RIET, JAIPUR

Univ. Roll No. ----------------

B.TECH II Yr (IV SEM) I Mid Term Exam February 2018

BRANCH: - Electronics & Communication Engineering

SUBJECT: EMI

TIME: 2 Hours **MAX. MARKS: 20**

Instructions to Candidates:-

Attempt all four questions. All questions carry equal marks. Schematic diagrams must be shown wherever necessary.

Q1. What do you mean by accuracy and precision? Explain them.

OR

Q1. Define the following for Gaussian distribution of data:

(i) Precision index (ii) Probable error

Q2. A Circuit was tuned for resonance by eight different student and the Values of resonant frequency in KHz as 532, 548, 543, 535, 546, 531, 543 and 536. Calculate (i) Deviation from mean (ii) arithmetic mean (iii) Average and standard deviation (iv) variance.

OR

Q2. The following 9 observations were recorded when measuring a voltage: 31.6, 31.0, 31.7, 31.0, 32.1, 31.9, 31.0, 32.5 and 31.8 volt. Find

(i) The probable error of one reading

(ii) The probable error of mean.

Q3. Describe the construction and working of thermocouples. Discuss about 'seeback' effect.

OR

Q3. Write short note on strain gauge?

Q4. Explain construction and working principle RTD.

OR

Q4. Explain the following errors

(i) Systematic errors.

(ii) Random errors.

EMI SOLUTION

Ans.1 **Accuracy:** Accuracy is the degree of closeness with which an instrument reading approaches the true value of quantity being measured.

Accuracy

- Point accuracy (accuracy in terms of pt ex: 0.4, 0.2)
- Accuracy as % of scale range
- accuracy as % of true value.

Point → This is the accuracy of the instrument only at one pt on the scale. The specification of this accuracy do not give any information about the general accuracy of the instrument

Accuracy as % of scale range → when an instrument has the uniform scale its accuracy may be expressed in terms of scale range.

Accuracy as % of true value → It is the best way of expressing the accuracy expressed in terms of true value of quantity being measured.

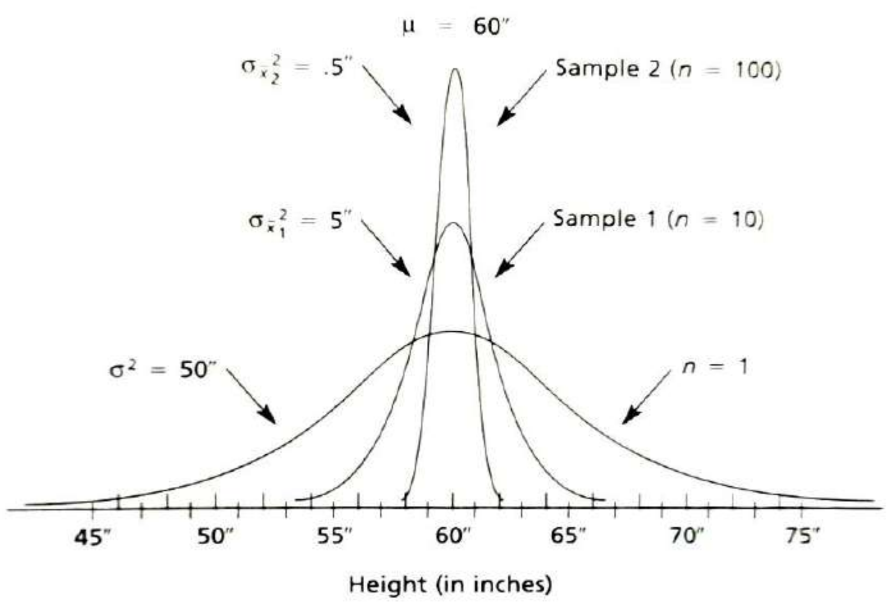
Precision: Precision indicates the repeatability or reproducibility of an instrument (but does not indicate accuracy).

Precision means repetition of successive readings, but it does not guarantee accuracy; successive readings may be close to each other, but far from the true value. On the other hand, an accurate instrument has to be precise also, since successive readings must be close to the true value (that is unique).

