Bipolar Junction Transistor ; BJT

BJT :

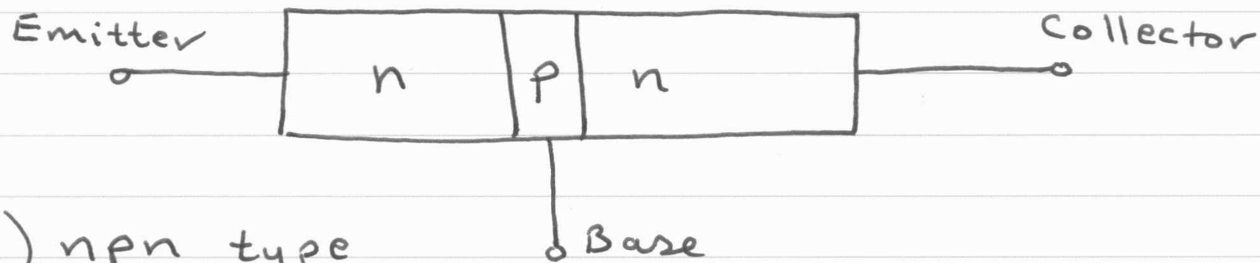
1 - It is a semiconductor device that can amplify electrical signals such as radio and television signals

2 - It is essential ingredient of every electronic circuits ; from the simplest amplifier or oscillator to the most eleborate digital computer

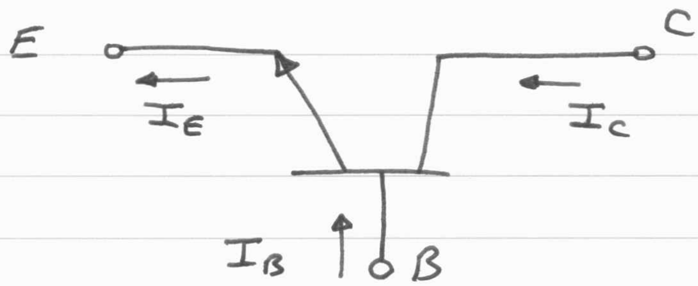
3 - It is a three terminal device ; Base, emitter, and Collector

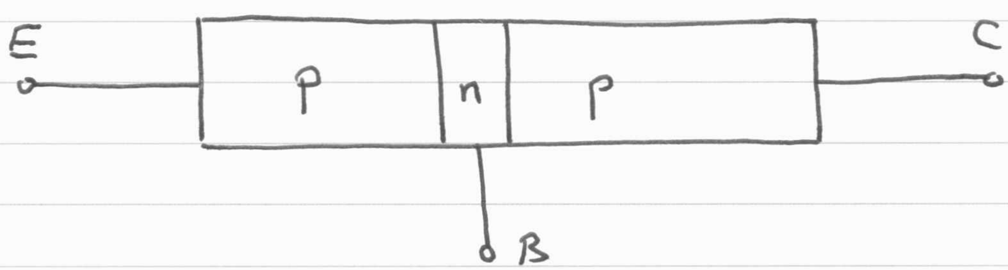
4 - There are two types of BJT :
npn type
pnp type

