UNIT- II

TRANSISTORS

Transistor is a three terminal semiconductor device.

Bipolar Junction Transistor (BJT):-

* BJT is a three terminal semiconductor device.
* It will operate depend on the interaction of both majority and minority carriers.
* Here the name Bipolar.
* It is used in amplifier circuits.

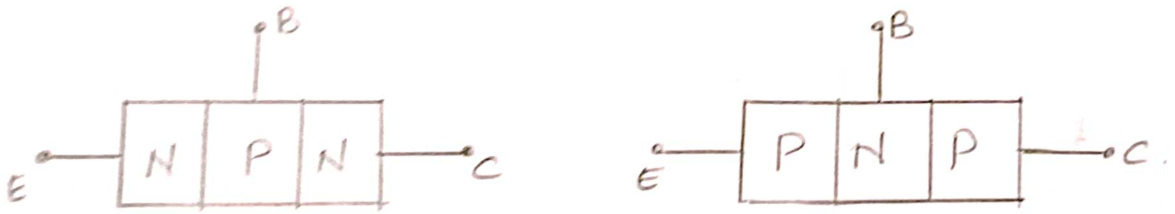
Construction :-

Two types of BJT.

* NPN transistor
* PNP "

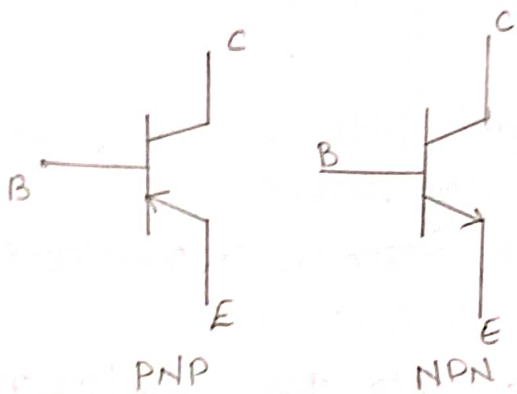
Three terminals are

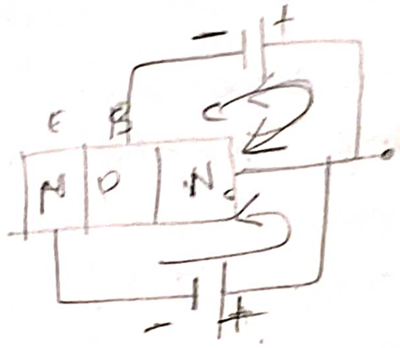
* Emitter (E)
* Base (B)
* Collector. (C).



* Emitter is heavily doped, so that it can inject large number of charge carriers into the base.
* Base is lightly doped and very thin.
* Collector is moderately doped.

