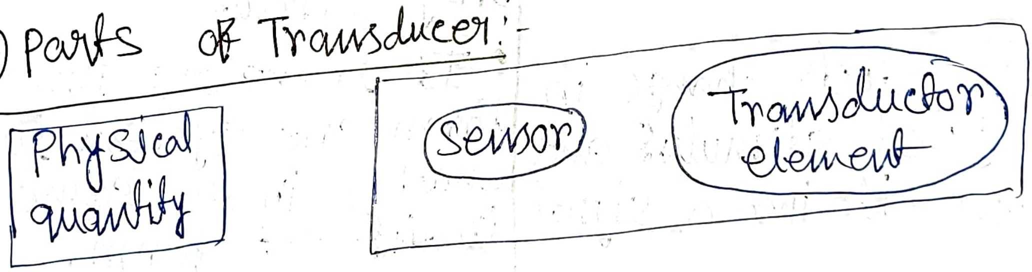
⊛ SENSOR and Transducer ⊛

1. Sensor:- Sensor is the device that detect the change in the environment. It can be temperature sensor, Pressure sensor or Humidity sensor. As we know sensors sense just like eyes and ears. Sensor measured information shall be sent to the processor or controller for them to work on it.

⊛ Transducer:-

Transducer is the device which transform energy from one form to another. It also transform a non-electrical physical into an electrical signal. It provides output response to specific input measured which may be physical quantity.

⊛ Parts of Transducer:-



- Temperature
- Pressure
- Light intensity
- Force

(*) Difference b/w Sensor and Transducer:-

Sensor	Transducer
• A device that convert Physical parameters to electrical output.	• A device that convert energy one form to another form is known as Transducer.
• The uses of sensor is for sensing element itself.	• The uses of transducer is for sensing element and also for circuitry
• In sensor changes its resistance with temp.	• In ~~sens~~ Transducer change in resistance to change in voltage
• All the sensors are not Transducer	• All Transducer contains a sensor
• It is a sensor when it responds to a stimulus.	• It becomes transducers when connected in a bridge circuit
• It detects change in Physical stimulus and turn it into a signal	• It transfers power form one system to another in the same or in different form.
• Example: Temperature sensor, and proximity sensor.	• Example: Strain gauge and piezoelectric Transducer.

⊛ Classification of Transducer:-

- → Based on transduction principle:-
  - → Resistance Transducer
  - → Capacitance
  - → Inductance
- → Active and passive Transducer
- → Primary and secondry Transducer
- → Analog and digital Transducer
- → Transducer and Inverse Transducer

⊛ Classification based on source of Energy:-

(i) **Active Transducer:-** In Active Transducers, the energy from the input is used as a control signal in the process of transferring energy from power supply to proportional output.

For exm:- A strain gauge is an Active Transducer

* **Passive Transducer:-** In passive Transducer the energy from the input is directly converted into the output.

For exm:- ThermoCouple is a passive transducer

(*) Characteristics of Transducer:-

Performance characteristics of transducer can be further classified into two types:

- Static characteristics
- Dynamic characteristics

(i) Static characteristics:-

The static characteristics of a transducer is a set of performance criteria that are established through static calibration i.e description of the quality of measurement by essentially maintaining the measured quantities as constant value or varying very slow.

(*) Some important static characteristics:-

(i) Accuracy:- It is specified by inaccuracy or usually error:

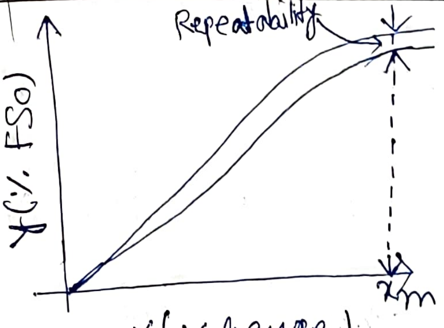
$$\varepsilon_a \% = \frac{x_m - X_\varepsilon}{X_\varepsilon} \times 100$$

or

$$\varepsilon_a \% = \frac{x_m - x_t}{x_t} \times 100$$

[t stand for true value
m for measured value, and
x stands for measurand]

(b) Precision:- Describes how far measured quantity is reproducible as also how close it is to the true value.



(iii) **Resulation:-** Is defined as the smallest incremental change in the input that would produce a detectable change in the output.

$$R_{max}(\%) = \frac{100(\Delta x)_{min}}{MR}$$

(iv) **Sensitivity:-**

It is the ratio of the incremental output to incremental input, that is

$$S = \frac{\Delta y}{\Delta x}$$

In normalized form, this can be written as,

$$S_n = \frac{\Delta y / \Delta x}{y / x}$$

2) **Dynamic characteristics:-**

The dynamic characteristics of transducer relate to its performance when the measured quantity is a function of time i.e. It varies rapidly with respect to time.

Dynamic ch:-

(i) Speed of Response

(ii) Fidelity - closeness to the true value

(iii) Measurement lag - classified into two types:- (a) Retardation type - Delay in seconds

(b) Time delay - Delay in minutes

(iv) Dynamic Error - measurement value - True value.

(v) Errors and its classification:-

- Gross Error
- Systematic error
  - Instrumental error
  - Environmental error
  - Observation error
- Dynamic error

(i) Gross Error:-

- Caused by human being
- Reading should be taken only after steady State is reached
- If not gross error occurs

② SYSTEMATIC Error:-

- Caused by fault in instruments
- classified into 3 types:

i) Instrumental error:-

- caused by wrong construction of the instrument
- Loading effect
- Hysterists, friction
- Improper handling of instrument can also couse an error.

(ii) Environmental Error:-

- Caused due to environmental conditions
- ~~Factors like improper vision angle of the observer~~
- Factors like pressure, humidity, temp can cause environmental error.

(iii) Observation Error:-

Caused due to improper vision angle of the observer.

Error caused by server is also called paralla error.

3.) Dynamic Error:-

- Caused by sudden changes in the experimental condition, noise

• Factors like voltage function, noise, resistance cause dynamic errors.

⊛ STRAIN GAUGE:-

- It is a type of electrical resistive transducer.
- Working on the principle of Piezo electric effect.

⊛ PIEZO Electric Effect:-

If a metal conductor is stretched and compressed its resistance changes on account of fact that both length and diameter of conductor changes. There is a change in the value of resistivity of the conductor when it is strain.

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

Where, R = Resistance of metal
ρ = Resistivity
L = Length of the material
A = Area of the metal.

Uses:-

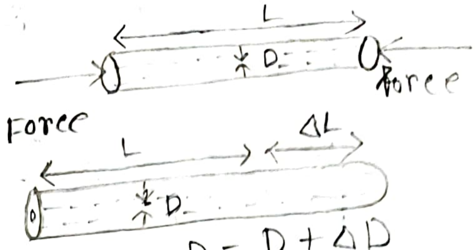
- Strain Gauge are used as tranducer in experimental stress analysis.
- Used with load cells, torque meter, diagram type, pressure gauge as secondary transducer.

Working Principle:-

$$R = \frac{\rho L}{A} \quad \text{—(1)}$$

$$\frac{\partial R}{\partial S} = \frac{\rho}{A}\frac{\partial L}{\partial S} - \frac{\rho L}{A^2}\frac{\partial A}{\partial S} + \frac{L}{A}\frac{\partial \rho}{\partial S} \quad \text{—(2)}$$

Divide by $\frac{1}{R}$



$D = D + \Delta D$
$L = L + \Delta L$

$$\frac{1}{R}\cdot\frac{\partial R}{\partial S} = \frac{1}{L}\frac{\partial L}{\partial S} - \frac{1}{A}\frac{\partial A}{\partial S} + \frac{1}{\rho}\frac{\partial \rho}{\partial S} \quad \text{—(3)}$$

WKT, $A = \frac{\pi D^2}{4}$

$$\frac{\partial A}{\partial S} = \frac{2\pi D}{4}\cdot\frac{\partial D}{\partial S}$$

Divide by A

$$\frac{1}{A}\cdot\frac{\partial A}{\partial S} = \frac{2\pi D}{4} \Big/ \frac{\pi D^2}{4}$$

$$\frac{1}{A}\cdot\frac{\partial A}{\partial S} = \frac{2}{D}\cdot\frac{\partial D}{\partial S} \quad \text{—(4)}$$

$$\frac{1}{R}\cdot\frac{\partial R}{\partial S} = \frac{1}{L}\cdot\frac{\partial L}{\partial S} - \frac{2}{D}\frac{\partial D}{\partial S} + \frac{1}{\rho}\frac{\partial \rho}{\partial S} \quad \text{—(5)}$$

Poisson ratio = $\frac{\text{Lateral strain}}{\text{Longitudinal strain}}$

$$\mu = -\frac{\partial D/D}{\partial L/L}$$

$$\frac{\partial D}{D} = -\mu\cdot\frac{\partial L}{L} \quad \text{— 6}$$

Substitute (6) in (5)

$$\frac{1}{R}\frac{\partial R}{\partial s} = \frac{1}{L}\frac{\partial L}{\partial s} + \frac{2}{\partial s}\cdot \mu \frac{\partial L}{L} + \frac{1}{\rho}\frac{\partial \rho}{\partial s}$$

$$\Delta R = \frac{\partial R}{\partial s}, \quad \Delta L = \frac{\partial L}{\partial s}, \quad \Delta \rho = \frac{\partial \rho}{\partial s}$$

$$\frac{\Delta R}{R} = \frac{\Delta L}{L} + \frac{2\mu}{L}\Delta L + \frac{\Delta \rho}{\rho}$$

$$\left[\frac{\Delta R/R}{\Delta L/L} \quad \frac{\Delta L}{L} = \epsilon_1 \right.$$

Divide by $\Delta L/L$

Gauge Factor, $GF = 1 + 2\mu + \frac{\Delta\rho}{\rho}/\epsilon$

Piezo electric effect

$$\boxed{GF = 1 + 2\mu}$$

Types:-

1. unbonded metal guage
2. Bonded Metal strain guage
3. Bonded Metal foil strain gauge
4. vaccum deposited thin metal film strain guage.
5. sputter deposited thin metal film strain gauge
6. Bonded Semi-conductor strain gauge
7. Diffused metal strain guage.

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Application:-

- Experimental stress analysisis of machines & streaches
- Construction of force, torque, pressure, flow and allelaration. transducer.

