Unit - Electronic Component

Passive component

The E Comp which are not capable of amplifying or processing an electrical signal are called passive component

Eg: resistor, capacitor and inductor

① Resistors

It is a component, used to limit the amount of current or divide the voltage in an electronic circuit. The ability of a resistor to oppose the current is called resistance

R is ohm (Ω)

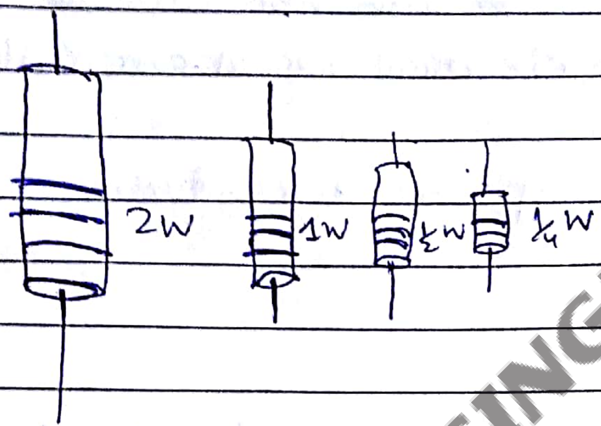
⇒ Type of Resistor

(i) Resistance (ii) power rating.

① Fixed Resistor

The resistor which have fixed value of resistance are called fixed resistor.

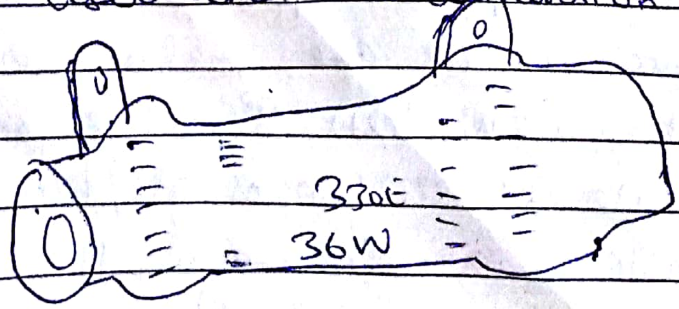
a) Carbon - composition Resistor: Most common in electronic circuit are carbon resistor with a low power rating (2 watts). This type of resistor is made of mixture of carbon or graphite and clay. The two material are mixed in the proportion needed for the desired value of R. The resistor element is enclosed in plastic case for insulation and mechani- strength. The leads, made of tinned copper are joined to the two ends of carbon resistance element.



b) Wire-Wound Resistors.

A wire wound resistor is shown in fig. Its construction; a resistance wire (nichrome, tungsten, maganin) is wrapped around a hollow porcelain cylindrical core. The ends of the wire are attached to metal pieces fixed at the two ends of the core. This assembly is coated with an enamel containing powdered glass and is heated which develops the coating. Known as vitreous enamel.

This hard and smooth coating provides mechanical protection to the resistance wire. It also helps in dissipating ~~heating~~ heat away from the unit quickly. The value of resistance depends upon the resistivity of material used and the dimension of resistance wire.

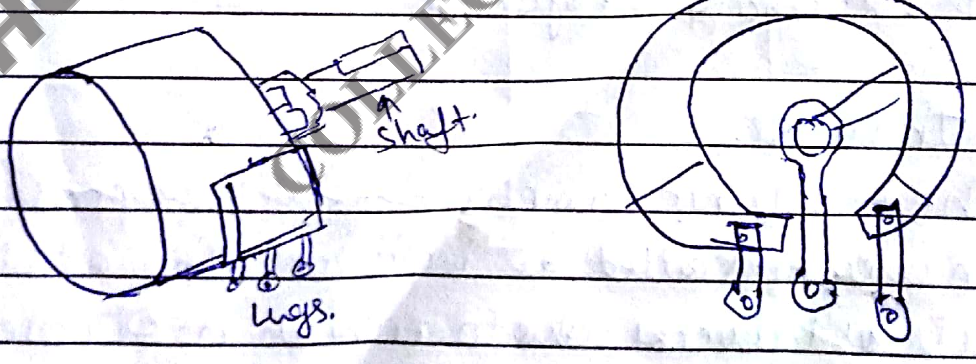


(2) Variable Resistor.

Sometime, in electronic circuit, it become necessary to adjust the value of current and voltage.
eg: Change of volume of sound in transistor station.

a) Carbon-composition resistor.

A carbon-composition variable resistor. The outer view of resistor, whereas, the internal construction of resistor. A thin carbon coating on pressed paper or a molded carbon disc constitutes the carbon-composition resistance element. The two ends of disc are joined to external soldering lug - terminal 1 and 3. The middle terminal is connected to the variable arm that contacts the resistor element by a metal spring wiper. As the shaft of control is turned, the variable arm move the wiper to make contact at different point on the resistor element which change the value of resistance inserted in circuit.



b) Wire-wound variable resistance

Capacitor

The two conducting plates separated by an insulating material forms a capacitor. The basic purpose of a capacitor is to store the charge. The capacity of a capacitor to store charge per unit potential difference is called capacitance.

Type of capacitor

1. Paper capacitor
2. Mica capacitor
3. Ceramic capacitor
4. Electrolytic capacitor

Inductor

The electronic component which oppose of current in circuit is called an inductor. The ability of a coil or inductor due to which it opposes the change of current flowing through it is known as inductance.

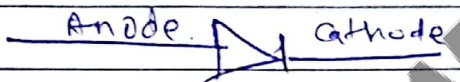
-> Type of Inductor

1. Filter chokes
2. Radio-frequency chokes

Semiconductor Device (Diode)

① PN Junction diode

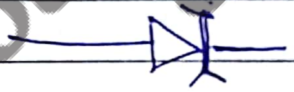
It conducts current easily when forward biased and practically no current flow when it is reverse biased. This unidirectional conduction characteristic of P-N junction is similar to that of a vaccum diode. Therefore a p-n junction is called semiconductor diode.



P-N Jn. diode

② Zener diode

A specially designed silicon diode which is optimised to operate in the breakdown region is known as Zener diode.



It is a very useful type of diode as it provide a stable reference voltage. As a result it is used in vast quantities. It is run under reverse bias condition and it is found that when certain voltage is reached it breakdown.