Circuit Symbol :-

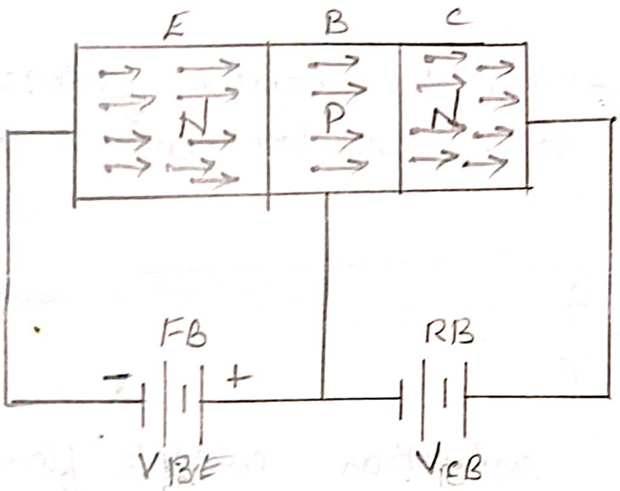


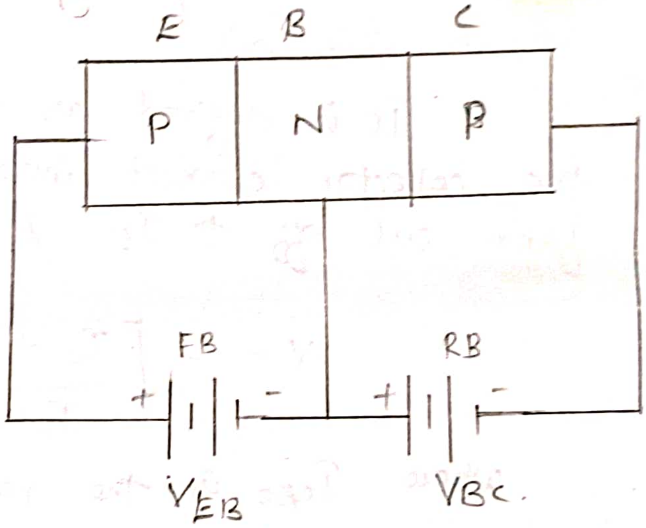


Transistor Biasing :-

There are two types of biasing they are

* Forward biasing
* Reverse biasing





Operation of NPN :-

The forward bias is applied to the emitter base junction of NPN transistor. causes lot of electrons from the emitter region to cross over to the base region.

As the base is lightly doped, the number of holes in base region is very small and hence electron combine will also be small.

The remaining electrons crossover to the collector region to constitute a collector current I_C.

$$I_E = I_B + I_C.$$

PNP Operation :-

The forward bias is applied to emitter - base junction of PNP transistor causes lot of holes from the emitter region to the base region.

The base region is lightly doped with electrons, so the holes combined will also be very slow.

Hence a few holes combined with electrons to constitute the base current. (I_B).

The remaining holes crossover into the collector region.

$$I_E = I_C + I_B.$$

This equation gives the fundamental relationship between the bipolar transistor circuit.

Current gain (α)

It is defined as the ratio of the negative feedback of the collector current increment to the emitter current charge from cut off to I_E ie.

$$\alpha = -\left[\frac{I_C - I_{CBO}}{I_E - 0}\right].$$

where I_{CBO} is the reverse saturation current flow through the reverse biased collector base junction.

I_{CBO} is negligible.

$$\alpha = -\frac{I_C}{I_E}.$$

I_C & I_E will be in opposite directions, α will alway be +ve

α will be approx 0.90 to 0.995.

$$I_C = -\alpha I_E + I_{CBO}(1 - e^{V_C/V_T})$$

current amplification factor.

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

if V_C is large $I_C = -\alpha I_E + I_{CBO}$

$\because$ I_C & I_E flow in opp directions

$$I_E = -(I_C + I_B)$$

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

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

Types of Configuration:-

When a transistor is connected in a circuit, one terminal is used as input, the other terminal as output and third terminal is common to input and output.

Depending upon the input and output terminal, transistor can be connected in three configurations. They are

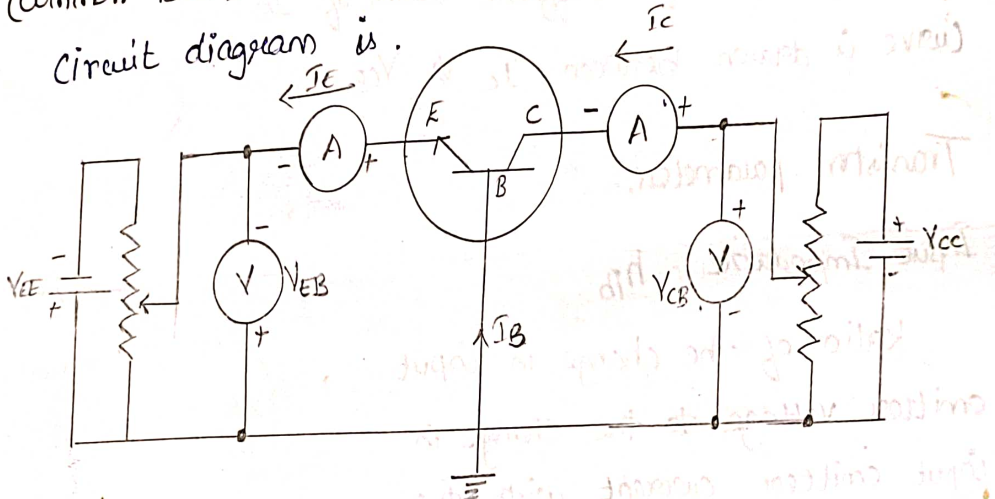
* Common Base (CB)
* Common Emitter (CE)
* Common Collector (CC).