Resistance Temperature Detector (RTD):-

- Resistance Thermometer, another name of RTD.
- An RTD is a sensor whose resistance changes as its temperature changes. The resistance increases as the temperature of the sensor increases. The resistance VS temperature relationship is well known and is repetable over time. An RTD is a passive device
- **Principle:** The value of R changes, when temp is changed
- **Construction:** $R = R_0(1+\alpha_1 T_1 + \alpha_2 T_2 + \cdots + \alpha_n T_n)$

- Positive temp co-efficient
- Platinum — withstand high temp
  — excellent stability
  — less susceptible for contamination

• Other matrials:-

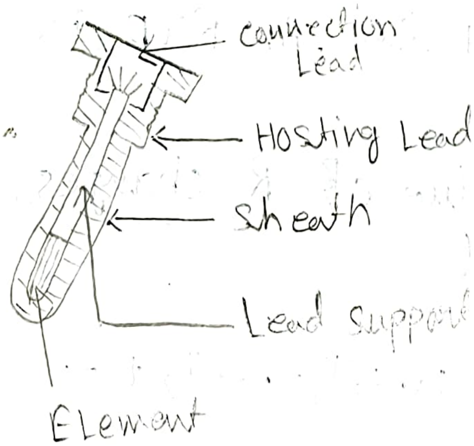
• Silver and gold → less resistivity
• Tungsten → high resistivity
• platinum nickle and Alloy nickle

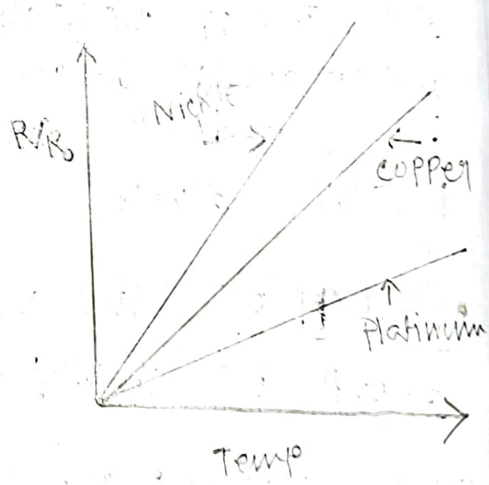
* Requirements:-

(i) R=↑, The changes in the resistance of material per unit change in temperature should be as large as possible.

(ii) Material should ~~be~~ have high value of resistivity, so that minimum value of meterial is used.

(iii) Resistance of material should have a continuous and a stable relationship with temperature.





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(*) Thermistor:-

Thermistors are a type of semiconductor, meaning they have greater resistance than conducting materials, but lower resistance than insulating materials.

- It is a special type of resistor whose resistance changes with change in temp.
- When temp is increasing the resistance value is decreasing.
- Thermistor have a -ve temp co-efficient of resistance.
- Thermistor are used for presistion temp measurement, temp control and temp compensation.
- Thermistor varies from -60°c to 15°c

Resistance varies from 0.5 Ω to 0Ω

Thermistor are highly sensitive but have a non-linear characteristis of resistance vs temp.

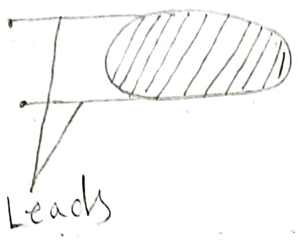
* Construction:-

- Manganeos (Mn), Neckle, cobult, copper iron and urenium are the materials that are used to construct the thermistor.

• Thermister is having different shapes and sizes.

i) Bead ii) Glass probe (iii) Disc

i) Bead:-

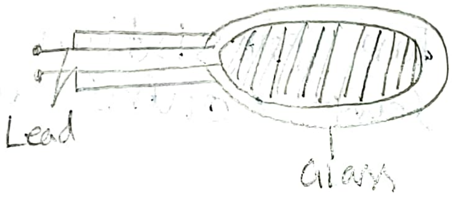


Daimeter of 0.015mm to 1.25 mm

(ii) Glass probe:

Diameter of 2.5 mm
length - 6mm to 50mm

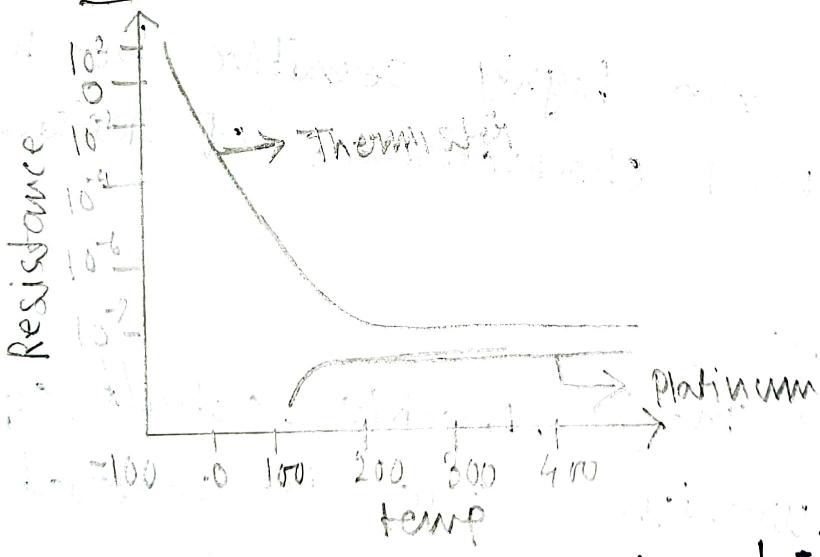
(iii) Disc



Diameter - 2.5mm to 25 mm

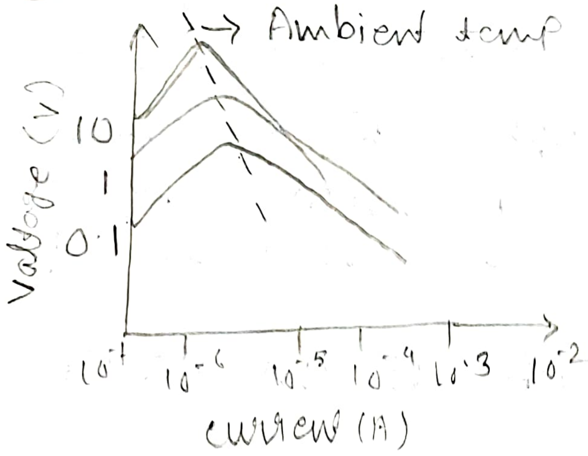
⊛ Characteristics:-

(i) Resistance VS Temp

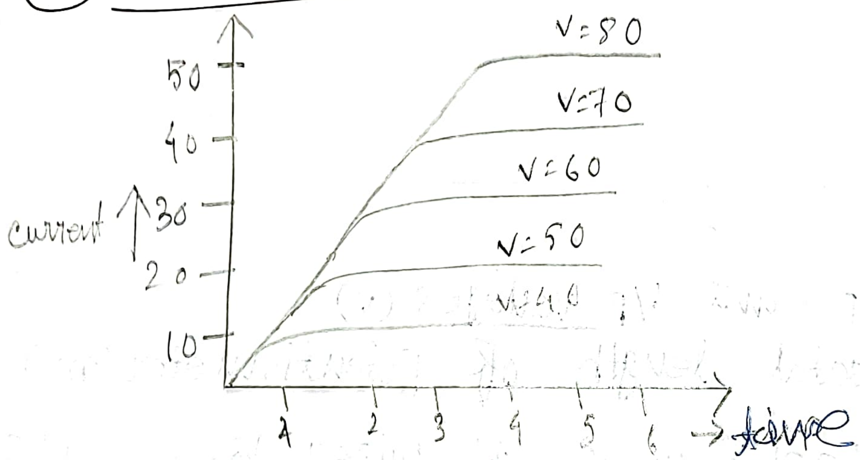


$$R_T = R_{T_2}\left[\exp\left(\beta\left[\frac{1}{T_1} - \frac{1}{T_2}\right]\right)\right]$$

(iii) Voltage and current characties:-



(iii) current -~~Temp~~:- Time



(*) ADVANTAGES:-

compact, rugged and ~~inexpensive~~ less expensive

Good stability, highly sensitivity

Response time is fast,

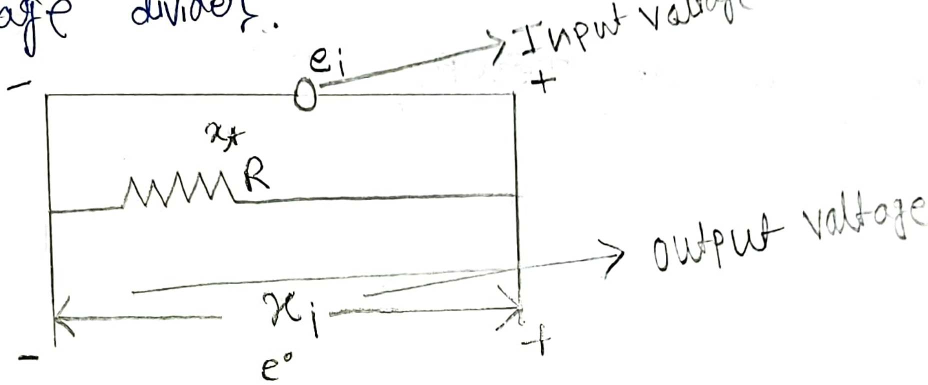
~~Not affected by strong electric and magnatic field~~

Not affected by electrical and magnetic Feild.

⊛ Resistance patentiometer (POT)

A patentiometer (also know as a POT or patmeter) is defined as 3 terminal variable resistor in which the resistance is manually varied to control the flow of electric current.

A patentiometer acts as an adjustable valtage divider.



$e_o\ e_i \rightarrow$ O/P and I/P valtages (V)

$x_t \rightarrow$ total length of patentiometer (m)

$x_i \rightarrow$ Displacement of wiper from its zero position (m)

$R_p \rightarrow$ Total resistance of patentiometer

Resistance per unit length $= R_p / x_t$

output valtage $e_o = \left(\dfrac{\text{Resistance at O/P}}{\text{Resistance at I/P}}\right) \times$ I/P valtage

$$e_o = \frac{R_p (x_i / x_t) \cdot e_i}{R_p}$$

$$\frac{e_o}{e_i} = \left(\frac{x_i}{x_t}\right)$$

$$\frac{O/P}{I/P} = \frac{e_o}{e_i} = \frac{x_i}{x_t}$$

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Characteristics of POT:-

(i) Resistance potentiometer are (POT) are type of electrical resistive transducer.