⇒ Characteristics of a Zener diode

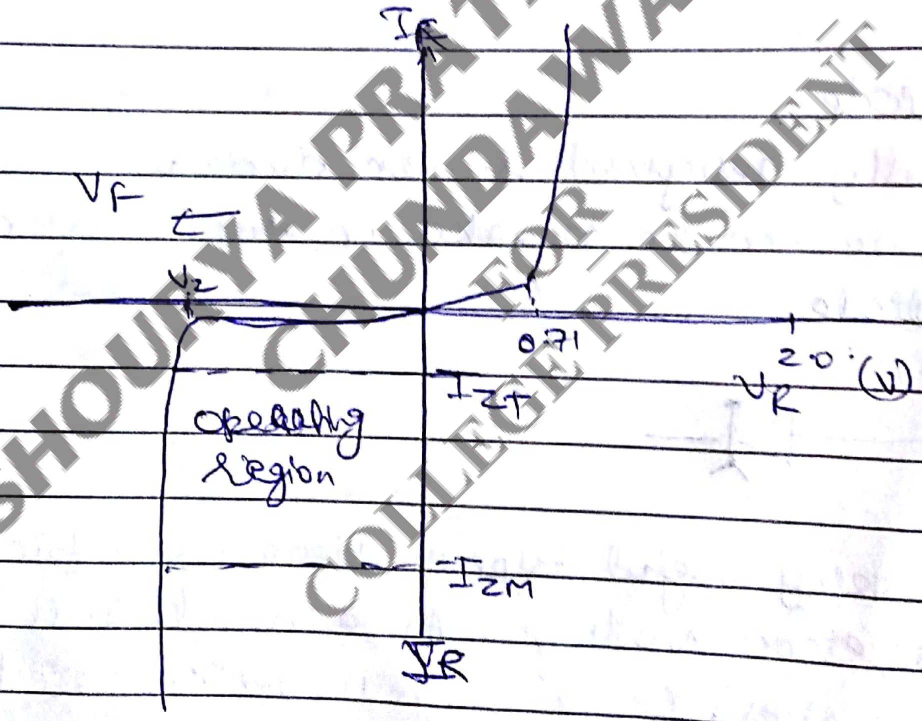
①. Its characteristics are similar to an ordinary rectifier diode with the exception that it has sharp breakdown voltage called Zener voltage V_Z

(ii) It can be operated in any of the three region i.e. forward, leakage or breakdown. But usually it is operated in breakdown region.

(iii) The voltage is almost constant (V_Z) over the operating region.

(iv) Usually, the value of V_Z at a particular test current I_{ZT} is specified in data sheet.

(v) During operation it will not burn as long as the external circuit flowing through it below the burn out value i.e., I_{ZM}.



Avalanche Breakdown.

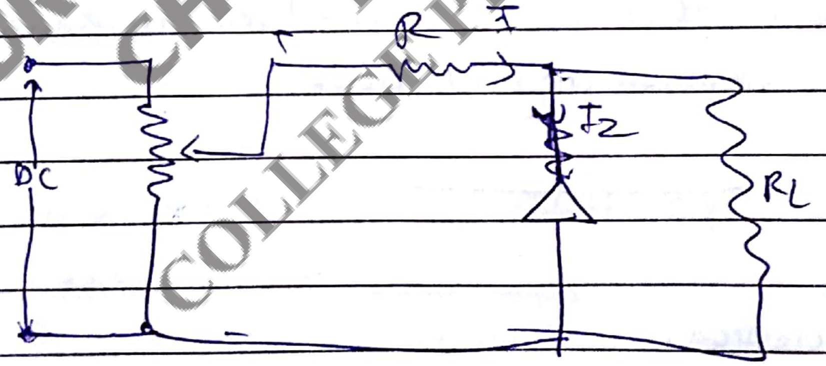
For thicker junction the breakdown mechanism is by the process of avalanche breakdown. In this when the electric field existing in depletion layer is sufficiently high, the velocity of the carriers crossing depletion layer

→ Zener Breakdown
It place in a very thin jn i.e., when both side of jn are very heavily doped and consequently the depletion layer is narrow.

Application of Zener Diodes

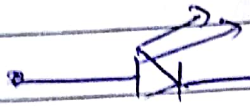
① As voltage stabiliser
The major application of a Zener diode in the electronic circuit is as a voltage regulator. It provides a constant voltage to the load from a source whose voltage may vary over sufficient range. The Zener diode of Zener voltage V_z is reverse connected across the load R_L across which constant voltage is desired.

Let a variable voltage V_{in} be applied across the load R_L



LED
When a diode is forward biased the potential barrier is lowered. The conduction band free electron from n-region cross the barrier and enter the p-region. As these elect enter p-region, they fall into the holes lying in the valen band. Hence they fall from a higher energy level to a lower energy level.

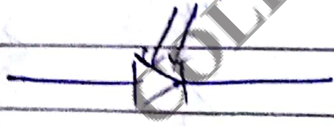
The LEDs are different. These are made from gallium arsenide phosphide (GaAsP) and gallium phosphide (GaP). In LEDs, the energy is radiated in form of light and hence they glow. A manufacturer can produce LEDs that radiate red, green, yellow, blue, orange, or infrared light.



Photodiode

When a diode is reverse biased, a minute current flows in the diode due to minority carriers. These carriers exist because of thermal energy which dislodge the valence electron from their orbits producing free e^- and hole in the process.

A diode that is optimised for its sensitivity to light is known as photodiode.

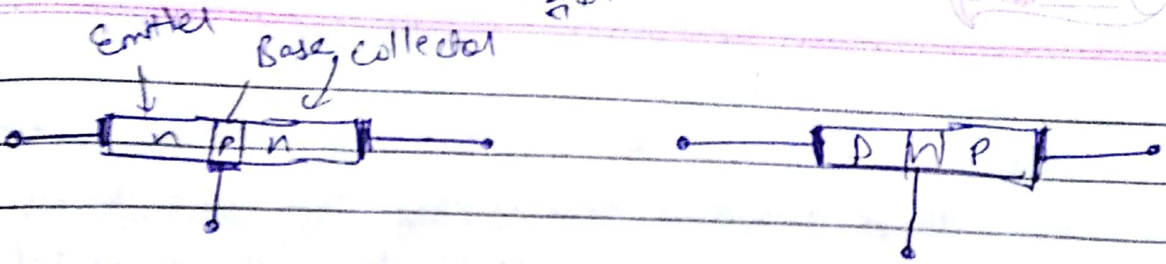


Transistor.

