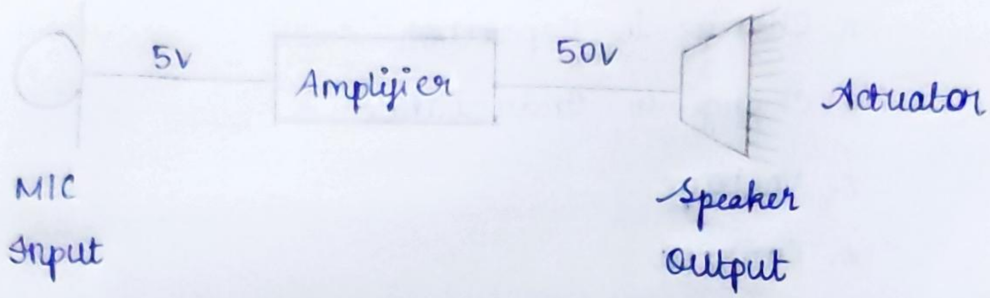
18.8.22
Friday

UNIT - I



MIC ⇒ Input transducer (or) sensor

Speaker ⇒ Output transducer

Sensor

A device that receives and responds to a server

Transducer

A device that converts one form of energy into another.

Sensor + Actuator = Transducer

Physical Quantity. (Measurand)

* Temperature
* Pressure
* Force
* Motion
* displacement
* Humity
* light flow

Electrical Quantity.

- ★ Change in Resistance
- ★ Change in Capacitor
- ★ Change in Inductance
- ★ Voltage
- ★ Current

Sensor

Non-electrical (or) Physical Quantity ⟹ Sensor ⟹ Electrical Equavalent form

Transducer

Transducers

Mostly in Physical Quantity

Input Signal ⟹ Sensors + Signal Conditioning Circuits ⟹ Output Signal

16.08.22
Tuesday

Signals based on Energy.

- ★ Electrical → current, voltage, resistance, capacitance, inductance
- ★ Thermal → Thermal, Heat flow, state of matter, entropy
- ★ Mechanical → Length, Area, Volume, torque, Mass.
- ★ Magnetic → Field intensity, Flux density, Magnetic Moment
- ★ Radient → Intensity, Phase, refractive index, reflectance, transmittance, absorbance, wave length
- ★ Chemical.
  → Oxidation/reduction Potential.

classification

* Energy based
* Technology based
* Application based.

Technology based

* MEMS (Micro Electro Mechanical Sensors).
* CMOS Image Sensor.
* Displacement and motion
* Magnetic and ultrasonic flow meters.
* Photo electric
* Hall effect
* Infrared
* Integrated circuit (IC)
* Radar based sensor.

CMOS.	IR/Ultrasonic	Biosensors.	MEMS.
Traffic Surveliance. Blind spot detection Biometric Videoconf.	obstruction detection (Robots)	Water testing food testing contamination detection.	Vehicle dynamic system.

22/08/22

Sensors Characteristics

* Static
* dynamic

Static Characteristics

1. Accuracy
2. Precision
3. Resolution
4. MDS (Minimum Detectable signal)
5. Threshold
6. Sensitivity
7. Selectivity (or) specificity
8. Non-linearity.

Dynamic Characteristics

1. Transfer function
2. Frequency
3. Impulse response
4. Step response
5. Evaluation of time dependent output

1. Accuracy.

$$E_a = \frac{x_m - x_t}{x^t} \times 100$$

x = measured

t = true value

m = measured value.

2. Precision.

How a measured Quantity is represent-ed

3. Resolution

Smallest ~~change~~ incremental change infact tha would predict detectable change in Output

(MR - Measure Range)

(MR - Max input - Minimum output)

4. Threshold.

At zero value condition, of measured an the smallest input produces a detectable output

5. MDS

Nil

6. Sensitivity

$$S = \frac{\Delta y}{\Delta x} = \frac{\text{Incremental Output}}{\text{Incremental Input}}$$

23/08/22
Tuesday

Environmetal Measures.

- Temperature
- Pressure
- Humidity
- Vibration.

parameters which affect the performance

~~Electrical~~ characteristics

- Electrical
- Mechanical
- Optical

* Thermal
* Chemical
* Biological

Electrical characterisation.

