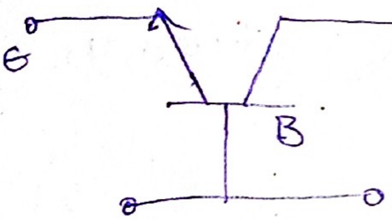
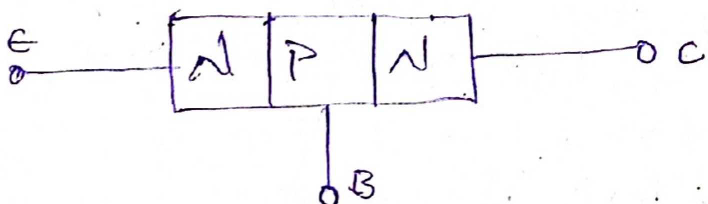
UNIT-III

* BJT :-

-> BJT (Bipolar Junction Transistor)
-> BJT means having both majority carriers and minority carriers.
-> BJT is mainly divided into two types
1) NPN Transistor
2) PNP Transistor

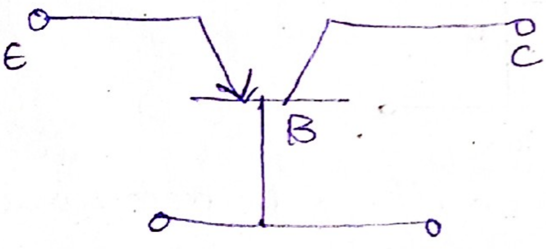
NPN Transistor:

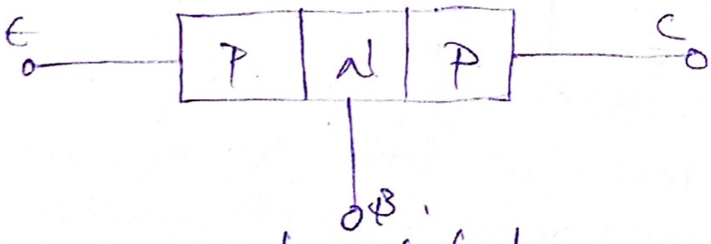




* Here first 'N' shows the emitter, 'P' shows the Base and last 'N' shows the collector.
* As shown in figure if both N-type material is produced between a single p-type material then it is called NPN Transistor.
* In this flow of current direction will produce outside.

PNP Transistor:





* If two p-type material is produced between a single N-type material, then the transistor is said to be PNP transistor
* Here first 'P' shows the emitter, 'N' shows the Base and last 'P' shows the collector

* In this the flow of current will always produce inside (inside flow of current direction).

Types of Regions produced in transistor:

They are three types of regions namely
1) Emitter 2) Base 3) Collector.

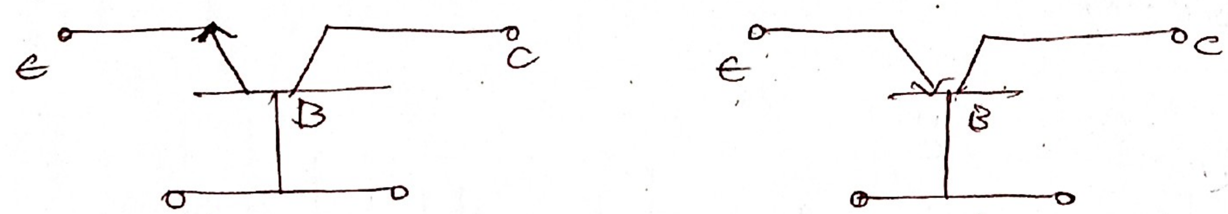
1) **Emitter:**
* Emitter region is always called as heavily doped because the most of the carriers are produced.

2) **Base:-**
* Base region is always called as lightly doped and is also very thin in size
* The middle portion of any transistor is produced as base region.

3) **Collector:**
* Collector region is also called as moderately doped region because half of charge carriers are produced by emitter and remaining half are produced by base.

Biasing of a transistor:

Transistor basing can be produced in two ways;
1) NPN Transistor
2) PNP Transistor.



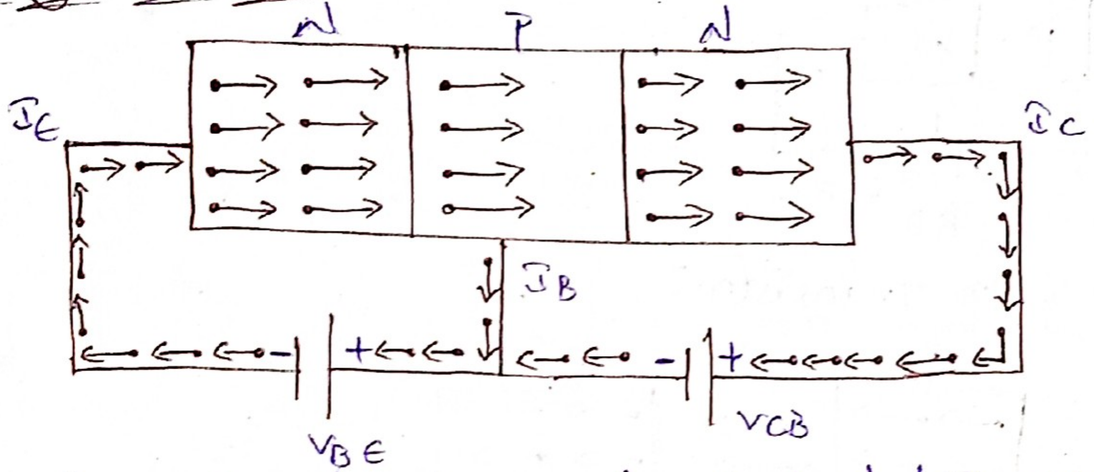
NPN PNP

As shown in both figures in the emitter side arrow mark defines flow of current direction.
* For NPN transistor the flow of current direction is produced outside of the transistor where as per PNP transistor the flow of current direction is inside the transistor.

