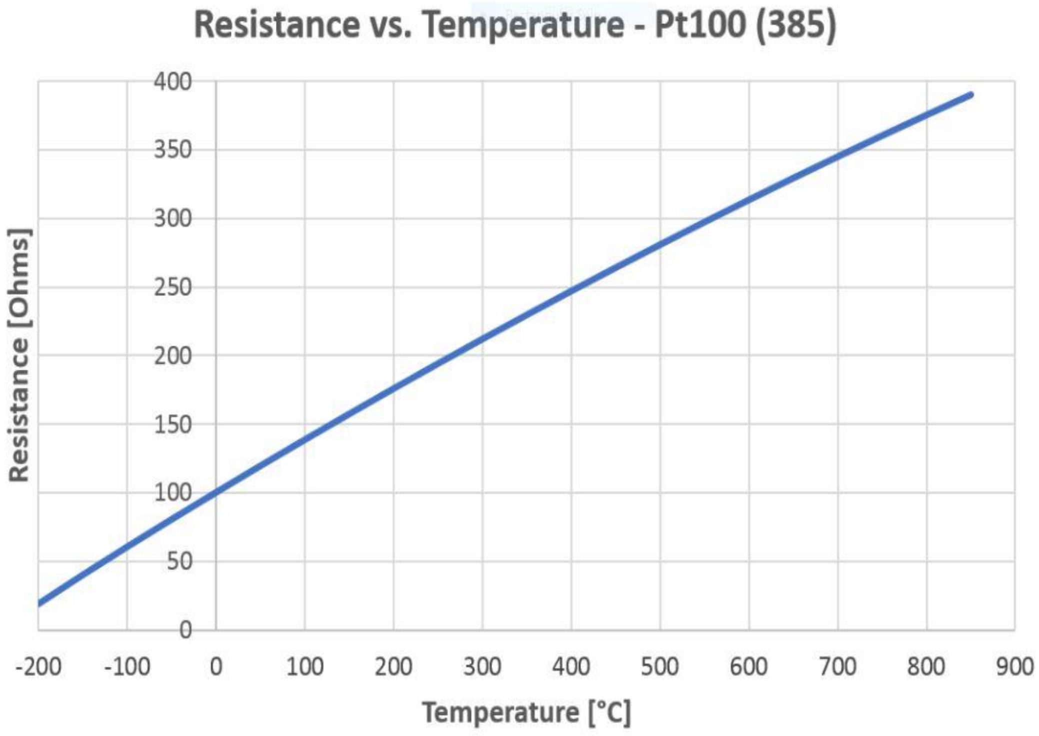
Resistive Sensor

Resistive Thermometer

- The resistive thermometers are based on the electrical resistance changing.
- When temperature changes, the resistance of metal generally increase with temperature, hence the change in resistance
- It is linear with temperature i.e. the change in resistance with temperature is linear with temperature over range of -100 ℃ to 800℃
- In general the relation is given by,

$$R_t = R_o(1 + \alpha t + \beta t^2 + \gamma t^3 + \cdots)$$



Resistive Thermometer….