A semiconductor device consisting of two pn jn formed by sandwitching ethier p-type or n-type semiconductor b/w a pair of opposite type is known as a transistor.

① npn transistor:-

② pn-p transistor.



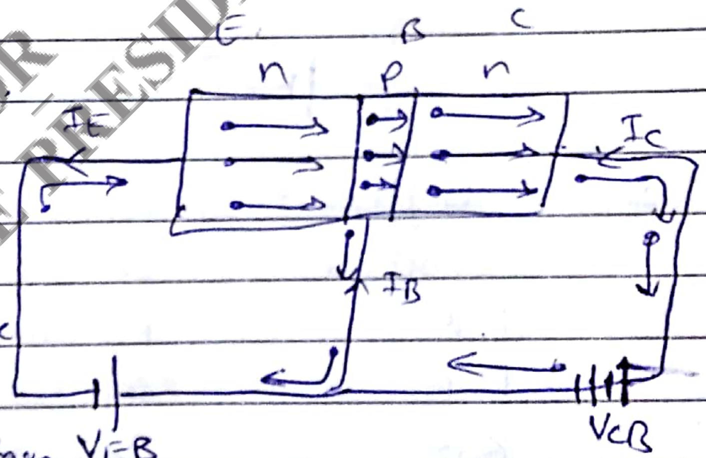
Transistor Terminals.

① Emitter :- The section on one side of transistor that supplies a large no. of majority carriers is called emitter. The emitter is always forward biased wrt base.

② Collector: It collect the major portion of majority carriers supplied by emitter is called collector. The collector-base jn is always reverse biased.

③ Base:- The middle section which form two pn jn b/w emitter and collector is called base.

Working n-p-n Transistor.

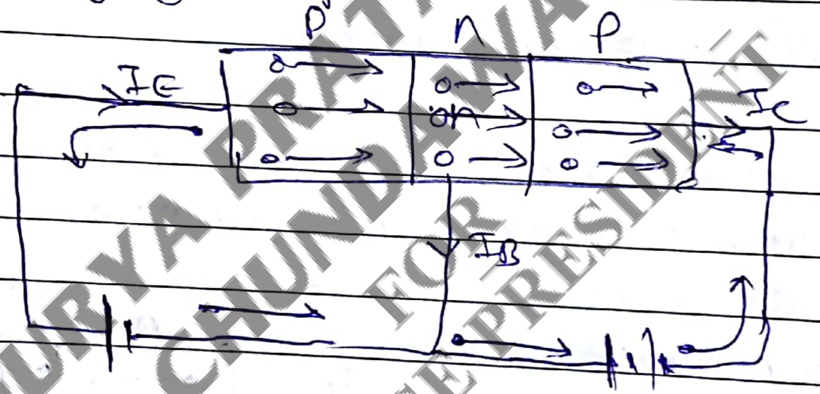


An npn transistor circuit
The emitter-base Jn is forward while collector-base Jn is reverse biased.
The forward biased voltage V_{EB} is quite small, where reverse biased voltage V_{CB} is high.
As emitter-base Jn is forward biased, a large no. of e^- in emitter are pushed toward the base. This constitutes the emitter current I_E. When these e^- enter the p-type material (base) they tend to combine with holes. Since the base is lightly doped and very thin, only a few e^- (5%) combine with hole to constitute base current I_B.

The remaining e^- (95%) diffuse across the thin base region and reach the collector space charge layer. These e^- then come under influence of positively biased n-region and attracted or collected by collector. This constitutes collector current I_C.

$$I_E = I_C + I_B$$

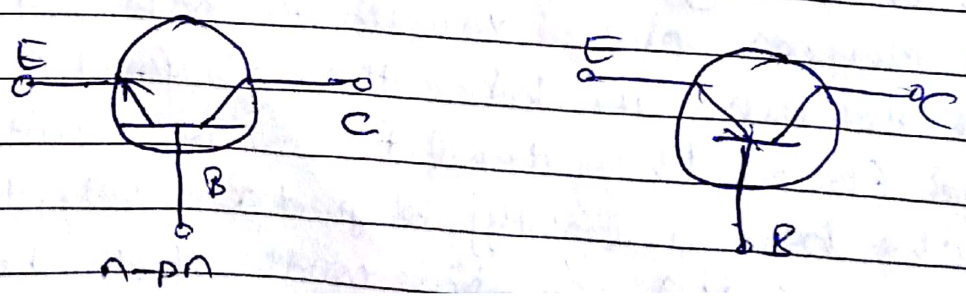
Working of P-np transistor.



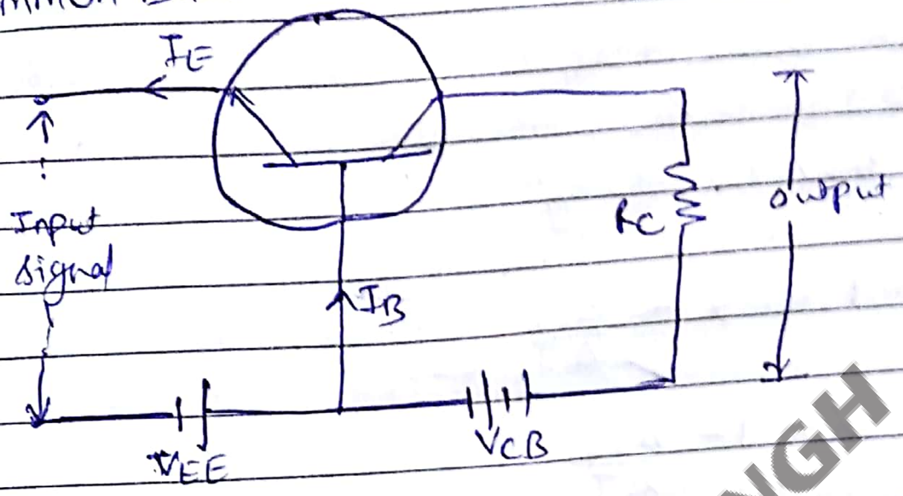
Different operating condition of transistor.

