Subject- Physics
Semester-IV
Unit:- 1 Solid State Electronics

By

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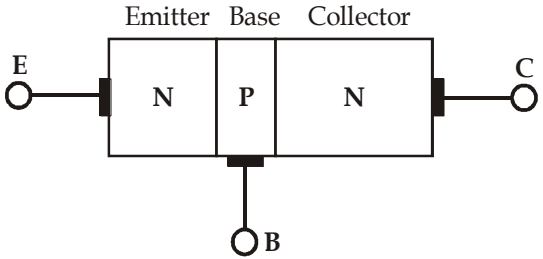
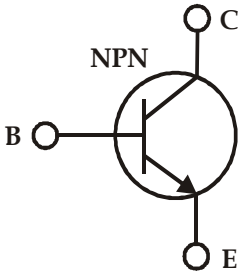
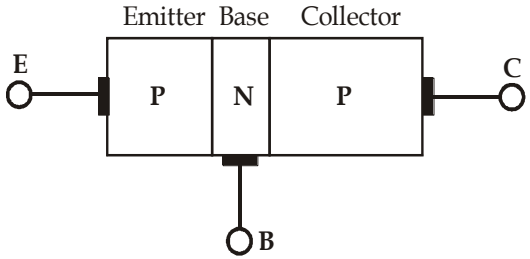
Bipolar Junction Transistor

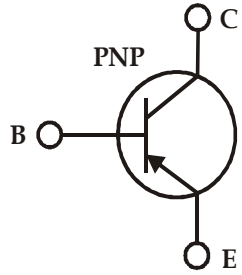
- Transistor = transfer + resistor
- It transfer signal from low to high resistance.
- Bipolar junction transistor (BJT)
  - electrons
  - holes

