A transistor consists of two pn junction formed by sandwiching either P-type or n-type semiconductor between a pair of opposite type.

Bipoler Junction Transistor (BJT)

BJT is a three terminal device

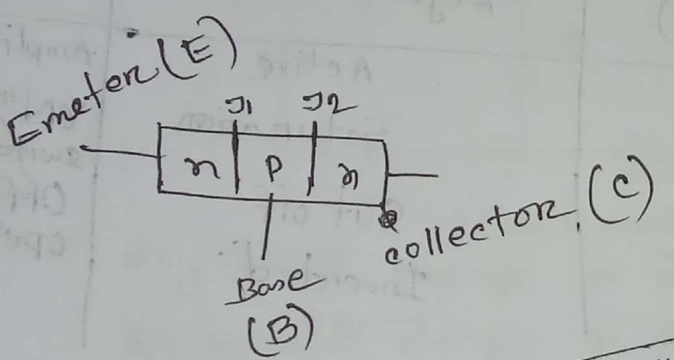
→ used in amplification to week signals

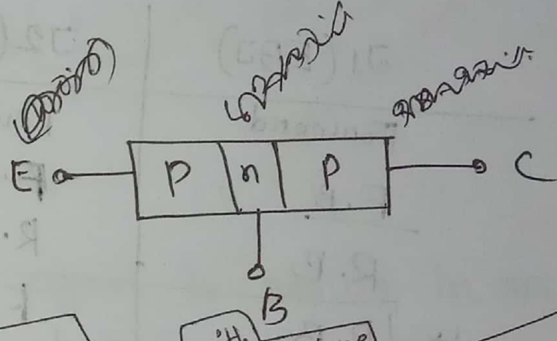
→ also used in switching operation

2 types of BJT

(i) npn (e)

(ii) pnp (h)





collector (largest) → collect the charges always reverse bias. remove charges from it's junction ~~from~~ with the base

Base (smallest) – form 2 pn junction between emiter and collector.

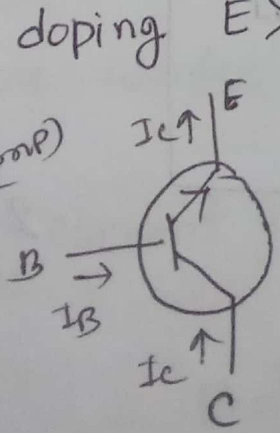
emeter – supplees charge carriers (e/holes) always forword so that it can supply large amount of majority carier.

2 Junction → J1 (emiter Base) F
J2 (Base collector) R

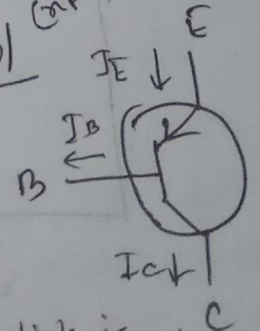
width : C > E > B

doping E > C > B

symbol : (pnp)



symbol (npn)



the resistance of emitter diode is small

~~Tran~~

Bipole Junction Transistor (Transfer + Resistor)

2 junction

J_1 = forwoard

J_2 = Reverse

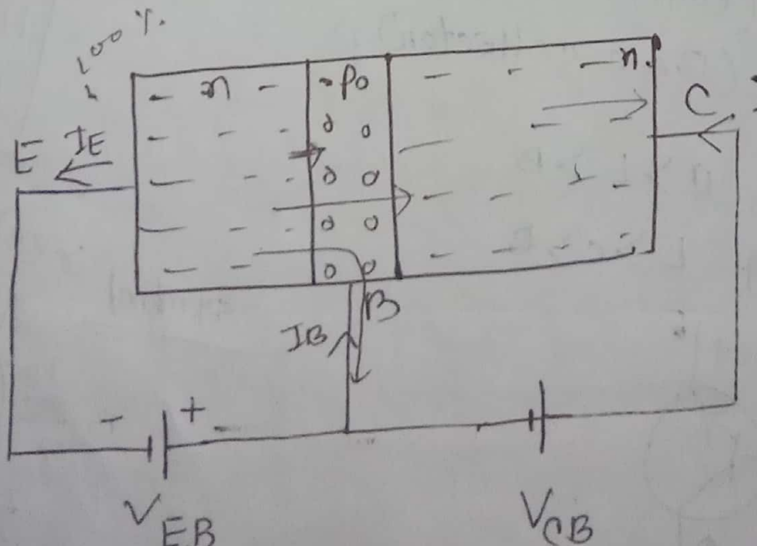
(i) e^-

(ii) holes } 2 polarities

Region of operation :