Where,

R_t = resistance at t°C

R_o = resistance at 0°C

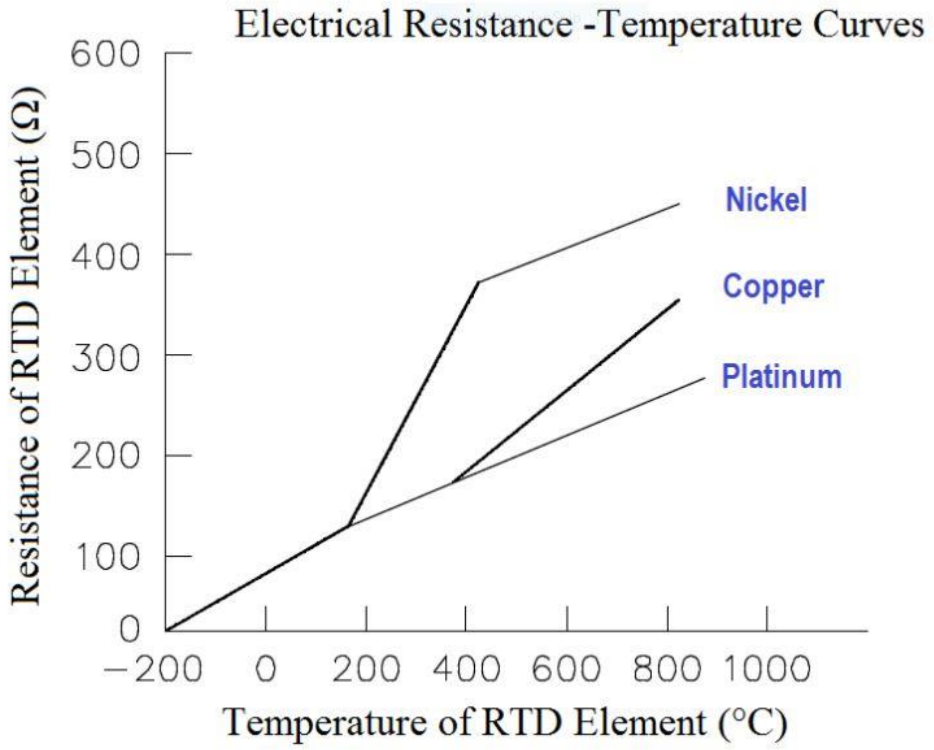
α, β, γ = temperature coefficient of resistance with $\alpha > \beta > \gamma$

- For an ideal linear relationship we have

$$R_t = R_o(1 + \alpha t)$$

- The resistance thermometers are made by winding Pt (platinum) wire or Nickel (Ni) wire or Copper (Cu) wire
- Platinum has closely linear relation between resistance & temperature and has long term stability.
- Platinum (Pt) has temperature range of about - 200 °C to 850 °C is relatively inert.
- It is more expensive than the other metals but is, however most widely used.

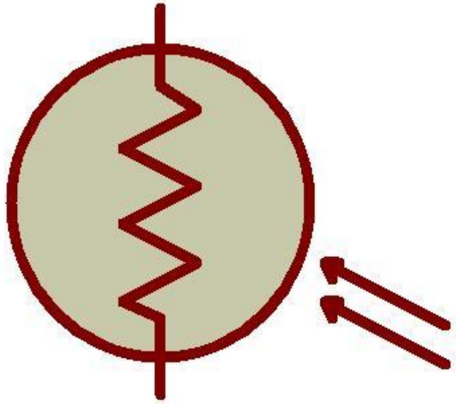
- Nickel & copper are cheaper but have less stability and can not be used for over such range of temperature.
- Nickel(Ni) has range of about -80 °C to 300 °C and for copper (Cu) -200 to 250 °C



Resistive Sensor

Photo conductive cells (or LDR):

- Photo conductive cells or light dependent resistors (LDR) are semiconductors used for their property of changing resistance when electromagnetic radiation is incident on such materials.
- When radiation of very high frequency is incident on such materials, electrons are excited from the valence-band to the conduction - band, with a result, a hole is produced in the valence - band for conduction and an electron for the conduction in the conduction band.
- The result is an increase in the number of charge carriers and hence a drop in resistance.