Types of Transistor







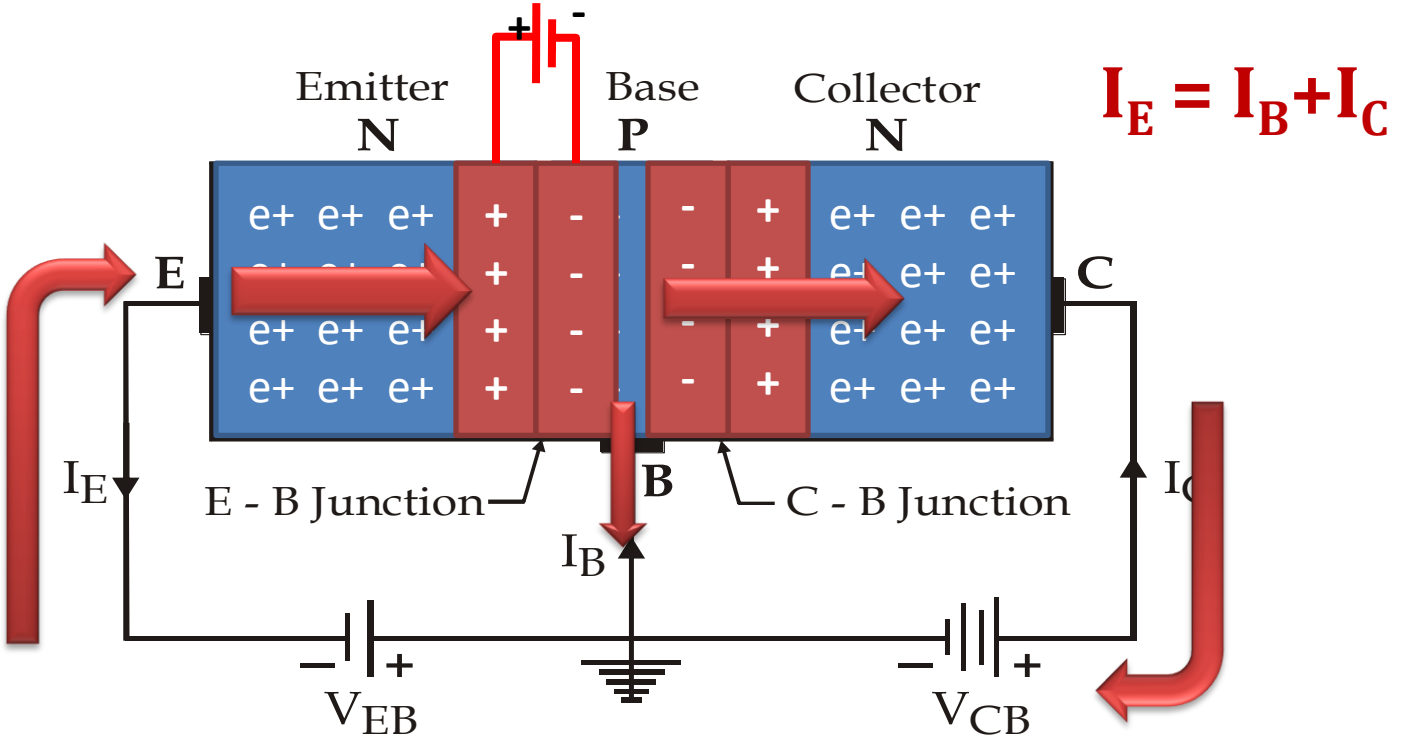


a) Emitter:- supplies charge carriers (electrons or holes).
It is **heavily doped** and is always connected in forward bias with respect to base, so that it can inject large number of majority charge carrier into the base region.
It is **moderate in size**.

b) Base:- It is **lightly doped** and very **thin** so that most of the emitter injected charge carrier passed to the collector region.

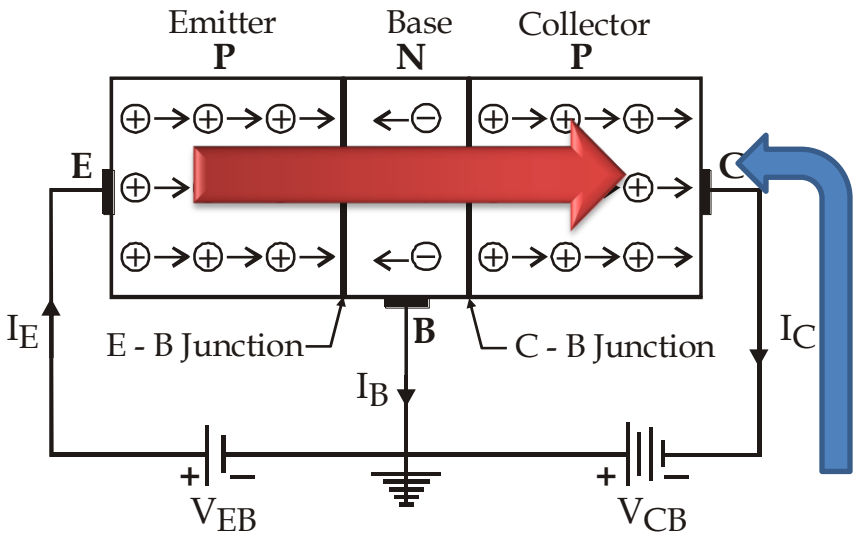
c) Collector:- collector collects charge carrier emitted by emitter.
The collector is **moderately doped** and is **wider** than both base and emitter.