Biasing of Transistor Junctions:-

Emitter Junction	collector Junction	Region	Application.
forward Bias	Reverse Bias	Active	Amplifier
forward Bias	forward Bias	saturation	on-switch
Reverse Bias	Reverse Bias	cut-off	off-switch
Reverse Bias	forward Bias	inverted	—

working of NPN Transistor:-

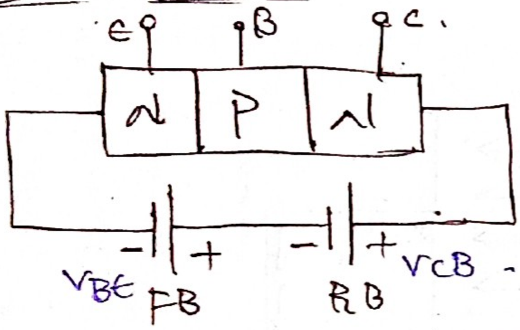


* As shown in the figure when first N-type material is connected to negative terminal and the second N-type material is connected to positive terminal then NPN transistor is formed.
* As shown in the figure V_{BE} is called as forward Biased and V_{CB} is called as Reverse biased voltage.
* The forward Bias in the Emitter junction collides the electron flow from N-type to P-type as a result emitter currents produced.
* As the base is Lightly doped and very thin only few electrons combine with holes and produces a current called as base current (I_B)
* The remaining number of electrons are produced in the collector region because collector in reverse bias as a result current produced is called as collector current (I_C).

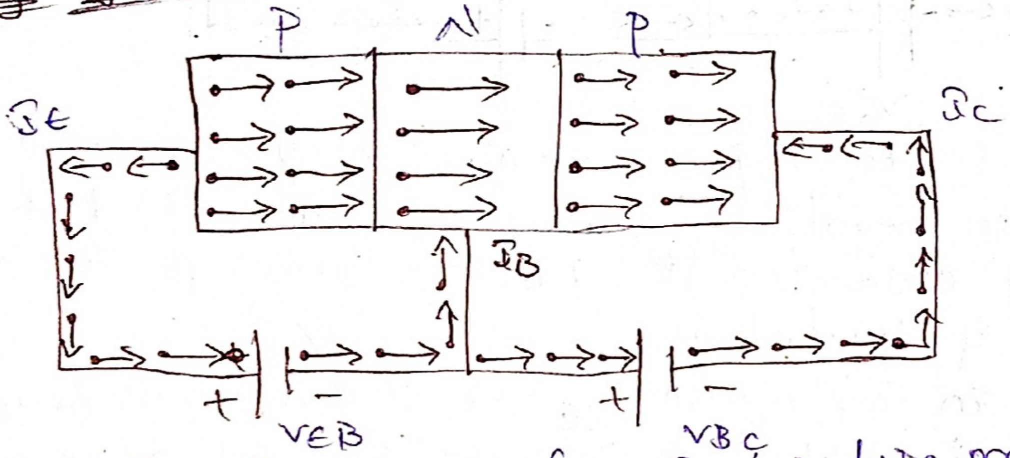
* Therefore the complete emitter current flows towards collector region.
* As a result the Emitter current is produced as sum of base current and collector current.

$I_E = I_B + I_C$ [∵ I_E = Emitter current
I_B = Base "
I_C = collector "]

NPN Transistor :-



Working of PNP Transistor :-

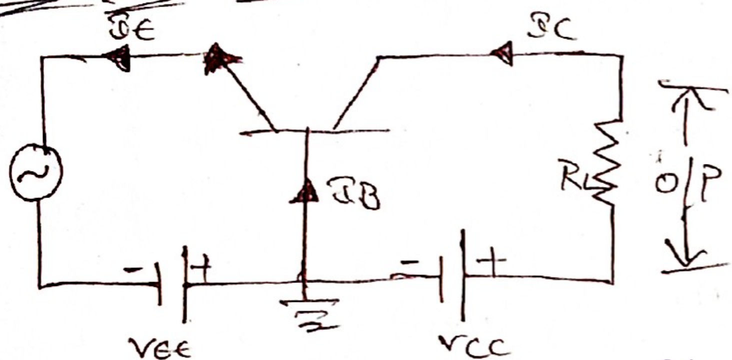


* As shown in the figure when first P-type material is connected to positive terminal and the second P-type of material is connected to Negative terminal of battery then PNP transistor is formed
* As show in the figure VEB is called as forward baised to voltage and VCB is called as Reverse Biased voltage.
* The forword bias in the emitter junction collides the electrons flow from P-type to N-type as a result emitter current is produced.

* As the base is lightly doped and very thin only few holes combine with electrons and produces a current a current called as base current (I_B)
* The remaining number of holes are produced in the collector is in reverse bias, as a result current produced is called as collector current (I_C).
* Therefore the complete emitter current flows towards the collector Region.
* As a result the emitter current is produced as sum of base current and collector current.

$$\boxed{I_E = I_B + I_C}$$

Transistor as an Amplifier



* As shown in the figure it is the basic circuit of a transistor which acts as an amplifier
* As shown in the figure the circuit produces in the form of common base connection.
* The input signal is applied between emitter and base junction
* The output is taken across collector terminal which is connected to load resistor Rc (collector resistance)
* To produce amplification the input circuit should be always forward biase
* DC voltage called as V_{EE} (Emitter voltage) is applied in series with I/P signal.
* The applied DC voltage is also known as bias voltage because its magnitude is arranged such that input

circuit will remain always forward bias.