OR

Ans.1 (i) Precision index: When x=0 than y= $\frac{h}{\sqrt{\pi}}$

Thus it is clear from equation y depends upon h. The largest the value of h the sharper the curve. Thus the value of h determines the sharpness of the curve. Since curve depends upon h.



(ii) Probable error: Probable error defines the half-range of an interval about a central point for the distribution, such that half of the values from the distribution will lie within the interval and half outside. The Probable error r is given by

$$r = \frac{0.4769}{h}.$$

Ans.2

Sol. (a) (i) Arithmetic mean

$$\bar{x} = \frac{1}{n}\sum_{i=1}^{n} x_i$$

$$\bar{x} = \frac{1}{6}[532+548+546+531+543+536]$$

$$\bar{x} = 539.33$$

Ans.

(ii) Average deviation

$$D_{av} = \frac{|d_1|+|d_2|+.....+|d_6|}{n}\Big|_{n=6}$$

$$d_1 = x_1 - \bar{x} = 532 - 539.33 = -7.33$$

$$d_2 = x_2 - \bar{x} = 548 - 539.33 = 8.67$$

$$d_3 = x_3 - \bar{x} = 546 - 539.33 = 6.67$$

$$d_4 = x_4 - \bar{x} = 531 - 539.33 = -8.33$$

$$d_5 = x_5 - \bar{x} = 543 - 539.33 = 3.67$$

$$d_6 = x_6 - \bar{x} = 536 - 539.33 = -3.33$$

$$D_{av} = \frac{7.33+8.67+6.67+8.33+3.67+3.33}{6}$$

$$D_{av} = 6.33$$

Ar

(iii) Derivation from mean :

$$d_1 + d_2 .... + d_n = 0$$

....

Value of d_1, d_2, d_3, d_4, d_5, d_6 in equation (i), we get

$$= -7.33 + 8.67 + 6.67 - 8.33 + 3.67 - 3.33$$

$$= 0$$

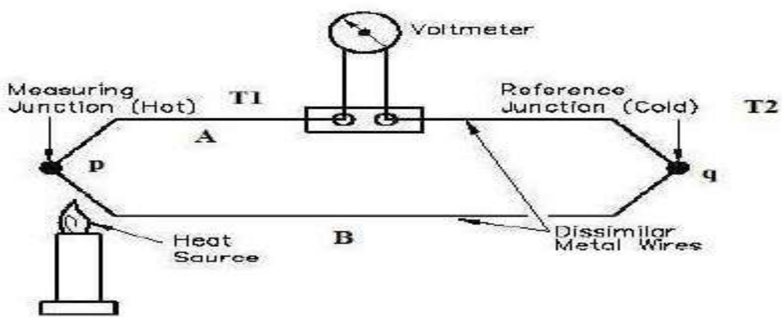
A

(iv) Variance $$V = \frac{1}{n-1}\sum_{i=1}^{6} d_i^2$$

$$= \frac{1}{5}[53.72+75.16+44.48+69.38+13.46+11.08]$$

$$= 53.456$$

Ans.3 A **thermocouple** is a device made by two different wires joined at one end, called junction end **or** measuring end**.** The two wires are called thermo elements or legs of the thermocouple: the two thermo elements are distinguished as positive and negative ones. The other end of the thermocouple is called tail end or reference end. The junction end is immersed in the environment whose temperature T_2 has to be measured, which can be for instance the temperature of a furnace at about 500°C, while the tail end is held at a different temperature T_1, e.g. at ambient temperature. Because of the temperature difference between junction end and tail end a voltage difference can be measured between the two thermo elements at the tail end: so the thermocouple is a temperature-voltage transducer. The flow of current due to temperature difference is called as seeback effect .



Thermocouple Circuit

Construction or Parts of thermocouple: Thermocouple junction, compensating lead, protecting well, mill voltmeter.