Working of N-P-N transistor



$$I_E = I_B + I_C$$

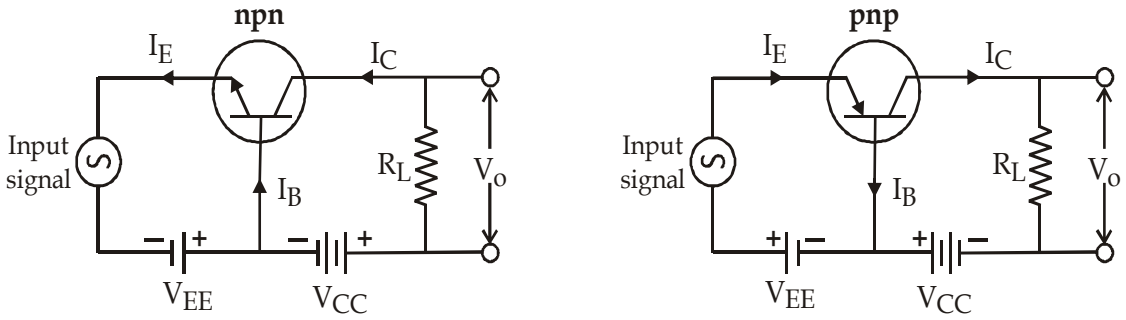
Working of PNP transistor



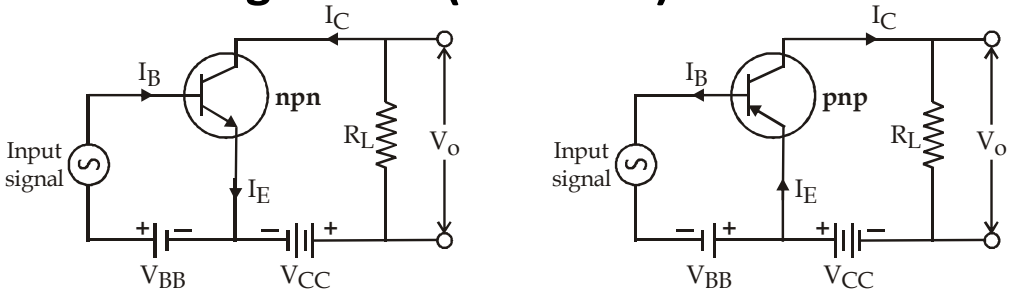
1. As hole reach collector region, a fresh electron is released from negative terminal of battery V_{CB} and recombine with holes.
2. Also for each hole which is lost in collector region, a covalent bond is broken in the emitter and electron is liberated which enters the positive terminal of V_{EB} and the holes produce move towards base
3. In PNP transistor, the current flow inside the transistor is carried by holes and in external circuit by electrons

Transistor Configuration or Mode

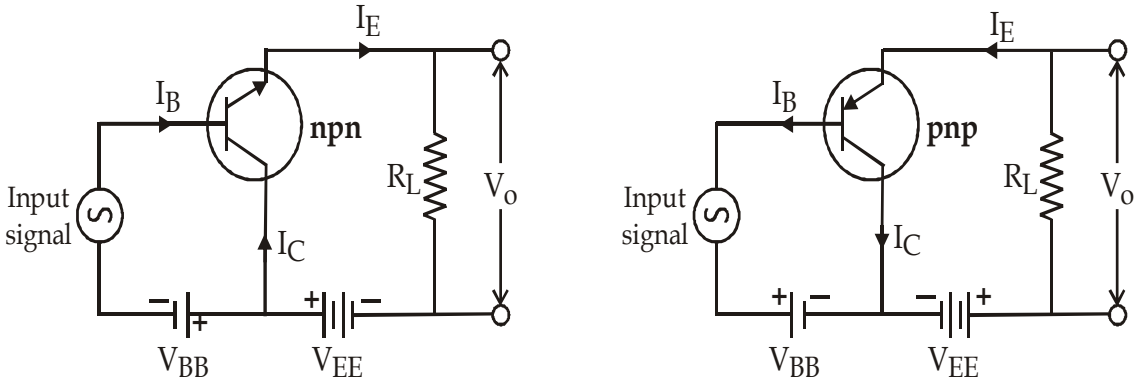
1) Common Base configuration (CB mode):



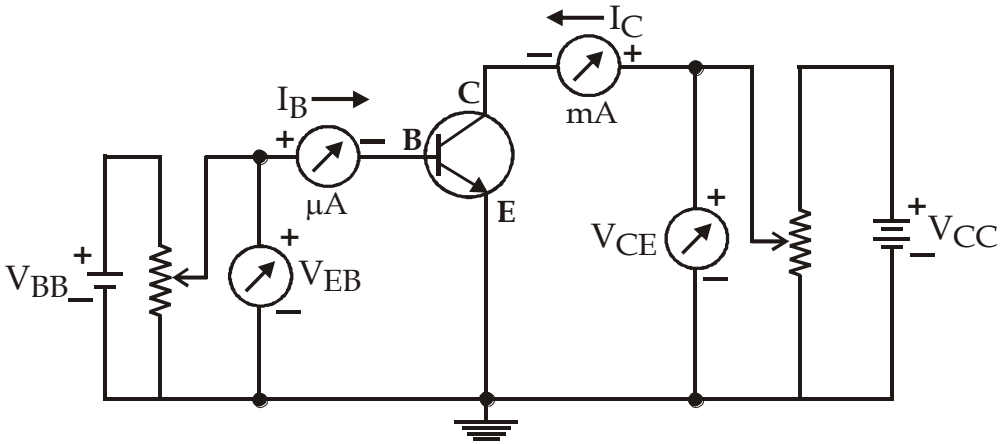
2) Common Emitter configuration (CE mode):



