Bipolar Junction Transistor (BJT)

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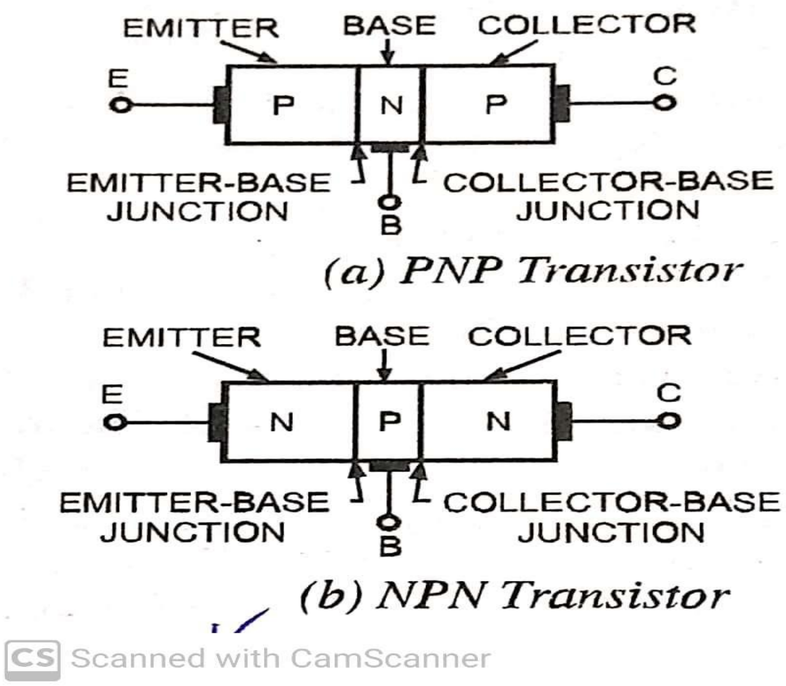
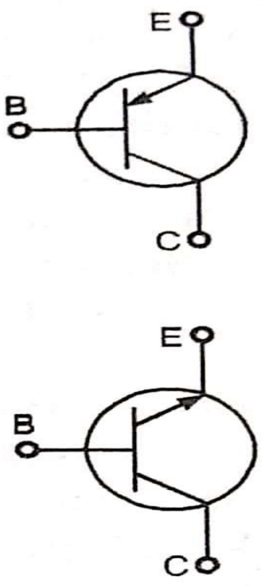
INTRODUCTION:

- BJT is a three layer, two junction semiconductor device.
- Two types of formation: p-n-p and n-p-n.
- Emitter, base and collector
- Each type of transistor has two junctions: emitter junction (J_E) and collector junction (J_C).



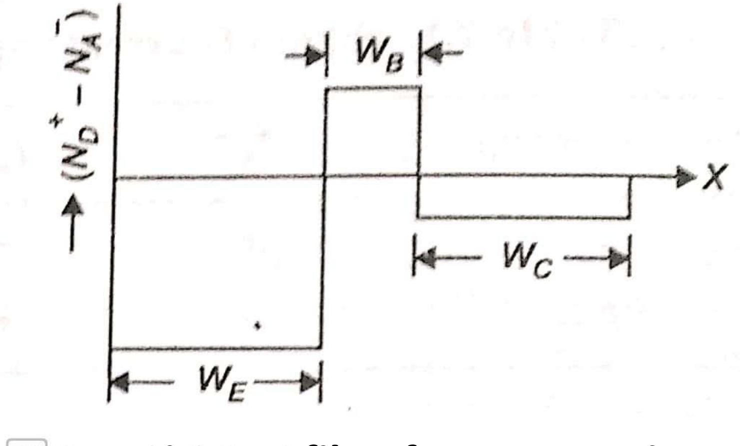


Circuit symbol

- **Since both majority and minority carriers are involved in a junction transistor, so this device is termed the bipolar junction device.**