* Impedence, Voltage, Current
* Breakdown, Voltages and Fields
* Leakage current → Insulation is not proper
* Noise → electromagnetic interference
* Crosstalk → overlapping of signals between two adjacent transducer elements

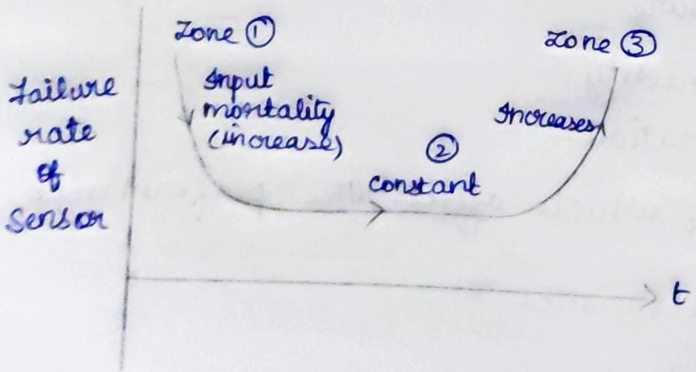
3 Reasons for Breakdown.

* Dielectric breakdown
* Wear out
* Current induced breakdown.

Mechanical and Thermal characterisation.

* Failure.

Turn Tub Process.



26/08/22 Friday

Standard ~~Inpal~~ Integrated Type Sensors (BITS)

(a) High temperature Burn In - 125°C for 48 hours.

(b) High temperature Storage Bake - 250°C for several hours

(c) Electrical Overstress test - 50% in excess of Specification.

(d) Thermal Shock test → Mainly done for packing defects
65 deg to 125 deg from 10 sec to 10 min.

(e) Mechanical Shock test → Dropping from Specified height
3 to 10m.

Types of Errors.

* Gross Errors
* Systematic Errors
* Random Errors

Gross Errors

Human Mistakes

1. Due to oversight 21.5° will be read as 31.5°
2. Great care is must during reading.
3. 2 or 3 or more reading should be taken.

Systematic Errors

* Instrumental Errors
* Environmental Errors → Due to external conditions
* Observational Errors → Incorrect Estimate.

Instrumental errors

* Inherent shortcoming of instruments
* Misuse of instruments

Random errors

* Affected by many happenings in the Universe

29/08/22
Monday

Selection of Transducers

1. Operating Principle → 5V
2. Sensitivity → 10V
3. Operating Range → 15V
4. Accuracy → Error free
5. Cross Sensitivity
6. Transient & Frequency response
7. Loading effects → High i/p impedance & low o/p impedance
8. Environmental Compactability → noise
9. Usage
10. Electrical Aspects
11. Stability and Reliability.

Mechanical Sensors.

Input → Mech Quantity.
Output → Electrical, Magnetic, Optical, Thermal
Mech Quantity → Motion, displacement, speed, Velocity, force, acceleration, torque.

Named as "electro Mechanical & Mechano-electrical Sensors.

Resistive Potentiometers.

POT

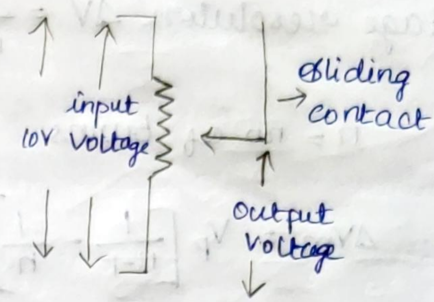
Ohm's Law

$V = IR$

$R = \frac{I}{V} \propto V \propto \frac{1}{I}$

30/08/22
Tuesday

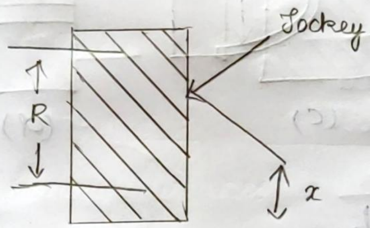
Resistive Potentiometers



1. Strain gauges
2. RTD
3. Thermistor
4. Wire anemometer
5. Piezo resistor.

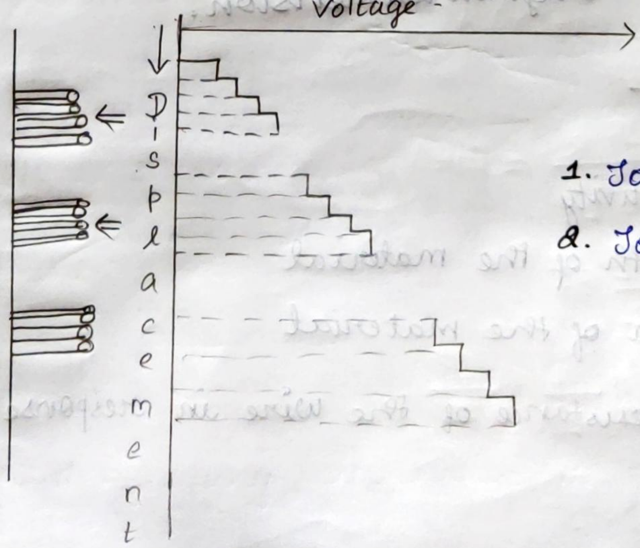
many more.