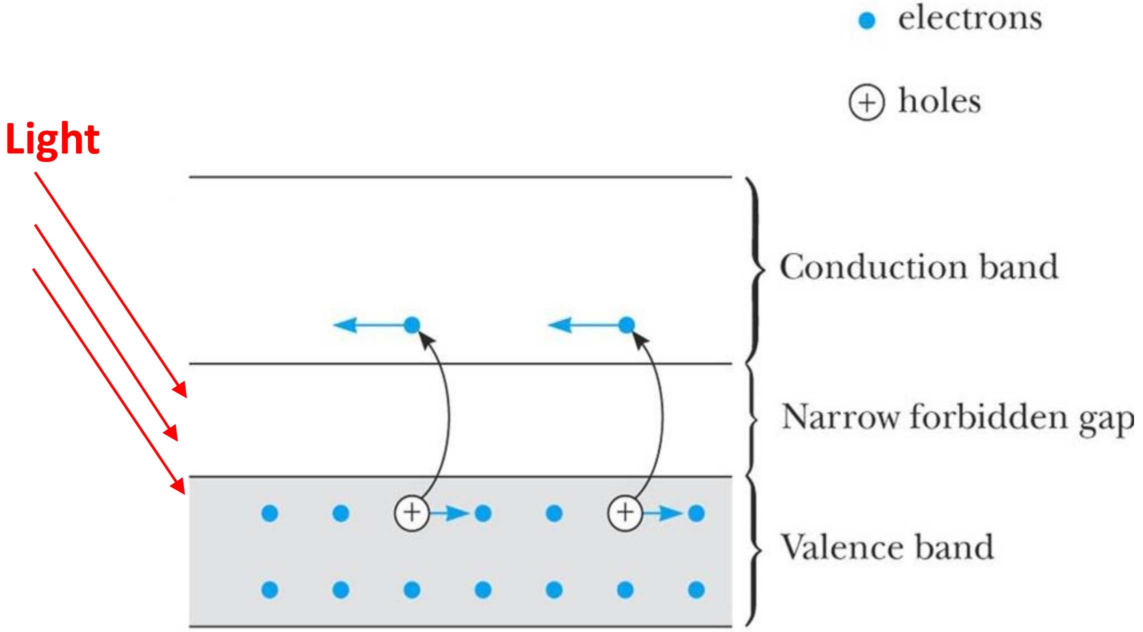
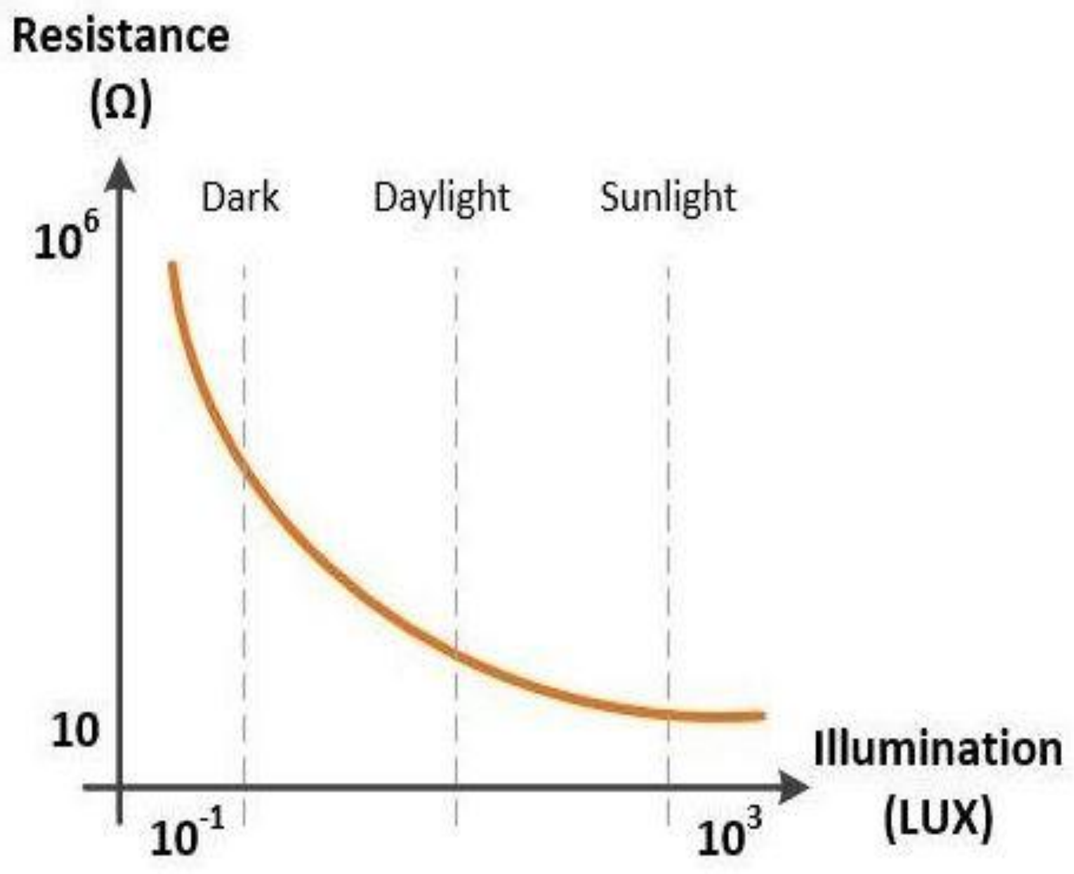


