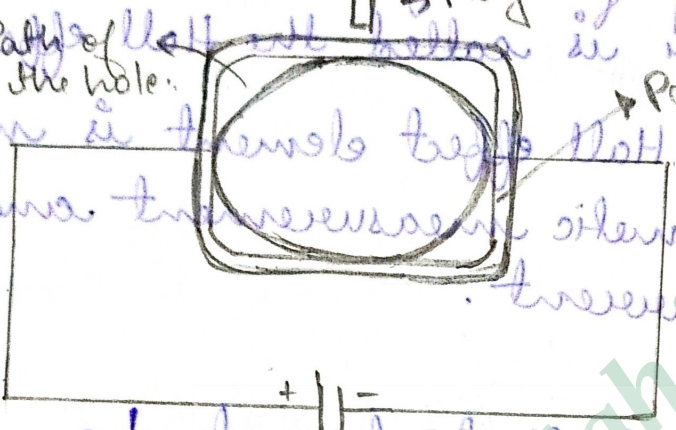
Unit :- 05

Hall Effect - Transducer...

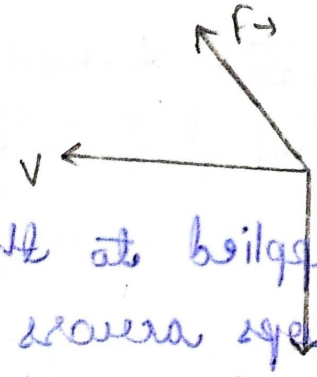
29/01/25

≫ Hall Effect:-



When a magnetic field is applied perpendicular to a current carrying conductor or a semiconductor, a voltage is developed across the direction perpendicular to both the current and the magnetic field. This phenomenon is called Hall effect and the voltage is developed is called hall voltage.

A steady state will be achieved when the force due to magnetic field will be balanced by to transverse electric field.



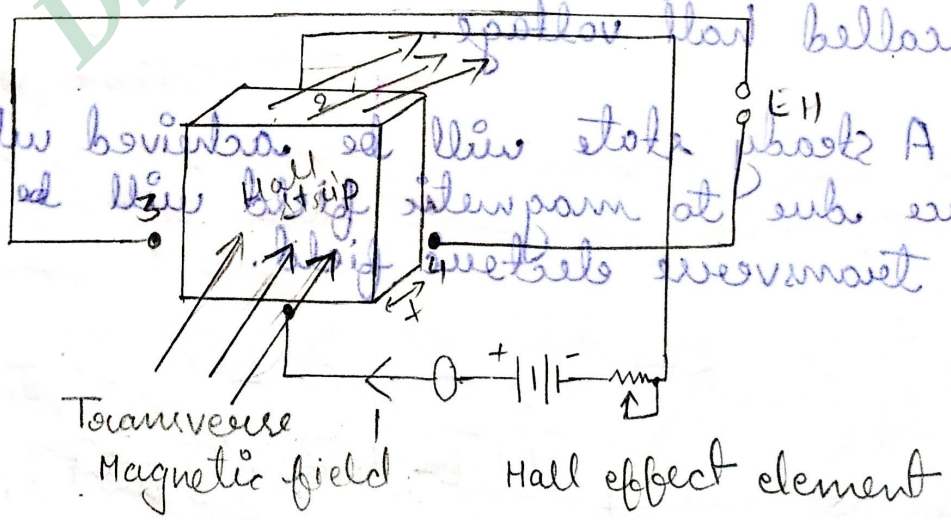
((Lf lorenty force) Left hand).

Hall-effect (Principle) :-

If the current carrying strip of the conductor is placed in transverse magnetic field, then the EMF developes on the edge of the conductor. The magnitude of the develop voltage depends on the density of the flux and this property of a conductor is called the Hall effect.

The Hall effect element is mainly used for magnetic measurement and for sensing the current.

Consider the hall effect element shown in the figure below. The current supply through the lead 1 and 2 and the output is obtained from the strip 3 and 4. The lead 3 and 4 are at same potential when no field is applied across the strip.



→ When the magnetic field is applied to the strip the output voltage develops across the output leads 3 and 4. The developed voltage

is directly proportional to the strain of the material.