Precision Wire Wound Potentiometer.



* Used as a sensor
* large output
* Resolution and noise are important aspects.

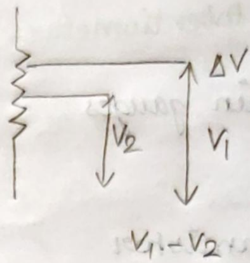
Cross section of the N-turn Winding.



1. Touching only one wire
2. Touching two turns.

Supply Voltage V

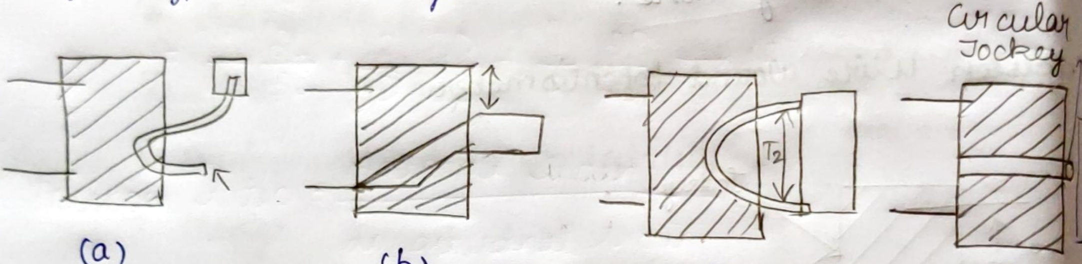
Voltage resolution $\Delta V = \frac{V}{n} \rightarrow (1)$



n = no of turns.

1. $\Delta V_m = V_p \left[\frac{1}{n-1} - \frac{1}{n}\right] \rightarrow (2)$
2. $\Delta V - \Delta V_m = \frac{V}{n} - V_p \left[\frac{1}{n-1} - \frac{1}{n}\right] \longrightarrow$ from (1) and (2)

A few types of Jockeys



(a) (b) (c) (d)

Jockey rad / wire rad = 10 for a perfect Sensor.

2.9.22
Friday.

Strain Gauge.

$$\text{Strain} = \frac{\text{Change in Dimension}}{\text{Original Dimension.}}$$

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

ρ - Resitivity

L - Length of the material

A - Area of the material

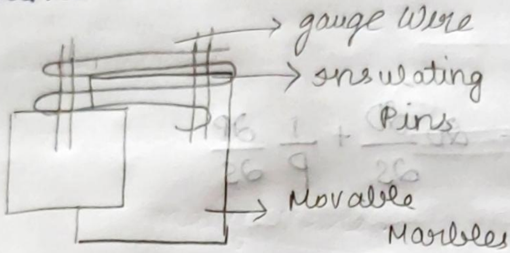
Change in Resistance of the wire in response to strain produced.

Strain Gauge

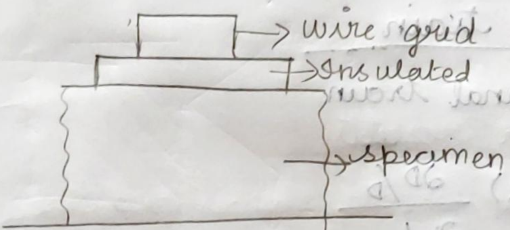
Resistance — Unbonded, Bonded.

Semi-conductor — Bonded, Diffused

Resistance Unbounded



Bounded.



Strain gauge gauge factor derivation.

$$\text{strain} = \frac{\text{Change in dimension}}{\text{original dimension}} = \frac{\Delta L}{L}$$

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

$$\frac{dR}{ds} = \frac{d}{ds}\left(\frac{\rho L}{A}\right)$$

$$\frac{dR}{ds} = \frac{\rho}{A}\frac{\partial L}{\partial s} - \frac{\rho L}{A^2}\frac{\partial A}{\partial s} + \frac{L}{A}\frac{\partial \rho}{\partial s}$$

$$\frac{d}{ds}(A^{-1}) = -1A^{-1-1} = -\frac{1}{A^2}$$

$\div R$

$$\frac{1}{R}\frac{dR}{ds} = \frac{\rho}{AR}\frac{\partial L}{\partial s} - \frac{\rho L}{A^2 R}\frac{\partial A}{\partial s} + \frac{L}{AR}\frac{\partial \rho}{\partial s}$$

$$\frac{1}{R}\frac{dR}{ds} = \frac{\rho}{A\frac{\rho L}{A}}\frac{\partial L}{\partial s} - \frac{\rho L}{A^2\frac{\rho L}{A}}\frac{\partial A}{\partial s} + \frac{L}{A\frac{\rho L}{A}}\frac{\partial \rho}{\partial s}$$

$$\frac{1}{R}\frac{dR}{dS} = \frac{1}{L}\frac{\partial L}{\partial S} - \frac{1}{A}\frac{\partial A}{\partial S} + \frac{1}{\rho}\frac{\partial \rho}{\partial S}$$