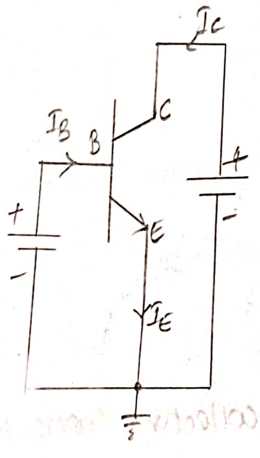
when device switched ON $V\downarrow I\uparrow$

Switched OFF $V\uparrow I\downarrow$

CB (Common Base):-

Circuit diagram is.

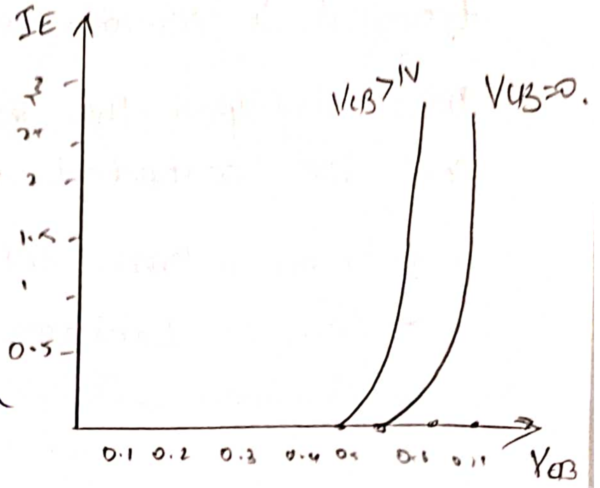




Input characteristics:-

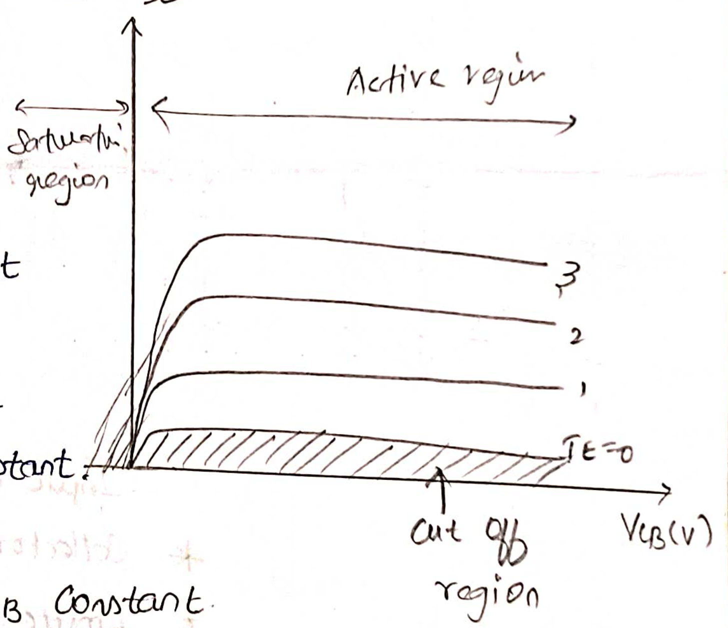
* Collector base Voltage V_{CB} is kept at 0 V.
* Emitter Current I_E should be increased in equal steps by increasing V_{EB}.
* This is repeated for maximum values of V_{CB}.
* A curve is drawn between emitter current and emitter base Voltage. at Constant V_{CB}.

* When $V_{CB} = 0$, Emitter base junction is forward biased, junction behaves as forward biased diode so that I_E ↑ rapidly.
* When V_{CB} ↑ keeping V_{EB} constant, width of the base region will decrease.



Output characteristics:

* Emitter current I_E is kept constant by adjusting V_{EB}.
* V_{CB} is ↑ and I_C is noted for each value of I_E.
* This is repeated for different values of I_E.
* Curve is drawn between I_C Vs V_{CB}.



Transistor parameters:

Input Impedance :- h_{ib}.