→ The output voltage is

$$E_H = K_H I B / t$$

where K_H – Hall effect coefficient;

$$\frac{V-m}{A-Wbm^2}$$

t = thickness of strip; m

The I is the current in ampere and the B is the flux densities in wb/m^2.

Application of Hall effect transducer:-

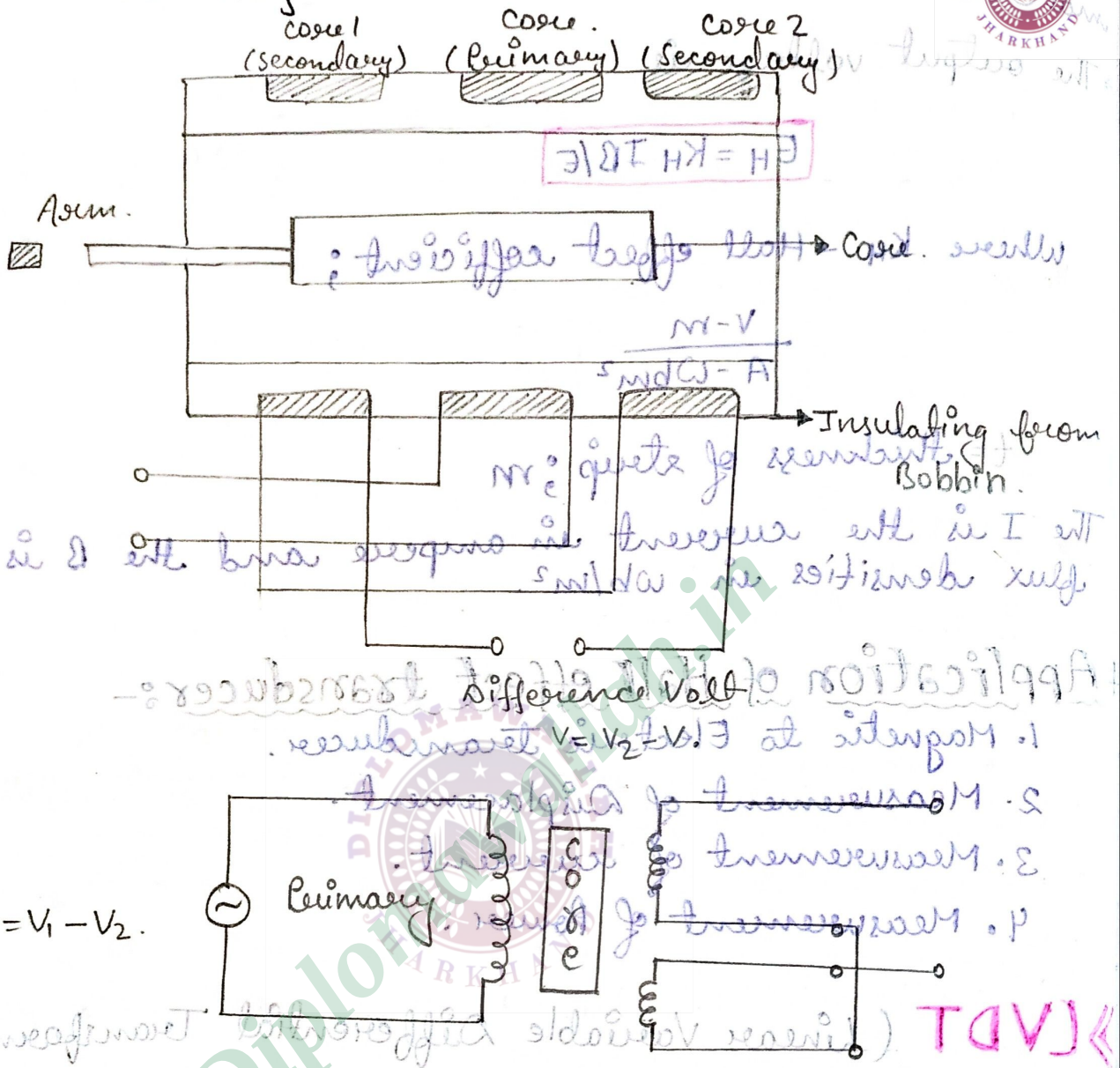
1. Magnetic to Electric transducer.
2. Measurement of Displacement.
3. Measurement of current.
4. Measurement of Power.