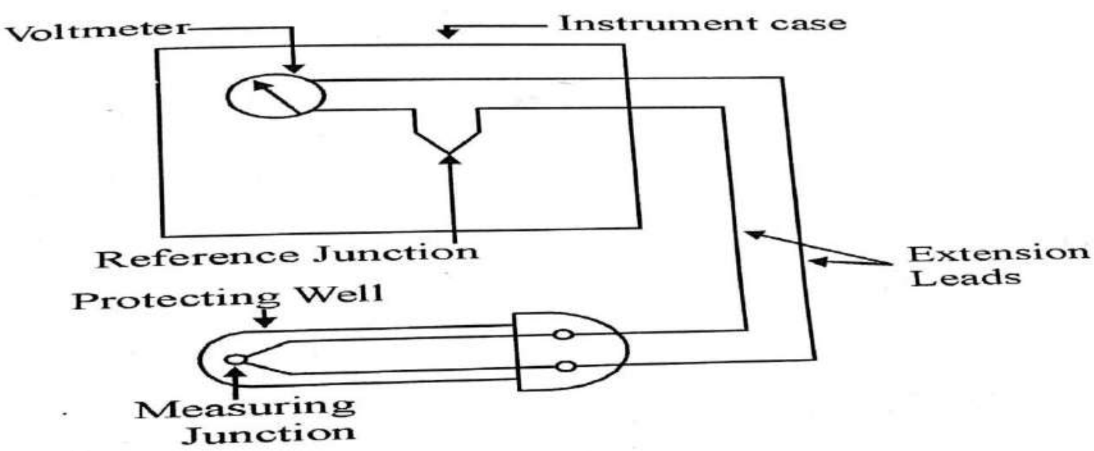


Figure Construction of thermocouple

Following are advantages of Thermocouple type of instruments:

1. The thermocouple type of instruments accurately indicates the root mean square value of current and voltages irrespective of the waveform. There is a wide varieties of range of thermocouple instruments are available in the market.
2. Thermocouple type of instruments give very accurate reading even at high frequency, thus these types of instruments are completely free from frequency errors.
3. The measurement of quantity under these instruments is not affected by stray magnetic fields.
4. These instruments are known for their high sensitivity.
5. Usually for measuring the low value of current bridge type of arrangement is used i.e. ranging from 0.5 Amperes to 20 Amperes while for measuring the higher value of current heater element is required to retain accuracy.

Disadvantages of Thermocouple Type Instruments:

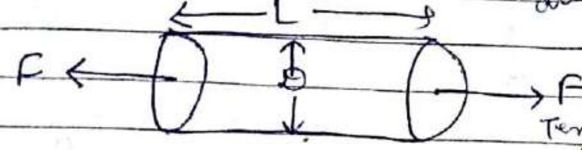
Instead of many advantages these type of instruments posses one disadvantage, The over load capacity of thermocouple type of instrument is small, even fuse is not able to the heater wire because heater wire may burn out before the fuse blows out.

OR

Ans.3 Strain Gauge: A **strain gauge** is a device used to measure **strain** on an object. As the object is deformed, the foil is deformed, causing its electrical resistance to change. This resistance change, usually measured using a Wheatstone bridge, is related to the **strain** by the quantity known as the **gauge** factor.

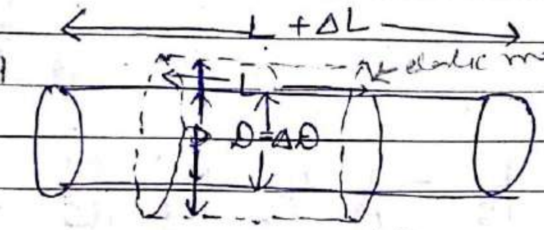
Strain - gauge :-

Mechanical energy —convert→ Resistance variation
(or displacement) (changes due to force)



(a)

Longitudinal → L
lateral → D



(b)

ΔL = change in length
ΔD = change in diameter
ΔA = change in area
ΔR = change in resistance.

Resistance of conductor is

$R = \frac{\rho l}{A}$ — (a)

R = resistance, A = area, l = length, ρ = resistivity of material

diff w.r.to S

$$\frac{dR}{dS} = \frac{\rho}{A} \cdot \frac{dL}{dS} - \frac{\rho L}{A^2} \frac{dA}{dS} + \frac{L}{A} \frac{d\rho}{dS} \quad (1)$$

Dividing this equation by R →

$$\frac{1}{R}\frac{dR}{dS} = \frac{\rho}{AR}\frac{dL}{dS} - \frac{\rho L}{A^2 R}\frac{dA}{dS} + \frac{L}{AR}\frac{d\rho}{dS} \quad (2)$$