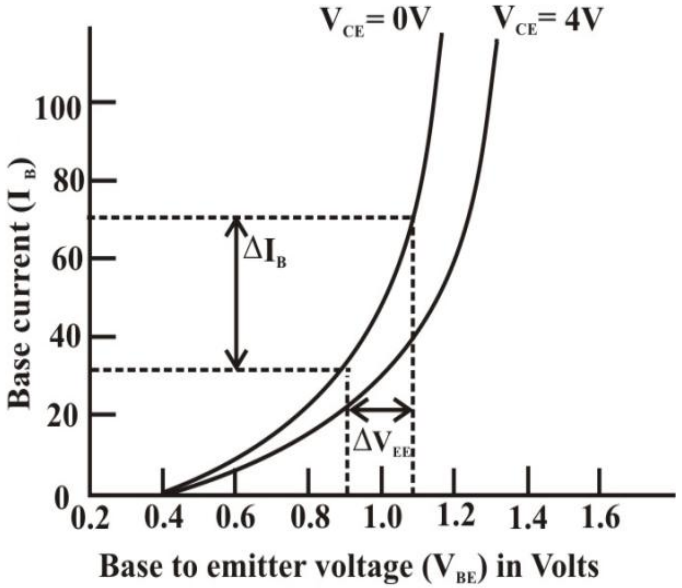
- **3) Common Collector configuration (CC mode):**