Condition	Emitter	Collector	Region
FR	Forward	Reverse	Active
FF	Forward	Forward	Saturation
RR	Reverse	Reverse	Cutt-off
RF	Reverse	Forward	Inverted

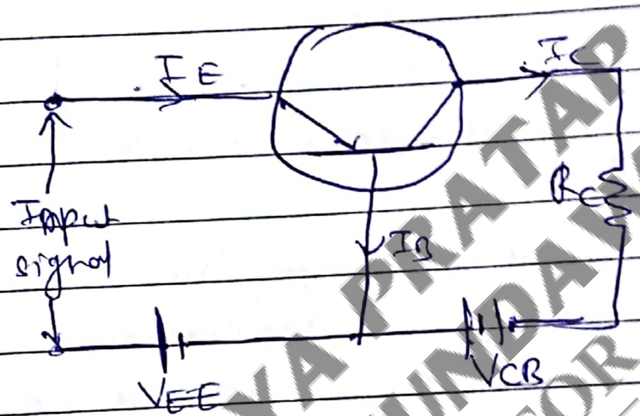
Transistor symbol.



Common Base Connection (CB configuration)



npn transistor



PNP

⇒ Current Amplification factor (α)
The ratio of output current to input current is known as current amplification factor.
Output current = I_C Input current = I_E

Thus, the ratio of change in collector current to change in I_E at constant collector base voltage V_{CB} is known as current amplification factor.

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

$$I_E = I_C + I_B$$

$$\Delta I_E = \Delta I_C + \Delta I_B$$

Divide by ΔI_E to eq^n

$$1 = \alpha + \frac{\Delta I_B}{\Delta I_E}$$

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

⇒ Collector current.

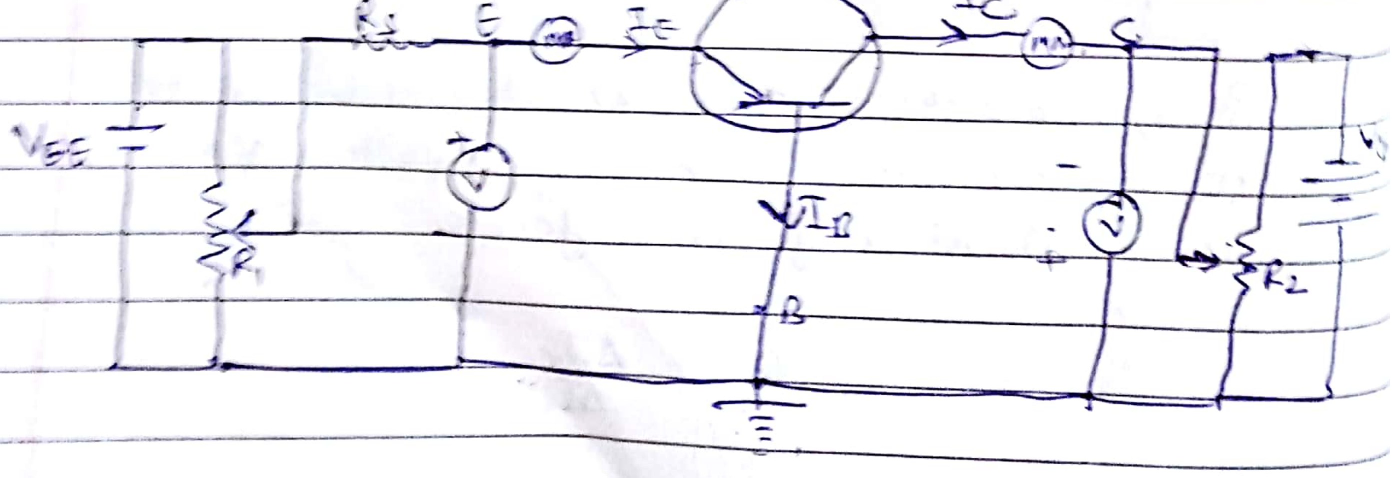
① A large % of I_E that reaches the collector terminal i.e. αI_E

② The leakage current $I_{leakage}$. This current is due to movement of minority carrier across the CB junction because it is reverse biased.

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

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

Input characteristics

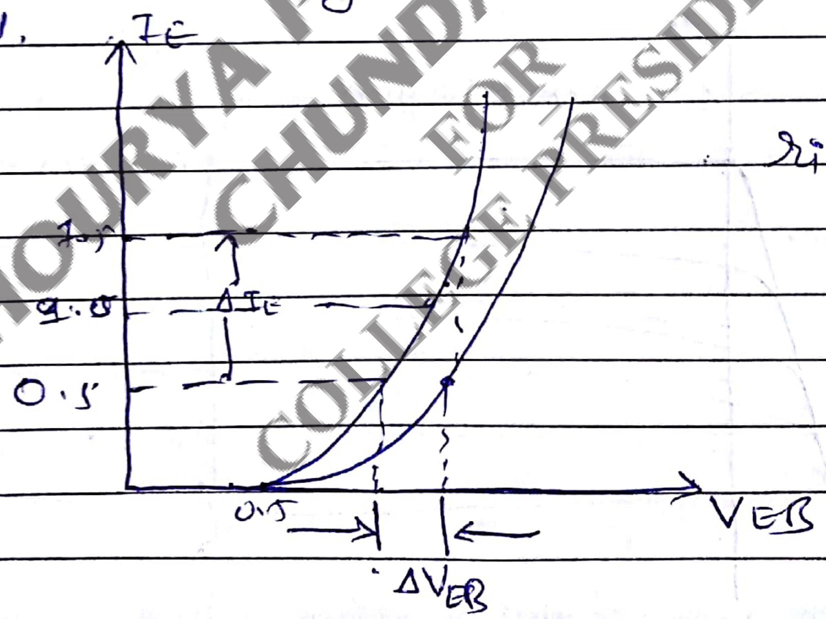


In CB configuration: the curve plotted b/w I_E and V_{EB} at constant V_{CB} is called input characteristics.

(i) For a particular value of V_{CB}, the curve is just like a diode characteristic in forward region. Here pn emitter jn is forward biased.

(ii) V_{CB} is increased, the value I_E increase slightly for given value V_{EB}.

(iii) The I_E increase rapidly with a small increase in emitter base voltage V_{EB}. It mean input resistance is very small.



$$r_i = \frac{\Delta V_{EB}}{\Delta I_E}$$

at constant V_{CB}

⇒ Output characteristic:
The curve plotted b/w I_C and V_{CB} at constant I_E is called output characteristic.