» LVDT (Linear Variable Differential Transformer):-

Introduction:-

- LVDT is a mechanical type of transducer.
- The main function of this is to convert the rectangular movement of an object to the equivalent electrical signal.
- LVDT is used to calculate displacement, and works on the transformer principle.
- The excitation voltage of AC is 0.5 - 12 V and the operating frequency is given by 50 to 400 H_2.

Circuit Diagram :-



Working Principle :-

The working of the LVDT ckt diagram can be divided into three cases based on the position of the core.

In Case I :- When the core of the LVDT is at the null location, then both the minor winding flux will equal, so the induced emf is similar in the windings. So for no dislocations, the output value (eout) is zero. because both the e_1 & e_2 are equivalent.

In Case 2 :- When the core of the LVDT is up to the null point in this case, the flux involving minor winding S_1 is additional as contrasted to flux connecting with S_2 winding. Due to this reason e_1 will be added as that of e_2. Due to this e_{out} is positive.

In Case 3 :- The core of the LVDT is shifted ~~up to~~ down to the null point, in this case the amount of e_2 will be added as that of e_1. Due to this e_{out} output volt will be (-ve).

» Thermistor

A thermistor is a type of resistor whose electrical resistance varies significantly with temperature change.

The term "thermistor" is a combination of thermal and "resistor" thermistor is widely used for temperature sensing and measurement due to their sensitivity and accuracy.

Types of Thermistor :-

① **Negative Temperature Coefficient :- (NTC) Thermistor.**
In NTC thermistor resistor decreases as temperature increases. They are commonly used in temperature sensing applications.

② **Positive Temperature Coefficient (PTC) Thermistor :-**
In PTC thermistor resistance increases as temperature rises they are often used in current limiting applications

* Working Principle:-

Thermistor operate based on the principle that their resistance changes with temperature. By measuring the resistance the corresponding temperature can be determined property makes them suitable precise temperature measurement.

* Application:-

- A temperature measurement:-
  Used in digital thermometers and various temperature monitoring devices.
- Automotive Application:-
  Monitor engine and ambient temperatures to ensure optimal performance.
- Household Appliances:-
  Regulate temperature in devices like ovens refrigerators and air conditions.
- Circuit Protection :-
  PTC thermistor are used to limit inrush current, protecting circuits from surge.

* Advantages:-

→ High sensitivity to temperature changes.

→ Compact size and robust construction.

→ Cost effective solution for temperature sensing.

* **Disadvantages:-**

→ Non linear response, which may require calibration.
→ Limited temperature range compared to other sensor.
→ Thermistors are essential components in modern electronics providing reliable and accurate temperature measurement across various industries.

Thermocouple:-

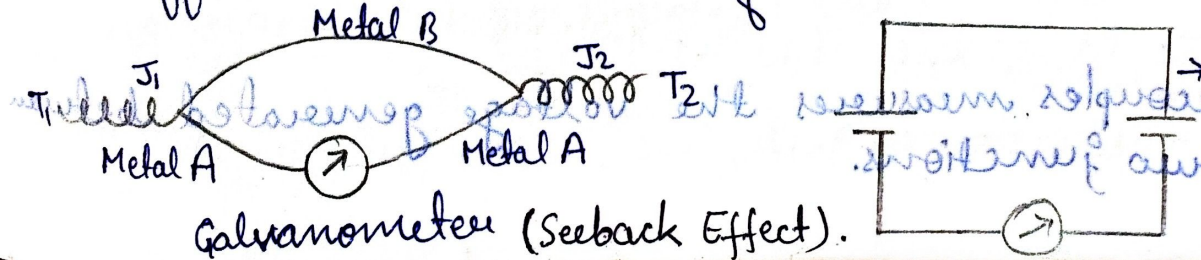
It is a type of temperature sensor that measures temperature based on the voltage generated at the junction of two different metals.