Characteristic of NPN transistor in CE mode

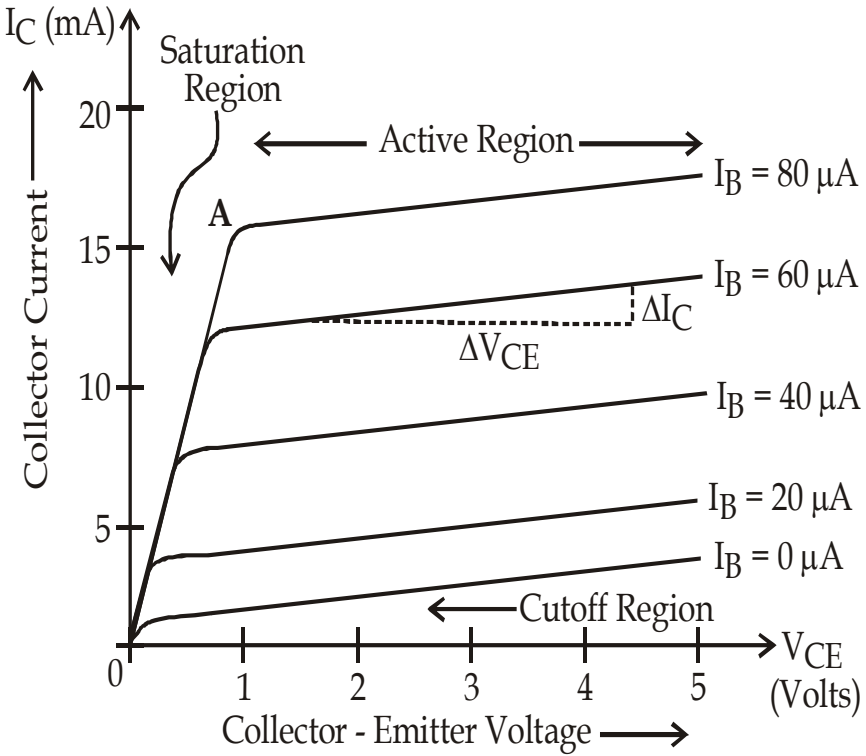


Input Characteristic



$$r_i = \left(\frac{\Delta V_{BE}}{\Delta I_B}\right)$$

Out put characteristic



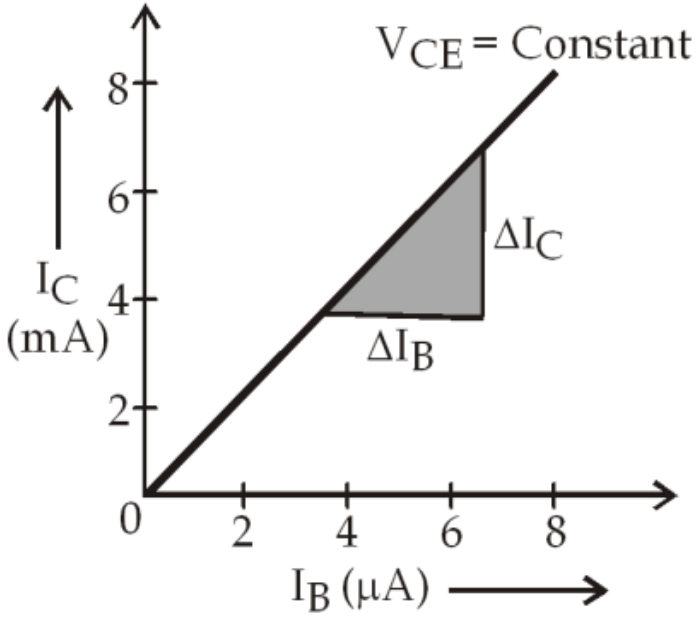
a) Saturation Region: The region of the curve to the left of the line OA is known as saturation region. In this region both junctions are forward biased.

b) Cut-off Region: The region below the curve I_B=0 is known as cut-off region. In this region both the junction are reversed biased.

c) Active Region: The central region where the curve are uniform in spacing is called as active region. In this region E-B junction is forward biased and C-B junction is reversed biased.

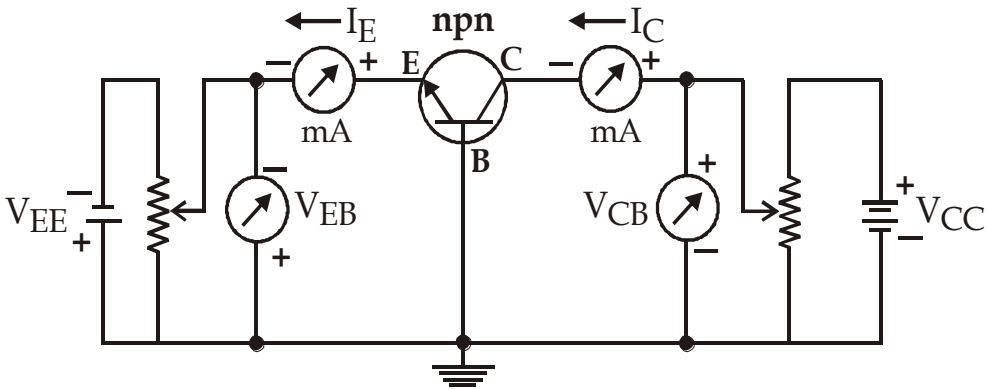
$$\beta = \left(\frac{\Delta I_C}{\Delta I_B}\right)$$