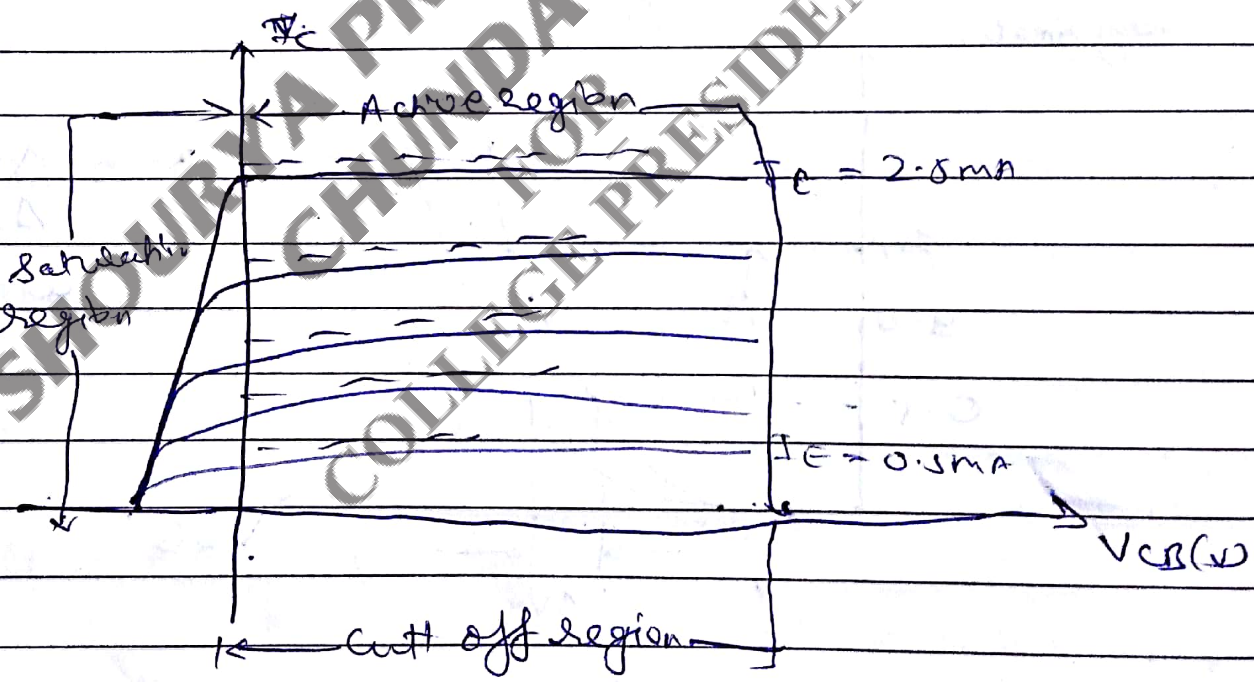
(i) In active region, where CB Jn is reverse biase, the I_C is almost equal to I_E.

(ii) In active region, the curves are almost flat. A very large change in V_{CB} produce only a tiny change in I_C.

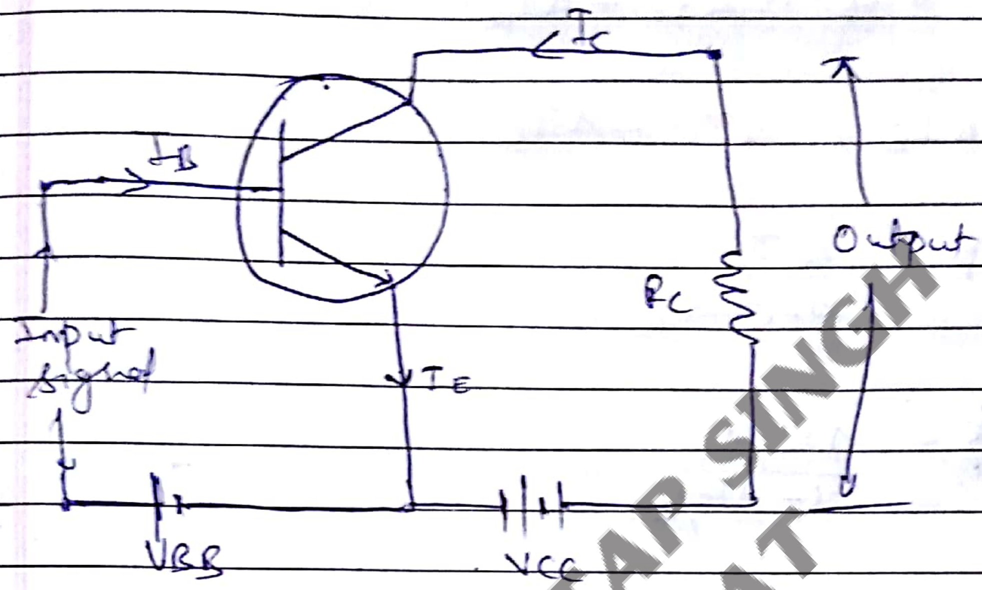
(iii) When V_{CB} become +ve i.e. I_B Jn is forward biased, the collector current I_C decrease.

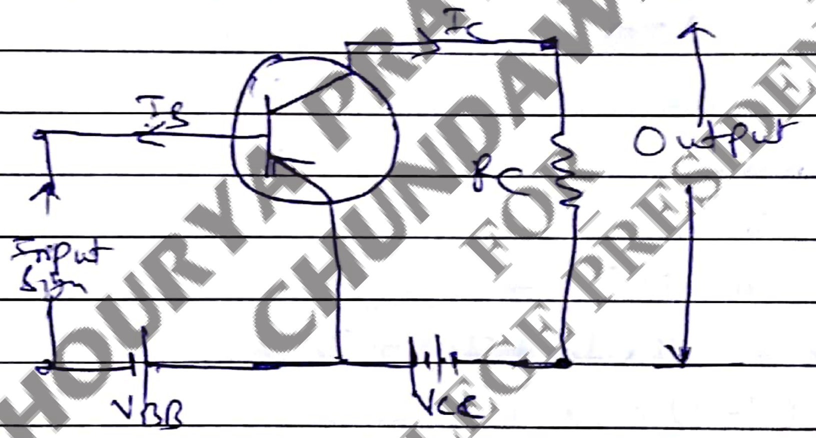
(iv) When $I_E = 0$, collector current I_C is not zero, although it value is very small.

