Module -2 (5) → Sensor

Thermal Sensor

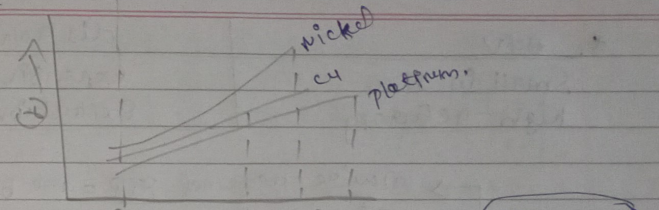
* Thermal / temp (S) is a device that is designed to measure the degree of hotness / coolness in an obj.
* Temp is an imp parametr in many control system.
* A thermomtr is the most common non-electrical (S).
* Common electrical (S) –
  a) RTD
  b) Thermistors
  c) Thermocouples.

a) Resistance Temp detector (RTD) =

* Also → Resistance thermomtr.
* It is an electronic device used to determine the temp by measuring the (R) of an electrical wire.
* This wire is referred to as a temp (S).
* If we want to measure temp with high accuracy, an RTD is the ideal sol^n, as it has gd linear characteristics over a wide range of temp.
* (R) Tses as the temp of (S) Tses.
* An RTD is a passive device, it does not produce an output on its own.
* RTD convert temp into electrical (R), which can be measured using wheatstone bridge.
* It is based on (R)-temp relationship of the material used for its construction.

principle

* material



RTD vs temp

- element usually made of a metal, solid material, metallic alloy.
- The variation of (R) R with temp (T) for metallic materials can be represented by an eq.

$$R_T = R_0(1 + a_1T, a_2T^2 \cdots + a_nT^n)$$

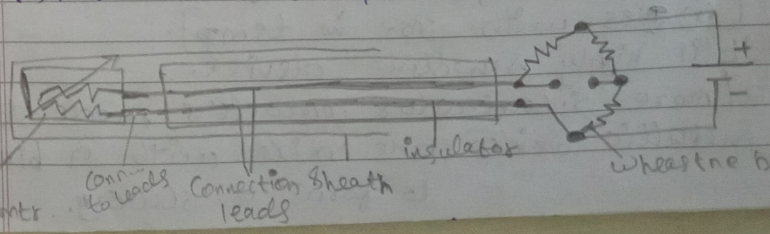
* Characteristics of materials used in (R) Thermometers –

$$R_T = R_0(1 + \alpha \Delta t)$$

$$R_T = R_0(1 + \alpha t - t_0)$$

α → temp coefficient as t_0
R_0 is (R) at t_0

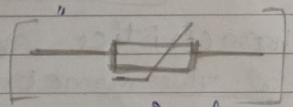
* Construction
- (R) elemnts are long, spring like wires enclosed in a metal sheath.
- (R) elemnt is surrounded by a porcelain insulator which prevents short circuit b/w wire & metal sheath.



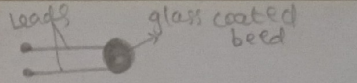
Adv	disadv
Small in size	expensive.
high accuracy	Excitation needed.

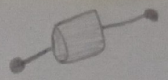
* RTD →
  - a) wire-wound RTD = are built using a small diamtr wire, typically platinum, which is wound into a coil.
  - b) Thin film RTD = made by depositing a thin layer of resistive material, typically platinum film onto a ceramic substrate.
  - c) coiled RTD Sensors
  - d) PT100 " "
  - e) PT1000 " "
  - f) 2 wire " "
  - g) 3 wire " "

b) Thermistor = (t)



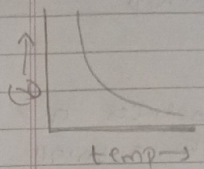
* type of resistive (t) whose (R) is dependent on temp.
* (t) is a passive component & the sensing paramtr is (R).
* made up of certain conducting & semi conducting material (manganese, Ni, Cu, Fe or & cobalt).
* has high -ve temp (coe) of (R) & it creates a change in its electrical pro) due to physical change in heat.
  [R ↓es with ↑se in temp].
* It is highly sensitive device.
* 2/more S.conductor powders made of metallic oxides are mixed with a binder to form a slurry.





