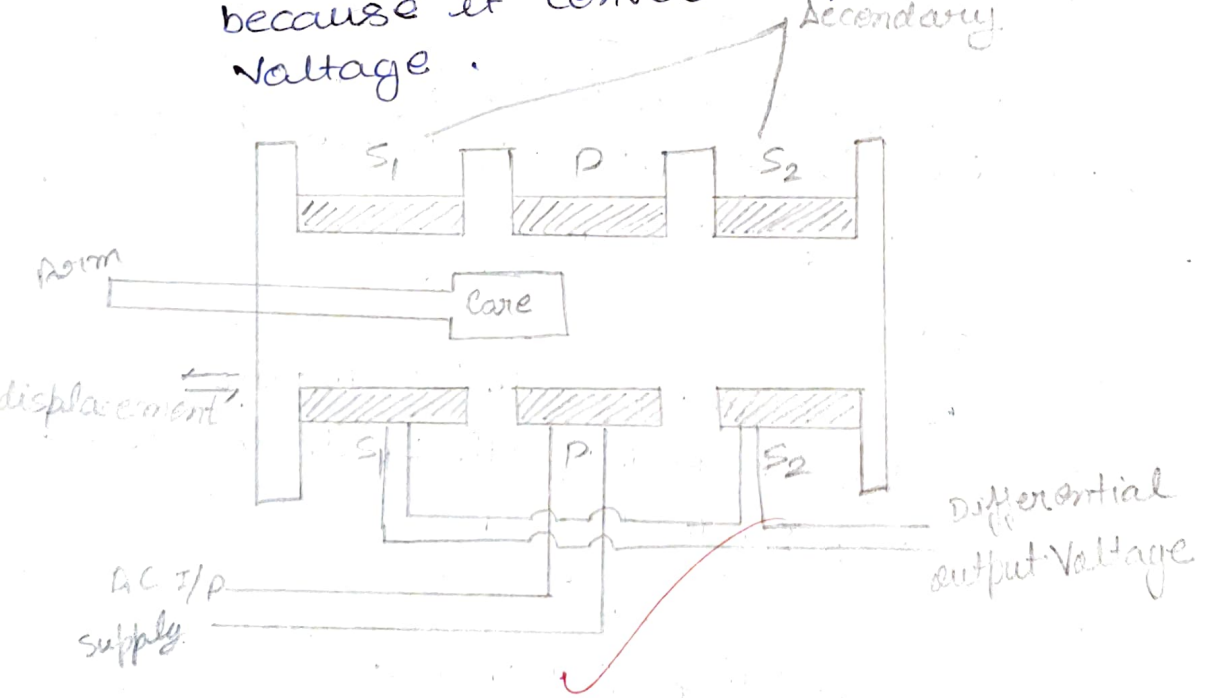
$$V_{bridge} = \frac{V\Delta R}{4R}$$

Question no:- 10

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

LVDT (Linear Variable Differential Transducer)

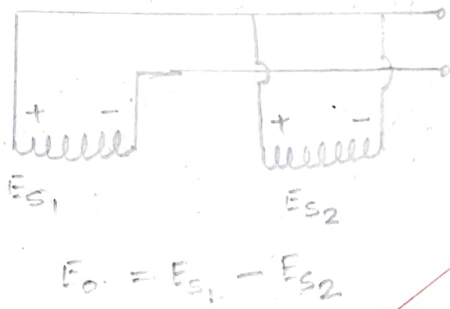
- LVDT is the mutual inductance transducer.
- It is also known as non-self generating transducer.
- It is type of Passive transducer because it requeries external Power source
- It is the type of electrical transducer because it convert displacement into voltage.



Principle of Operation and working :-

As the primary is connected to an AC source so alternating current and voltages are Produced in the secondary of the LVDT. The output is secondary S_1 is E_{S_1} and in the secondary S_2 is E_{S_2}. so the differential output is,

$$E_o = E_{S_1} - E_{S_2}$$



Case - I :-

when core is at rest Position.

$$E_{S_1} = E_{S_2}$$

flux linkage with both secondary winding is same so the output voltage

$$E_o = 0 \text{ volt}$$

Case - II :-

when core move to right side flux linked with S_2 is more as compared to S_1

$$E_{S_2} > E_{S_1}$$

So that output voltage

$$E_o = (-)Ve$$

where output voltage is out of Phase with input voltage.

Case-III :-

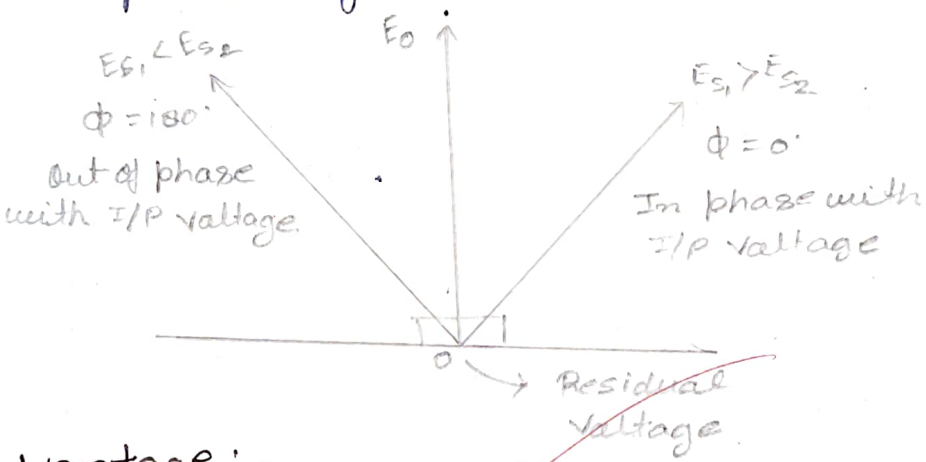
when core move to left side, flux linked with S_1 is more as compared to S_2

$$E_{S_1} > E_{S_2}$$

So that output voltage.

$$\boxed{E_o = (+)\,Ve}$$

Output voltage is same in phase with input voltage.



Advantage :-

1. High output
2. High sensivity
3. Very good linearity
4. provided less friction
5. low power consuption.

Disadvantage :-

1. Very high displacement is required for generating high voltage.
2. Shilding is required since it is sensitivity to magnetic field
3. it affect by temp. change and vibration.

Suraj 22/12/22