$$r_o = \frac{\Delta V_{CB}}{\Delta I_C} \text{ at constant } I_E$$



Common Emitter Connection (CE configuration)





⇒ Base current Amplification factor (β)

Thus, the ratio of change in I_C to change in base current is known as base current amplification factor.

$$\beta = \frac{\Delta I_C}{\Delta I_B}$$

⇒ Relationship b/w α, β

$$\beta = \frac{\Delta I_C}{\Delta I_B} \qquad \alpha = \frac{\Delta I_C}{\Delta I_E}$$

$$I_E = I_C + I_B$$

$$\Delta I_E = \Delta I_C + \Delta I_B$$

$$\Delta I_B = \Delta I_E - \Delta I_C$$

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

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

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

⇒ Collector current

$$I_E = I_C + I_B$$

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

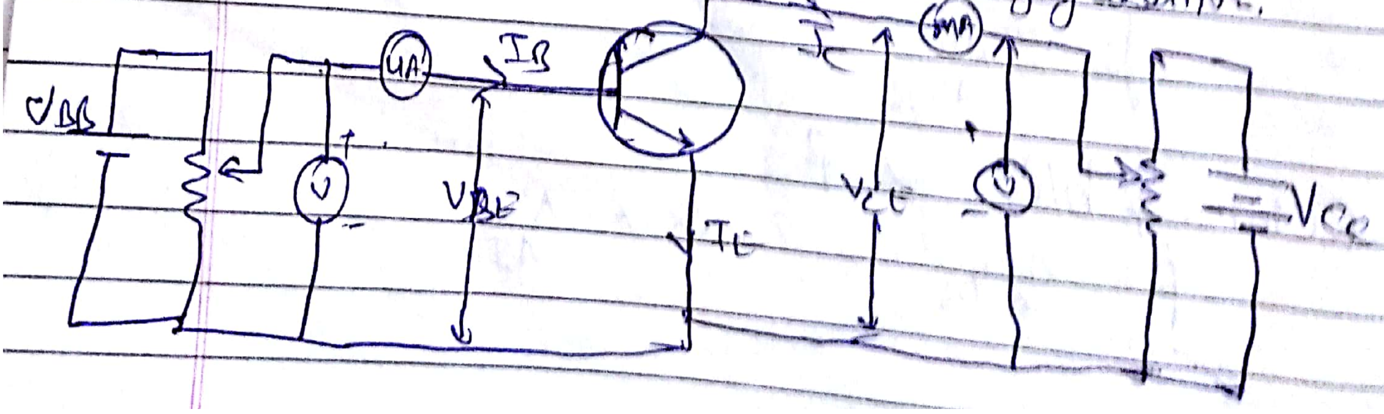
$$I_C = \alpha (I_C + I_B) + I_{CBO}$$

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

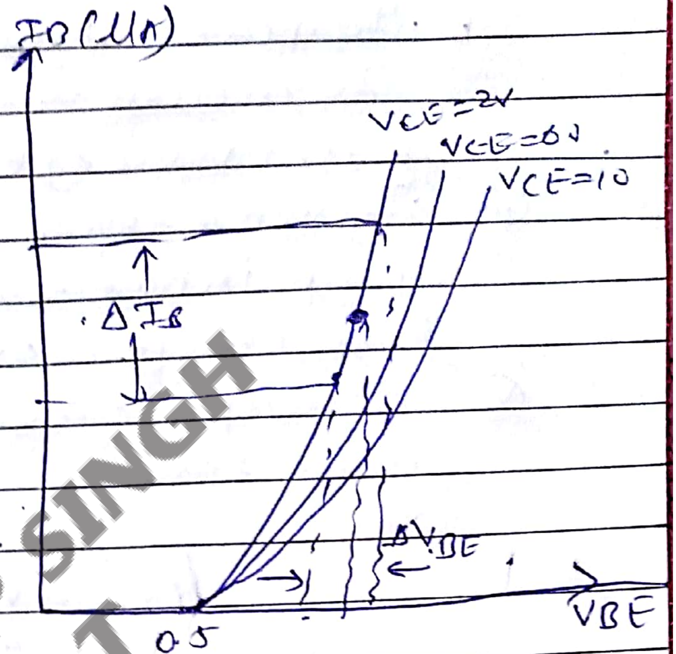
$$I_C = \frac{\alpha}{1-\alpha} \cdot I_B + \frac{1}{1-\alpha} \cdot I_{CBO}$$

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

Characteristics of CE configuration.



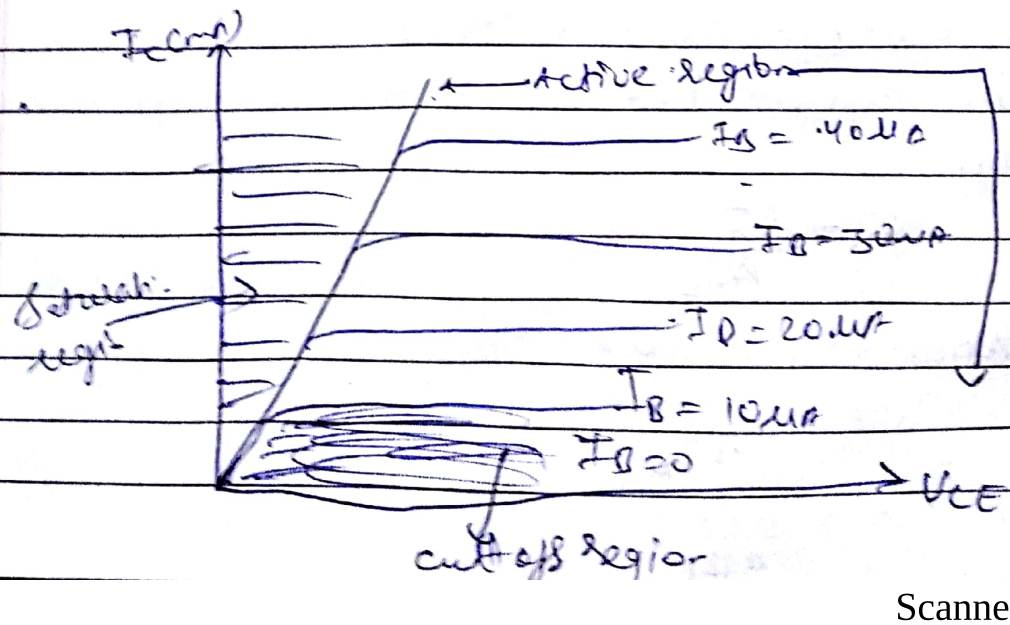
* Input characteristics.
The curve plotted b/w I_B and V_{BE} at constant V_{CE} is called input characteristic.