Transistor structure

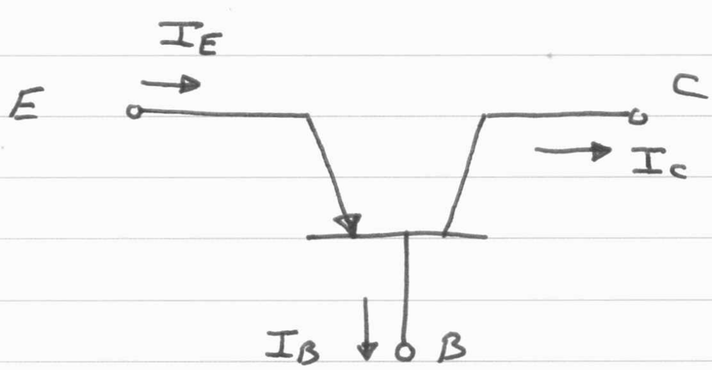


a) npn type





b) pnp type



Transistor biasing

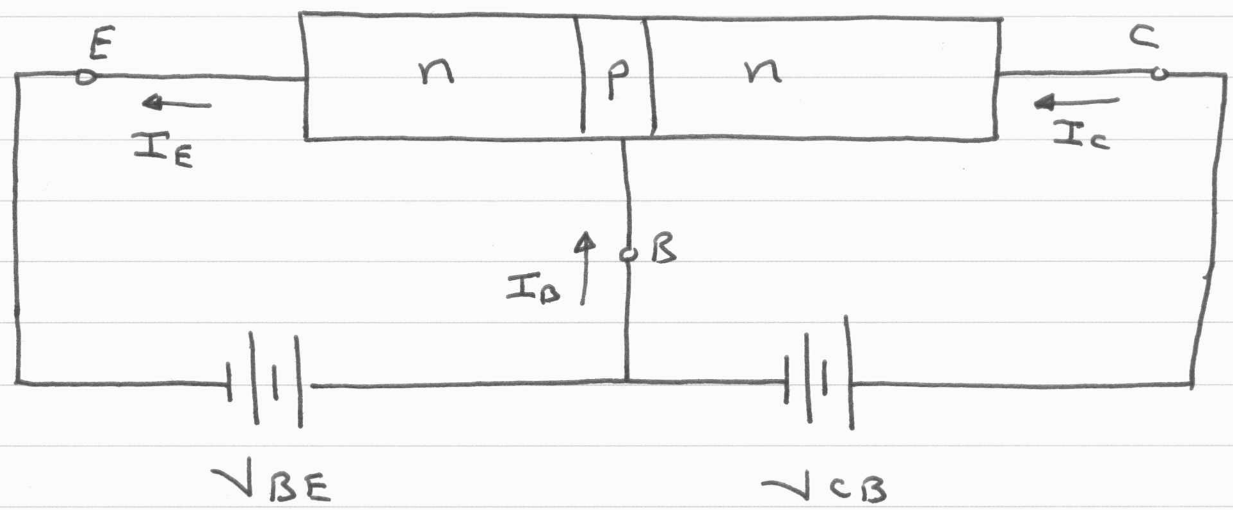
In order to operate properly as an amplifier, it is necessary to correctly bias the two pn junctions with external voltages.

Depending upon external bias voltage polarities used ; the transistor works in one of the four regions (modes).

Region (Mode)	Base emitter junction	Base collector junction
Active	Forward biased	Reverse biased
Saturation	Forward biased	Forward biased
Cutoff	Reverse biased	Reverse biased
Inverse	Reverse biased	Forward biased

For the transistor to be used as an Active device (Amplifier); the emitter base junction must be forward biase, While the Collector base junction must be reverse biased.

In the active region



- The base region is thin and Lightly doped
- The base emitter junction is forward biased, thus the depletion region at this junction is reduced
- The base Collector junction is reverse biased, thus the depletion region at this junction is increased
- The forward biased BE junction Causes the electrons in the n type emitter to flow toward the base; this Consitutes the emitter Current I_E.
- As there electrons flow through the p-type base; they tend to recombine with holes in p-type base

- Since the base region is Lightly doped; very few of the electrons injected into the base from the emitter recombine with holes to Constitute base current I_B and the remaining Large number of electrons Cross the base and move through the Collector region to the positive terminal of the external dc source; this Consituter Collector Current I_C.

- There is another Component for I_C due to the minority Carriers; I_{CBO}

$$\therefore \quad I_C = \underbrace{\alpha I_E}_{\text{majority}} + \overbrace{I_{CBO}}^{\text{minority}}$$

$$0.998 > \alpha > 0.9$$

$$I_C = \alpha I_E + I_{CBO}$$

$$I_E = I_C + I_B$$

$$I_C = \alpha (I_C + I_B) + I_{CBO}$$

$$\therefore \quad I_C = \frac{\alpha}{1-\alpha} I_B + \frac{1}{1-\alpha} I_{CBO}$$