Ratio of the change in input emitter voltage to the change in input emitter current with the output collector voltage kept constant.

$$h_{ib} = \frac{\Delta V_{EB}}{\Delta I_E}, \quad V_{CB} \text{ Constant.}$$

Output Admittance :- h_{ob}.

Ratio of change in the output collector current to the corresponding change in the output collector voltage with I_E kept constant.

$$h_{ob} = \frac{\Delta I_C}{\Delta V_{CB}}, \quad I_E \text{ Constant.}$$

Forward current gain (h_{fb}).

Ratio of change in the output collector current to the change in the input emitter current keeping V_{CB} constant

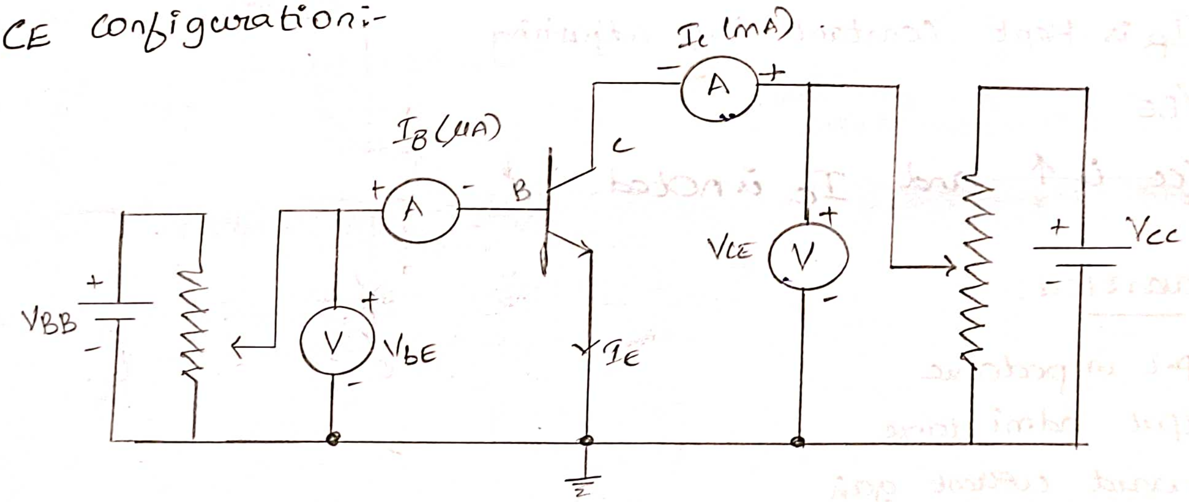
$$h_{fb} = \frac{\Delta I_C}{\Delta I_E}, \quad V_{CB} \text{ constant.}$$

Reverse voltage gain (h_{rb}):-

Ratio of change in the input emitter voltage to change in output collector voltage with I_E constant.

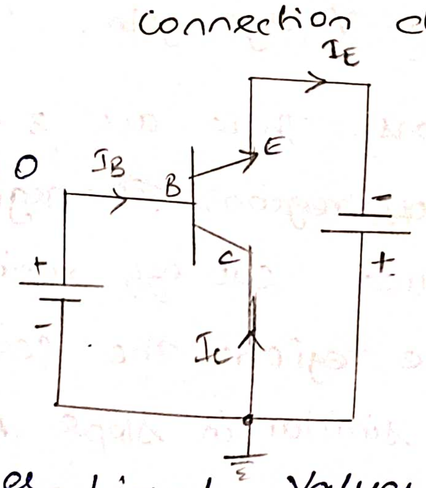
$$h_{rb} = \frac{\Delta V_{EB}}{\Delta V_{CB}}, \quad I_E \text{ constant.}$$

CE configuration:-



Input characteristics.