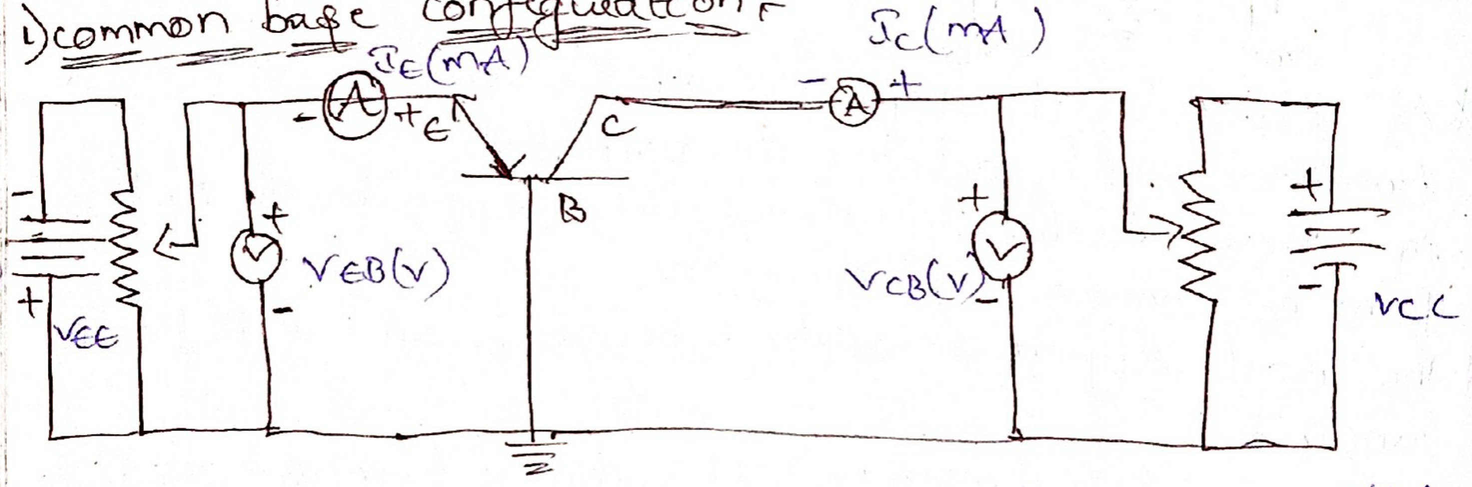
* A small change in input voltage causes large change in emitter current.
* As a result emitter current is transferred to collector terminal with the help of via transistor.
* collector current (I_C) flowing through load resistance R_C produced a large change in which its resistance order is of kilo ohms (KΩ)
* Hence transistor acts as an amplifier because of increase the signal strength.

Transistor configuration:-

* Transistor is mainly divided into 3-types of configurations there are.

1) common base configuration
2) common emitter configuration
3) common collector configuration.

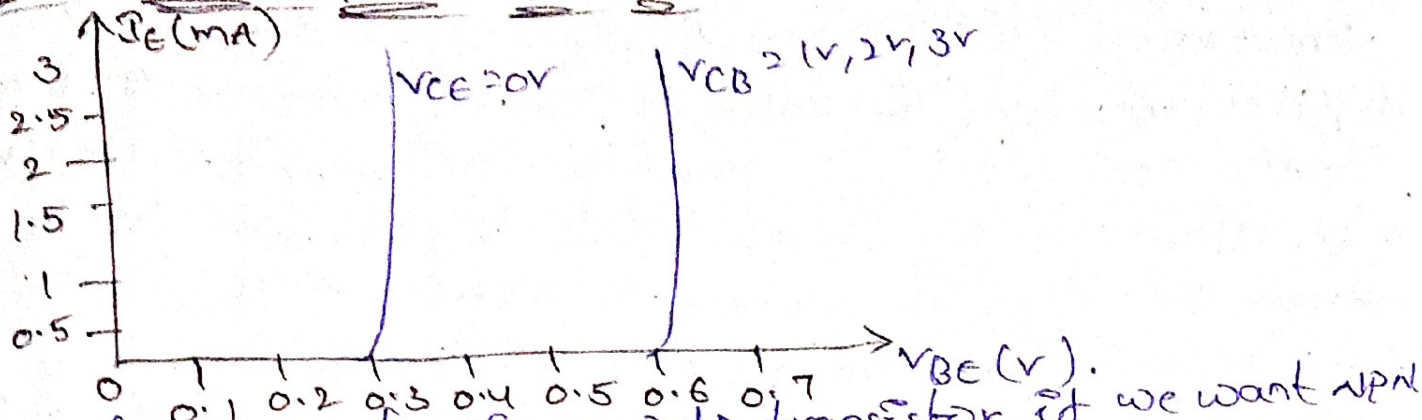
1) common base configuration:-



* As shown in the figure input is taken as emitter terminal whereas output is taken as collector terminal
* Here base is grounded means common to both input and output terminals.
* This configuration is produced by two types of characteristic :- i/p and o/p.

