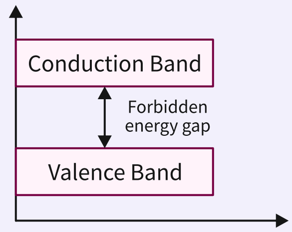
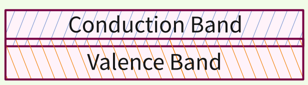
Energy Band

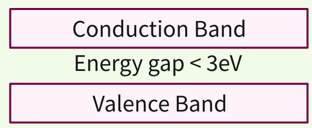
- The band which is completely filled with electrons at 0K is called **valence band**.
- **Conduction Band** is completely empty at 0K.
- **Energy band** gap is the difference between Valence band and Conduction band.



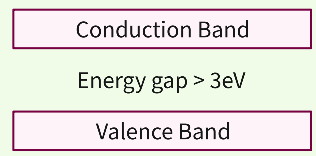
On the basis of Energy Band Theory



Conductor (Metal)
Conduction & valence bands overlap eachother



Semiconductor



Insulator

Classification of Metals, Insulator and Semiconductor on the basis of Conductivity

1) For metals:

$\rho \sim 10^{-2} - 10^{-8}\ \Omega$ m

$\sigma \sim 10^{2}$ - 10^{8} s/m

They have high conductivity.

2) For Semiconductors:

$\rho \sim 10^{-5} - 10^{6}\ \Omega$ m

$\sigma \sim 10^{5} - 10^{-6}$ s/m

They have intermediate conductivity to metals and insulators.

3) For insulators:

$\rho \sim 10^{11} - 10^{19}\ \Omega$ m

$\sigma \sim 10^{-11} - 10^{-19}$ s/m

They have low conductivity.

σ = electrical conductivity.

ρ = resistivity

14. SEMICONDUCTOR ELECTRONICS: MATERIALS,DEVICES AND SIMPLE CIRCUITS

Doping

The process of adding impurity in an controlled quantity with pure semiconductor to promote its conductivity.

SEMICONDUCTOR AND ITS TYPES

Semiconductors exhibit electrical conductivity between conductors and non – conductors.

Intrinsic Semiconductors

1) Pure Semiconductors are intrinsic semiconductors.
3) Examples:- Ge, Si

Extrinsic Semiconductors

1) The doped semiconductors are said to be extrinsic semiconductors
2) Impurities are added to improve conductivity

P – type Semiconductor

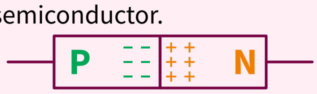
1) Si or Ge doped with trivalent (B, Al) elements.
2) Holes are majority charge carriers.
3) Electrons are minority charge carriers.

N – type Semiconductor

1) Si or Ge doped with pentavalent elements (P, As)
2) Electrons are majority charge carriers.
3) Holes are minority charge carriers.

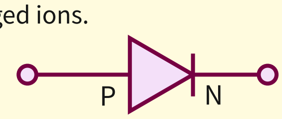
P – N junction

A junction formed either when a p-type semiconductor is grown in n-type semiconductor or n-type is grown in a p-type semiconductor.



P – N junction diode

- P – N junction diode is the combination of P – type and N – type semiconductor.
- P – region has mobile majority holes and immobile – ve ions.
- N – region has mobile majority free electrons and immobile positively charged ions.



Potential Barrier

Potential barrier is the potential difference developed across depletion region.

V_B = 0.7 for silicon

= 0.3 for germanium

Forward Bias

In Forward Bias
1) +ve terminal of the battery to p – side
2) -ve terminal of the battery to n – side
3) depletion layer reduced
4) diffusion current increases

Reverse Bias

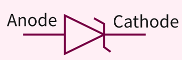
In reverse Bias
1) -ve terminal of the battery to p – side
2) +ve terminal of the battery to n -side
3) depletion layer increases
4) very small reverse current

Avalanche Breakdown

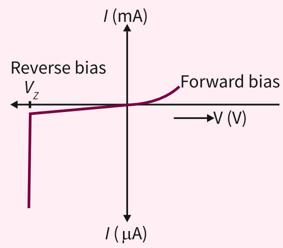
This phenomenon takes place in,
1) p - n junction having 'Low doping'
2) p - n junction having thick depletion layer.
Here, p–n junction damages permanently due to abruptly increment of minorities during repetitive collisions.

Zener Diode

Specially designed junction diodes which can operate in the reverse breakdown voltage region continuously without being damaged.



Zener Diode



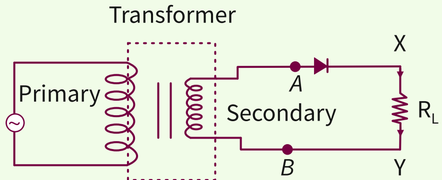
I-V characteristics

Zener Breakdown

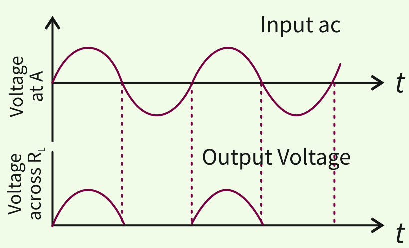
This phenomenon takes place in
1) p – n junction having ' high doping'
2) p – n junction having thin depletion layer
Here, p -n junction does not damage permanently

Applications of Junction Diode

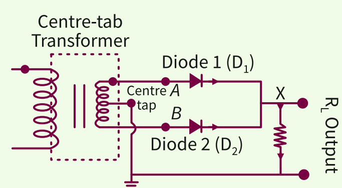
1. Half Wave Rectifier



A half-wave rectifier circuit

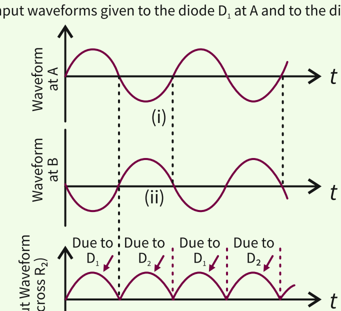


1. Full- Wave Rectifier



A full-wave rectifier circuit

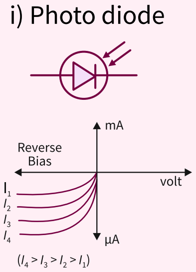
Input waveforms given to the diode D_1 at A and to the diode D_2 at B



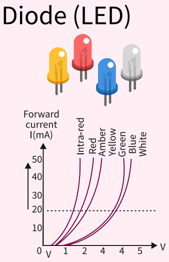
Output waveform across the load R_L connected in the full-wave rectifier circuit.

Optoelectronic Junction Devices

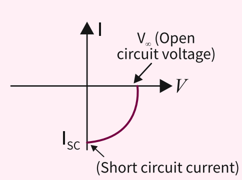
i) Photo diode



ii) Light-Emitting Diode (LED)



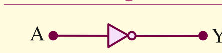
iii) Solar cell



I-V characteristics of solar cell

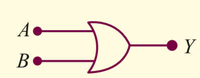
Basic Logic Gates

NOT



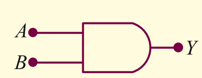
$Y = \overline{A}$

OR



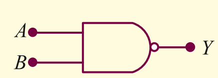
$Y = A + B$

AND



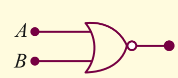
$Y = A \bullet B$

NAND



$Y = \overline{A \bullet B}$

NOR



$Y = \overline{A + B}$