Application:-

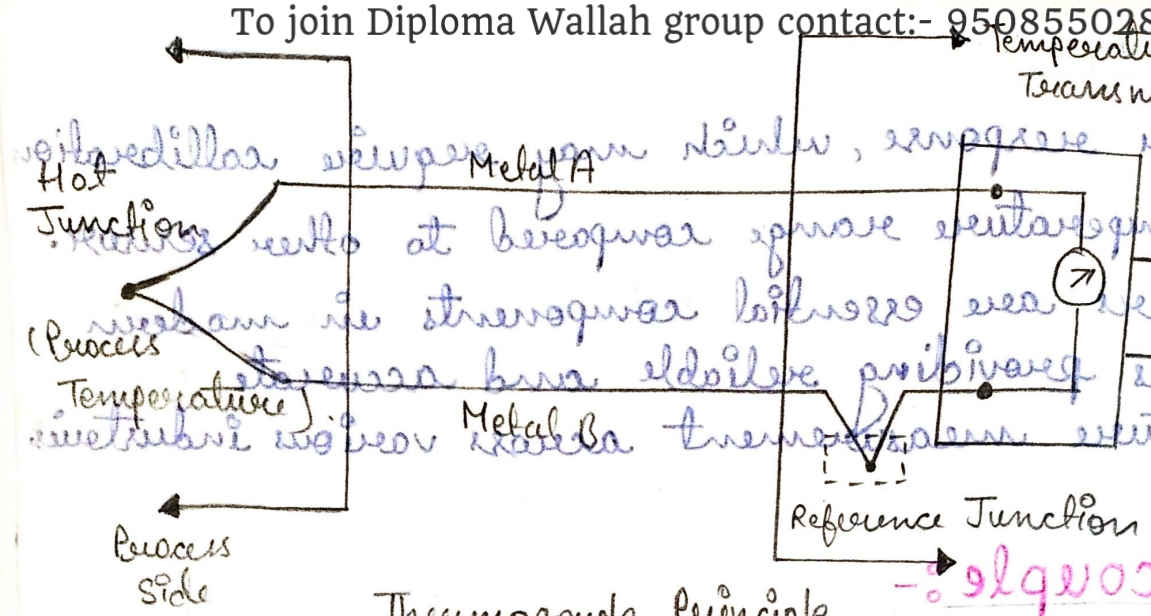
Thermocouple is composed of atleast two metals joined together to form two junctions. One junction is connected to unknown body / hot junction / measuring junction. Another junction is known as temperature reference / cold.

1) Seebeck Effect:

* This effect states that when two different or unlike metals are joined together at two junctions, an electromotive force (emf) is generated at the two junctions.
* The amount of emf generated is different for different combination of the metals.



Galvanometer (Seebeck Effect).