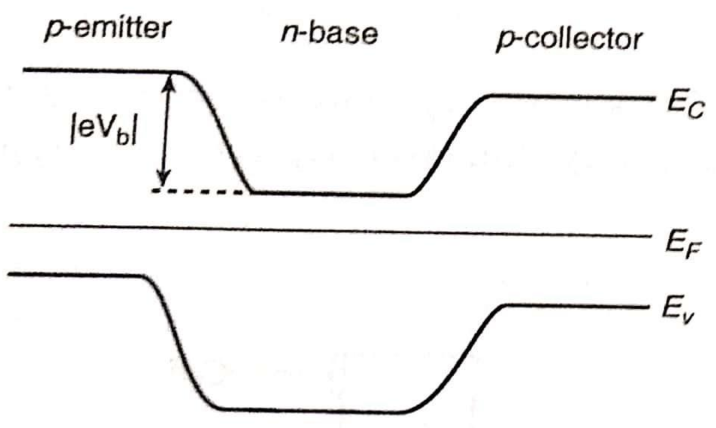
- **Due to transistor action it is found that an almost same current passes from a low resistance input circuit to a high resistance ouput circuit. The term transistor has been derived from the words "transfer resistor"**

- **The doping of the emitter of a transistor is greater than of the collector. The base region is oppositely doped at a level intermediate between the emitter and the collector.**



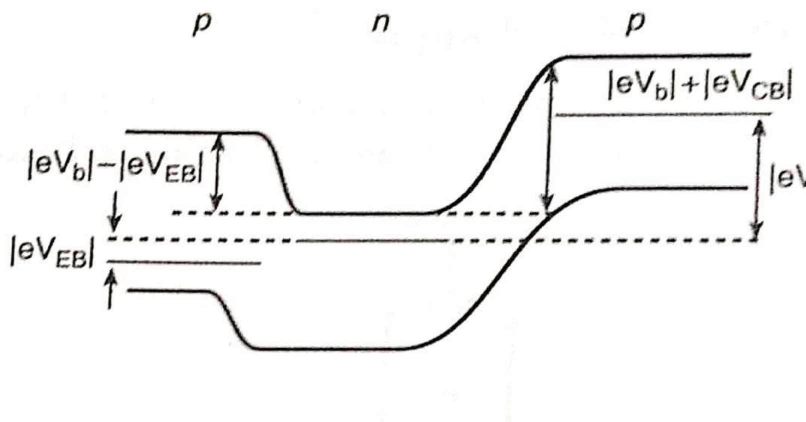
Doping profile of p-n-p transistor

Energy band diagram of a symmetric transistor:



(a)

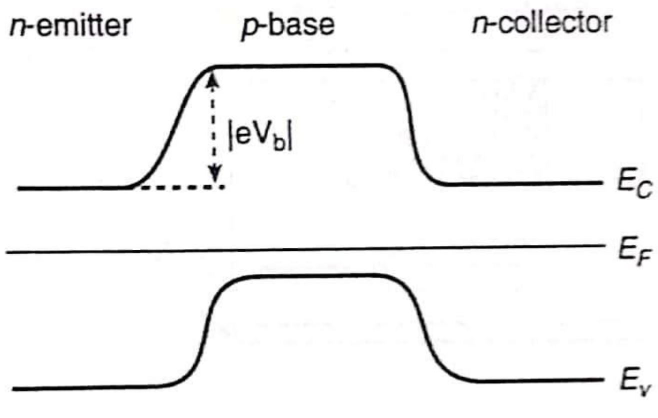
Unbiased



(b)

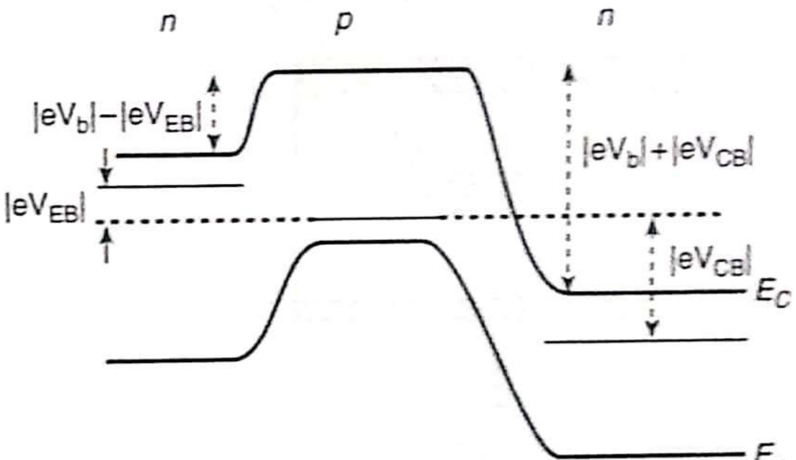
Biased

Energy band diagram with E-B junction forward bias and C-B junction reverse bias.