let $\beta_{eta} = \frac{\alpha}{1-\alpha}$

$$\therefore \quad I_C = \beta I_B + (\beta + 1) I_{CBO}$$

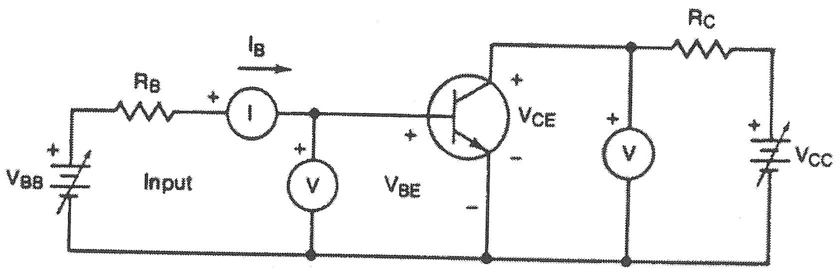
$$I_C = \beta I_B + I_{CEO}$$

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

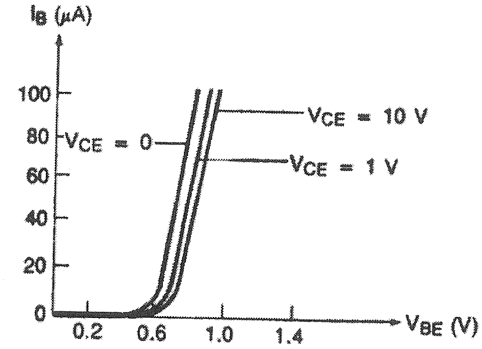
if $\alpha = 0.99 \longrightarrow \beta = 99$

if $\alpha = 0.995 \longrightarrow \beta = 199$

input characteristic curve



(a)



(b)

$$i_B(t) = I_{B0}\left(e^{\frac{v_{BE}(t)}{\eta V_T}} - 1\right)$$

$$i_B(t) \approx I_{B0}\, e^{\frac{v_{BE}(t)}{\eta V_T}}$$

$$i_C(t) = \beta\, i_B(t)$$

$$i_C(t) = I_s\, e^{\frac{v_{BE}(t)}{\eta V_T}}$$

In the active region

$$I_C = \alpha I_E + I_{CBO}$$

$$I_C = \beta I_B + (\beta+1) I_{CBO}$$

$$I_C = \beta I_B + I_{CEO}$$

$$I_E = I_C + I_B$$

Approximate relationships

$$I_C \cong \alpha I_E \approx I_E$$

$$I_C \cong \beta I_B$$

$$I_E \cong (\beta+1) I_B$$

output characteristic Curve

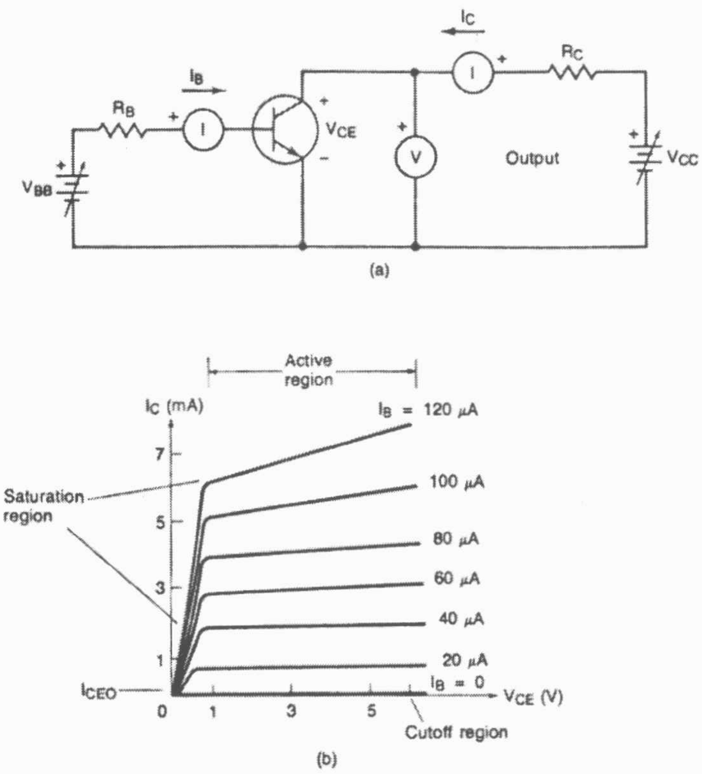


FIGURE 4-15 Common-emitter silicon npn BJT output curves: (a) test circuit; (b) typical curves.