$A = \pi r^2 \quad r = \frac{D}{2}$

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

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

$$\frac{1}{R}\frac{dR}{dS} = \frac{1}{L}\frac{\partial L}{\partial S} - \frac{1}{\frac{\pi D^2}{4}}\frac{\pi}{4} 2D\frac{\partial D}{\partial S} + \frac{1}{P}\frac{\partial P}{\partial S}$$

$$= \frac{1}{L}\frac{\partial L}{\partial S} - \frac{2}{D}\frac{\partial D}{\partial S} + \frac{1}{P}\frac{\partial P}{\partial S} \rightarrow (2)$$

Poisson ratio = $\frac{\text{lateral train}}{\text{longitudnal train}}$

$$\gamma = \frac{-\partial A/A}{\partial L/L} \text{ (or) } \frac{\partial D/D}{\partial L/L}$$

$$\partial D/D = -\gamma\, \partial L/L$$

Subsitute $\partial D/D$ value in eq (2)

$$\frac{1}{R}\frac{dR}{dS} = \frac{1}{L}\frac{\partial L}{\partial S} + \frac{\partial \gamma}{L}\frac{\partial L}{\partial S} + \frac{1}{P}\frac{\partial P}{\partial S}$$

$$= \frac{1}{L}\frac{\partial L}{\partial S}(1+2\gamma) + \frac{1}{\rho}\frac{\partial \rho}{\partial S}$$

Gauge factor = $\frac{\Delta R/R}{\Delta L/L}$ = GF

$$\Rightarrow \frac{\Delta R}{R} = \frac{\Delta L}{L} GF$$

$$\frac{\Delta R}{R} = \frac{\Delta L}{L} + 2\gamma\frac{\Delta L}{L} + \frac{\Delta P}{P}$$

$$\div \frac{\Delta L}{L}$$

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

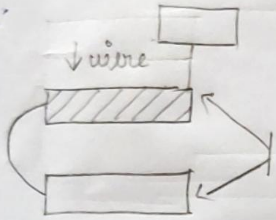
5.9.22
Monday

Semi-Conductor Strain Gauge

* Bonded semiconductor strain Gauge
* Diffused semiconductor strain Gauge.

Gauges of Different Shapes and Mountings.

1.



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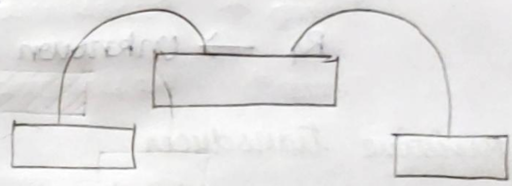

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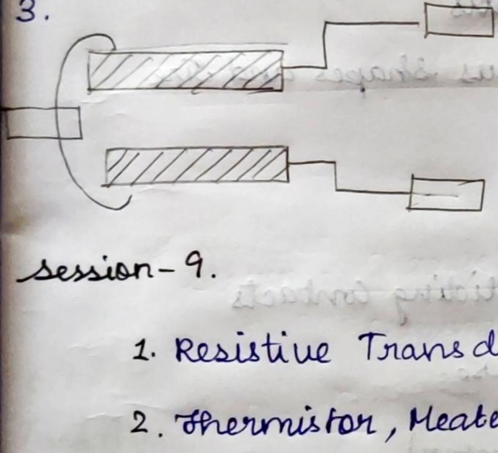
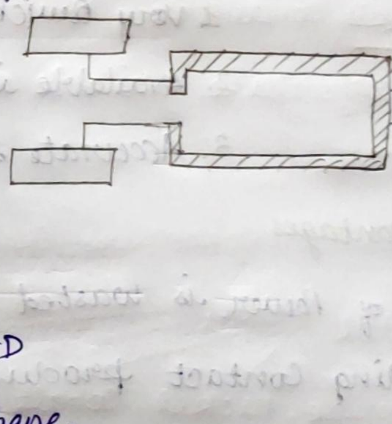


4.



session-9.