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

$$\Rightarrow \frac{1}{R}\frac{dR}{dS} = \frac{\rho}{A\left(\frac{\rho L}{A}\right)}\frac{dL}{dS} - \frac{\rho L}{A^2\left(\frac{\rho L}{A}\right)}\frac{dA}{dS} + \frac{L}{A\left(\frac{\rho L}{A}\right)}\frac{d\rho}{dS}$$

$$\Rightarrow \frac{1}{R}\frac{dR}{dS} = \frac{1}{L}\frac{dL}{dS} - \frac{1}{A}\frac{dA}{dS} + \frac{1}{\rho}\frac{d\rho}{dS} \quad (3)$$

if $\frac{dR}{R}$ is per unit change in resistance.

then $\frac{\Delta L}{L}$ per unit change in length.

$\frac{\Delta A}{A}$ " " " in area

$\frac{\Delta \rho}{\rho}$ " " " resistivity

Area $= \pi r^2$

$r = \frac{D}{2} = \frac{\text{Diameter}}{2}$

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

diff w.r.t S to area

$$\frac{dA}{dS} = \frac{\pi}{4}(2D)\cdot\frac{dD}{dS}$$

$$\frac{dA}{dS} = \frac{\pi}{2} D \cdot \frac{dD}{dS} \quad — (4)$$

Dividing equation by A.

$$\frac{1}{A}\frac{dA}{dS} = \frac{\pi}{2}\frac{D}{A}\frac{dD}{dS}$$

$$\frac{1}{A}\frac{dA}{dS} = \frac{\pi}{2}\frac{D}{\frac{\pi}{4}D^2}\frac{dD}{dS}$$

$$\frac{1}{A}\frac{dA}{dS} = \frac{2}{D}\cdot\frac{dD}{dS} \quad — (5)$$

from eq (3) & (5)

$$\frac{1}{R}\frac{dR}{dS} = \frac{1}{L}\frac{dL}{dS} - \frac{2}{D}\frac{dD}{dS} + \frac{1}{\rho}\frac{d\rho}{dS} \quad — (6)$$

since Poisson ratio

$$\boxed{\sigma = -\frac{dD/D}{dL/L}}$$

$$\frac{dD}{D} = -\sigma\frac{dL}{L} \quad — (B)$$

Multiplying equation (6) by dS

$$\frac{dR}{R} = \frac{dL}{L} - \frac{2}{D}dD + \frac{1}{\rho}d\rho \quad — (7)$$

from (B) & 7

$$\frac{dR}{R} = \frac{dL}{L} + 2\sigma\frac{dL}{L} + \frac{d\rho}{\rho} \quad — (8)$$

gauge factor

$$GF = \frac{dR/R}{dL/L}$$

$$\frac{dR}{R} = G_F \frac{dL}{L}$$

since ϵ = strain $\epsilon = \frac{dL}{L}$

$$\frac{dR}{R} = G_F \cdot \epsilon$$

Dividing eq (8) by $\frac{dL}{L}$

$$\boxed{\frac{dR/R}{dL/L} = 1 + 2\sigma + \frac{d\rho/\rho}{dL/L}}$$

$$\frac{dR/R}{dL/L} = 1 + 2\sigma + \frac{d\rho/\rho}{\epsilon}$$

G_F = resistance change due to change of length + resistance change due to change in area + resistance change due to change in Piezo electric effect.

If the change in resistivity of material is neglected, the gauge factor is:-

$$\boxed{G_F = 1 + 2\sigma} \quad (\sigma \text{ or } \mu)$$

σ = poisson's ratio

The σ (poisson ratio) is b/w 0 & 0.5 for all metals.

Types of strain Gauge:-

1.) Bonded Metal strain Gauge (w.r.to base)
2) Unbonded Metal strain Gauge (no-base)
3) Bonded metal foil strain Gauge.
4.) Vacuum straingauge.
5.) sputter deposited metal strain Gauge
6.) semi-conductor strain gauge.
7.) Diffuse strain gauge. flat grid.