(a)

Unbiased

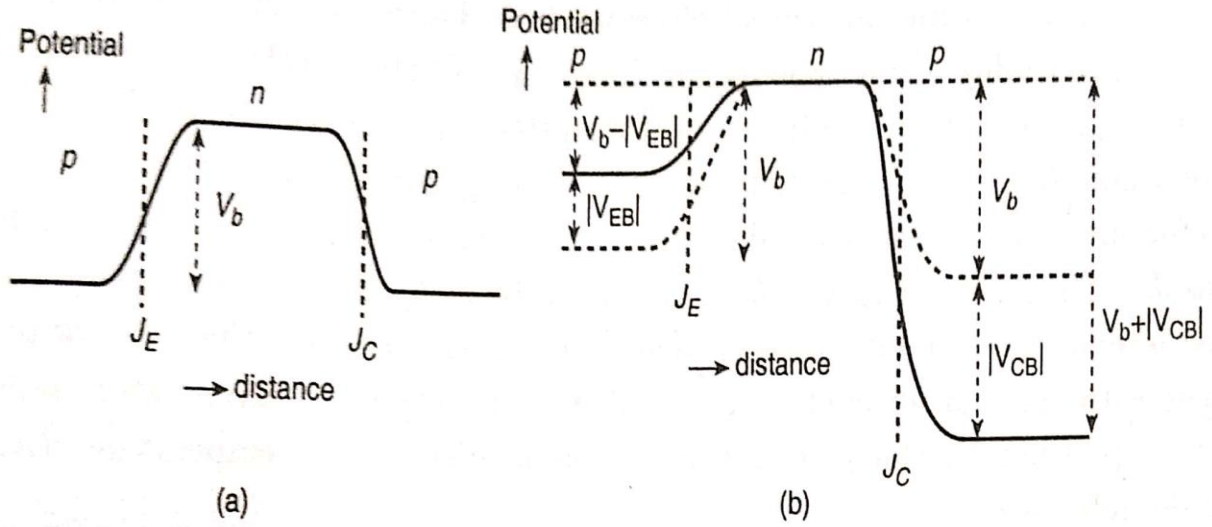


(b)

Biased

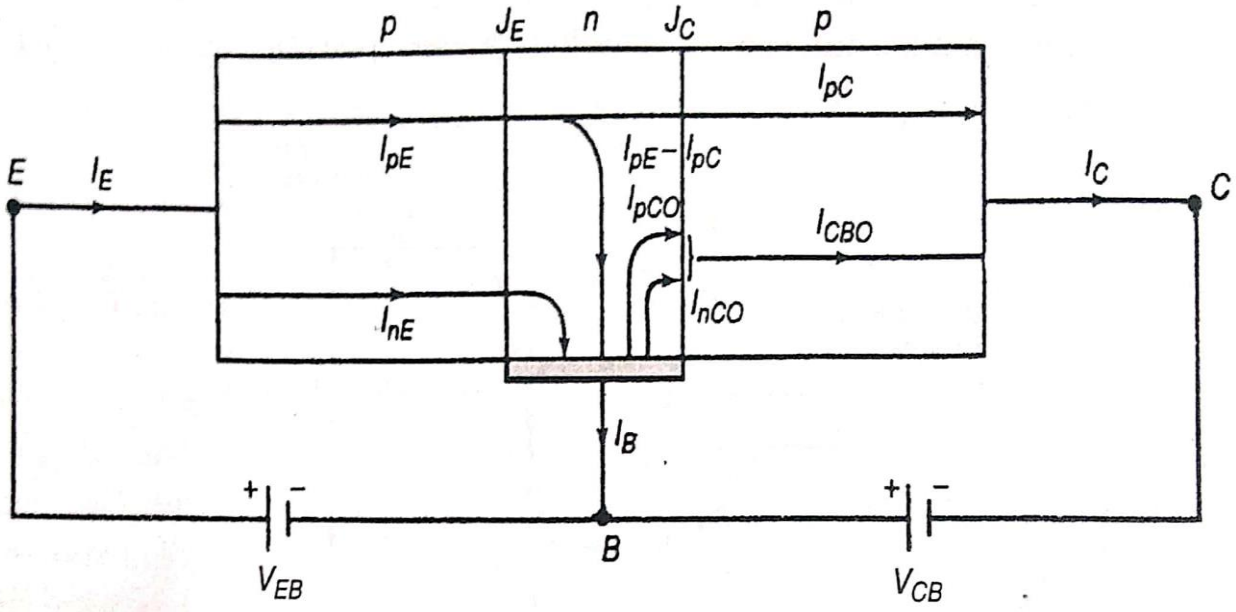
- ❑ The forward biasing of E-B junction reduce the intrinsic energy barrier eV_b to $eV_b - eV_{EB}$
- ❑ The reverse biasing of C-B junction reduce the intrinsic energy barrier eV_b to $eV_b + eV_{EB}$