(ii) It converts non electric energy to electric enegy. that is displacement/resistance converts into valtage.

(iii) The resistance $R = \frac{\rho L}{A}$

(iv) potentiometer consits of a resistive element provide with sliding ~~con~~ wiper.

(v) The motion of the sliding contract can be translational or rotational.

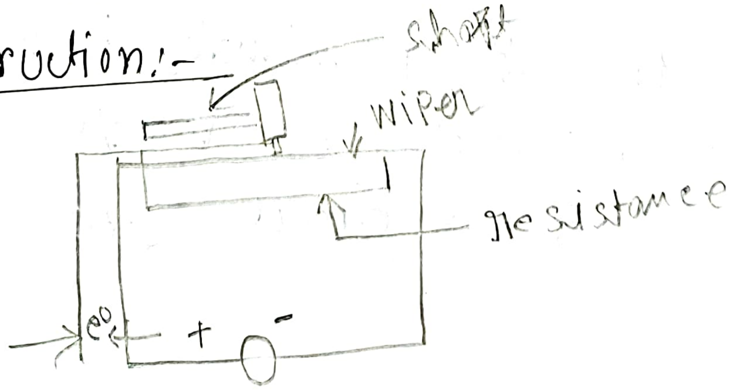
(vi) Resistance element can be exited by either AC or DC valtage.

(vii) POT possible transducer, It requires for its operation an external source.

(viii) Resistive body of potentiometer may be wire wound

(ix) 0.01 mm diameter of Platinum are nickle alloy is carefully wounded on an insulator format.

* construction:-



Linear POT

(#) potentiometer Types:-

- Ratary potentiometer.
- Linear Potentiometer

(i) Ratary Patentiometer:-

The rotary type potentiometers are used mainly for obtaining adjustable supply valtage to a part of electronic circuits and electrical circuits.

Ex:- The valume controller of a radio transistor is a popular example of a rotary potentiometer where the rotary knob of the potentiometer contpols the supply to the amplifier.

(ii) Linear Potentiometers:-

The linear patentiometer is basically the same but the only difference is that here instead of ~~a straight resistor~~ rotary movement the sliding contact gets moved on the resistor linearly

This type of patentiometer is mainly used to measure the valtage across a branch of a circuit etc.

Value-12

Explain in detail about various types of errors associated in measurment and how these errors can be minimized

→ আগের আগেত Types of error :-

Minimized the error :-

You can ~~errors the~~ avaid systematic error through careful design of your sampling, data collection, and analysis procedures.

- Make sure the formulas used for measuriment are correct
- cross checked the measured value of a quantity for improved accuracy.

use the instroment that has the highest precision

It is suggested to pilot test measuring ~~intr~~ instruments for better accuracy.

use multiple measures for the same construct.

(i) Gross error:-

This category basically account on human oversight and other mistake reading record ing. The most common human error in measurment falls under this category of measurment error.

- caused by human being.
- Reading should be taken only after steady state reduced.

(ii) Systematic error:-

This type of error caused by fault in instrument.

This divide into 3 part:-

(i) instrumental error:-

This error occurs due to fault ~~construction~~ construction and calibration of the measuring instrument.

(i) Loading effect, friction

(ii) Improper handling of instrument is also caused of this error

(ii) Environmental error:-

This type of error arises due to environmental condition, and also pressure himudity, temp can caused for this error.

(iii) Observational error:-

This type of error arises due to improper vision angle of the observer. In this error caused by server which is called parallal error.

(3) Dynamic error:-

Dynamic error caused by sudden changes in the experimental condition, noise factors like valtage function, noise resistance caused dynamic error.

(4) characteristics of sensor:-

(i) Electrical characteristics
(ii) mechanical "
(iii) Thermal "
(iv) Optical "
(v) Biological "
(vi) chemical "

UNIT-2

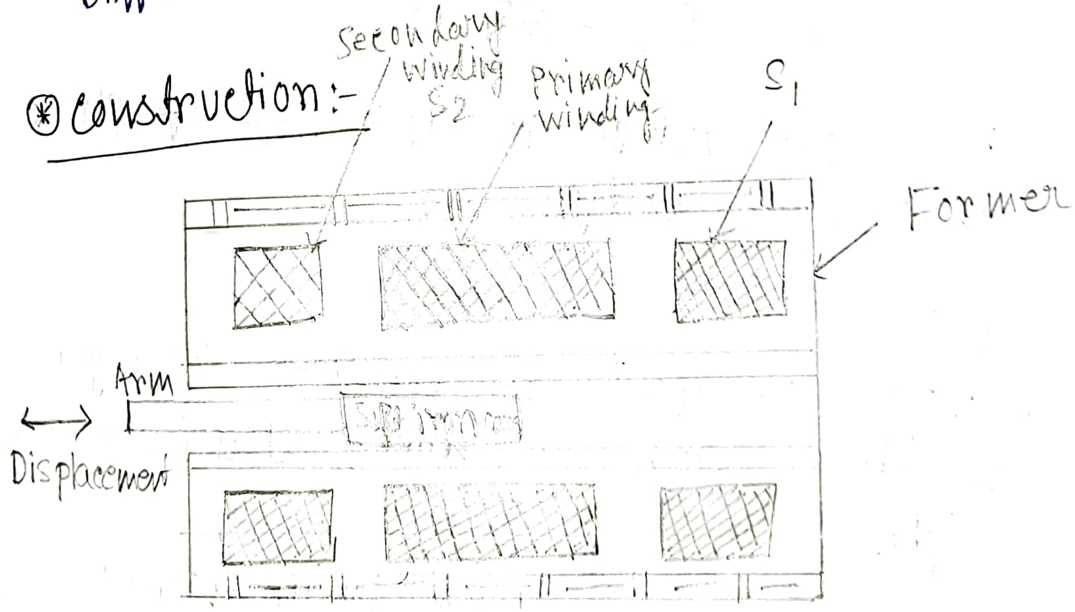
Q.1 Linear variable Differential Transfer (LVDT)

⇒ Explain:-

Introduction:- Linear variable Differential Transformer LVDT is the most used inductive transducer for converting translating linear motion into electrical signal. This transducer converts a mechanical displacement proportionally into electrical signal.

- Linear motion converted into electrical signal.
- Transformer — Primary windings / secondary windings
- Differential → Difference of the output voltage.

✻ Construction:-



(*) Working Principle:-

The core at the center,
The output valtage E_0 is

$$E_0 = ES_1 - ES_2$$

$$ES_1 = ES_2$$

$$E_0 = 0$$

The core is moving left to the arm

$$E_0 = ES_1 - ES_2$$

$$ES_1 > ES_2$$

$$E_0 = ES_1 - ES_2$$

The output valtage is inphase with the Primary valtage.

(*) The core is moving right to the arm

$$ES_2 > ES_1$$

$$E_0 = ES_2 - ES_1$$

The output valtage is 180°c out of phase in Primary valtage.

(*) Application:-

- LVDT is used to measure the physical quantities such as force, tension, Pressure, Weight, etc.
- It is mostly used in industries as well as a servomechanism.
- It is also used in Industrial Automation, Aircraft, Turbine, satellite, hydraulics etc.

- Range of Measurment:- ±0.25 m to ± 750 mm
- operating Temp: (−265 to 600) degree celsius
- Frequency Range: 50 Hz to 20 KHZ

Advantage:-

1.) Smooth and wide range of operation
2. High sensitivity
3. Low Hysteresis Losses
4. Low friction Losses
5. Rugged operation
6. Low power consumption
7. Direct convertion to Electrical signal
8. Fast dynamic Response.

Dis advantage:-

Since, LVDT is inductive Transducer, so it is sensitive to stray magnetic field. Hence an extra setup is required to protect it from stray magnetic field.

Since it is an electromagnetic device, so it also gets affected by the vibration and temperature variation.

Parallel plate capacitive sensor:-

Introduction:- A parallel plate capacitor behaves as open circuited when we connect a DC source across it, while it acts as a short circuit when we connect an AC source to it. The said property of a parallel plate capacitor makes it suitable for filtering of harmonics from AC supply.

Capacitive sensor measure a physical quantity by measuring the change in capacitance.

→ Parallel plate capacitance is given by

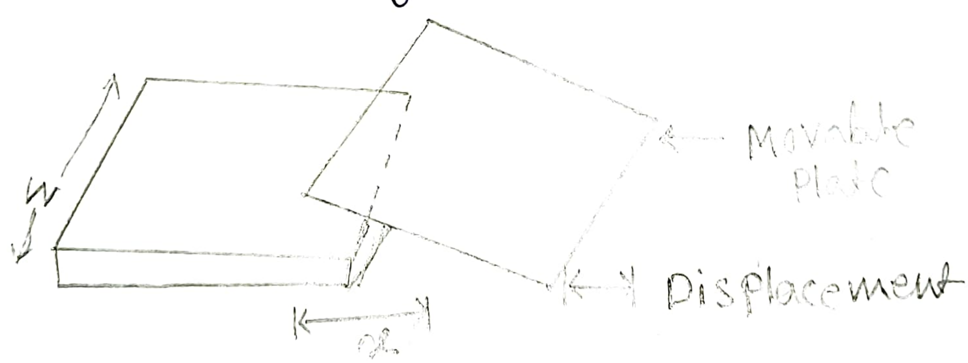
$$C_p = \frac{\varepsilon A}{d} = \frac{\varepsilon_0 \varepsilon_r A}{d} \quad \text{--- (i)}$$

ε → Permitivity of the medium.