Ans.4 **RTD:**

An RTD (resistance temperature detector) is a temperature sensor that operates on the measurement principle that a material's electrical resistance changes with temperature. The relationship between an RTD's resistance and the surrounding temperature is highly predictable, allowing for accurate and consistent temperature measurement. By supplying an RTD with a constant current and measuring the resulting voltage drop across the resistor, the RTD's resistance can be calculated, and the temperature can be determined.

The relation b/w the resistance & temp is given by

$$R = R_0 (1 + \alpha_1 T_1 + \alpha_2 T_2^2 + \dots \alpha_n T_n^n)$$

R_0 = resistance at temp 0°K

α_1, α_2 = const

$T_1, T_2 \dots T_n$ = Temp.

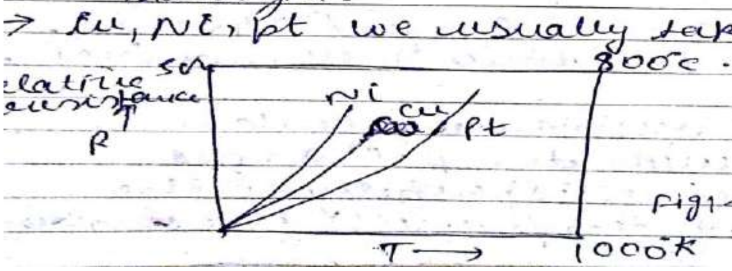
$$R = R_0 (1 + \alpha_1 T)$$

RTD is passive transducer.

Materials used for RTD should be :-

1.) high temp coefficient.
2.) high sensitive.
3.) linear relation b/w R & T.
4.) stability of the electrical characteristic.
5.) enough mechanical strength.

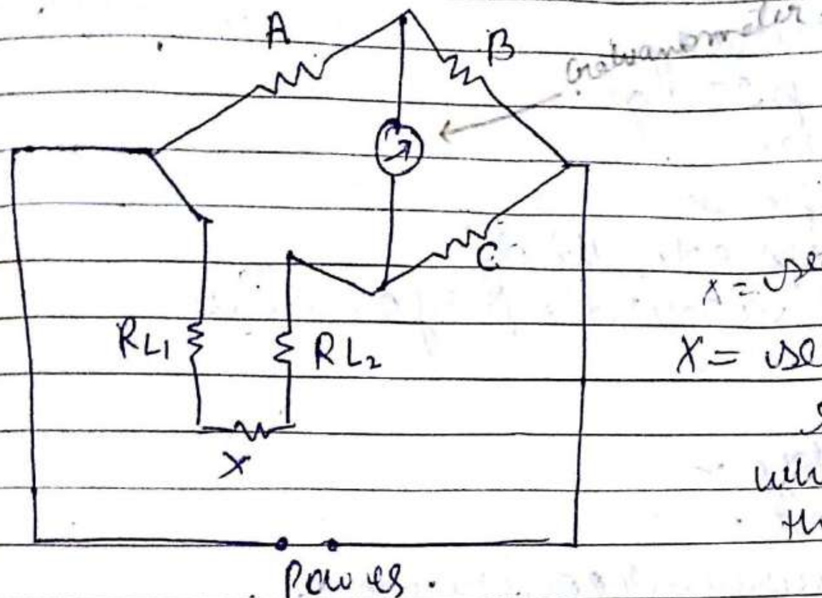
> Cu, Ni, Pt we usually take for the manufacturing of RTD.



Both of three are giving linearly relation.