Transfer characteristic

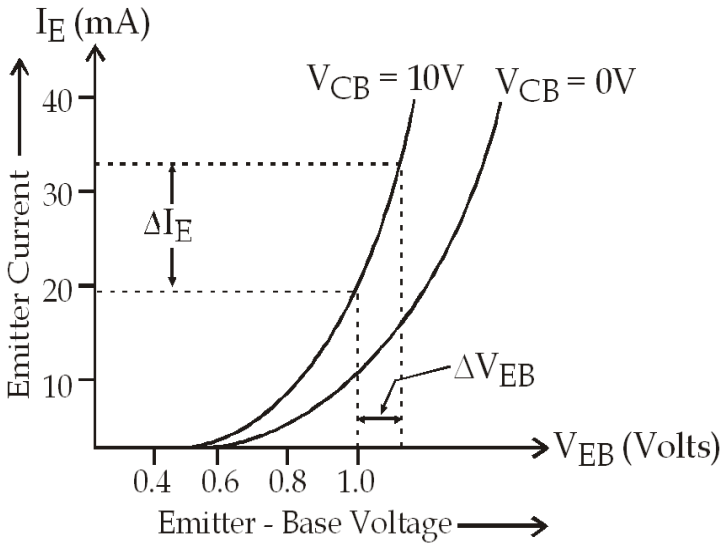


$$\beta = \left(\frac{\Delta I_C}{\Delta I_B}\right)$$

Characteristic of NPN transistor in CB mode

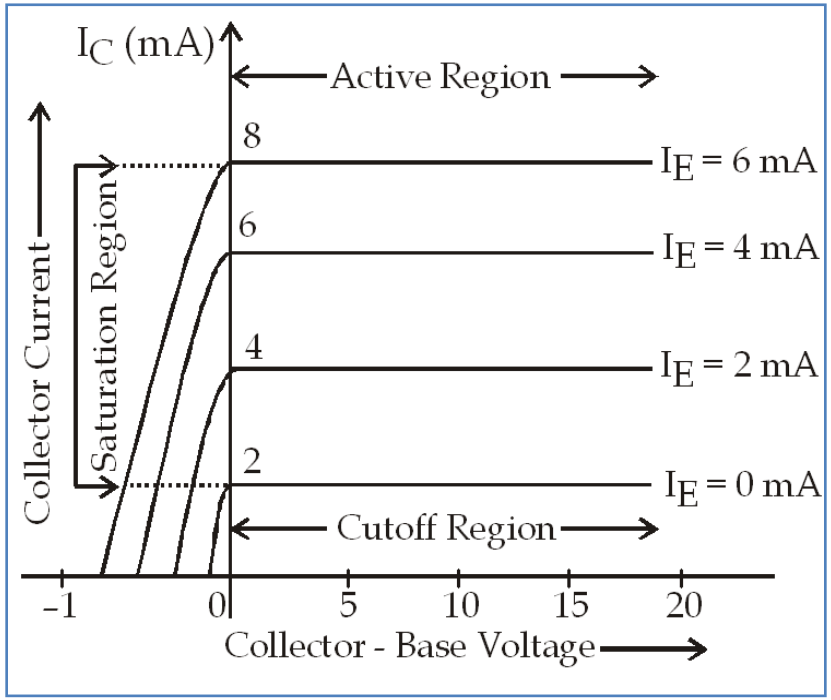


Input Characteristic

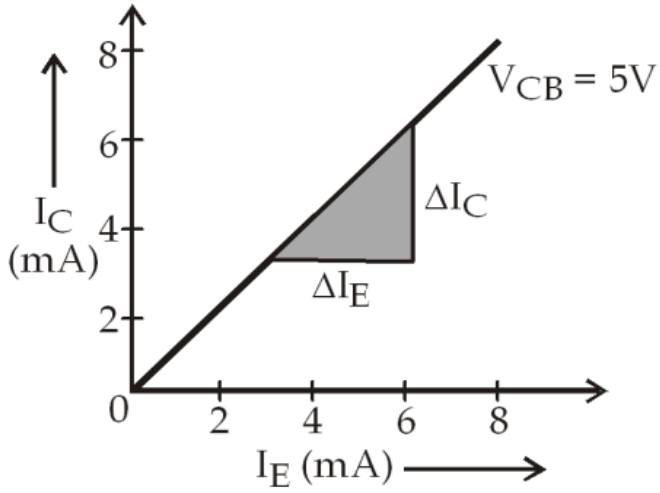


$$r_i = \left(\frac{\Delta V_{EB}}{\Delta I_E} \right)$$

Out put characteristic



Transfer characteristic



$$\alpha = \left(\frac{\Delta I_C}{\Delta I_E}\right)$$

Relation between α and β

The emitter current in the circuit is given by, $I_E = I_B + I_C$

For small change, we have, $\Delta I_E = \Delta I_B + \Delta I_C$

Divide by ΔI_C, we get, $\frac{\Delta I_E}{\Delta I_C} = \frac{\Delta I_B}{\Delta I_C} + 1$

But, $\alpha = \left(\frac{\Delta I_C}{\Delta I_E}\right)$ and $\beta = \left(\frac{\Delta I_C}{\Delta I_B}\right)$

$\therefore \quad \frac{1}{\alpha} = \frac{1}{\beta} + 1$

$\therefore \quad \frac{1}{\alpha} = \frac{1+\beta}{\beta}$

$\therefore \quad \alpha = \left(\frac{\beta}{1+\beta}\right)$

And, $\frac{1}{\beta} = \frac{1}{\alpha} - 1$

$\therefore \quad \frac{1}{\beta} = \frac{1-\alpha}{\alpha}$

$\therefore \quad \beta = \left(\frac{\alpha}{1-\alpha}\right)$