$\varepsilon = \varepsilon_0 \varepsilon_r$

d = distance

A = overlapping Area



$$C = \frac{\varepsilon A}{d} = \frac{\varepsilon x w}{d}$$

$$\text{sensitivity} = \frac{\partial C}{\partial x} = S$$

$$S = \frac{\partial C}{\partial x} = \partial\left[\varepsilon x w / d\right]$$

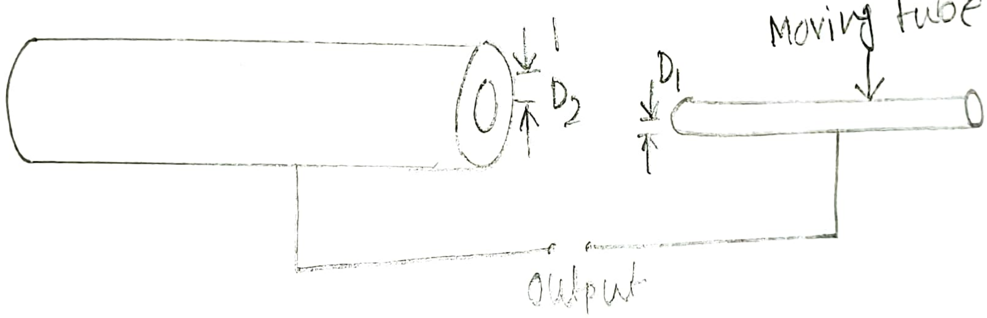
$$\frac{\partial C}{\partial x} = \frac{\varepsilon_1 w}{d}$$

* **sensitivity :-**

$$S = \frac{1}{C} \cdot \frac{\partial C}{\partial x} = \frac{d}{\varepsilon A} \times \frac{\varepsilon W}{d} \quad (\because A = w x)$$

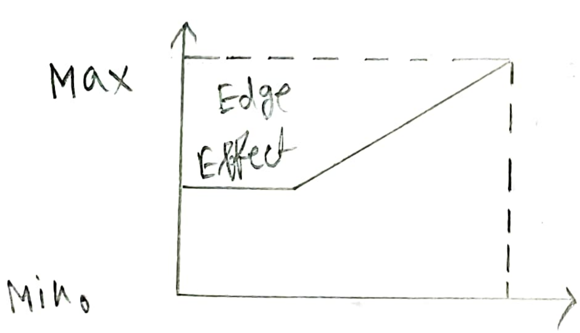
$$S' = \frac{1}{C} \cdot \frac{\partial C}{\partial x} = \frac{1}{x}$$

(*) Measure Linear displacement ranging ~~from to~~ from 1mm to 10mm



$$C = \frac{2\pi \varepsilon x}{\ln(D_2/D_1)}$$

$$S = \frac{\partial C}{\partial x} = \frac{2\pi\varepsilon}{\ln(D_2/D_1)} \quad F/m$$



UNIT-3

Write short notes about various types of thermo couple based on metarial used and temp of operation.

→ A Thermocouple is a sensor used to measure temperature. A thermocouple consists of two dissimilar metals, joined together at one end, which produced a small valtage when heated. This valtage is measured and used to determine the temperature of the heated metals. The valtage for any one temperature is unique to the combinatio of metals used.

Types:-

Type-B:- Type B thermocouples can be used up to 1600°c with short term excursions up to 1800°c. They have a low electrical output, therefore are rarely used below 600°c.

Type E:- Type E thermocouples are often referred to as chrowel-constant thermocouples. They are more stable than type-K.

Type-J:- J type of thermocouple is formed with iron and constantan. 0 to 760° is its temperature range.

J-types thermocouple is best suited for vacuum and inert environment.

K-Type:- Type K thermocouples are the most widely used thermocouples in the oil & Gas and refining industries due to their wide range and low cost.

Type -N:- Type N thermocouples can handel higher temperatures than type K, and offer better repeatibility in the 300 - 500°c range.

Type-R:- Type R thermocouples cover similar applications as Type S but offer improved stability and a marginal increase in range.

Type R tend to be used in preference to type S.

Type-S:- Type 'S' thermocouples can be used at temp up to 1450°C. temp range 980°c to 1450°C. S type thermocouple is used in applications invalving very high temperatures. This type is widely used across various

T-type:- It is formed with Copper and Constantan. Temp range between -200°c to 370°c. They are rarely used in industrial applications. They are commonly used in food production.

Unit-3 value-4

Characteristics of Radiation sensor:-

Radiation is the ~~from~~ emission of energy from matter in the form of rays or high-speed particles. Broadly it can be thought of as either electromagnetic radiation or particle radiation.

Radiation sensor or Radiation Detectors are devices that can sense and measure radiation. The radiation sensor discussed here are mostly based on the Photoelectric ~~efects~~ effect.

Types:- detectors

(i) Gas-filled radiation detectors
(ii) scintillation radiation "
(iii) solid-state radiation "

Types of Radiation:-

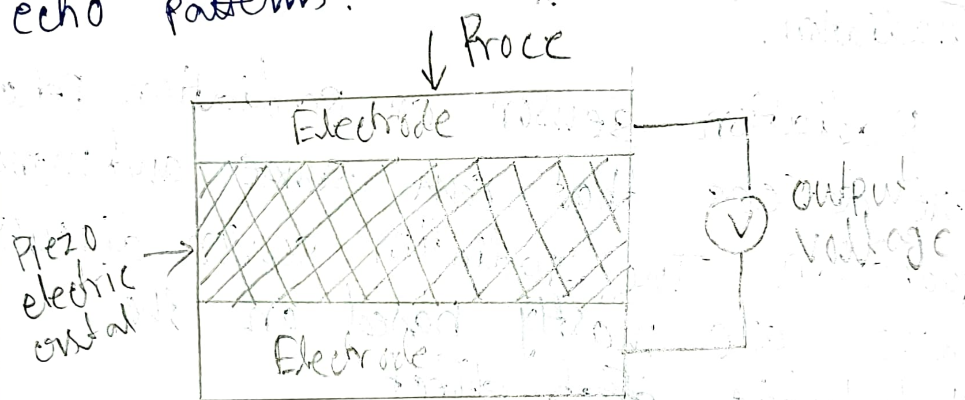
(i) Alpha radiation
(ii) Beta "
(iii) Gamma radiation

① Short note on ultrasonic sensor?

→ An ultrasonic sensor is an ~~[illegible]~~ instrument that measures the distance to an object using ultra sonic waves.

An ultrasonic sensor uses a transducer to send and recive ultra sonic pulse that relay back information about an object's proximity.

High frequency sound waves reflect from boundaries to produce distinct echo patterns.



(*) ultra sonic piezo crystals operate in the range of 0.5 - 10 MHZ

(*) For continuos wave operation, the sensor is energized by a tuned oscillator.

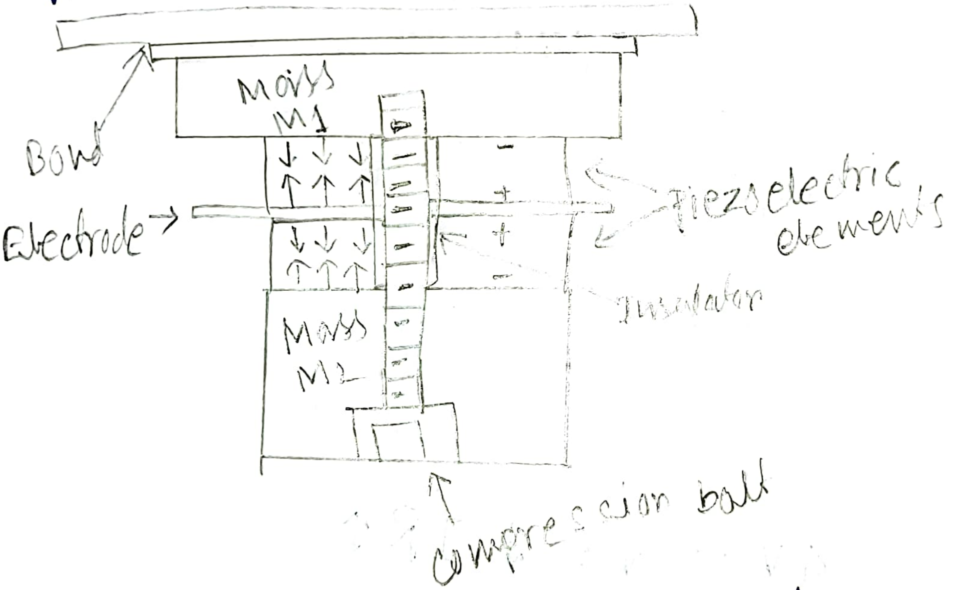
(*) A strong piezo electric effect has been observed through $PbZrO_3 - PbTiO_3$

⊛ Magneto-strictive Transducer ?

A magneto-striction transducer is a device that is used to convert mechanical energy into magnetic energy and vice versa.

A change in mechanical stress of a ferromagnetic material causes its permeability to change. This phenomenon is called as Joule effect.

The reverse effect of Joule effect is called as magneto striction or villari effect.



Note:- Magnetostrictive transducer is not popular as a transducer, because of its limitation.

It is two different type → ① The variable permeability type and ⓘⓘ the variable remanence type.

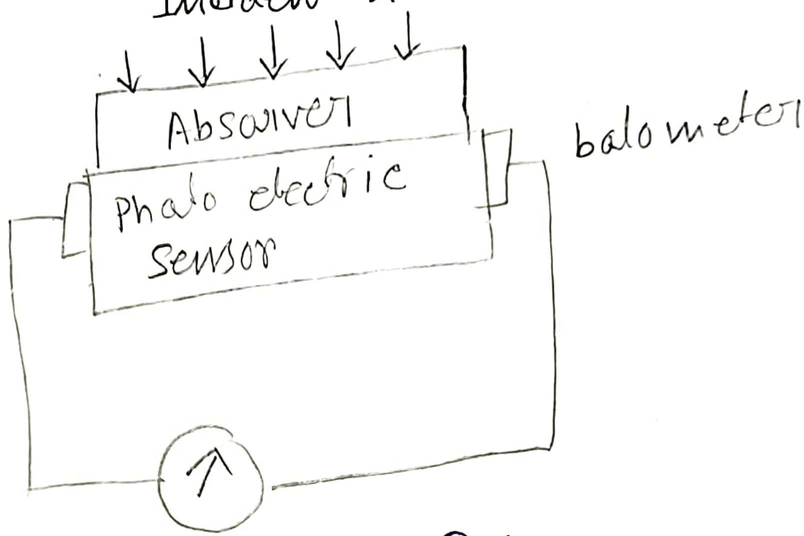
(9) Acoustics temperature sensor:-

(9) scintitation sensor
capacitive transducer.

(*) Pyro electrical Thermal sensor:-

→ It is a thermal detector
→ It is made of ~~Infar~~ Infrared sensitive electronic component.

Incident radiation.



$\Delta V = V = \downarrow IR \uparrow$

Types:-
(i) Through beam
(ii) Retro reflective
(iii) Diffused.

Thermal Sen
temp. meas
(f) Pyro electr
It is us
stations f

It is use
caldness.