Fig:- characteristics of material

RTD Bridge circuit →



X = sensing element

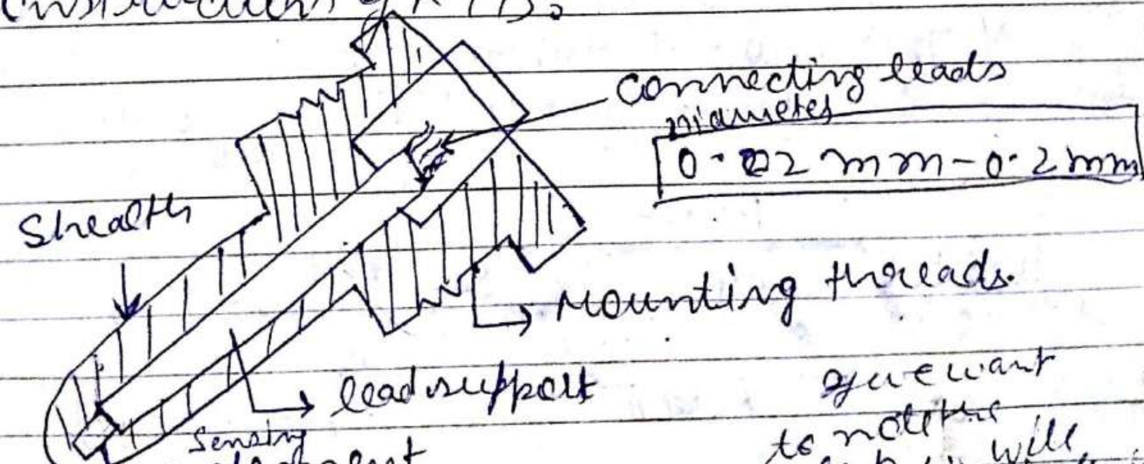
X = sensitive (ENV) resistance which varies with the Temp.

variation in X will cause disturbing the wheatstone bridge and that we can calculate from the Gal. (T)

Balance condition

$$\frac{A}{B} = \frac{R_{L1} + R_{L2} + X}{C}$$

Construction of RTD :-



if we want to note the temp we will put this device at that place

OR

advantages :-

Applications →
(i) In nuclear station
(2) In heating ovens

1) High accuracy.
2) wide temp range.
3) small size
4) fast response
5) good reproducibility
6). stable & accurate performance

Disadvantage :-
1.) High cost.
2) power supply requirement.
3) Need of Bridge circuit.
4) edge ~~High~~ calculation required.

Ans.4 (i) Systematic errors

Systematic errors in experimental observations usually come from the measuring instruments. They may occur because:

- there is something wrong with the instrument or its data handling system, or
- Because the instrument is wrongly used by the experimenter.

Two types of systematic error can occur with instruments having a linear response:

1. Offset or zero setting error in which the instrument does not read zero when the quantity to be measured is zero.
2. Multiplier or scale factor error in which the instrument consistently reads changes in the quantity to be measured greater or less than the actual changes.

These errors are shown in Fig. 1. Systematic errors also occur with non-linear instruments when the calibration of the instrument is not known correctly.

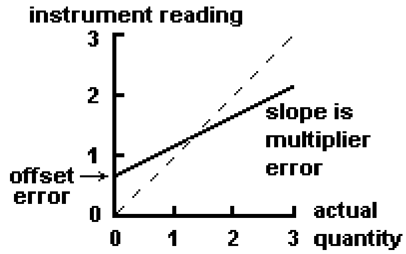


Fig. 1. Systematic errors

Examples of systematic errors caused by the wrong use of instruments are:

- errors in measurements of temperature due to poor thermal contact between the thermometer and the substance whose temperature is to be found,
- errors in measurements of solar radiation because trees or buildings shade the radiometer.

The accuracy of a measurement is how close the measurement is to the true value of the quantity being measured. The accuracy of measurements is often reduced by systematic errors, which are difficult to detect even for experienced research workers.

(ii)Random Errors

Random errors in experimental measurements are caused by unknown and unpredictable changes in the experiment. These changes may occur in the measuring instruments or in the environmental conditions.

Examples of causes of random errors are:

- electronic noise in the circuit of an electrical instrument,
- Irregular changes in the heat loss rate from a solar collector due to changes in the wind.

Random errors often have a Gaussian normal distribution (see Fig. 2). In such cases statistical methods may be used to analyze the data. The mean m of a number of measurements of the same quantity is the best estimate of that quantity, and the standard deviation s of the measurements shows the accuracy of the estimate. The standard error of the estimate m is s/sqrt(n), where n is the number of measurements.

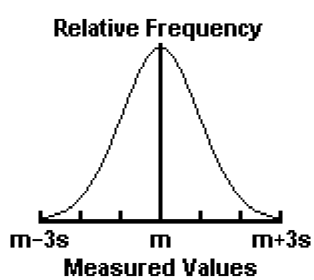


Fig. 2. The Gaussian normal distribution.

The **precision** of a measurement is how close a number of measurements of the same quantity agree with each other. The precision is limited by the random errors. It may usually be determined by repeating