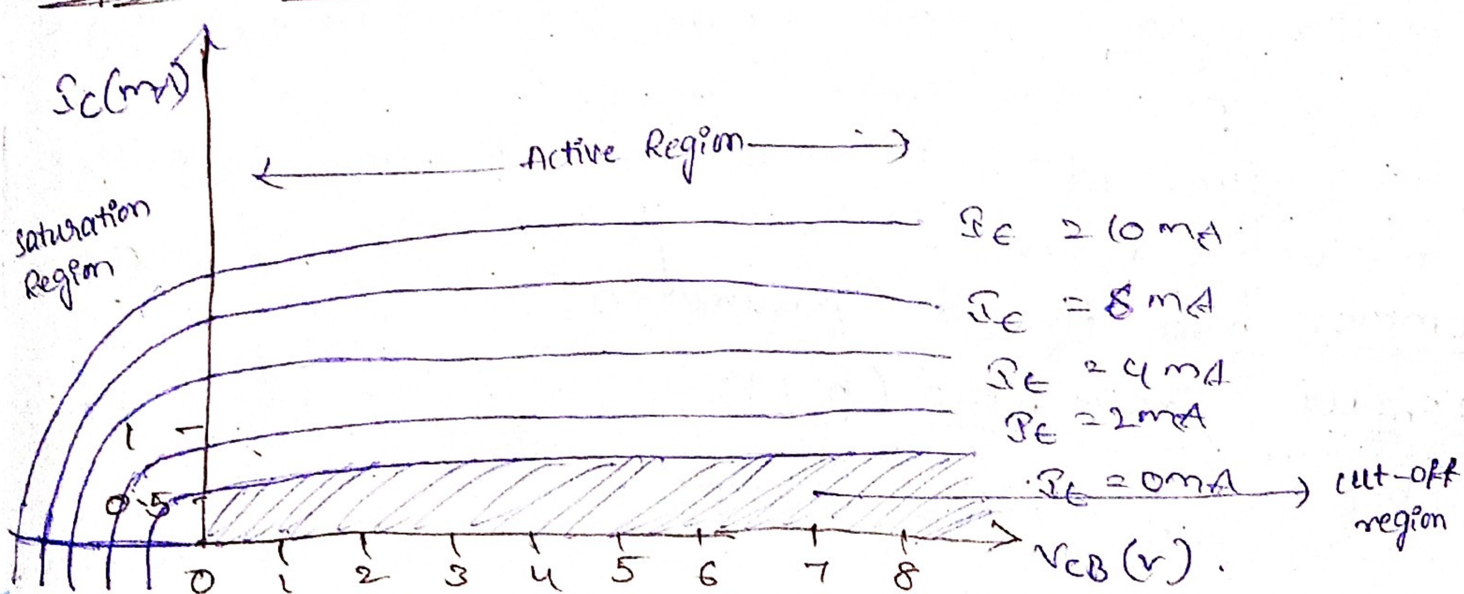
* If a transistor produces both input and output characteristics then it is called as static characteristics.

Input characteristics of CB



* As shown in the figure PNP transistor, if we want NPN transistor then both input and out terminals get reverse
* As shown in the figure to produce input characteristics the output term collector should be kept constant. equal to 0V constant
* Initially by keeping $\boxed{V_{CB} = 0V}$ is equal in the input ie there by increasing both terms and V_{EB}.
* After sometime V_{CB} is increased to either 2V, 4V, 6V and there by increasing both I_E and V_{EB}.
* Initialy both voltage and current thats not get increased, when it reaches a voltage of 0.3V Germanium diode (Ge diode), 0.6V (Si diode).

Output characteristics of CB



* output characteristics was produced by keeping emitter current constant & ~~theory~~ thereby varying both I_C & V_{CB}
* Initially by keeping I_E = 0mA constant thereby increasing both I_C and V_{CB}
* After some time the value of I_E is increased to 10mA, 15mA and 20mA .... thereby increasing both I_C & V_{CB}
* As shown in figure the characteristics are produced from the negative values to positive values.
* In this output characteristics 3 types of regions.

1) saturation region:- In this region both emitter to base voltage (V_{EB}) and collector to Base voltage (V_{CB}) are forward biased region.

* The values which are produced and negative is called as saturation.
* If both V_{EB} and V_{CB} are forward bias, the both input and output voltages are also F.B

2) cut-off region:- In the region both junction V_{EB} and V_{CB} are reverse biased.

* If both junctions are reverse biased then input and voltages are also reverse bias.
* cutt-off region produced beyond 0mA.

3) Active region:- In this region Input terminal V_{EB} is FB whereas o/p terminal V_{CB} is R.B.

* The values which produces constant change is called as active region.

common base Hybrid parameters:-

1) Input Impedence (h_{ib}):-

$$\boxed{h_{ib} = \frac{\Delta V_{BE}}{\Delta I_E}, \; V_{CB} \text{ constant}}$$

The change in i/p Base to emitter voltage by change in i/p emitter current and by keeping V_{CB} constant is called input impendence.

The Typical value of h_{ib} varies from $\boxed{h_{ib} = 20\Omega \text{ to } 50\Omega}$

2) output impedance (h_{ob})

$$\boxed{h_{ob} = \frac{\Delta I_C}{\Delta V_{CB}}, \; I_E \text{ constant}}$$

The change in o/p collector current by change in o/p collector to Base voltage and keeping I_E as constant is called output impedence

* Typical value of h_{ob} varies from $\boxed{m = 0.1 \text{ to } 10 \; \mu\text{mhos}}$

3) forward current gain (h_{fb})

$$\boxed{h_{fb} = \frac{\Delta I_C}{\Delta I_E}, \; V_{CB} \text{ constand}}$$

* The change in o/p collector current by change in in emitter current and keeping V_{CB} as constant is called as forward current gain.