It is
magnetic

(1) Pyro elec

(2) When
friction
to the

(3) The
the p
the oxys

(4) This
tempara

(5) This
by A

(6) B
detac
inced

Thermal Sensor is used to detect the temp.
temp. measurment through electrical signal.

(*) Pyro electrical Thermal Sensor Application
It is used in Airport and railway stations to detect the unwanted metarials.

It is used to find degree of hatness and caldness.

It is used to detect the electro - magnetic ~~field~~ radiation.

1. Pyro electric sensor are thermal detector
2. When subjected to a small temp ~~friction~~ friction they can give rise to the temp valtage.
3. The change in the temp modifies slightly within the position of atom the crystal structure.

4. This leads to be development of temporary valtage accross the crystal.
5. This temp - gradient can be created by Absorption of light.
6. Bolometer is a device used for detaching & measuring power of incedent E.M.R

8) P.E.s can be used as a temp. sensor element.

In P.E heat is generated and ~~temp~~ with temp changes.

9) This change in temp give rise to temporary voltage across the P.E.s

10) It is fine for sensor but not for ~~meani~~ meaning generation

$\Delta V = V = IR$

value-4

Synchro :-

The synchro is a type of transducer which transforms the angular position of the shaft into an electrical signal. It is used as an error detector and as a rotary position sensor.

The error occurs in the system because of the misaligment of the shaft.

types:-

1. control type synchro
2. Torque Transmission type Synchro

(i) Torque

This ty
output
for ru
Pointer

(ii) contro

The
error

Rotor
coil

(*) wo

The
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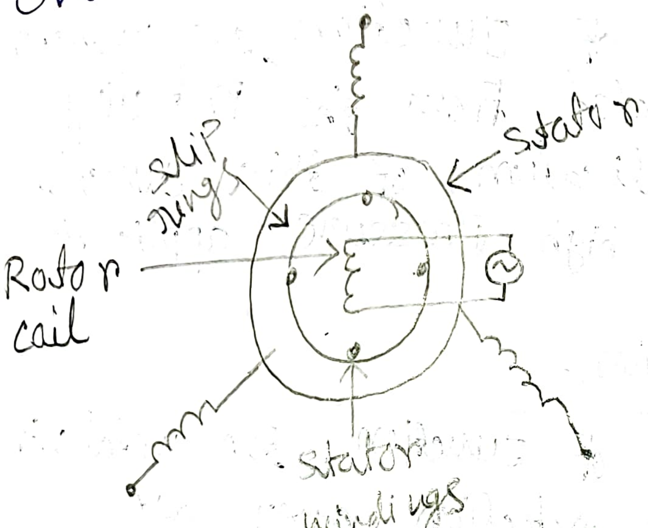
me

(i) Torque Transmission Type synchros

This type of synchros has small output torque, and hence they are used for running very light load like a pointer.

(ii) control type synchros system:-

The controls synchros is used for error detection in positional control system.



(*) working Principle of thermocouple:-

Thermocouple is type of sensor ~~which~~ used to measured the temperature. A thermo-couple consist of two dissimilar metal, which are both to connected together at end point. which produced a small voltage when heated. This voltage is measured and used used to determine the temp of the heated metal.

Construction:-

It used to different metal wires and that are connected together at the Junction end. The end of the Junction classified into 3 types – (i) ungrounded
(ii) grounded
(iii) Exposed Junction

(i) Ungrounded Junction:-

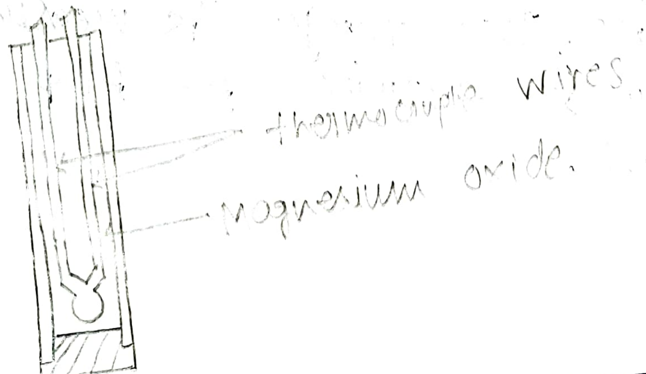
In this type of Junction, the conductors are totaly separated from the protecting cover. The application of this Junction mainly used in high pressure application works.

(ii) Grounded Junction:-

In this type of Junction the metal wire as well as the protection cover are connected together.

(iii) Exposed Junction:-

The exposed Junction is applicable in the areas where a quick response is required. This Junction is use to measure the gas temperature.



ct-3

① smart Sensor:-

A smart sensor is a device that takes input from the physical environment and uses built-in compute resources to perform predefined functions upon detection of specific input and then process data before passing it on.

smart sensor enable more accurate and automated collection of environmental data

sensors + Interfacing hardwares = smart sensors.

(*) Features of smart sensor:-

1.) Automatic ranging and calibration of data through a built-in system.

2.) Automatic DAS and storage of calibration constants in a local memory of the field device

3. Automatic linearization of non linear transfer function

4. Auto-correction of offset, time and temp.

5. self-tuning control algorithm.

6. Intiates communication through a serial bus.

(*) Application :→

(i) General Application
(ii) Industrial "
(iii) Medical "

(i) General Application:-

(i) Adjust the deviation of the output of the desired value.

(ii) Broadcast information about its own status.

(iii) Allows one to obtain the average variance and standard deviation for the set of measurments.

(ii) Industrial Application:-

(i) Smart sensors so implemented for this structural monitoring application are used for detecting any type of defects.

(ii) Geological Mapping is needed mainly to detect the minerals in the geological areas.

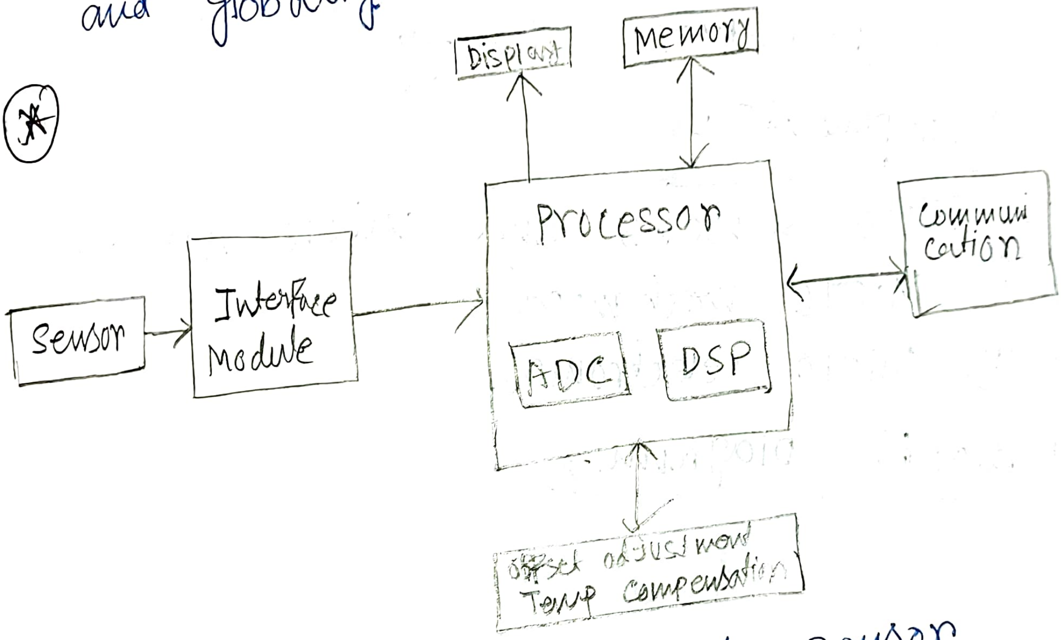
(iii) Digital imaging & interpretation of tunnel geology

(iv) Remote measurements of tunnel response.

✱ Medical Application:->

1.) Medical diagnostics
2.) safety hazards detection and warning
3.) Food Safety.
4.) Biological hazards detection
5.) Health monitoring.
6.) Environmental monitoring both locally and globally

✱



* Block diagram of smart sensor.

Micro Electro mechanical system:→

Introduction:→

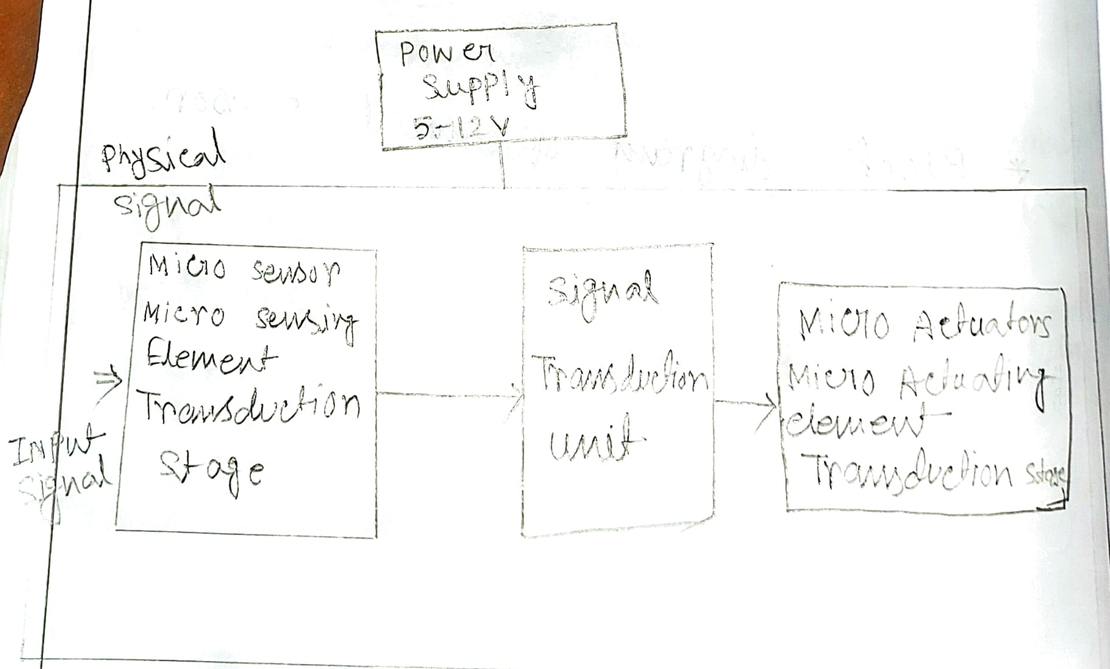
Miniatured Mechanical and Electromechanical elements that are made using the techniques of micro fabrications, micromachining or ~~wa~~ micro manufacturing.

