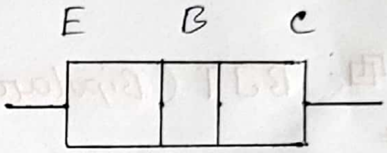
BJT (Bipolar Junction Transistor)

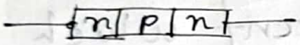
BJT is a type of semiconductor device that can amplify or switch electronic signals.

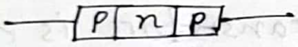
It consists of three layers of semiconductor material, each with different doping levels.

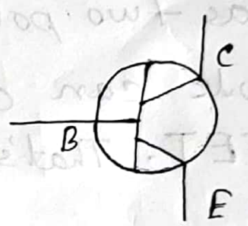
1. The emitter
2. The base
3. The Collector

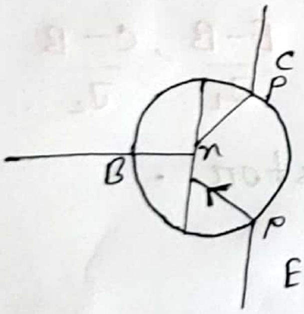


BJTs come in two types -

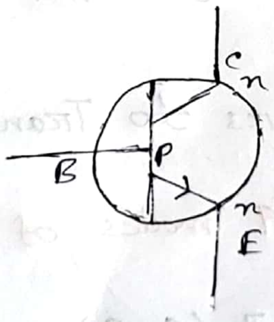
1. NPN


2. PNP


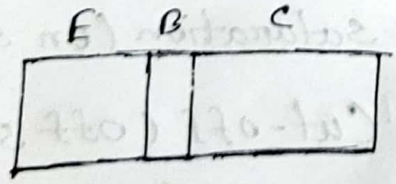




p-n-p



n-p-n



width : C > E > B

Doping : E > C > B

Commercially, n-p-n transistor is used more.
The mobility of electron is more compared to hole. Electron is more light-weight.
In n-p-n, the number of electron is more than p-n-p. That's why n-p-n is used more in commercial sector.

BJT (Bipolar Junction Transistor)

* BJT has two polarity - e^- and hole. In BJT, both e^- and hole can conduct current which is not happened for FET. That's why this transistor is called Bipolar.

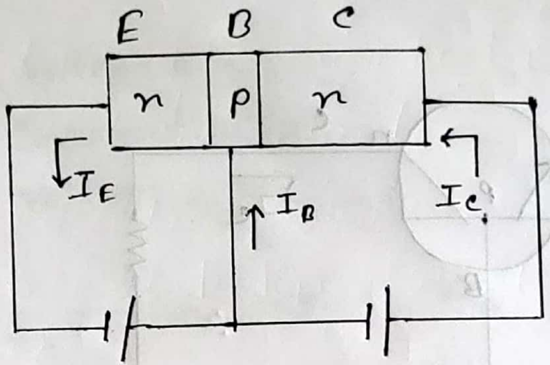
* There are two junction in BJT - E-B, C-B
(J_1, J_2).

* Transistor refers to Transfer Resistor.

There are 4 modes of BJT.

J_1(E-B)	J_2(C-B)	Mode
Forward	Reverse	Active (Amplifier).
Forward	Forward	Saturation (On state switch)
Reverse	Reverse	Cut-off (off state switch)
Reverse	Active	Inverted / Reverse active (Rarely used)

Active mode:

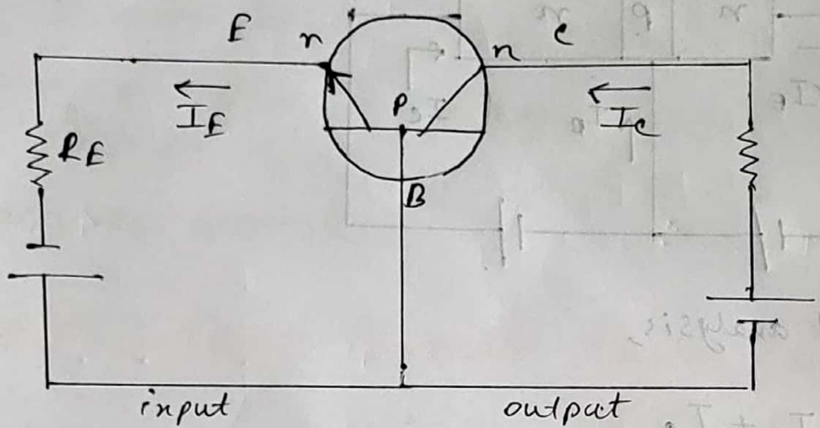


Applying nodal analysis,

$$I_E = I_B + I_C$$

$$I_E \simeq I_C$$

Common Base



The emitter side will always be input.