* The Typical value of h_{fb} varies from $\boxed{h_{fb} = 0.9 \text{ to } 1.0}$

4) Reverse voltage gain (h_{rb}):-

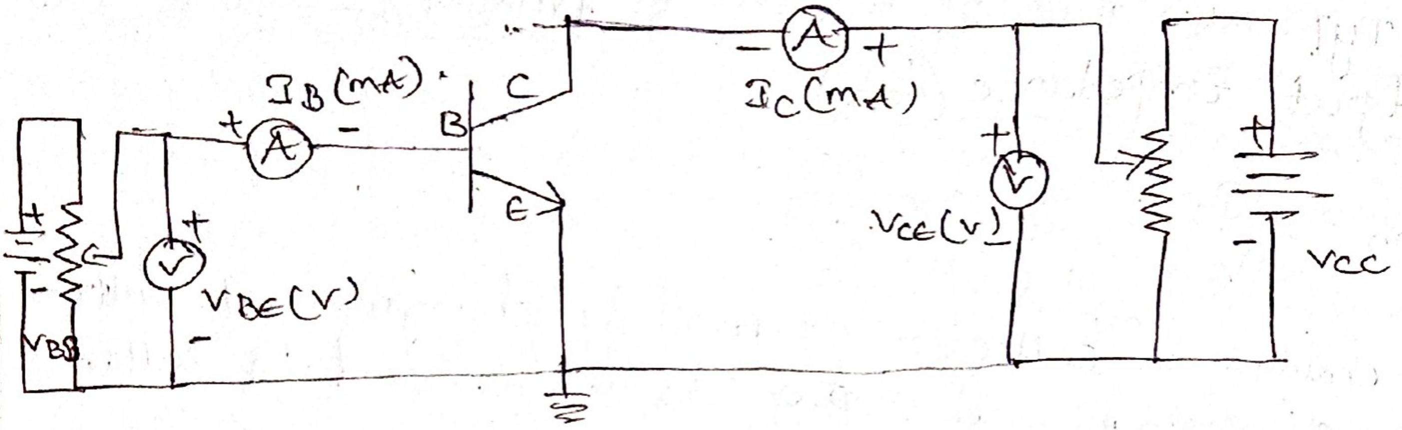
$$\boxed{h_{rb} = \frac{\Delta V_{EB}}{\Delta V_{CB}}, \; I_E \text{ constant}}$$

* The change in input emitter to Base voltage by change in o/p collector to Base voltage and keeping I_E as constant.

* The typical value varies from $\boxed{h_{rb} = 10^{-5} \text{ to } 10^{-4}}$

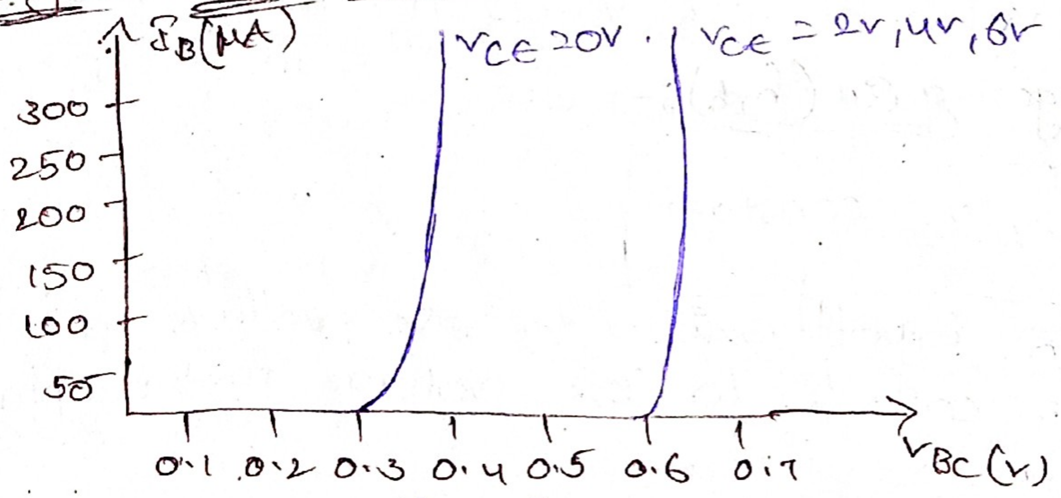
2) common Emitter (CE) configuration:-

fig(a): circuit diagram of CE configuration:-



* As shown in the figure i/p is taken as Base terminal whereas o/p is taken as collector ~~and~~
* Here Emitter is grounded means common to both i/p & o/p terminals.
* This configuration is produced by two types of characteristics :- i/p & o/p
* If a transistor produces both i/p & o/p characteristics then it is called as static characteristics.