In other word, MEMS is a precision device technology that integrates mechanical element, sensors, actuators and electronics on a common silicon substrate through micro fabrication technology.

components:→

(i) Micro sensors and micro Actuators
(ii) Micro mechanical
(iii) Micro electronics.

Block Diagram:→



(*) working:-

manufacturing Process:-

(i) Micro maching / Micro manufacturing
(ii) Isatropic & Anisotropic etching
(iii) Depositing and patterning
(iv) Deep x-ray Litography
(v) Electroplating.

(*) Advantage:→

(i) smaller in size
(ii) Lower power construction
(iii) More sensitive to input variation
(iv) cheaper to mass protection.
(v) battery Stability

(*) DisAdvantage:→

(i) complex design
(ii) micro component or costly
(iii) establishment required huge cost

(*) Application:-

(i) It is used in automative industries.
(ii) Hand craft and chemical
(iii) Industrial automation and manufacturing
(iv) Defence space and aromatical.
(v) Environmental and help sciences.
(vi) computing and communication
(vii) consumer product.

⊛ NANO Sensor:-

Introduction:- It is a nano scale device convert physical quantity into electrical quantity.

Defination:- Nanosensors are nonoscale devices that measure physical quantit and convert these to signals that can be detected and analyzed

In other words, "Nanosensor" are chemical or mechanical sensors that can be used to detect the presence of chemical species and nanoparticles, or monitor physical Parameters such as temperature on the nanoscale." They find use in medical diagnostic applications, Food and water quali sensing, and other chemicals"

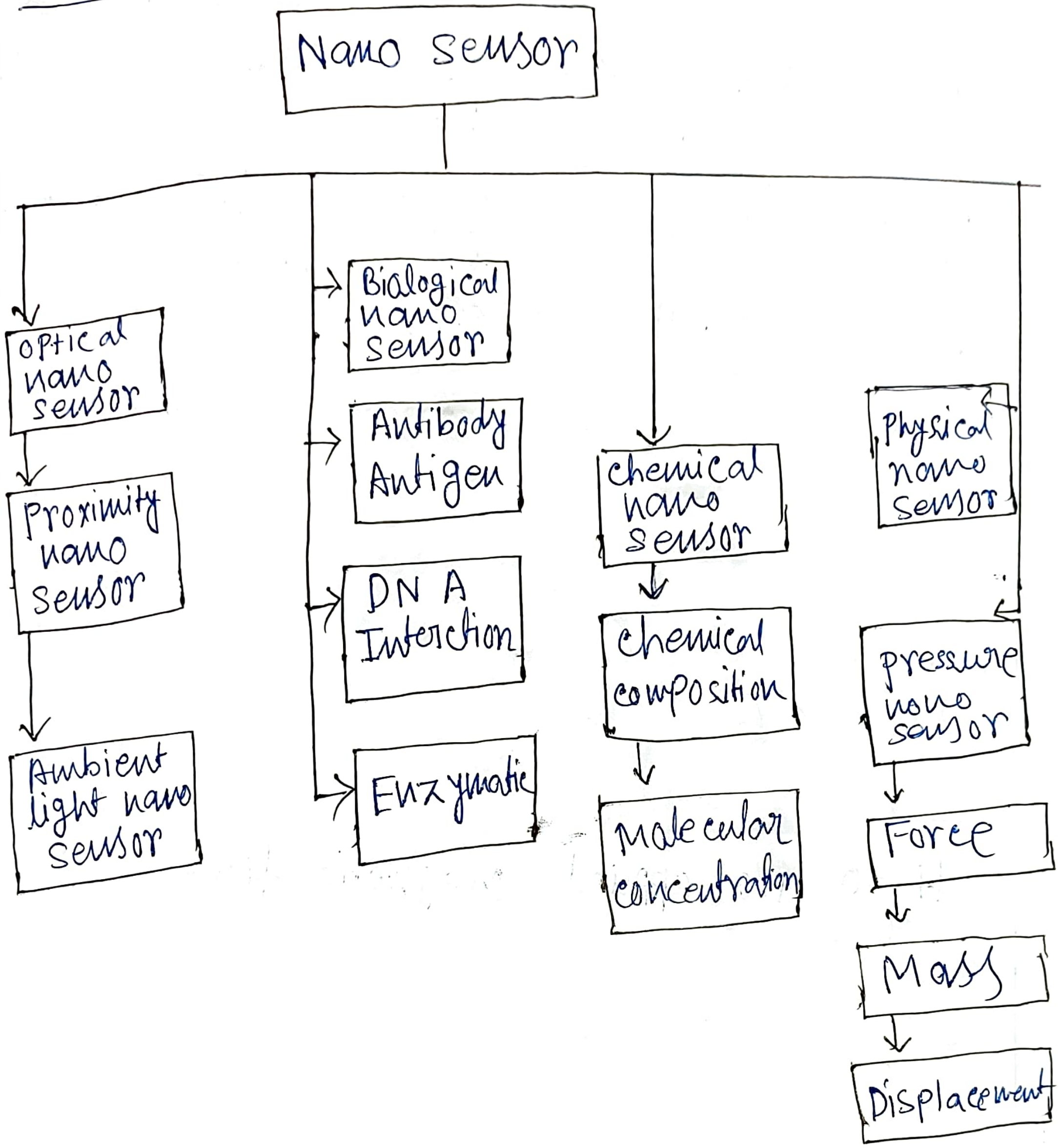
Types:-

(i) Top Down Litography
(ii) Bottom up Assembly

⊛ Application:-

(i) To detect various chemicals in gases for pollution monitoring.
(ii) Defense and Military
(iii) For medical diagnostic purposes
(iv) As accelerometers in MEMS devices like airbag sensors.
(v) Agriculture

Types of nano sensors:-

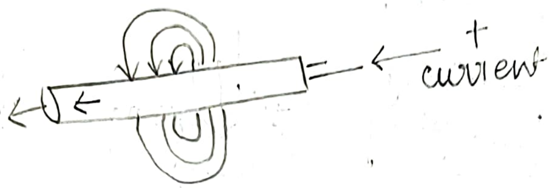


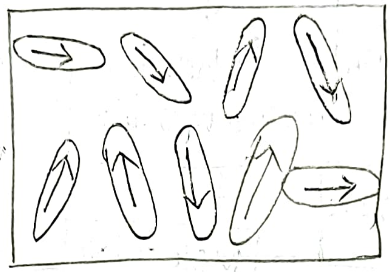
Villari Effect:-

It is a converse of megnetostriction process. The longitudinal deformation leads to change in magnetic permeability (M) of the material in the direction of the applied stress. It is also called as Inverse Magnetostrictive effect.

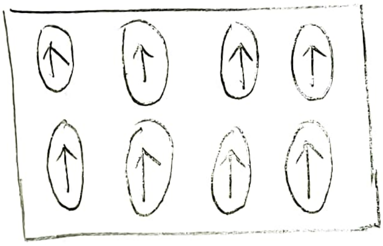
widemann effect:-

The widemann effect is one of the the manifestations of magnetostriction in a field formed by the combination of a longitudinal magnetic field and a circular magnetic field that is created by an electric current.

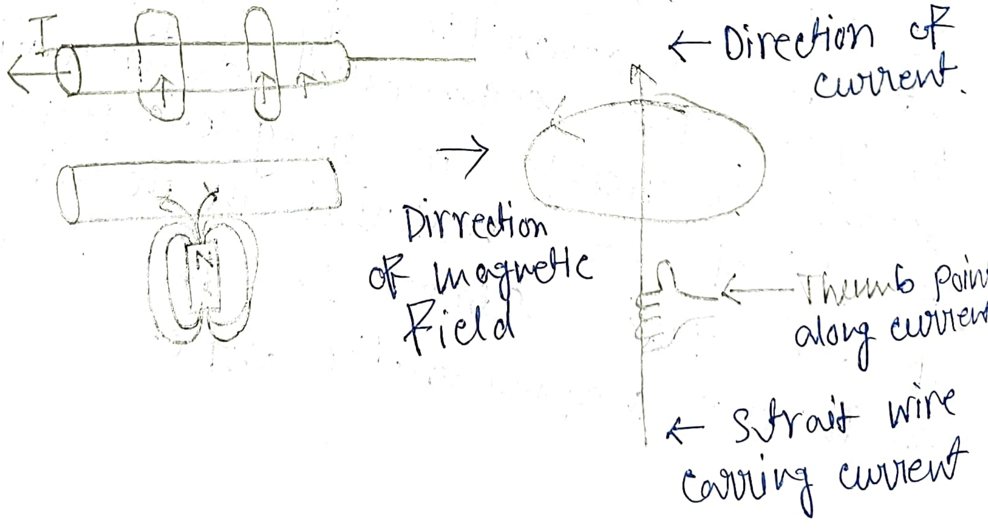




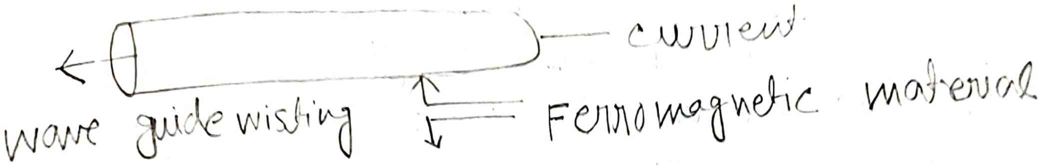
H = 0 No applied Magnetic field

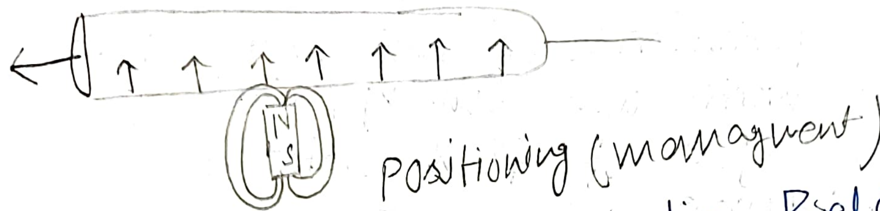


↑H field (vertical) Magnetic field



Due to circular Magnetic field ↑ Due to axial magnetic field ←or→





Hall effect:- when a magnetic field is applied to current carry conductor in a direction perpendicular in that of flow of current a patential difference transfer electric feild is created across a conductor this phenomenan is called hall effect.