Now,

$$I_E = I_B + I_C$$

Here,

$$I_E \cong I_C.$$

Now,

Current Amplification factor, $\alpha = \frac{output}{input}$.

$$\therefore \alpha = \frac{I_C}{I_E}$$

$\Rightarrow I_C = \alpha I_E$; which is for ideal consideration.

But, in this case, it's in Active mode. So, there will be a reverse saturation current for output reverse side which is I_{CBO}.

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

Input Characteristic

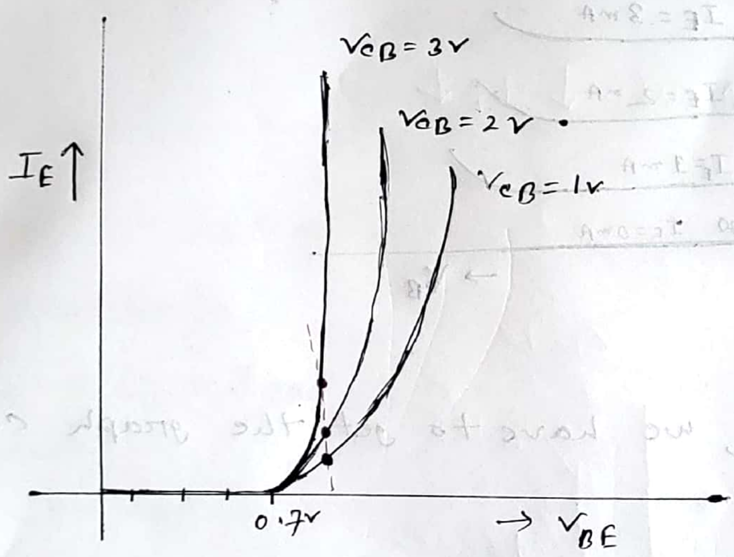
Here,

Input voltage = V_{BE}

Input current = I_E

output voltage = V_{CB}

$\therefore$ I_E vs V_{BE} for different V_{CB}



W = width of deplation layer.

Here,

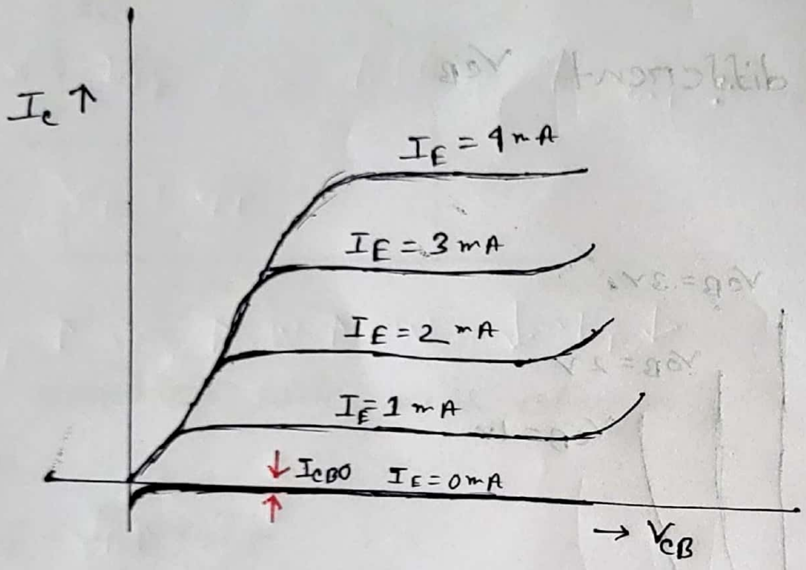
V_{CB} is in reverse condition. So, if we increase V_{CB}, the width of deplation layer will increase which means the efficiency of deplation layer (W_{eff}) will be lower. So, most of the current will go in emitter. So, I_E will increase.