J1 (EBJ)	J2 (CBJ)	Region of operation	
Forwoard	Reverse	Active	Amplifier
F.B	F.B	Saturation	"ON"/ switch
R.B	R.B	Cut off	Off/ open
R.B (rarely used)	F.B	Inverted	

Transistor operation : (common base)



Active mode:

$J_1 \rightarrow F.B \rightarrow R = 0$

$J_2 \rightarrow R.B \rightarrow R = \infty$

2-5% combined into base

95-98% going to collector

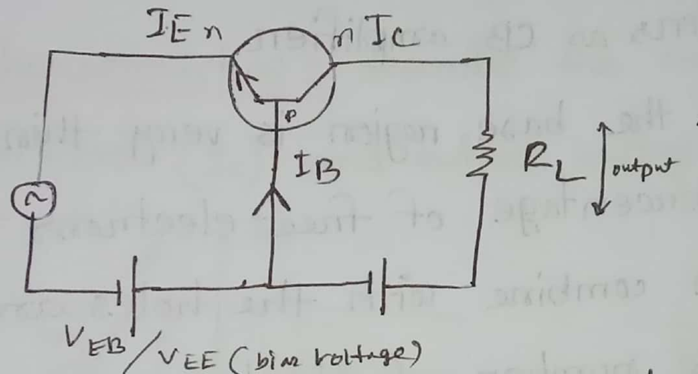
$$I_C = \alpha I_E + I_{CBO}$$

$$I_E = I_C + I_B$$

} they are true for all transistor

Transistor as an amplifier v.v.I

Transistor acts as an amplifier by raising the strength of a week signal. The DC bias voltage applied to the emitter base junction, makes it remain in forword bias condition.



The input circuit (emitter-base) Junction has low resistance & output circuit (collector base Junction) has high resistance.

any small change in input signal to result in an appreciable change in the output

The emitter current caused by the input signal contributes the collector current, which when flows through R_L, result in a large a voltage drop across it. Thus a small input voltage results in a large output voltage, which shows that the transistor works as amplifier.

current gain, $\beta = \dfrac{\Delta I_C}{\Delta I_B}$

β → transistor parameter

$\beta = 20 - 500$

$V = RI$

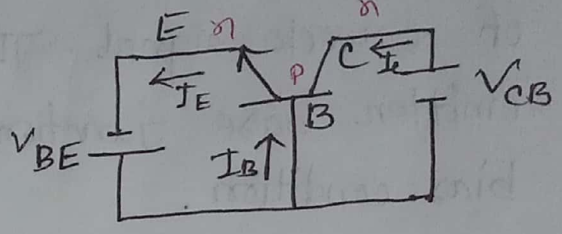
reverse I

R অনেক বেশি হওয়ায়

V এর মান ও অনেক বেশি হয়।

4 CB, CE, CC configurations and their input output characteristics

CB (common base)



input terminal → emitter
output " → collector
common terminal → base
sometimes it refferes as CB amplifier

4 The width of the base region is very thin. Therefore only a small percentage of free electrons from emitter region combine with the holes and the remaining large number of electron cross the base region and enters into the collector region. These electron of collector ~~are~~ att will experience an attractive force from the positive terminal of the battery. Thus, electric current is produced in the collector region. So, $I_E = I_B + I_C$

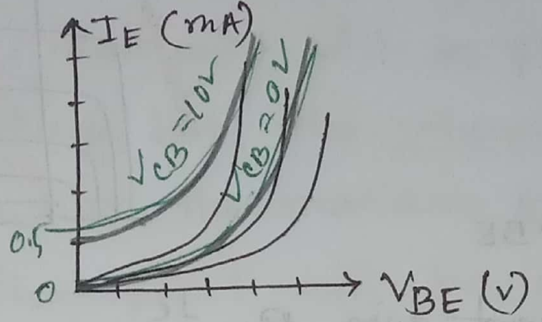
since input current (I_E) > output current (I_C)

~~The current gain, β =~~ the gain of amplifier < 1

J_{BE} → forward bias J_{BC} → reverse bias.