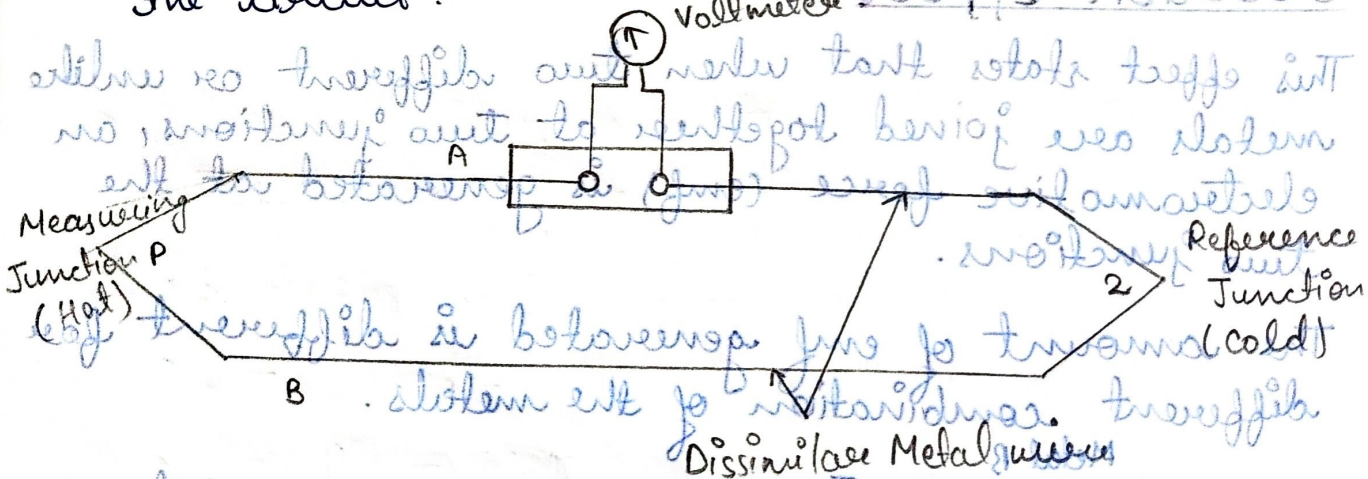
Thermocouple Principle

2) Peltier Effect :-

* When two dissimilar are joined together to form two junctions, emf is generated within the circuit due to the different temperature of the two junctions of the circuit.

3) Thomson Effect :-

* When two unlike metals are joined together to form two junctions, the potential axis within the circuit due to temperature gradient along the entire length of the conductor within the circuit.



* Thermocouples measures the voltage generated between the two junctions.

* The emf produced in the thermocouple is given by :-

$$E = a(\Delta\theta) + b(\Delta\theta)^2$$

$\Delta\theta$ = difference in temperature between the two junctions (°C)

a, b = Constants

$$\varepsilon = a\Delta\theta$$

$$\Delta\theta = \frac{E}{a}$$

* In thermocouple temperature measuring circuit, the emf setup is measured by sending a current through a moving coil instrument the deflection being directly proportional to the emf.

* The reference junction is usually at 0°c

* Thermocouples → upto to 1400°c

* Combination of metals used for thermocouple, should always produce a linear rise in emf.

$E_0 = a\Delta\theta$

b → neglated.

Advantages of Thermocouple :-

1.) High temperature Range :- Thermocouples can measure temperature up to 2500 °c (4500° F).

2.) Fast Response Time :- Thermocouples have a fast response time, making them suitable for measuring rapid temperature changes.

3.) low Cost :- Thermocouples are relatively inexpensive compared to other temperature measuring devices

4.) Simple Construction :- Thermocouples have simple construction, making them easy to and maintain.

Disadvantages of Thermocouple :-

* lower accuracy, against contamination.
* should be protect against contamination to ensure long-life.
* Placed remote from measuring devices.

Types of Thermocouple :-

→ Thermocouples metals selection is based on the following factors :-

- Melting Point
- Thermoelectric Output in combination
- Electrical Conductance
- Repeatability
- Cost
- Easy handling and fabrication.

→ Based on above qualities, the most commonly combination of metals, the various types are -

- K - Chromel / Alumel
- J - Iron / Constantan
- R - Pt - PtRh (Pt - 87% Rh - 13%)
- S - Pt - Pt - Rh (Pt - 90%, Rhodium - 10%)

- B - Pt Rh 30% - Pt Rh 6%.
- T - Copper Constantan
- E - Chromel Constantan.

Thermocouple Comparison on the basis of temperature range:

Type	Temperature range °C (Continous)	Temperature rang °C (Shorter).
K	0 to + 1100	-180 to +1300
J	0 to + 700	-180 to + 800
N	0 to + 1100	-270 to + 1300
R	0 to + 1600	-50 to + 1700
S	0 to + 1600	-50 to + 1750
B	+ 200 to 1700	0 to 1820
T	-185 to +300	-250 to +400
E	0 to 800	-40 to +900

» Piezoelectric Sensor / Transducer

A Piezoelectric sensor / Transducer is a device that uses the piezoelectric effect to measure pressure acceleration, strain or force by converting them to an electrical signal.

Piezoelectric effect :-

The piezoelectric phenomenon corresponds to generation of an electrical potential on the surface of some crystals (quartz, tourmaline, etc) when they are mechanically deformed.