Current component:



Unbiased **Biased**

Potential variation through a symmetrical p-n-p transistor



I_{pE} = emitter current due to hole

I_{nE} = emitter current due to electron

Emitter current, $I_E = I_{pE}+I_{nE}$

Base current, $I_B = I_{pE} - I_{pC}$

I_{pC}= collector current due to hole

I_{nCO}=current due minority carrier flowing from p-side to n-side

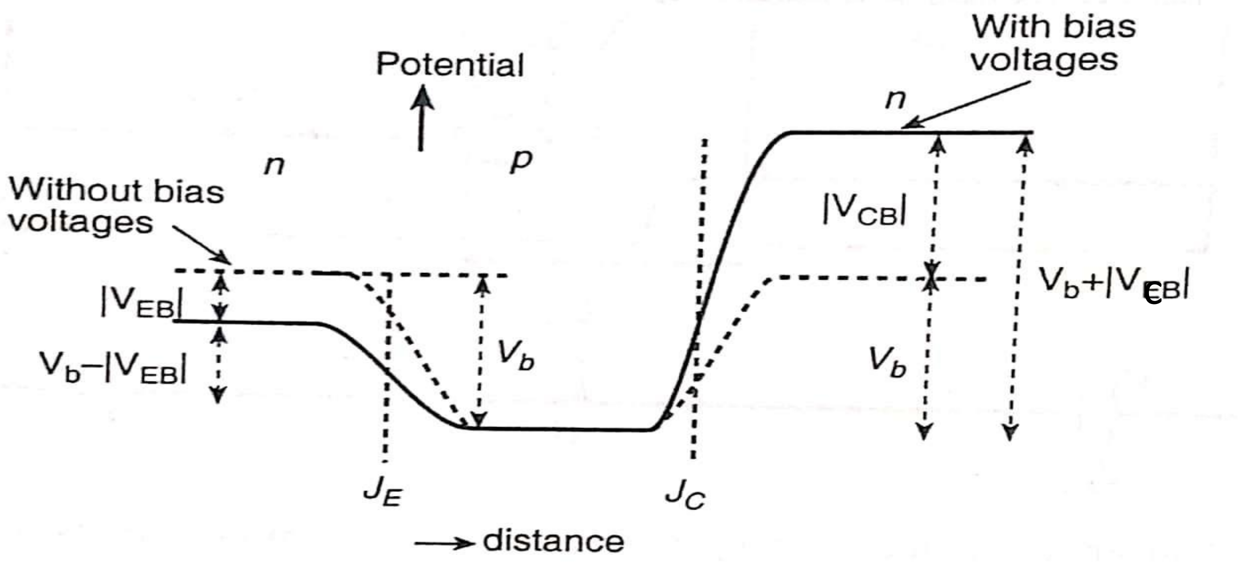
I_{pCO}=current due minority carrier flowing from n-side to p-side