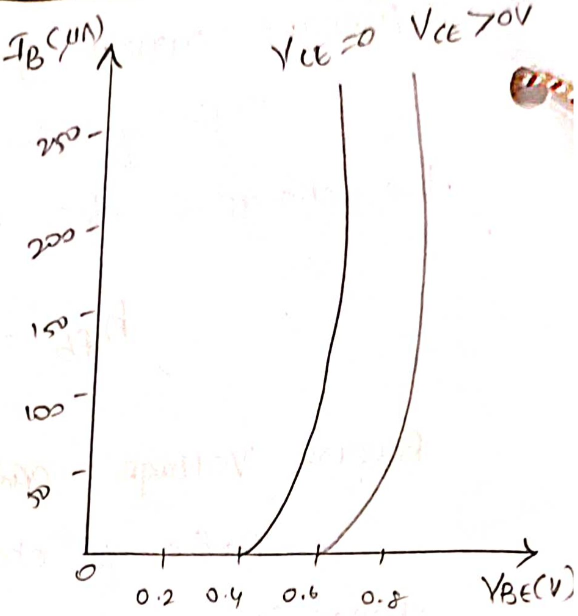
Connection diagram



* V_{CE} is kept constant at 0 Volt and base current I_B is increased from 0 by increasing V_{BE}.
* The value of V_{BE} is noted for each setting of I_B.

This procedure is repeated for higher fixed values of V_{CE}.

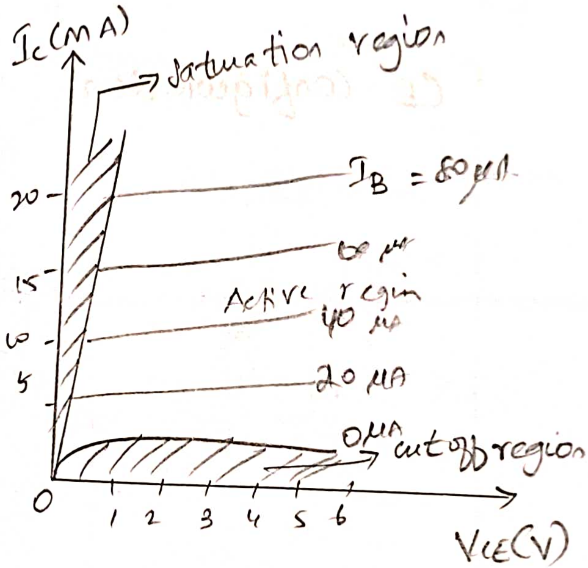
* $V_{CE} = 0$, Emitter base junction is forward biased.
* $V_{CE} \uparrow$ width of the depletion region at Collector Base junction will increase.
* Width of the base will decrease I_B will $\downarrow$



* To get same value of I_B at $V_{CE} = 0$, We should increase V_{BE}
* The curve shifts to right.

Output characteristics :-

* I_B is kept constant by adjusting V_{BE}
* V_{CE} is $\uparrow$ and I_C is noted.



Parameters:

input impedance
Output admittance
Forward current gain
Reverse Voltage gain.

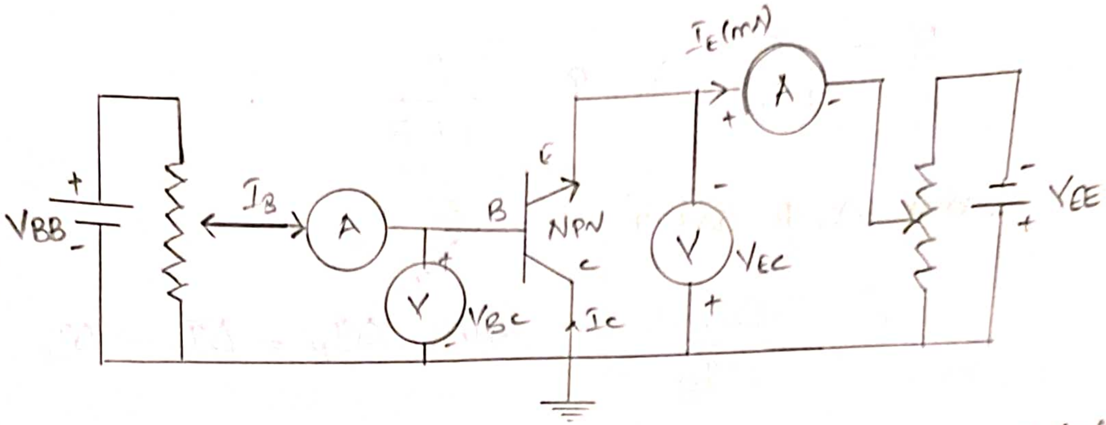
Regions:. There are 3 regions

cut off region:- The region below the curve where the $I_B = 0$ is called cut off region.

active region:- The central region where the curves are uniform and similar in slope is called active region.