Reversed effect, i.e when the crystal is placed into an oscillation electrical field, the piezoelectric starts mechanically to vibrate with the same frequency.

→ Piezoelectric sensors are used for quality assurance, process control and process development in many different industries.

Advantages :-

i) These sensors are rugged and have an extremely high natural frequency and an excellent linearity.

ii) Piezoelectric technology is insensitive to electro-magnetic field and radiation, enabling measurement under harsh conditions.

Disadvantages :-

It cannot be used for true static measurements. A static force with result in a fixed amount of charges on the piezoelectric material.

Transverse effect :-

A force is applied along a neutral axis (Y) and the charges are generated along the (X) direction. Perpendicular to the line of force. The amount of charges depends on the geometrical dimensions of the respective piezoelectric element.

Piezoelectric transducer (also known as piezoelectric sensor) is a device that uses the piezo electric effect to measures changes in acceleration, pressure, strain, temperature or force

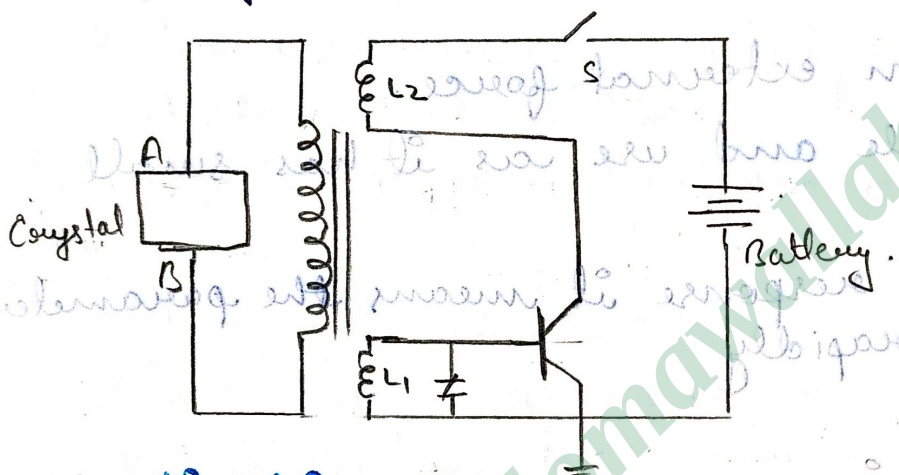
by converting this energy into an electrical charge.

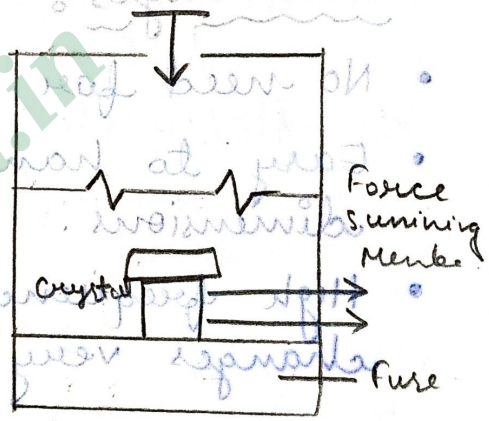
Working Principle :-

The Piezoelectric effect allow there transducer to generates voltage when mechanical stress is applied, which is then used to measured that stress.

Material Properties :-

Piezoelectric materials like quartz crystal are essential for the transducer function, responding uniquely to mechanical stress.