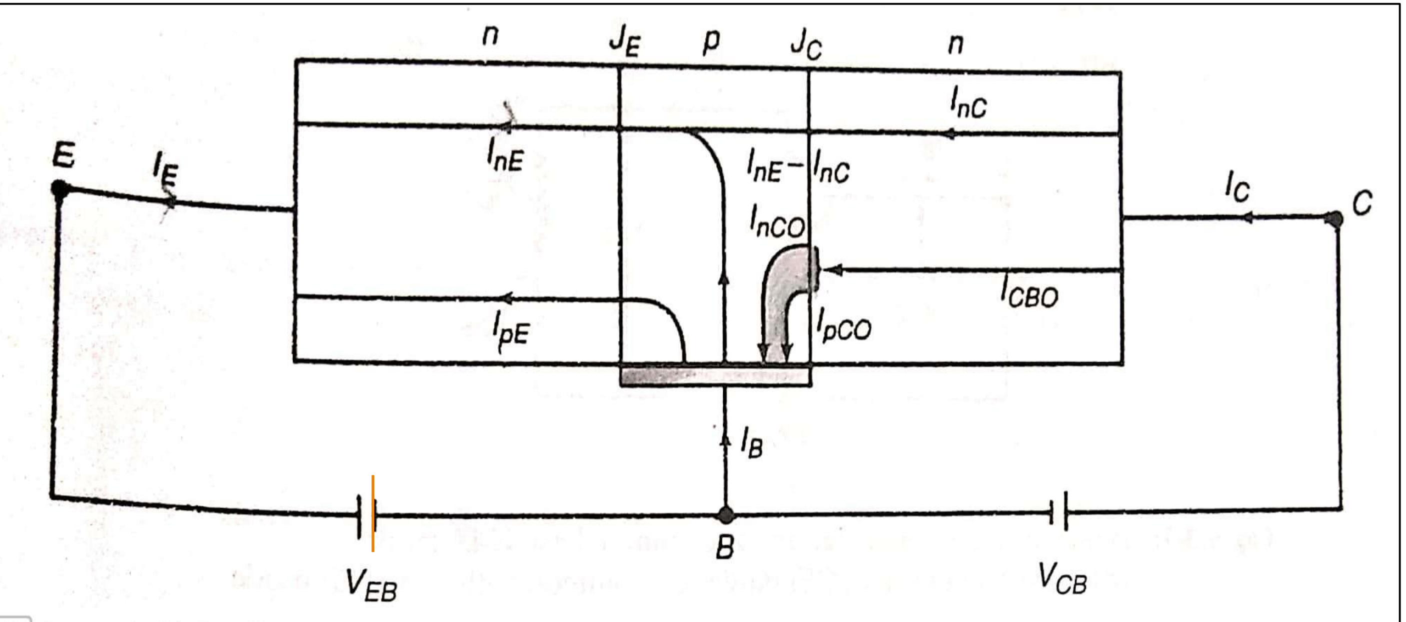
Reverse collector saturation current, $I_{CO} = I_{nCO} + I_{pCO}$

Collector current, $I_C = I_{pC} + I_{CO}$

$$I_E = I_B + I_C$$

Potential variation through a symmetrical n-p-n transistor





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Reverse collector saturation current, $I_{CO} = I_{nCO} + I_{pCO}$

Collector current, $I_C = I_{pC} + I_{CO}$

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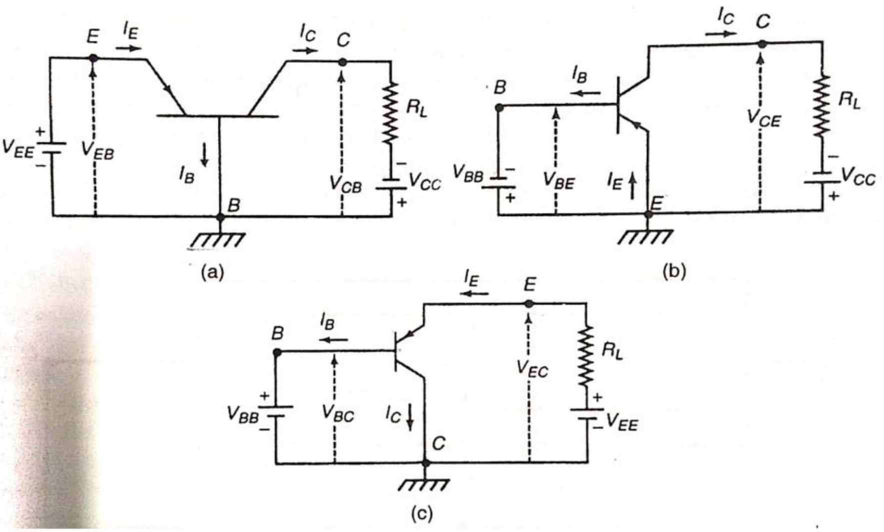
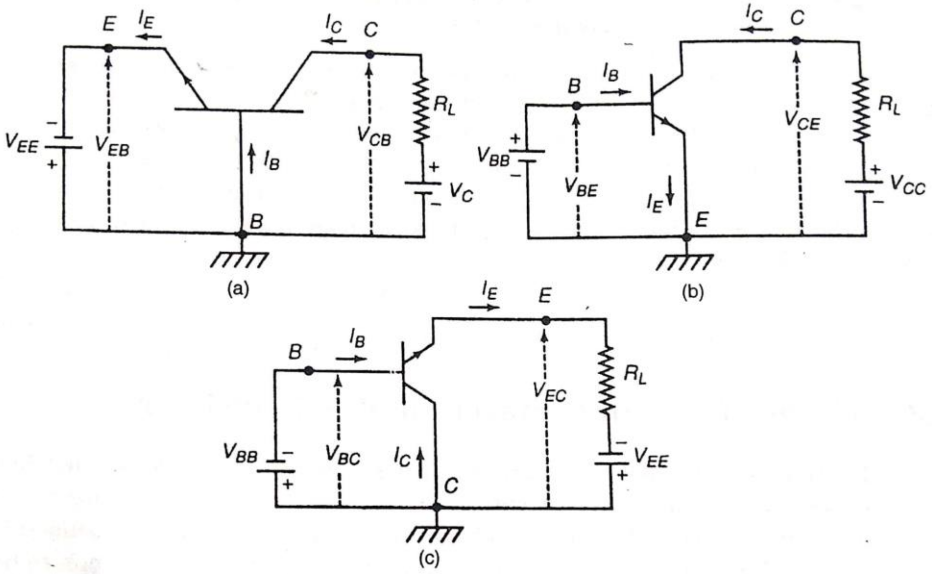
Modes of connection of a transistor:

- ❑ Common emitter (CE) mode
- ❑ Common base (CB) mode
- ❑ Common collector (CC) mode



p-n-p transistor connected in (a) CB (b) CE (c) CC mode



n-p-n transistor connected in (a) CB (b) CE (c) CC mode

Transistor α and β :

α represent the fraction of emitter current that can injected into the base and reach the collector. α is called dc current gain of the common base transistor. α lies between 0.95 to 0.995

α= $\frac{I_C}{I_E}$

The maximum current gain of a transistor operated in the common-emitter mode is denoted by the parameter **β**. It is also denoted by h_{FE}. Commercial transistor have values of h_{FE} in the range from 20 to 200

β=$\frac{I_C}{I_B}$

Relation between α and β:

We know, $I_E = I_B + I_C$

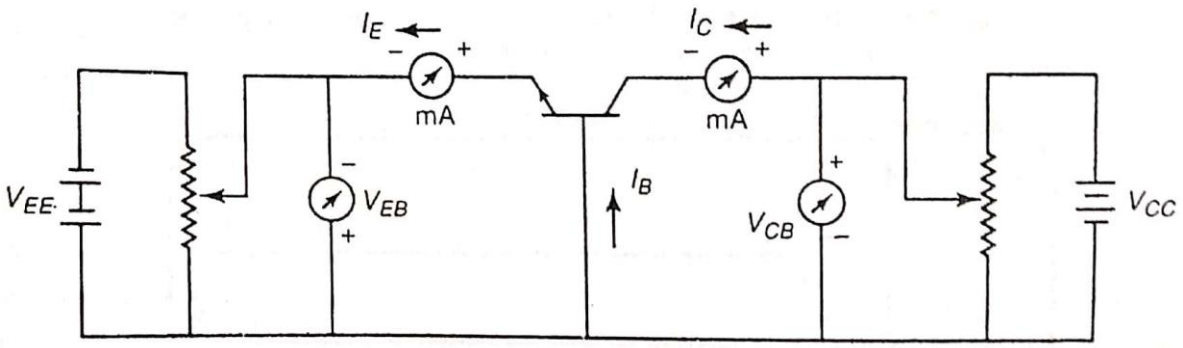
=> $\frac{I_E}{I_C} = \frac{I_B}{I_C} + 1$

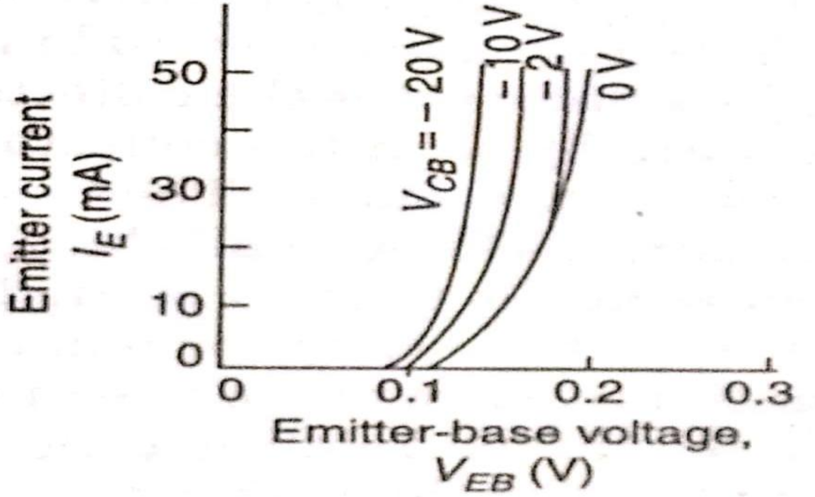
=> $\frac{1}{\alpha} = \frac{1}{\beta} + 1$