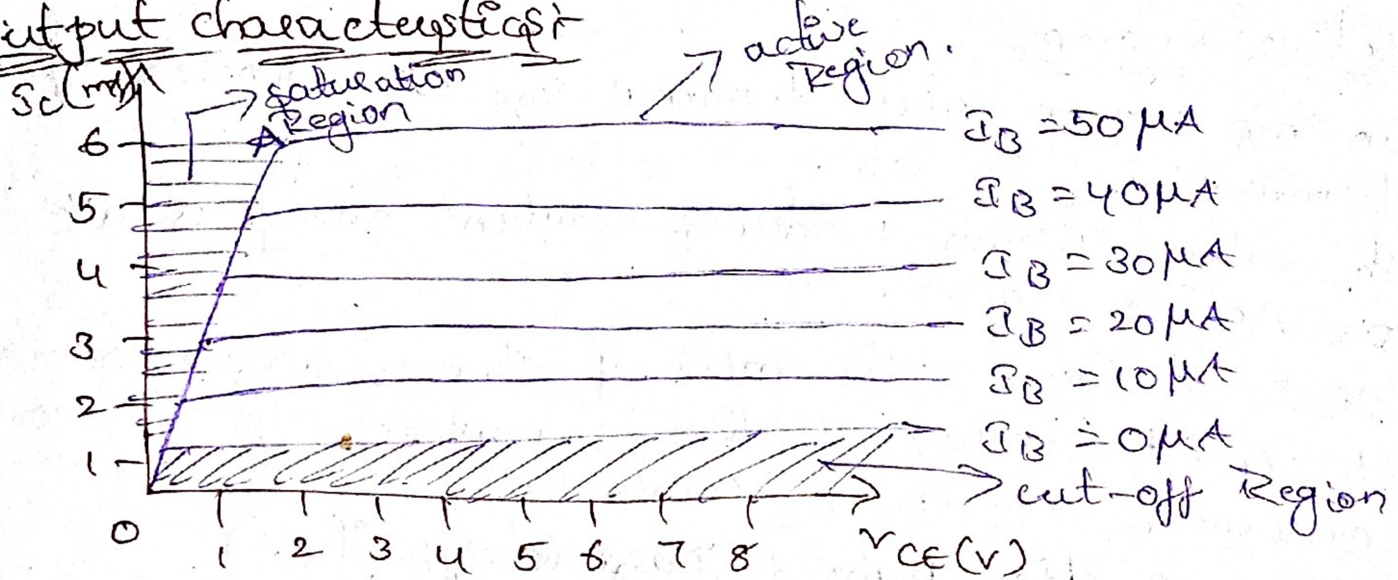
Input characteristics:-



* As shown in the figure if we want ~~to use~~ npn transistor then both i/p and o/p terminal both ~~are~~ reverse.

* As shown in the figure to produce i/p characteristics the o/p term collector to emitter voltage (V_{CE}) should be maintained constant.
* Initially by keeping V_{CE} is a volts constant, there by increasing both terms in the input I_B and V_{BE}
* After sometime V_{CE} is increased to either 2v, 4v, 6v and there by increasing both I_B & V_{BE}
* Initially both voltage and current does not get increased when it reaches a voltage of 0.3v (Ge diode) 0.6v (si diode) it increases

<u>output characteristics:</u>



* output characteristics is produced by keeping Base current is constant thereby increasing both I_C & V_{CE}.
* Initially by keeping $I_B = 0 \mu A$ constant by increasing both I_C & V_{CE}
* After sometime the value of I_B is increased to $10 \mu A$, $15 \mu A$, $20 \mu A$ ...... thereby increasing both I_C & V_{CE}.
* As show in the figure the characteristics are produced from the +ve values to -ve values
* In this o/p characteristics three types of region are formed;

1) **Saturation region**:- In this region both base to emitter voltage (V_{BE}) and collector emitter voltage (V_{CE}) are F.B

* If both V_{BE} and V_{CE} are F.B then both i/p & o/p voltages are also F.B

2) **cut-off region**:- In this region both Junction V_{BE} and V_{CE} are RB

* If both Junctions are R.B then input (V_{BB}) and o/p V_{CC} voltages are also R.B micro
* cutoff region is produced beyond o(mA)

3) **Active Region**:-

* In this region input terminal V_{BE} is F.B whereas o/p terminal V_{CE} is R.B.
* The values which produces constant change is called as Active region.
* It is defined as the ratio of change in o/p collector to emitter voltage to the change in o/p collector current by keeping I_B constant.

common Emitter Hybrid parameters (hie)

1) **Input Impedence (hie)**:-

$$\boxed{h_{ie} = \frac{\Delta V_{BE}}{\Delta I_B}, \quad V_{CE} \text{ constant}}$$

The change in i/p Base to Emitter voltage to the change in Base current is called I/P impedence.

* Typical value of hie varies from $\boxed{h_{ie} = 500 \text{ to } 2000\,\Omega}$

2) **Output Impedance (hoe)**:-

$$\boxed{h_{oe} = \frac{\Delta I_C}{\Delta V_{CE}}, \quad V_{BE} \text{ constant}}$$

*The change in o/p collector voltage by change in o/p collector to emitter voltage and by keeping V_{BE} constant is called o/p impedence.

* Typical value of hoe varies from $\boxed{h_{oe} = 0.1 \text{ to } 10\ \mu mhos}$

3) forward current gain (h_{fe}):-

$$\boxed{h_{fe} = \frac{\Delta I_C}{\Delta I_B},\ V_{CE} \text{ constants}}$$

The change in o/p collecto current by change in i/p Base current by keeping V_{CE} as constant is called as forward current gain.

* Typical value of hfe varies from $\boxed{h_{fe} = 20 \text{ to } 200}$

4) Reverse voltage gain (h_{re}):-

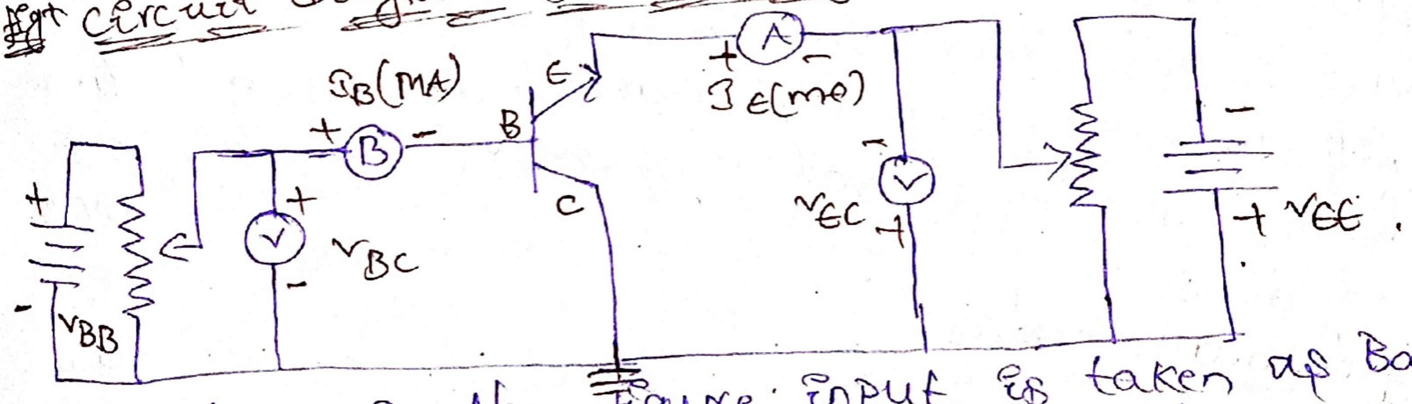
$$\boxed{h_{re} = \frac{\Delta V_{BE}}{\Delta V_{CE}},\ I_B \text{ constant}}$$