(i) These curve are similar to those obtained for CB configuration i.e. like a forward diode characteristic. I_B increase less rapidly with increase in V_{BE}.
(ii) The change in V_{CE} does not result in a large deviation of curve and hence the effect of change in V_{CE} on input characteristic its ignored for practical purpose.

$$r_i = \frac{\Delta V_{BE}}{\Delta I_B} \text{ at constant } V_{CE}$$

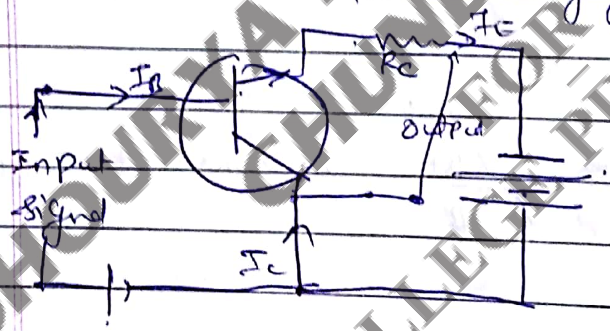
* Output characteristics
In CE configuration the curve plotted b/w collector current I_C and V_{CE} at constant I_B is output.



(i) · Ic increase slightly as VCE increase.
(ii) · Ic increase with increase in VCE at constant IB, the value of β also increase.
(iii) · In active region $I_C = \beta I_B$ hence, a small change in base current IB produced a large change in output current (I_C)
(v) When input current $I_B = 0$ collector current Ic is not zero

$$r_o = \frac{\Delta V_{CE}}{\Delta I_C} \text{ at constant } I_B.$$

Common Collector configuration (CC configuration)



⇒ Current amplification factor (γ)
Thus, ratio of change in emitter current to change in base current is known as current amplification factor.

$$\gamma = \frac{\Delta I_E}{\Delta I_B}$$

· Relation b/w γ and α

$$\gamma = \frac{\Delta I_E}{\Delta I_B}$$

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

$$I_E = I_C + I_B$$
$$\Delta I_E = \Delta I_C + \Delta I_B$$
$$\Delta I_B = \Delta I_E - \Delta I_C$$

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

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

⇒ Collector current
$$I_C = \alpha I_E + I_{CBO}$$

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

$$I_E - \alpha I_E = I_B + I_{CBO}$$
$$I_E(1-\alpha) = I_B + I_{CBO}$$
$$I_E = I_B\left(\frac{1}{1-\alpha}\right) + I_{CBO}\left(\frac{1}{1-\alpha}\right)$$

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

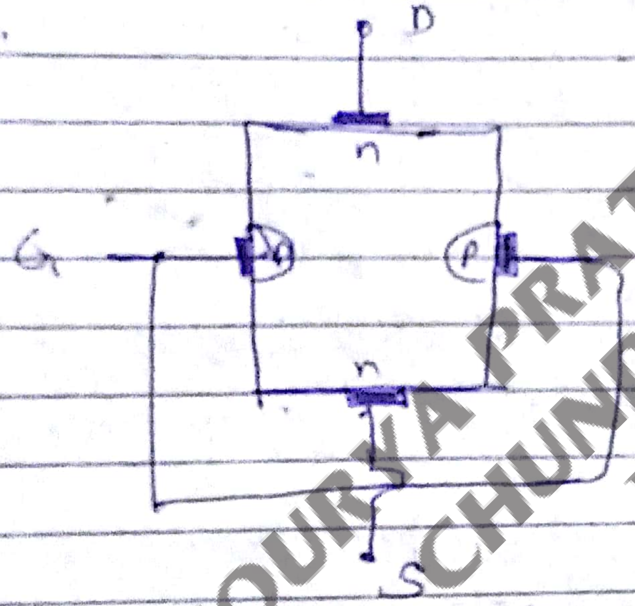
Comparison B/w Three Transistor Configuration

S.No.	Characteristics	CB	CE	CC
1	Input resistance	low (50 Ω)	Low (1 kΩ)	Very high (750 kΩ)
2	Output Resistance	Very high (500 kΩ)	High (10 kΩ)	Low (50 Ω)
3	Current gain	Less than unity (0.98)	High (100)	High (100)
4	Voltage gain	Small (150)	High (500)	Less than one.
5	Leakage gain	very small (5 μA for Ge, 1 μA Si)	Very large (500 μA for Ge 20 μA Si)	very large (500 μA for Ge 20 μA for Si)
6.	Application	For high frequency application	For audio frequency application	For impedance matching.

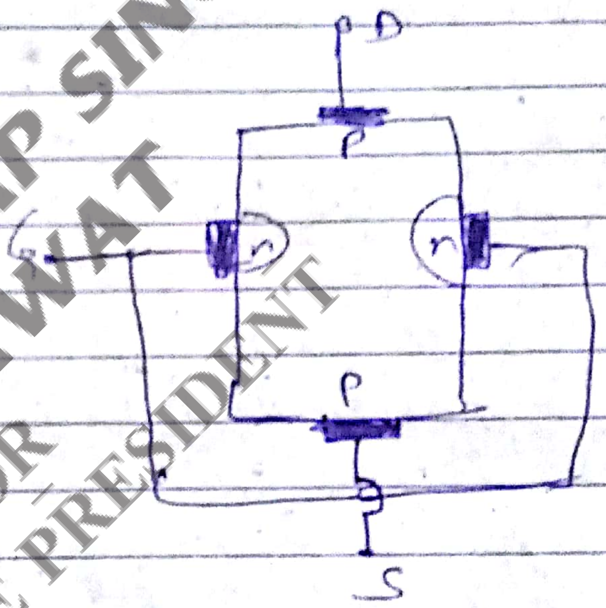
JFET

A JFET is a three terminal semiconductor device in which current conduction is by one type of carrier i.e. electron or holes.

