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Electronic Devices

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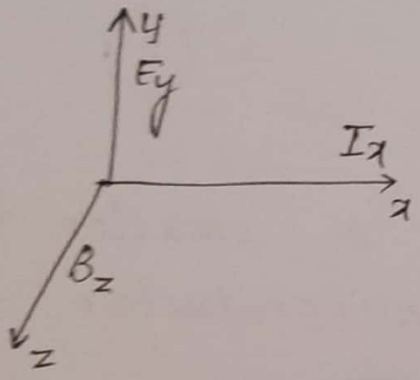
The Hall Effect

If a current 'I_x' carrying semiconductor is placed in a transverse Magnetic field 'B_z', then potential difference E_y is induced in the direction perpendicular to the current and Magnetic field.
The potential difference 'E_y' is called Hall Electric Field.



The Force at equilibrium between Magnetic Field & Electric field

$$q\, E_{H(y)} = q\, B_z\, v_d$$

$$\boxed{E_{H(y)} = B_z\, v_d} \quad -(1)$$

E_H : hall electricfield
B_z : Magnetic field
v_d : drift velocity.

The current density

$J = n q v_d$ — (2)

From (1)

$E_{H(y)} = v_d \cdot B_z$;

From (2)

$v_d = \frac{J}{nq}$ — (3)

(3) in (1)

$E_{H(y)} = \frac{J}{nq} \cdot B_z$ → (4)

R_H = Hall coefficient

$R_H = \frac{E_{H(y)}}{J \cdot B_z} = \frac{1}{nq}$ — (5)

For metals R_H value is smaller than compared to semiconductor

From (4)

$E_H(y) = \frac{J}{nq} B_z$ — (4)

$E_H(y) = \frac{\text{Voltage}}{\text{distance}} = \frac{V_H}{d}$ — (6)

(6) in (4)

$$\frac{V_H}{d} = \frac{J}{nq} B_z \qquad \left[J = \frac{I}{A} \right]$$

$A = t \times d$.

$$\frac{V_H}{d} = \frac{I_x}{n \cdot q \cdot A} \cdot B_z$$

$$\frac{V_H}{d} = \frac{I_x}{n \cdot q \cdot t \times d} \cdot B_z$$

$$\boxed{V_H = \frac{I_x}{n q t} \cdot B_z}$$

V_H = Hall voltage.

$$\boxed{V_H = \frac{I_x}{n q t} B_z}$$

Mobility μ_n of the charge carriers.

$\mu_n = \sigma R_H$.

W.K.T $R_H = \frac{1}{nq}$

$$\boxed{\mu_n = \sigma \cdot \frac{1}{nq}} \quad \text{—— (7)}$$

$\sigma = \frac{1}{\rho}$

or $\boxed{\mu_n = \frac{1}{\rho} R_H}$