1. Resistive Transducer, RTD
2. Thermistor, Meaterial, Shape.

Resistive transducer

* Electronic device capable of measuring various physical Quantities like temp, pressure, Vibration etc...
* R change $\rightarrow$ change in Physical Quantity.

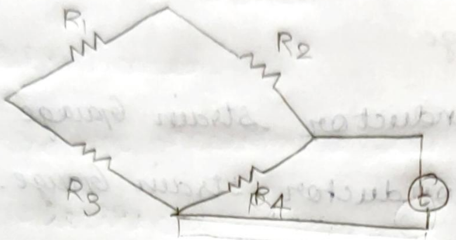
$V = IR\uparrow$ constant temp$\uparrow$

R refers to temp, pressure, vibration.

Working of R.T.

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

Unknown resistance.



$R_1, R_2, R_3 \rightarrow$ known resistance

$R_4 \rightarrow$ Unknown resistance.

Resistive transducer

Advantages

1. Very Quick results
2. Available in various shapes and size
3. Accurate shapes.

Disadvantages

* Lot of Power is wasted in sliding contacts
* Sliding Contact produce noise.

RTD (Resistance Temperature Detector)

Electronic device used to determine the temperature of measuring the resistance of an electrical wire

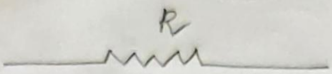
$$R_t = R_0 \left[1 + (t - t_0) + \beta (t - t_0)^2 + \ldots \right]$$

$R_t \Rightarrow$ Resistance at $t°C$

$R_0 \Rightarrow$ Resistance at $t_0°C$

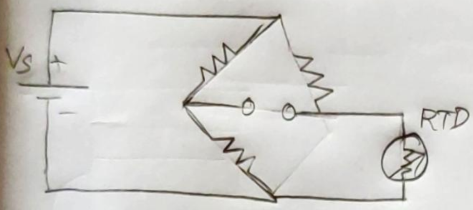
initial value

$$R_t = R_0 \left[1 + (t - t_0) \right]$$

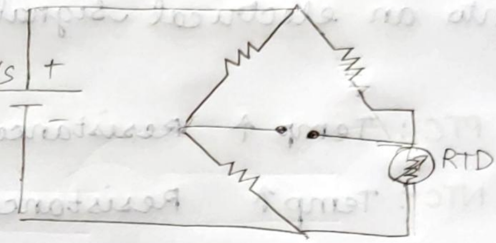


t_0	t_1	t_2
60°C	70°C	80°C
100 kΩ	200 kΩ	300 kΩ
50	150	250
R_0	R_1	R_2

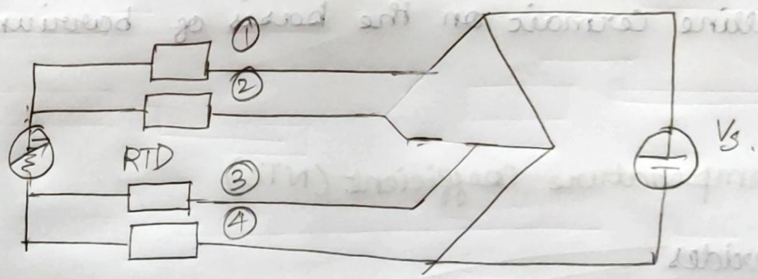
2 wire RTD Gauge



3 Wire RTD Gauges



4 Wire RTD Gauge



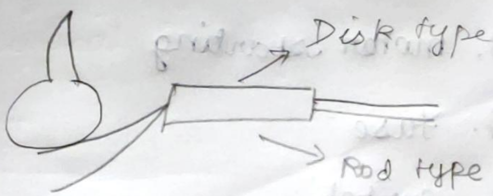
6.09.22
Tuesday

Thermistor

Uses resistance to detect temperature

$-40 \sim 150$

disk or rod.



Basic Working Principle

* Electrical resistance of the metal depends on temperature.

* By measuring change in resistance, temperature can be determined.

* Change in resistance can be easily converted into an electrical signal.

PTC : Temp ↑ Resistance ↑

NTC : Temp ↑ Resistance ↓

Positive Temperature coefficient.(PTC)

semi conductor

Poly Crystalline Cermaic on the basis of barrium tiatanate.

Negative Temperature Coefficient (NTC)

Metal Oxides

Manganese, nickel, cobalt, iron, copper.

Applications of PTC.

1. Over current Protection
2. Telecommunication applications
3. motor starting
4. Fuse
5. Switch
6. Temperature Sensor.

Applications of NTC.

1. General industrial applications, potographic processing, copy machines etc.

2. House Hold applications like Burglar alarm, detectors Refrigeration, Air conditioner etc...