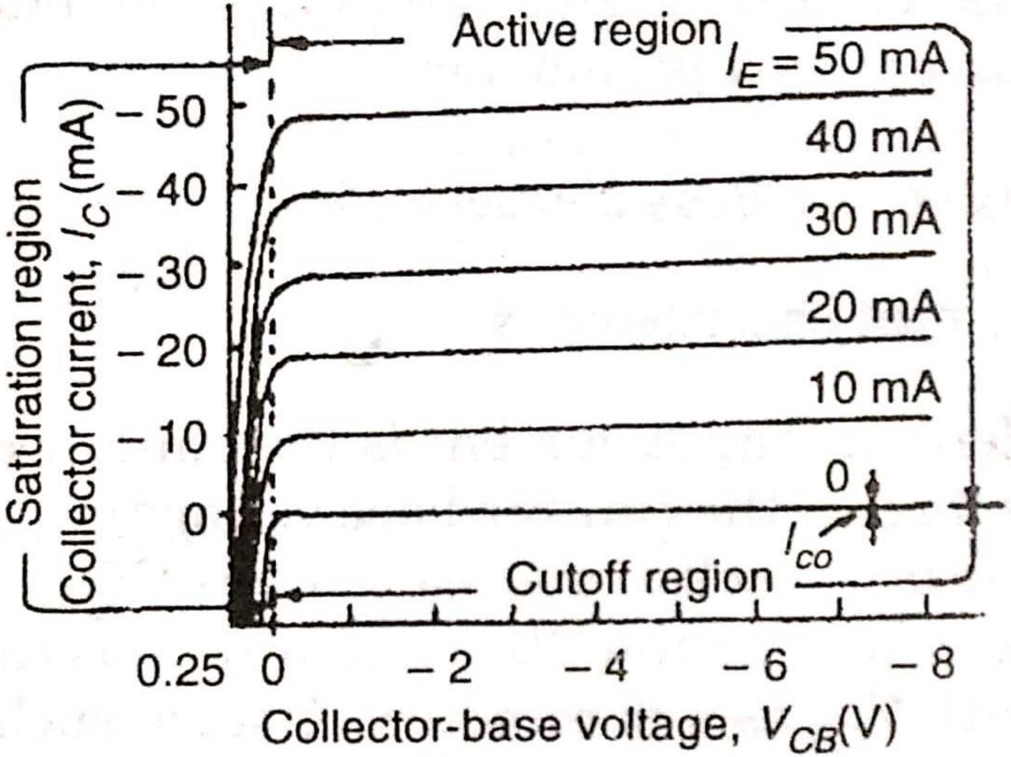
=> $\alpha = \frac{\beta}{1+\beta}$

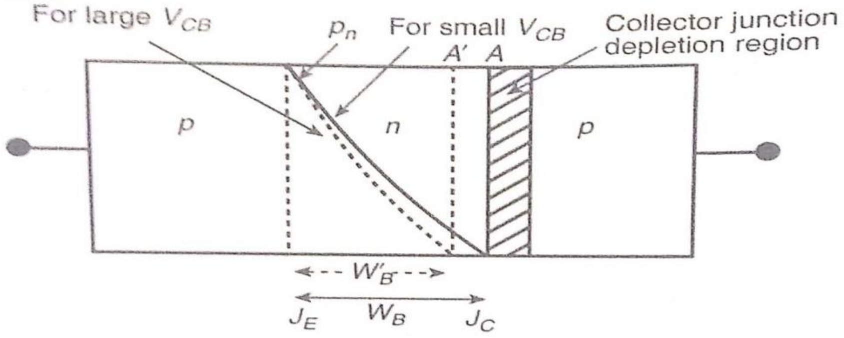
=> $\beta = \frac{\alpha}{1-\alpha}$

Common base characteristics:





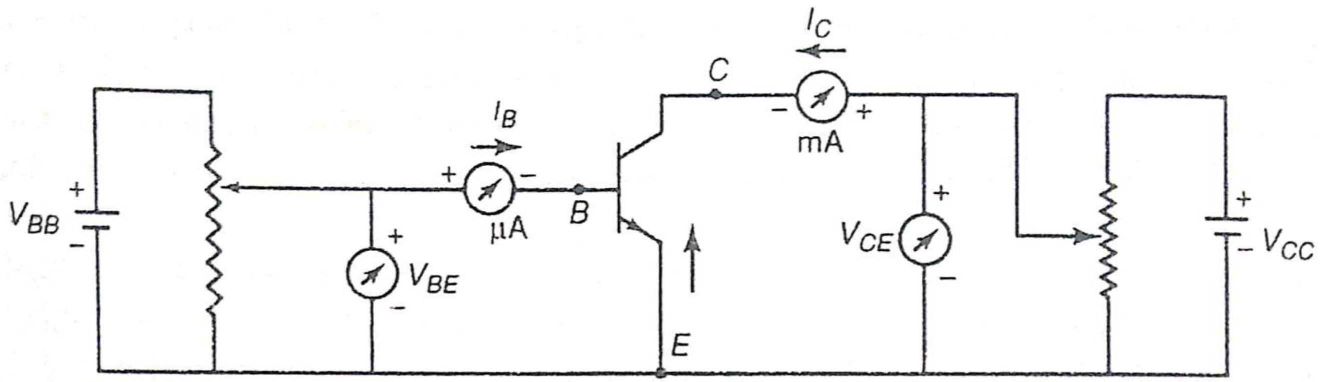


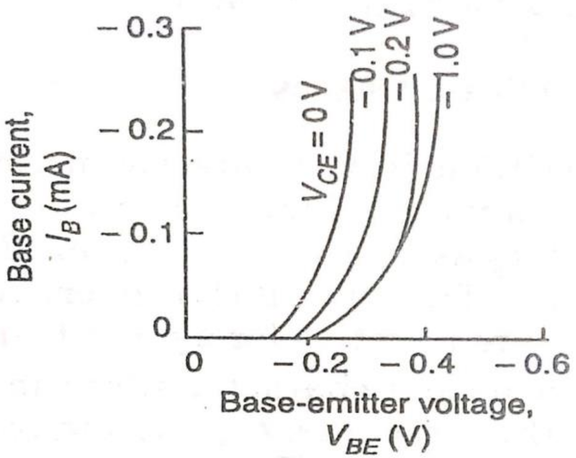


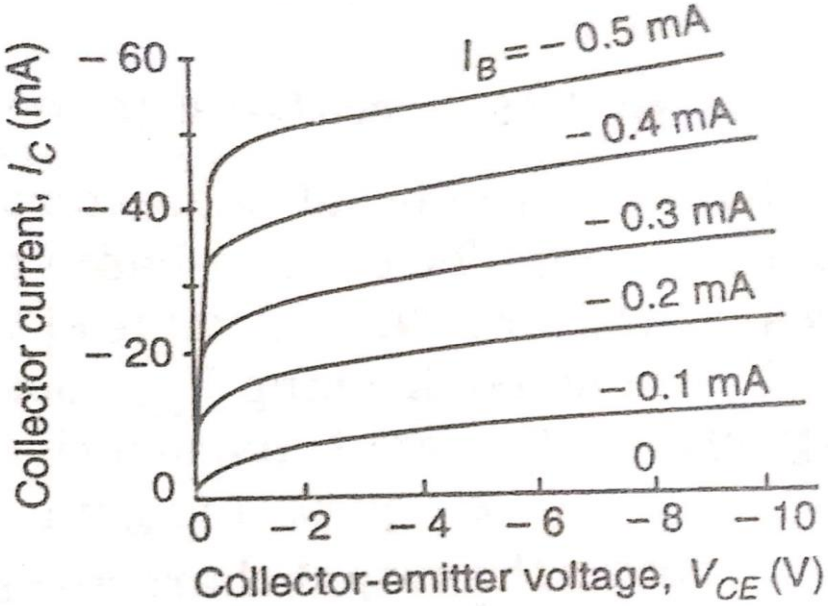
When V_{CB} increases, the width of the depletion region at the collector-Base junction increases, thereby reducing the effective base width. The change of the effective base width by the collector voltage is termed the **Early effect or base width modulation.

** punch through: at a certain reverse voltage of the Jc, reducing the effective base width to zero.

Common emitter characteristics:







Thank you