Therefore, The CB amplifier provides a low input impedance and high output impedence. Overall power gain of CB a is low as compared to the others transistor amplifier configuration.

Input Characteristics : describe the relationship between input current (I_E) and input voltage (V_{BE})

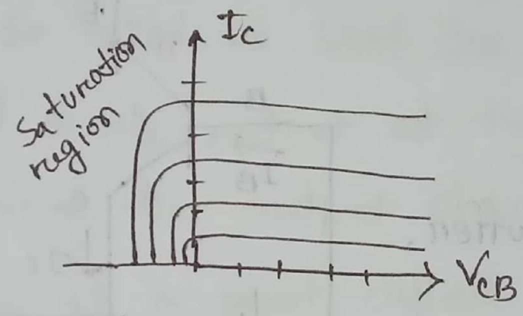


Output characteristics : describe the relationship between output current (I_C) and output voltage (V_{CB})

$I_C \to$ for I leckage 20:

$I_{CBO} \to$ Leckage current

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

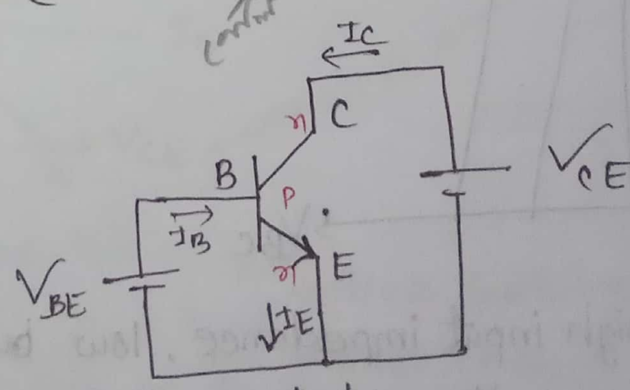


at saturation region,
J_{EB}, J_{CB} → forward B
if it is F.B then I_C increased

Current gain of transistor, $\alpha = \frac{I_C}{I_E}$ → ratio of output current to input current.
$\alpha = (0.9 - 0.99)$ — less then one

CE (common Emitter) : (→ most widely used)

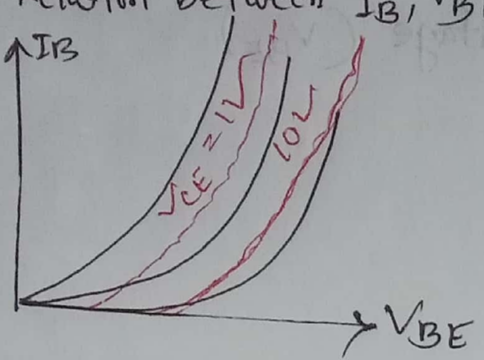
input terminal → base
output " → collector



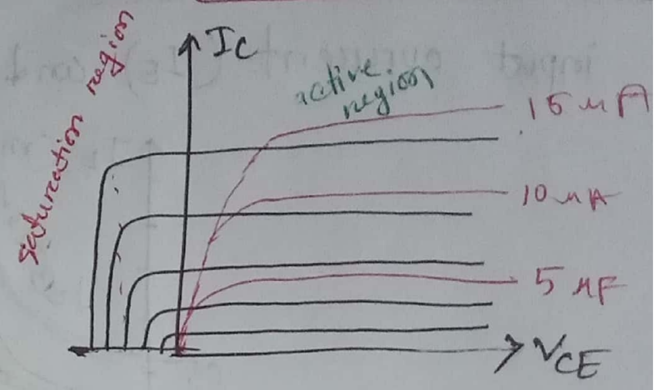
It's used when large curren gain is needed. medium input and output impedance. so, current gain and voltage gain is medium.