$\therefore$ $V_{CB} \uparrow - W \uparrow - W_{eff} \downarrow - I_E \uparrow$

(iii) Output Characteristic

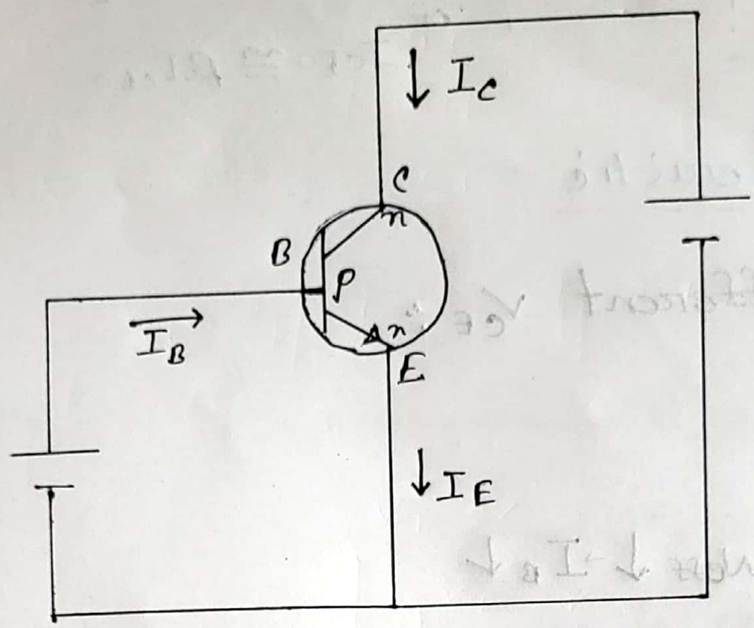
Output Current $= I_C$
Output voltage $= V_{CB}$
Input Current $= I_E$

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



In this case, we have to get the graph comparing to the formula.

Common Emitter



$$\alpha = \frac{I_C}{I_E} \Rightarrow I_C = \alpha I_E$$

But, Practically,

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

we know,

$$I_E = I_B + I_C$$

$\therefore$

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

$$\Rightarrow I_C = \alpha I_B + \alpha I_C + I_{CBO}$$

$$\Rightarrow I_C (1-\alpha) = \alpha I_B + I_{CBO}$$

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

$$\boxed{\Rightarrow I_C = \frac{\alpha}{1-\alpha} I_B + \frac{1}{1-\alpha} I_{CBO}}$$

Let's consider,

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

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

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

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

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

or, $I_{CEO} \cong \beta I_{CBO}$

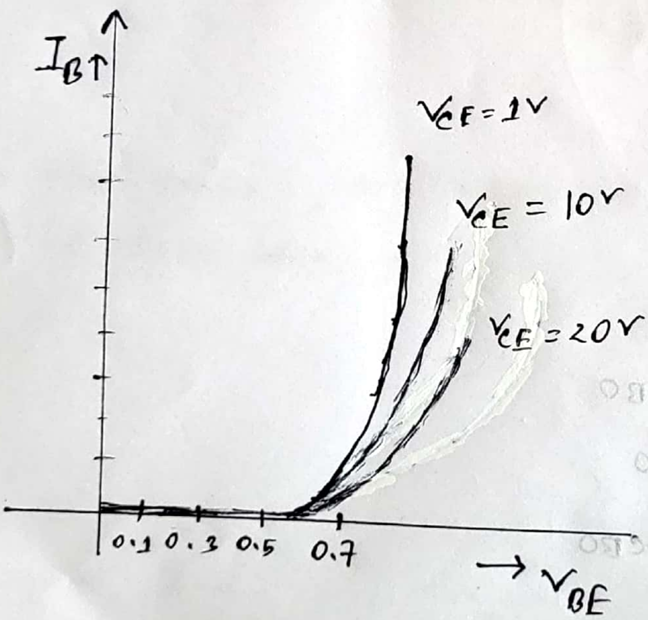
Input characteristic

I_B vs V_{BE} for different V_{CE}:

$V_{CE} = V_{CB} + V_{BE}$

so,

$V_{CE} \uparrow \rightarrow V_{CB} \uparrow \rightarrow W \uparrow \rightarrow W_{eff} \downarrow \rightarrow I_B \downarrow$



Output Characteristic

I_c vs V_{CE} for different I_B :