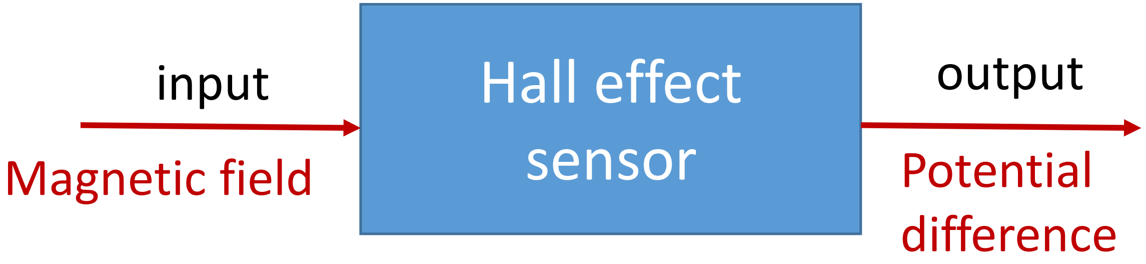
Photo conductive cells (or LDR)….

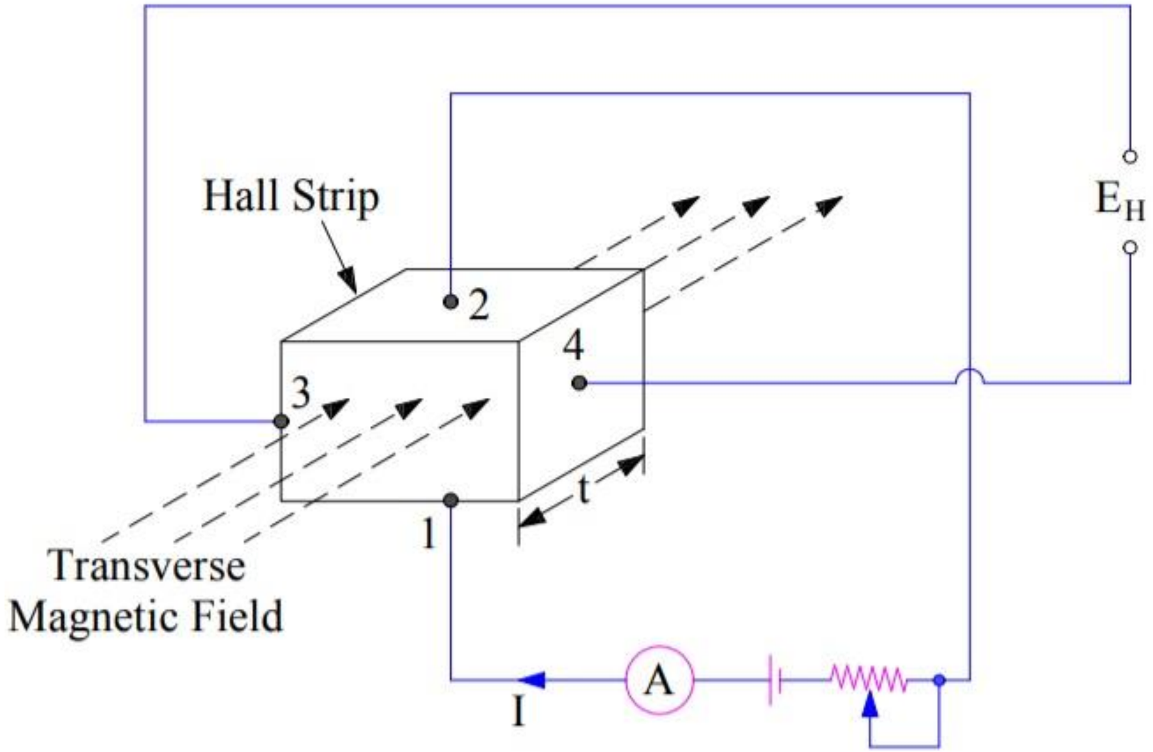
- As the intensity of radiation falling on the cell increases, the number of charge carriers available for conduction is increased and the resistance decreases
- Cadmium sulphide generally doped with atoms of other elements is a commonly material for photo - conductive cells.
- Fig, given below, shows the resistance versus the Intensity (in lux) curve that of Cadmium Sulphide (CdS_2) photo - conductive cell.