(*) Joule effect:- A magnetoelastic sensor operates based on Joule, villari and wideman The Joule effect and Joule law which is physical effect discovered by James prescott Joule. Joule heating a physical ~~heating~~ law expression the relation between the heated generated and current flowing through a conductor

UNIT-5

(*) Ultra Sonic flow meter :-

What is USFM :- An ultrasonic flow meter can be defined as a meter that is used to measure liquid velocity with ultrasound to analyze the volume of liquid flow. This is a volumetric flow meter that needs bubble or minute particles within liquid flow. These meters are suitable in the applications of wastewater but they will not work with drinking / distil water. So this type of flow meter is ideal for the applications wherever chemical compatibility, low maintenance and low-pressure drop are required.

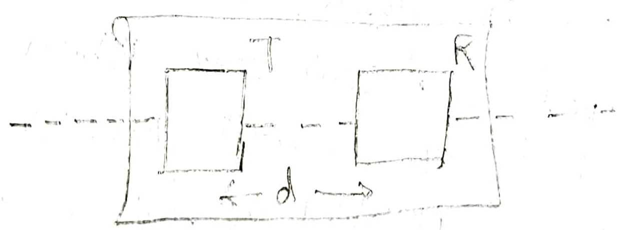
Principle :-

(*) Transmit Time

(*) under no flow condition

(*) under flowing condition.

(*) construction and working :-



(i) Transit time in the direction of flow $\Delta t_1 = \frac{d}{C-V}$

(ii) Transit time in the opposite

direction.

$$\Delta t_2 = \frac{d}{c-v}$$

$c \rightarrow$ velocity of sound propagation

$v \rightarrow$ linear velocity of flow

* A sinusoidal signal travelling in the flow direction has a phase shift.

$$\Delta \phi_1 = \frac{2\pi f d}{c+v} \text{ rad}$$

$$\Delta \phi_2 = \frac{2\pi f d}{c-v} \text{ rad}$$

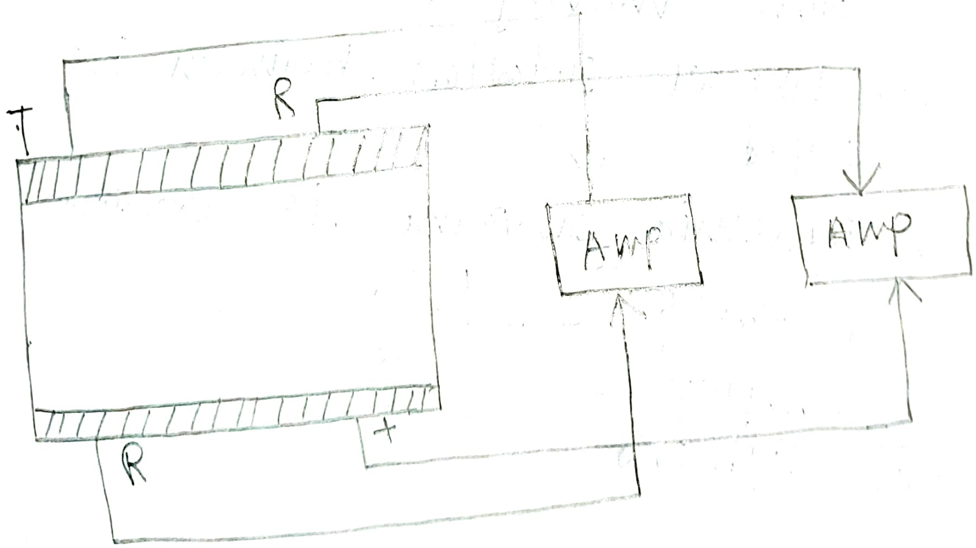
Difference in transmit time

$$\Delta t = \Delta t_1 - \Delta t_2$$

$$\Delta t = \frac{2dv}{c^2 - v^2}$$

if $c \gg v$

$$\Delta t = \frac{2dv}{c^2}$$



* Frequency Based System.

* Frequency in forward propagating [cut off]

is $\frac{1}{\Delta t_1}$

" " Backward " is → $\frac{1}{\Delta t_2}$

$$\Delta t_1 = \frac{d}{c + V\cos\theta}, \quad F_1 = \frac{1}{\Delta t_1} = \frac{c + V\cos\theta}{d}$$

$$\Delta t_2 = \frac{d}{c - V\cos\theta}, \quad F_2 = \frac{1}{\Delta t_2} = \frac{c - V\cos\theta}{d}$$

$$\Delta F = F_1 - F_2 \Rightarrow \boxed{\Delta F = \frac{2V\cos\theta}{d}}$$

* Advantage:-

(i) No abstraction to the flow

(ii) Insensitive to variation ~~in vis cost~~ in viscosity Density and temperature

~~Density and temp~~

(iii) None moving parts

(iv) Linear relation between input and output

(v) Dynamic response is excellent

* Dis Advantage:-

(i) complex

(ii) High cost

* Application:-

(i) Measure the velocity of liquids tha[t] allow ultra sonic waves to pass

Ex:→ Water, malten sulfur, cryogenic liquids and chemicals

(ii) Measure vapper and glass flow

(iii) It is used in industries like power chemical, load and pre villeges industries metal and mining, oil, Gas water and waste water industries.

Value-4

What is magnetoelastic sensor

→ A relatively new type of sensor, based on the magnetoelastic effect, is a simple, low-cost technalogy that uses non-contact sensing to provide accurate torque measurement for rotating or stationary shafts. The key components in a magneto elastic sensor is a ferromagnetic ring attached to the shaft being measured.

Working:- The key component in a magneto elastic sensor is a ferromagnetic ring attached to the shaft being measured. Alternatively, if the shaft is ferromagnetic a section of the shaft can be permanently magnetize to produce a ~~[illegible]~~ magnetic feild, eliminating the need. for an external ring.

9.) Venturimeter:-

Fluid flow measurement means measuring the rate of flow of a fluid flowing through a pipe or through an open channel. The rate of fluid flow through a pipe is measured by a venturimeter.

It is a device in which pressure energy is converted into Kinetic energy and is used to measure the rate of flow through a pipe.

Or in otherwords, a venturimeter is a tube with a constricted throat that increases velocity and decreases Pressure.

Ad:-

1) The power loss is considered low compared to others type of fluid measuring instrument.

2) These are employed where a small head is available.

3) Accuracy will achive higher over a wide flow range

Dis Adv:-

1) It is quite expensive to install
2) The device requires maintenance
3) This system require more space.
4) ~~ee~~ It is costly and bulky

(7) Hall effect:- Hall effect is a process in which a transverse electric field is developed in a solid material when the material carrying an electric current is placed in a magnetic field that is perpendicular to the current. This type of phenomena is called hall effect.

Hall effect sensor:- An electronic device which converts magnetic or magnetically encoded data into electrical signals is called a hall effect sensor.

Types of hall effect sensor:-

Hall effect sensor are classified into two categories:

(i) Linear Hall effect sensor:- Here the output valtage is in the linear relationship with the magnetic flux density.

(ii) Threshald sensor:- At every magnetic flux density, the output valtage will result in a sharp decrease

Formula:-

Hall valtage, represented using V_H is given as,

$$V_H = \frac{IB}{qnd}$$

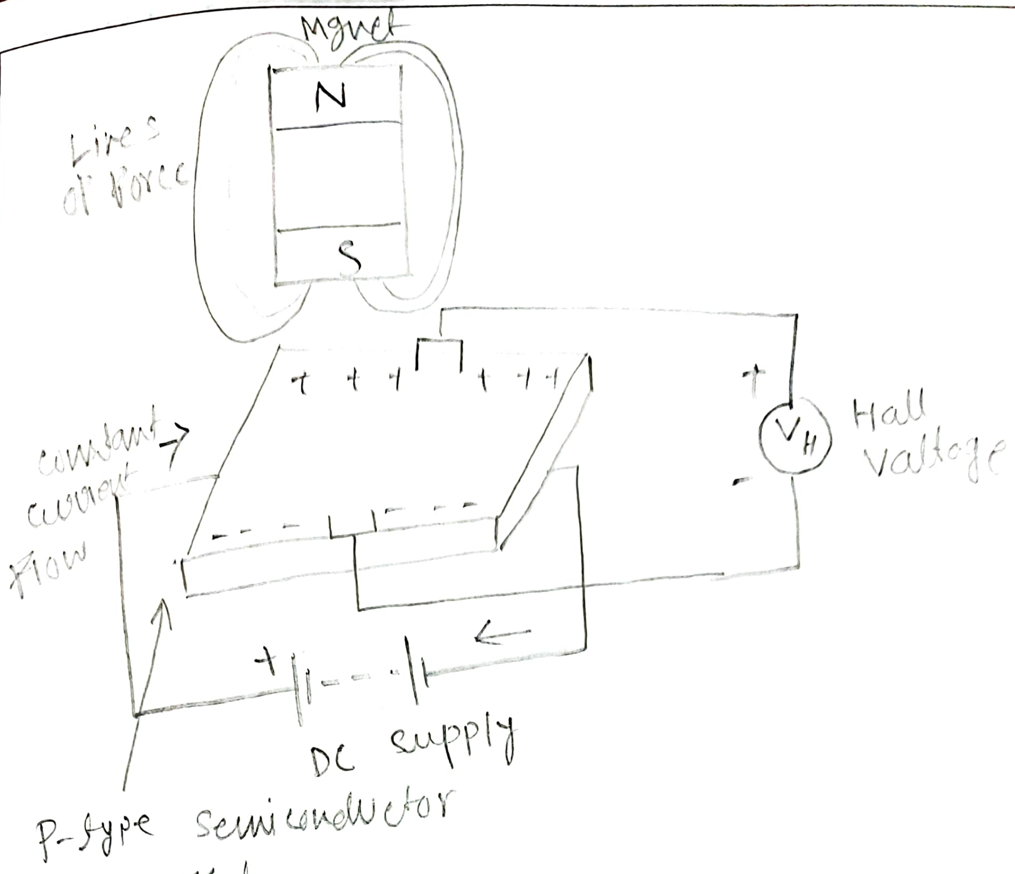
B = strength of magnetic f
q = charge
n = number of charge
d = thikness of the sensor
I = current flowing through the sensor

Hall co-efficient, represent using R_H

$$R_H = \frac{E}{JB}$$, R_H = Hall co-efficient.