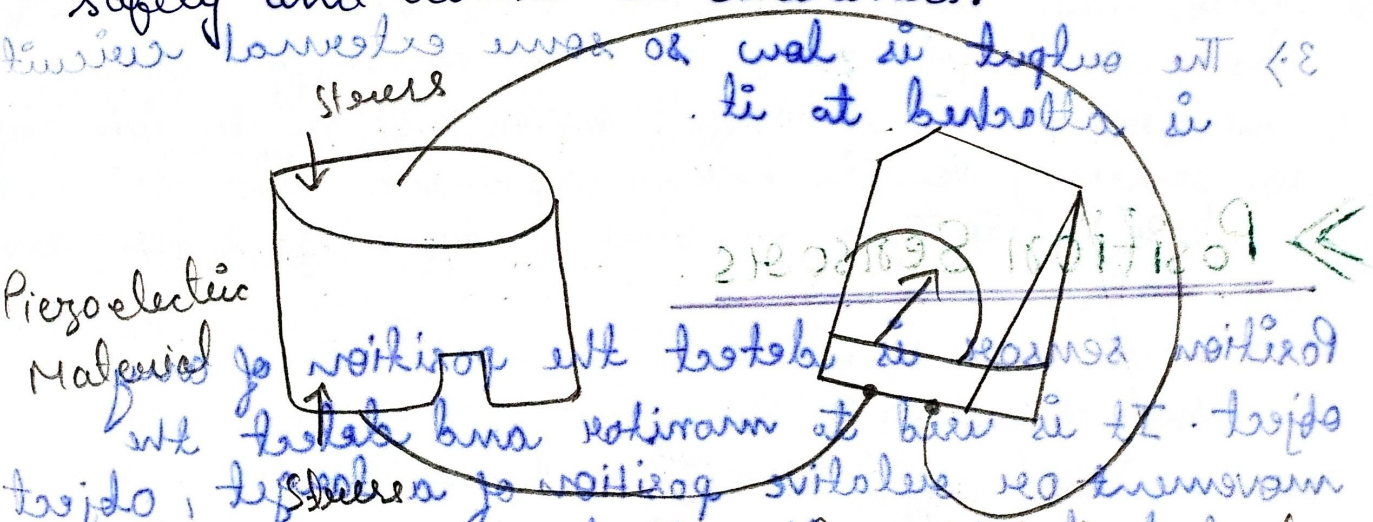


Piezoelectric Transducer

Application :-

Piezoelectric transducers are used in numerous fields.

Including medical diagnostics automative safety and consumer electronics.



Piezoelectric effects

→ They are used for studying high speed shock waves and blast waves.

→ Used infertility treatment.

→ Used in Inkjet printers.

→ Used in electric lighter that used in kitchens.

→ It is used in restaurants or airports where when a person steps near the door and doors are opens automatically.

* Advantages :-

- No need for an external force.
- Easy to handle and use as it has small dimensions.
- High frequency response it means the parameters changes very rapidly

* Disadvantages :-

1.) It is not suitable for measurement in static condition.

2.) It is affected by temperature.

3.) The output is low so some external circuit is attached to it.

Position Sensors

Position sensor is detect the position of any object. It is used to monitor and detect the movement or relative position of a target, object or obstacle from the fixed reference point is called a position sensor.

It is used to measure the distance between the reference point and the present location of the object

They can detect the presence or absence of an object and provides position information like speed, distance, motion, direction etc.

Application of Position Sensors :-

* Labelling Control.
* Control printing process.
* Machine builders.
* Automotive testing.
* Elevators.
* Bridge movement and many.

Types of Position Sensor :-

1.) Linear position Sensor → LVDT.
2.) Rotatory or angular position sensors → RVDT.
3.) Inductive Position sensors.

≫ Proximity Sensor :-

A proximity sensor is a device that can detect or sense the approach or presence of nearby objects and for this it doesn't need physical contact. These sensors then converts the information about presence or movement of an object into an electrical signal.

"The essence of proximity sensor is detecting the movement presence of object without physical contact and converting that data into an electrical signal."

It is also known as "Proximity Switches" (in Japanese industrial).

→ The two main types of proximity sensors are:—

1.) Inductive.

2.) Capacitive.

1.) Inductive Proximity:— Inductive sensor is use the eddy currently generated in mettalic objects by electromagnetic induction. (Iron, copper, aluminium, brass) and Capacitive Proximity sensor type detect changes in electrical capacity in both metallic and non-metallic objects when approaching them with sensor.

2.) Uses:—

* As a magnets reed switches.
* Ultrasonic, photoelectric sensing etc.

3.) Common application of IR proximity:—

* Distance measurement.
* Security system such as surveillance, burglar alarms etc.
* Monitoring and control applications.

4.) Application of capacitive proximity sensor:—

* Moisture control.
* Non-destructive sensing.
* Industrial application.
* due to production automation.
* fluid level / composition / pressure detection.