⇒ Construction: A JFET consist of p-type or n-type silicon bar containing two pn jn at the sides. The bar forms the conducting channel for charge carrier. If the bar is of n-type it called n-channel JFET & vice-versa. The two pn jn forming diodes are connected internally and a common terminal called gate. other terminal are source and drain taken out from the bar.



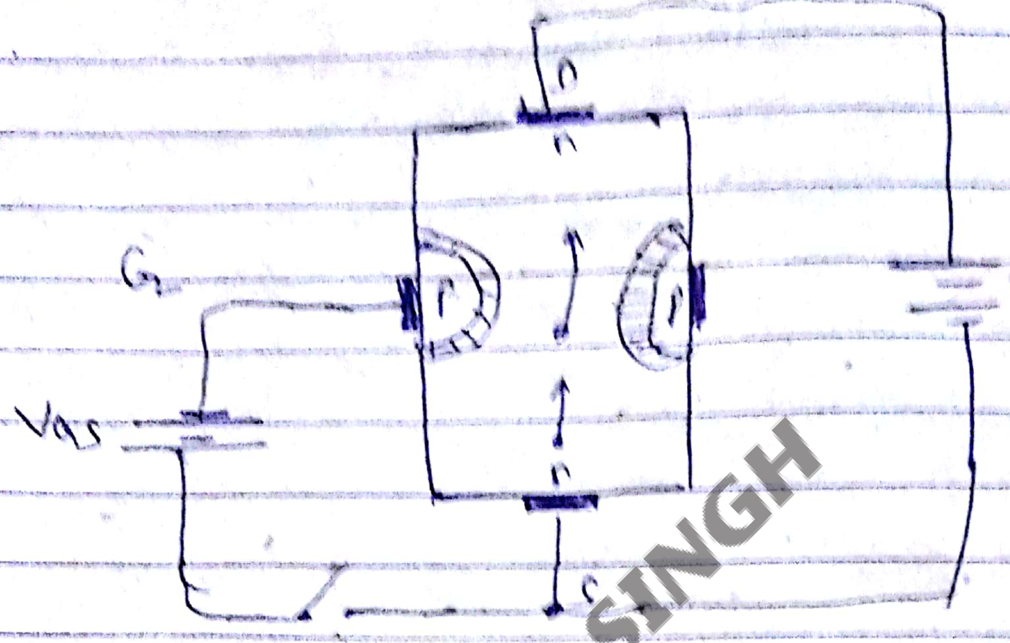
n-channel



Principle and Working

· Thus JFET operates on the principle that width and hence resistance of the conducting channel can be varied by chaning the reverse voltage V_{GS}

Working.

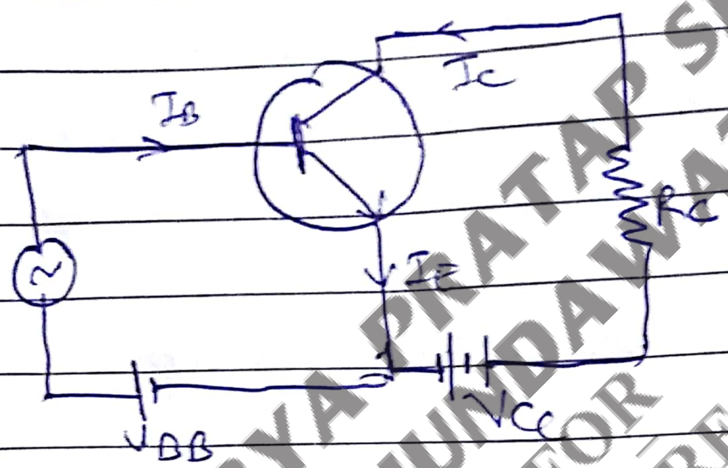


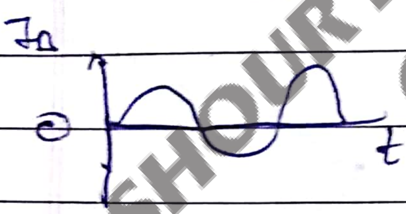
(I) When V_{DS} is applied b/w D & S terminal and Voltage on gate is zero, the two pn jn. at sides of bar establish depletion layer. The e^- will flow from S to D through channel b/w depletion layer.

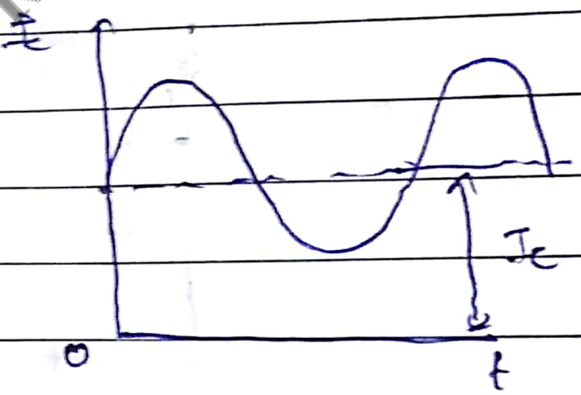
(II) When reverse voltage V_{GS} is applied b/w G & S, the width of depletion layer increases. This reduces the width of conducting channel thereby increasing the resistance of n-type bar. The current from S to D is decreased.
If the reverse voltage on gate is decreased the width of depletion layer also decreases.

Since the current from S to D can be controlled by application of potential (i.e. electric field) on the gate. For this reason the device is called Field effect transistor.

Transistor as an Amplifier.







During positive half-cycle of the signal the forward bias across the emitter base jn is increased. Therefore, more e^- flow from the emitter to the collector via the base. This causes an increase in collector current. The increased collector current produces a greater voltage drop across the collector load resistance R_C. However during the negative half-cycle of the signal, the forward bias across emitter-base jn is decreased. Therefore collector current decreases. This result in decreased output voltage. Hence an amplified output is obtained across the load.

⇒ Analysis of collector current :- When no signal is applied the input circuit is forward biased by battery V_{BB}. Therefore, a d.c. collector current I_C flow in collector circuit. This is called zero signal collector current.

(i) The d.c. collector current I_C due to bias battery V_{BB}. This is current that flow in collector in absence of signal.
(ii) The a.c. collector current i_c due to signal.
∴ Total collector current $i_C = i_c + I_C$.