* Characteristics of (t) =
  a) (R) - temp char.. →

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



R_{T_1} = (R) of (t) at absolute temp T_1.
R_{T_2} = " " " temp T_2.
β = a constnt depending up on the material of (t).

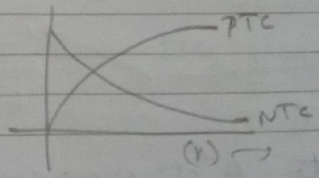
b) voltage - crnt char.. →
here ohm's law is followed & crnt is ∝ to the applied voltage.

c) crnt-time char..

* Types of (t) =
  a) -ve Temp (coe) = (NTC)

* here, whn the temp ↑se, (R) ↓se.
* whn temp ↓se (R) ↑se, hence NTC (t) temp & (R) & is inversely proportional.
* common type of (t).

b) +ve Temp (coe) = (PTC)
* has direct relationship b/w temp & (R)
* temp ↑se, (R) ↑se.
* PTC (t) act as crnt-limiting device & they are not common as NTC.



Adv.	Disadv.
Accurate, durable & sensitive	do not work well in extremely hot / cold temp.

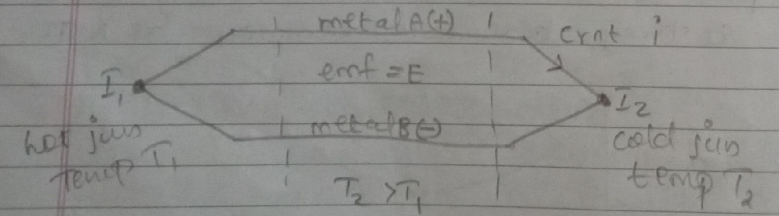
* Appli... →

* measurmnt of temp. → produces a large change in (V) with a small change in temp being measured.
* measurmnt of thermal conductivity

⇒ Thermo EMF Sensors =

Thermocouples = (Tr)

* It is a active (T).
* (S) used to measure temp.
* Also → thermal junction.
* consist of 2 diff types of metals joined together at 1 end.
* Whn the junction of 2 metals is heated/cooled, a voltage is created that can be correlated back to the temp.
* 1 junction is placed where the temp is to be measured, & the other is kept at a constnt lower temp.



Circuits of Thermocouple.

* emf produced, is ∝ of the diff^n in temp of hot & cold junctions,

$$E = a\Delta\theta$$

$\Delta\theta$ → diff b/w temp of hot & cold jun.

working principle =

* It is working principle is based on the Seebeck effect.
* consist of 2 wire legs made from diff^n metals.

~~* Types →~~

~~(a) T-type (Tr) (b) E-Type (c) J-type (d) K-type (e) S-type~~

* Types of (Tr) =

	T-type (Tr)	E-type (Tr)	J-type (Tr)	K-type (Tr)	S-type (Tr).
+ve wire	Cu	Chromel	Fe	Chromel	Platinum
-ve wire	constan tan	constan tan	⁻ⁱ	Alumel	Platinum
used upto	350°C	850°C	1000°C	1200°C	1400°C.

* crnt will flow frm the marked lead to -ve mi lead
* In (Tr), -ve lead is generally a red colored wire.
* Colour of the lead will be according to its type

Adv	Dis adv
are cheaper than (R) thermomtrs.	low accuracy. (T) is placed remote from measuring devices.

⇒ Radiation sensors = (R).

* Device which detects the emission of energy in the form of waves / particles through space / through a material medium.
* Based on the principle that the intensity of light received by observ
* Gas molecules gt ionized whn energetic charged particles propogated through a gas.