Input Characteristics

Relation between I_B, V_{BE}



output characteristic



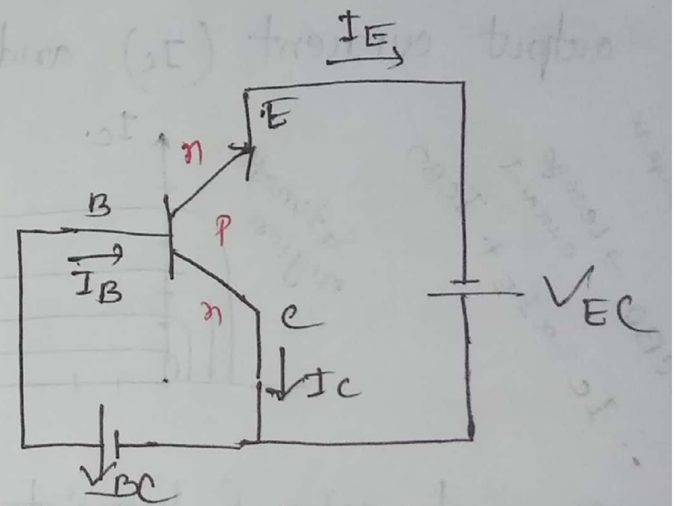
current gain, $\beta = \frac{I_C}{I_B}$

CC (common collector)

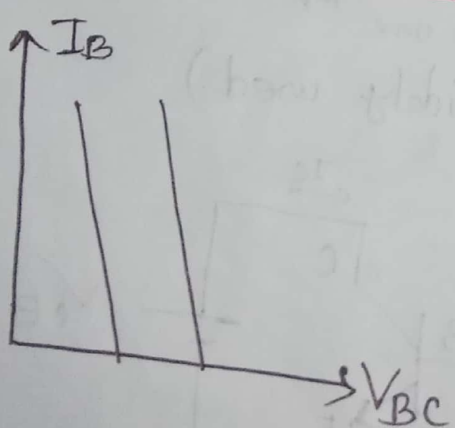
input → base

output → emitter

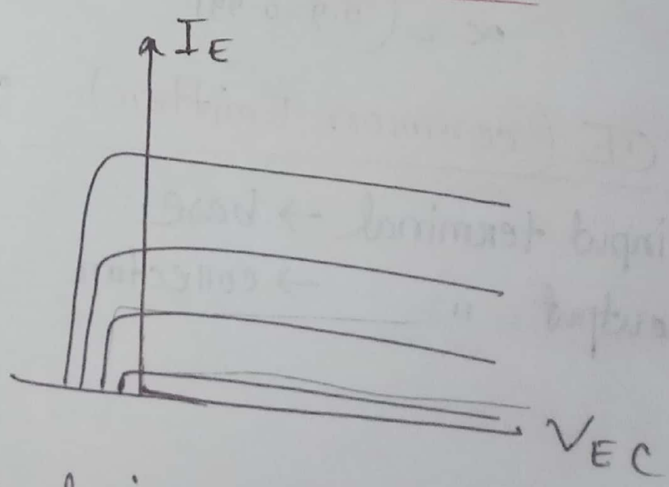
mostly used as voltage buffer.



Input characteristics:



Output characteristic



high input impedence, low output impedance

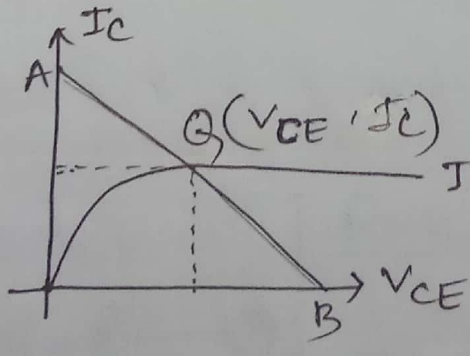
Low voltage gain, high current gain

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

Load line analysis , operating point (V.V.I) কোনোভাবে পড়ব

When a value for the maximum possible collector current is considered, That point will be present on Y-axis, which is nothing but the saturation point. As well when a value for the maximum possible V_{CE} is considered, that point will be present on the x-axis, which is the cutoff point.