The change in i/p Base to emitter voltage by change in collector to emitter voltage is called Reverse voltage gain.

* Typical value of hre varies from $\boxed{h_{re} = 10^{-5} \text{ to } 10^{-4}}$

3) common collector configuration:-

* circuit diagram of CC configuration:-

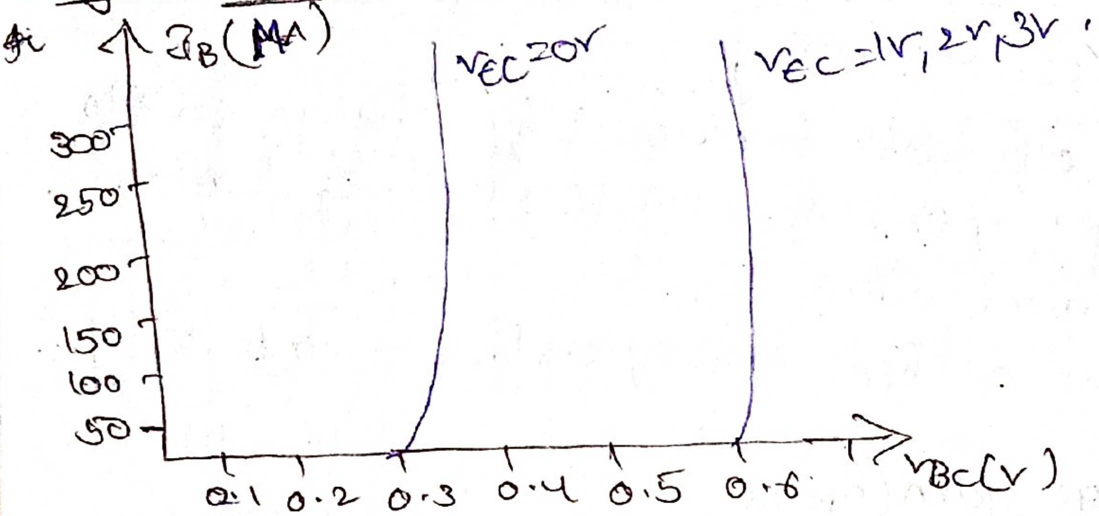


* As shown in the figure input is taken as Base terminal whereas o/p is taken as collector terminal.

* Here ~~emitter~~ collector is grounded means common to both i/p and o/p terminals.

* This configuration is produced by two types of characteristics :- I/P and O/P.
* if a transistor produces both i/p and o/p characteristics then it is called as static characteristics.

Input characteristics :-



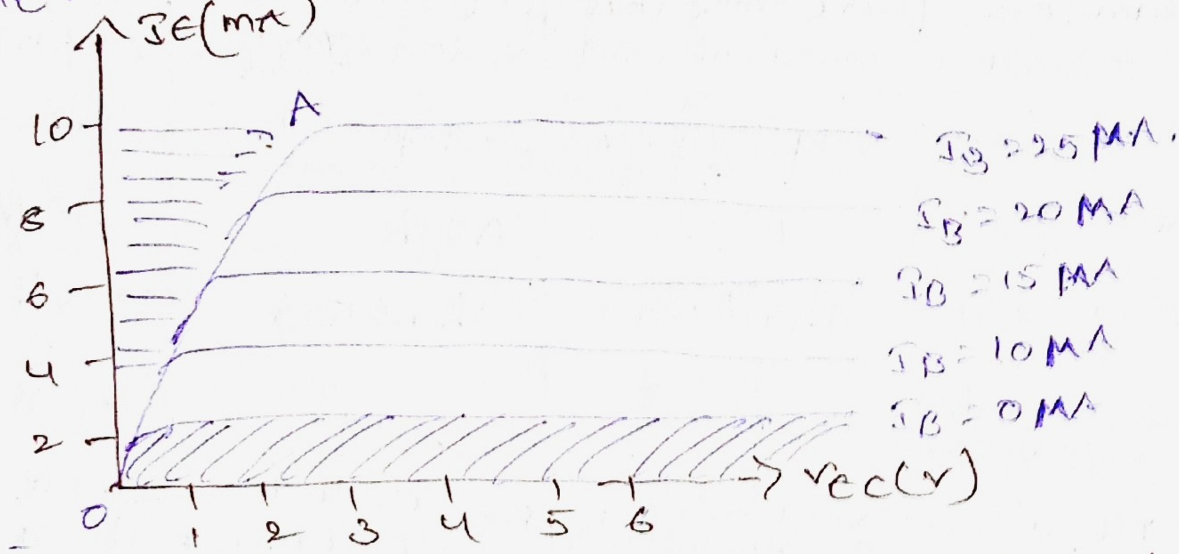
* As shown in the figure if we want to use alpal terminal both reverse transistor then both i/p and o/p terminal
characteristics
* As shown in the figure to produce i/p characteristics the o/p term collector to emitter voltage (V_{CE}) should be maintained constant.
* Initially by keeping V_{CE} is 0 volts constant, there by increasing both terms in the input I_B and V_{BE}.
* After some time V_{CE} is increased to either 2V, 4V, 6V and thereby increasing both I_B & V_{BE}.
* Initially both voltage and current does not get increase when it reaches a voltage of ~~0.3V~~ 8V (Ge diode) ~~0.6V~~ 6V. (Si diode)