Saturation region:- Both junctions will be forward biased, $\uparrow$ in I_B will not cause much change in the I_C. So this is called Saturation region.

CC configuration:-

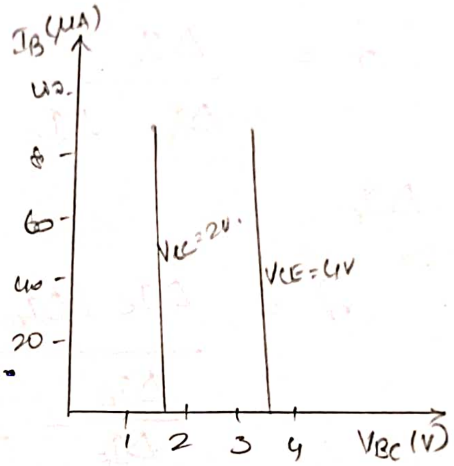


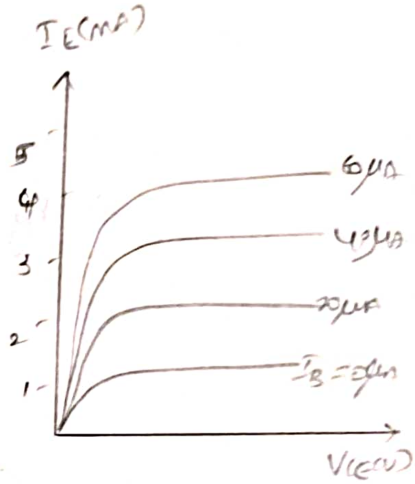
Input characteristics:-

* V_{EC} is kept constant (suitable value)
* V_{BE} ↑ , I_B noted

Output characteristics.

IIIr to CE characteristics.





Current Amplification factor.

CB configuration $\alpha = -\frac{\Delta I_c}{\Delta I_E}$

CE " $\beta = -\frac{\Delta I_c}{\Delta I_B}$

CC " $\gamma = -\frac{\Delta I_E}{\Delta I_B}$.

$-\alpha \Delta I_E + \Delta I_E$

$\frac{\Delta I_E (1-\alpha)}{\Delta I_C} = \frac{\Delta I_B}{\Delta I_c}$

$-(\Delta I_E (1-\alpha))$

Relationship b/w α and β.

$I_E = I_B + I_C$

W.K.T $\Delta I_E = \Delta I_c + \Delta I_B$. $\therefore \Delta I_c = \alpha \Delta I_E$

$\therefore \Delta I_E = \alpha \Delta I_E + \Delta I_B$.

ie $= \Delta I_B = \Delta I_E (1-\alpha)$

divide both sides ΔI_c

$$\frac{\Delta I_B}{\Delta I_c} = \frac{\Delta I_E}{\Delta I_c}(1-\alpha)$$

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

$$\beta = \frac{\alpha}{1-\alpha} \quad ; \quad \alpha = \frac{\beta}{1+\beta}.$$

Relation among α, β and γ.

$$\gamma = \frac{\Delta I_E}{\Delta I_B}. \qquad \text{sub } \Delta I_B = \Delta I_E - \Delta I_C$$

$$\gamma = \frac{\Delta I_E}{\Delta I_E - \Delta I_C}$$

$\div$ by ΔI_E

$$\gamma = \frac{\Delta I_E / \Delta I_E}{\frac{\Delta I_E}{\Delta I_E} - \frac{\Delta I_C}{\Delta I_E}} = \frac{1}{1-\alpha}$$

$$\gamma = \frac{1}{1-\alpha} = (\beta+1).$$

Biasing:-

* In order to produce distortion free output in amplifier circuits, the supply voltage and resistances in the circuit must be suitably choosen.
* These voltages and resistance establish a dc voltage + current
* Voltages + currents are called quiescent values which determines the operating point of transistor.

"The process of giving proper supply voltages and resistances for obtaining the desired operating point is called biasing".

The circuits used for getting desired operating point is called biasing circuits.