Hall effect sensor/transducer

- Hall Effect Transducer is a device which is used for the measurement of magnetic field strength.
- This transducer uses a conducting strip to convert magnetic field into proportional potential difference across the opposite faces of strip using Hall Effect.
- Hall Effect is basically the process of development of potential difference across the two faces of a current carrying strip when the strip is kept in a magnetic field.
- The magnitude of voltage depends upon the current, strength of magnetic field and the property of conducting material.
- The Hall Effect is found in conducting material and semiconductor in varying amount depending upon the density and mobility of current carrier.





- The current through the strip and the magnetic field are perpendicular to each other.
- Flow of current means the flow of positive charges in the direction of current. This means that, magnetic field will exert a force on the moving positive charges as per

$$F = q(v \times B)$$

- where v & B are the velocity and strength of magnetic field and in vector form.
- Since v and B are perpendicular to each other, the magnitude of force on the moving positive charges will be

$$F = qvB$$

- The direction of force F will be perpendicular to both the v and B as per the law of cross product of two vectors. This essentially means that F will be directed from edge 3 to 4 in the above figure.
- Due to this force on the positive charges, these charges will continue to accumulate on the face 3 which in turn will create an Electric Field.
- The direction of electric filed will be opposite to the direction of F i.e. from edge 3 to 4.
- Therefore, after some time, the magnitude of force exerted by electric filed E and F will become equal and hence there will not be any further movement of the charges.

$F = qE$ (qE is the force on the positive charge due to electric filed)

$$qE = qvB$$

$$\therefore E = vB$$

Due to set-up of electric filed E in the conducting strip across edge 3 and 4, a potential difference will be produced across this face.

Assuming the thickness of strip to be "t", the strength of potential difference across 3 & 4 is given as

$$E_H = Et$$

$$= vBt \text{ ....(1)}$$

Since the current density through a material is directly proportional to the velocity of carriers, therefore

$$v = K_H J \text{ ....(2)}$$

where J is the current density through the strip and K_H is a constant of proportionality called the Hall Effect Coefficient

$$\text{But } J = \frac{I}{A}$$

where A is the surface area, therefore,

$$J = \frac{I}{t^2}$$

Hence, from information (2),

$$v = \frac{K_H I}{t^2}$$

From information (1),

$$\boxed{E_H = \frac{K_H BI}{t}}$$

- The above expression gives the voltage developed due to Hall Effect.
- This voltage is called the hall effect emf and used to either measure the magnitude of current or magnetic field strength.
- The magnitude of Hall Effect emf is very small in conductors and hence very difficult to measure. However, its value is quite sufficient in semiconductors and can easily be measured by sensitive moving coil instruments