Types of ionising (R).
- Electromagnetic waves
  - X-rays
  - Gamma rays
- particles
  - Beta
  - Alpha
  - Neutron

Types of (R) Sensors
- Gas filled detectors
  - Ionization chamber
  - GM counter
  - Proportional counter
- Solid State (d)
  - P-I-N Jun
  - Silicon drift
  - Scintillation counter
- Charged coupled (d)
  - Indirect
  - Direct.

⇒ pressure (T) =

* It is a device which converts an applied pressure into a measurable electrical signal.
* Also → pressure transmitter.
* used in many control & monitoring applim like flow, air speed, level, pump systems, etc.

Construction →

* pres. are exerted by gases, vapours & liquids
* pres.(T) consist of mainly 2 parts —
  a) elastic material
  b) electrical device

Elastic material can be formed into many diff. shapes & sizes depending on the sensing principle

working principle → (E → energy)

* A pres.(T) converts pres. into an analog electrical signal.

fluid energy input → elastic elemnt pres. (T) → mechanical (E) output.

fluid (E) input → Elastic + electric elemnt pres. (T) → Electrical (E) output

Auxillary electrical (E) input

* 3 types of prem (P) →

a) Absolute prem → A barometric prem (T).
b) Gauge prem → A tire prem sensor
c) Differential prem → diff^n b/w oppo^t sides.

* 4 types of prem (T) →

a) Strain gauge prem (T)
b) Capacitance " "
c) potentiometric " "
d) Resonant wire " "

⇒ Manometer = (M).

* It is a device to measure pressures.
* It is an instrumnt that uses a column of liquid to measure prem

* Types of (M) →

a) Simple (M)
b) U tube (M)
c) well type (M)
d) Barometer (M)
e) Inclined tube (M)
f) Micromanometr.

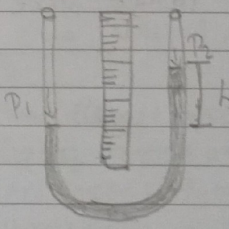
(1) U tube Manometer =

* Consist of a glass tube in U-shaped (end of which is connected to a point at which is connected to a point at which prem is to be measured & other end remains open to the atmosphere.
* used in the measurement of liquid or gas prem
→ Mercury is generally used as fluid.
* Manometric fluid of known specific gravity is used.

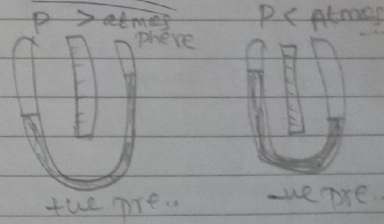
working principle →

$$P = \rho g h \qquad \Delta P = P_2 - P_1 = gh\,(\rho_m - \rho_f)$$

ΔP → differential prem
P_1 → prem at low-prem connection
P_2 → " at high-prem "
ρ → density of indicating fluid
g → acceleration of gravity.
h → diff^n in column heights.



⇒ U tube (M)

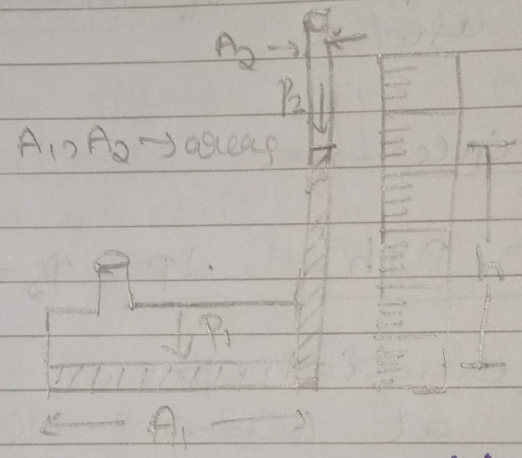


(2) well-type (M) =

* one leg is simple tube & other 1 is large well.

* If a unknown pressure P_1 is applied to port A, & port B is to the atmosphere, the gauge pressure is,

$$P_1 = gh\rho$$



cuell type (single leg) m)

Adv of (m)	Disadv of (m)
* Less expensive, * gd accuracy	* usually bulky & large size.