Application:-

- Magnetic field sensing equipment.
- For the measurement of direct current, Hall effect Tong Tester is used.
- It is used in phase angle measurment.
- Proximity detectors
- Hall effect sensor and probes
- For detecting wheel speed
- Linear or Angular displacement transducer



Hall effect.

→ Block diagram.

⊛ Proximity sensor:→

A proximity sensor is a general word for sensor that are design to detect without contacting and detecting object replace contact and detection.

ex → mobile phone.

Updated Answer:-

Q.1) Describe sensor and classify it based on measurands and technology?

→ Sensor:- Sensor is the device that detect the change in the environment. It can be temperature sensor, pressure sensor or humidity sensor. As we know sensors sense just like eyes and ears. Sensors measured information shall be sent to the processor or controller for them to work on it.

(*) classification of sensor:-

There are several classification of sensor made by different authors and experts.

- In the first classification of the sensors, they are divide into active and passive.
- The other type of classification is based on the means of detection used in sensor. Some of means of detection are electric, biological chemical, Radioactive etc.
- The final classification of the sensor are Analog and Digital sensor.

Types:-> There are many different type of sensor used for measuring one of the physical properties like Temperature, Resistance capacitance, conduction, Heat transfer etc.

1.) Temperature Sensor:→ One of the most common and most popular sensor is the Temperature sensor. A Temperature sensor, as the name suggest, sense the temperature, it measures the change in the temperature.

Ex:→ There are different types of Temperature sensors like Temperature sensors ICs, thermistors, Thermocouples, RTD etc.

2) Proximity Sensor:- A proximity sensor is a non-contact type sensor that detects the presence of an object. proximity sensors can be implemented using different techniques like optical, sound, Magnetic (Hall effect), Capacitive, etc.

ex:→ Mobile Phones.

3) Infrared Sensor (IR):- IR Sensors or Infrared sensor are light based sensor that are used in various applications like Proximity and object Detection. IR sensors are used as proximity sensors in almost all mobile phones.

4) ultra sonic sensor:- An ultrasonic sensor is a non-contact type device that can be used to measure distance as well as velocity of an object. An ultra sonic sensor works based on the properties of the sound waves with frequency greater than that of the

human audible range.

(4) **Alcohal Sensor**: As the name suggest an Alchohal sensor detects ~~d~~ alcohal. sensors are used in breathalyzer devices

(5) **Touch sensor**:- we do not give much importance to touch sensors but they became an integral part of our life. whether you known or not all touch screen devices (mobile, tablets, laptos, etc.) have touch sensors in them.

Ex:- A common application of touch sensor is laptop track pad.

(6) **Humidity sensor**:- ~~To~~ It is ~~you~~ use to monitoring ~~of~~ the temperature as well as humidity data. since relative humidity is dependent on temperature of air, almost all Humidity Sensors can also measure Temperature.

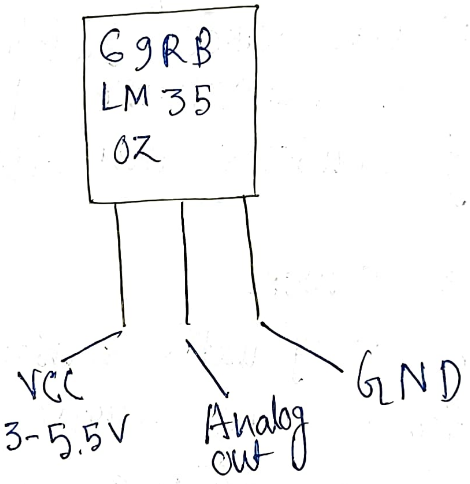
(7) **Smok and Gas sensor**:-

one of the very useful sensor in saftey related applications are smoke and Gas sensors. Almost all offices and industries are equipped with several smoke detectors, which detect any smoke (due to fire) and sound an alarm.

Q.) Explain the construction and working of semiconductor - based sensors for measuring temperature?

→ Introduction:- Temperature sensor is a device used to measure the temperature using an electrical signal. It requires a thermocouple or RTD (Resistance temperature Detector). It is the most common and most popular sensor.

Temperature sensor the change in the temperature correspond to change in its physical property like resistance or valtage



Working:- The working of the sensor is the valtage that read across to the diode. If increment in valtage then the temperature increases and there is a valtage decrement between the transistors terminals of emitter & base. That data saved by the sensor.

Types:-

① Thermocouple sensor:- A thermocouple sensor is a temperature measuring tool lies two different conductors that contact each other at one or more points. It produces a voltage when the temperature of one of the points differs from the reference temperature of one of the points differs from the reference temperature at other parts of the circuit.

② Thermistor:- This type of sensor is widely used in the human thermometers. If there are changes in the temperatures, then the electric current or resistance also change. The thermistor is made by using the semiconductor materials with a resistivity which is especially sensitive to temperature.

3) RTD:- Resistance temperature detector (RTD) are used in a wide temperatures range from -500C to 5000C for thin flim and for the wire wound range is from the +2000C to 8500C.

4) Thermometer:- It is a device which is used to measure the temperature of any class solid or liquid in this type of alcohal is used in a tube whose volume is changed by changing the temperature.

(5) IR Temperature :- These are an electronic and non contacting sensor which have a certain characteristic such that it can EMIT the IR radiations.

(6.) Semiconductor based sensor:-

It operates with the reverse bias has a small capacitance and low leakage current. They are formed ~~in~~ on thin wafer of silicon. They are compact, produce linear output and have a small range of temperature.

(Q) Inductive Sensor:-with equation?

→ Inductive sensors are use the Principle of electromagnetic induction to convert the measured non-electric quantity such as Pressure, Flow, vibration, etc, into the change of coil self-inductance L or mutual inductance M and then convert the change of inductance to the change of valtege or current output.

(*) Working Principle:-

The working principle of an inductive sensor mainly depends on the electromagnetic induction Principle for detecting or measuring objects. Inductive sensor mainly includes an induction loop which is enough for detecting electromagnetic. The working of these sensors can be done by generating an oscillating electromagnetic Field which is Formed by a ~~mag~~ magnetic object when it is in motion. The moving object activates the current Flow within the induction loop likewise with Faraday's law of induction. so it can be detected with the circuit of sensor.

(*) Application: ~~of~~ Inductive sensor:-

1) These Sensor are extensively used in industries, military, robotics, rail etc.
2) Used in proximity sensors or switches.
3) These sensors are used to notice metals like iron, steel, Nickel and cobalt
4) Used in the medical Field For MRI
5) It is used to assemble the automative body.
6) This sensors are used For detecting motion position & controlling the motion of an object.
7) Used in the production of transformer & coil.
8) Used to detect lid and broken bit.
9) Used in traffic sensors For noticing the moving car.
10) Used in machining procedures
11) Used in metal detectors
12) Used in automated industries
13) This are used in limit switching, speed detection
14) Used to measure the distance & position of the tool.

Q.4) Piezoelectric element :-

→ Piezoelectric Effect is the ability of certain materials to generate an electric charge in response to applied mechanical stress. ~~The word piezoelectric is derived from the Greek pie~~
Thus piezoelectricity is defined as "Electricity generated by application of mechanical stress or tension" and the materials that exhibit this property comes under the category of piezoelectric materials.

*) how Piezoelectric material works:-
Two modes :- The direct piezoelectric effect
converse

(i) Direct Piezoelectric Effect:-

When mechanical stress or friction is ~~applied~~ applied on these materials the geometry of the atomic structure of the crystal changes due to net movement of positive and negative ions with respect to each other resulting in polarization. The amount of voltage generated is directly proportional to the amount of stress or tension applied to the crystal.

(ii) converse :- When electricity is applied to these crystals electric dipoles appear, Forming the dipole movement which causes deformation of the crystal, thus giving rise to converse piezoelectric effect.

⊛ piezoelectric Equation:-

Direct effect:→ $S = s^E . T + d . E$

converse effect:→ $D = d . T + \varepsilon^T . E$

D = electric displacement vector.
T = the stress vector
s^E = matrix at constant electric field strength
S = Strain vector
ε^T = dielectric matrix at constant mechanical strain
E = electric field vector
d = direct or converse piezo electric effect.

Advantage:-

- piezoelectric materials can operate any temp conditions.
- They have low carbon footprint making them the best alternative for fossil fuel.
- characteristics of these materials make them the best energy harvesters.

Limitation:-

(i) While working with vibrations these devices are prone to pick up unwanted vibrations also.

(ii) Resistance and Durability apply limits to devices when used to tap energy from pavements and roads.

Q.5) Thermal expansion type thermometric sensor.

→ When the temperature gets increased then the volume of the material also gets increased. In general this called thermal expansion. we can describe thermal expansion as the fractional change in volume or length per unit change in the temperature. In this case of a solid expansion, normally the linear expansion co-efficient is employed.

Type:-

lets look at the types of expansion.

* Linear Expansion:- The linear expansion is described as the increase in the length of the solid.

For example if we consider a rod, where the rod's length is I, and suppose that we increase the temperature of a rod by a small amount. Then the linear expansion is given by,

$$\frac{\Delta L}{L} = \alpha_L \Delta T$$

where ΔT = change in Temp

ΔL = chang in Length

L = origin Length

α_L = is the linear coefficient of thermal expansion

(*) ~~Valume Expansion~~:- The valume expansion is described as the increased in the valume of the solid on heating, with a change in temp of Δt, the change in valume of a solid can be given by

$$\Delta V = V \gamma \Delta t$$

(3) Superficial Expansion:- ~~Where~~ when there is any change in the area of a body due to heating, the expansion is called areal or superficial expansion.

$$\Delta A = \beta A \Delta T$$

Here β is the coefficient of superfical expension.

(*) Application:-

Let us look at the thermal expansion concept used in our ~~life~~ daily life.

Thermometers:→

Thermal expansion in thermaters is used in temp measurment.

Removal of Tight Lids:- To open a battle cap that is tight enough, immerse it in hot water for a minute or so. Then the metal cap expands and becomes loose which would become easy to turn it to open.

Hot Ballons:→ You may have observed hot ballon on beaches. When the air inside the ballon is heated, it expands. Due to this, it displace more air and more upthrust acts on it.