Output characteristics :-

* output characteristics is produced by keeping Base current (I_B) constant and there by increasing both I_E and V_{EC}.

initially by keeping $I_B = 0mA$ constant there by increasing both I_E and V_{EC}

* After sometime the value of I_B is increasing to 10mA, 50mA and 20mA ..... there by increasing both I_E & V_{EC}
* As shown in the figure the characteristics are produced from the -ve values to +ve values/voltages.
* output resistance (Ro)
* In this o/p characteristics three types of regions are formed



1) saturation region:- In this region both base to collector voltage (V_{BC}) and emitter to collector voltage (V_{EC}) and emitter to collector voltage (V_{EC}) are F.B

* if both (V_{BC}) and (V_{EC}) are FB then both i/p & o/p voltages are FB.

2) cutt-off Region:- In this region both functions V_{BC} & V_{EC} are RB. In both functions are R.B the i/p V_{BB} & o/p. V_{EE} are also RB. cutoff region is produced beyond 0 milli ampheres.

3) Active Region:- (a) linear Region

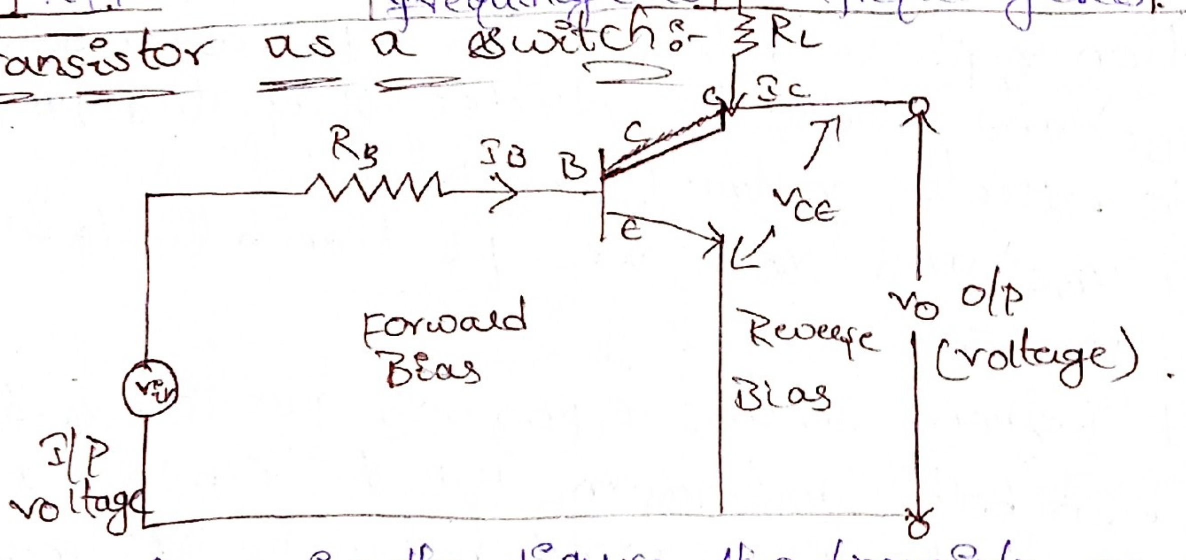
* In this region i/p terminal V_{BC} is FB whereas o/p terminal V_{EC} is R.B.
* The values which produces constant change is called

as Active region.

compassion b/w Transistor configuration write Parameters.

	Parameters	CB (common Base)	CE (common Emitter)	CC (common collector)
1.	I/p resistance	Low about 100kΩ	moderate ↳about 750Ω	very high about 750 kΩ.
2.	o/p resistance	very high ↳about 450kΩ.	high ↳about 45 kΩ.	Low value ↳about 50Ω
3.	current gain	1	high	high
4.	voltage gain	About 150	About 500	less than unity (<1)
5.	Phase shift b/w I/p & o/p voltages	0° (or) 360°	180°	0° (or) 360°
6.	Application	very high frequency ckts	for Audio frequency ckts	for impedence matching

Transistor as a switch:-



* As shown in the figure the transistor as a switch is produced in common emitter configuration because emitter is grounded.
* As i/p voltage is applied to base terminal and o/p voltage is produced b/w both collector & emitter terminals.

* Here R_s is source resistance which is applied to base terminal in which current produced is taken as I_B
* At the collector terminal R_L (load Resistance) is applied there by which current produces called as i_c
* V_{cc} is the voltage applied to the complete circuit which is of 5V.
* As shown in the fig base emitter side is FB where as collector to emitter side is RB
* At the base emitter side switch is produced for activating purpose whereas at the collector to emitter side, it acts as a switch means either open or closed
* The i/p wave form will be produced in the form of square wave whereas the o/p voltage is produced in the form of both current and voltage wave forms.
* The transistor is turned on if base emitter junction is FB, which increases collector current.
* When transistor will operating saturation region in which o/p voltage produces a value of V_{ce} saturation
* When transistor is of base emitter junction is RB in which o/p voltage is V_{cc}