When a line is drawn joining these two points, such a line can be called as Load line. This is called so as it symbolized the output at the load. This line when drawn over the output characteristic curve, makes contract at a point called operating point/Quiescent point / Q point.



The zero signal values of I_C and V_{CE} are known as operating point. It is called operating point because the variations of I_C and V_{CE} take place about this poin when signal is applied.

Active Saturation mode for si =
$V_{BE} = 0.7V$

Derive the relation between current amplification factor (α) and base current amplification factor (β). Also deduce the collector current equation in case of CE connection

$$\alpha = \frac{I_C}{I_E} \quad \text{and} \quad \beta = \frac{I_C}{I_B} \qquad [I_E = I_C + I_B]$$

$$= \frac{I_C}{I_B + I_C}$$

$$= \cancel{\frac{I_C}{I_B} + \frac{I_C}{I_C}}$$

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

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

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

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

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

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

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

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

In case of CE connection:

$$I_E = I_C + I_B$$

$$\Rightarrow I_C = I_E - I_B$$

about (95–98 %) current can flow into collecto to CE connection. the collector current is almost equal to the emitter current.

Q. $I_E = 25\ mA$, $\beta = 100$, $I_C = ?$ $I_B = ?$

$$\beta = \frac{I_E}{I_B}$$

$$\Rightarrow 100 I_B - I_C = 0 \quad \text{—— (I)}$$

$$\text{and} \quad I_B + I_C = 25 \quad \text{—— (II)}$$

$$I_B = 0.25\ mA$$

$$I_C = 24.75\ mA$$

বিকল্প :

$$\alpha = \frac{\beta}{\beta+1} = \frac{100}{100+1} = 0.99$$

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

$$= 0.99 \times 25$$

$$= 24.75\ mA$$

$$I_B = I_E - I_C$$

$$= 25 - 24.75$$

$$\simeq 0.25\ mA$$

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④ I_{CEO}, I_{CBO} How they related? are they typically closed in magnitude?

I_{CEO} is stand for collector to emitter current where base is open and I_{CBO} is collector to base current where emitter open.

$I_E = I_C + I_B$

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

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

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

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

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

$I_B = 0,\ I_C = I_{CEO}$

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

④ Why collector current is less then emitter current? ($I_C < I_E$)

The base contains more holes then electron. As the direction of current is opposite to the flow of e- ~~we can~~. Some of the electron combine with the holes of base and most of the electron are reached to the collector, crosing the collector base junction. So it can be said that collector current is always less then emitter current.

4 For a ~~regis~~ transistor, $\beta = 45$ and voltage drop across $1\,k\Omega$ which is connected to the ~~$1\,k\Omega$ current~~ collector circuit is 1 V. find the base current (I_B) fo CE

$V_{cc} = 1V$

$R_c = 1\,k\Omega$

$\beta = 45$

$$I_c = \frac{V_{cc}}{R_c} = 1\ mA$$

again, $\beta = \frac{I_c}{I_B}$

$$\Rightarrow I_B = \frac{I_c}{\beta} = \frac{1}{45} = 0.022\ mA$$

CEO → Collector to emitter where base is open.

$I_{CEO} > I_{CBO}$

$I_E = I_B + I_c$ — (I) and $I_c = \alpha I_E + I_{CBO}$ — (II)

(II) $\Rightarrow I_c = \alpha I_E + I_{CBO}$

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

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

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

$\Rightarrow I_c = \frac{\alpha}{1-\alpha} I_B + \frac{1}{1-\alpha} I_{CBO}$ ---- (III)

If base ckts is open ($I_B = 0$) then the collector current will be the collector to emitter current.

$$\boxed{\therefore I_{CEO} = \frac{1}{1-\alpha} I_{CBO}}$$ or $I_{CEO} = (\beta+1) I_{CBO}$

from (III) $\Rightarrow$ put I_{CEO} on replace $\frac{1}{1-\alpha} I_{CBO}$

$$I_c = \frac{\alpha}{1-\alpha} I_B + I_{CEO}$$

$$\Rightarrow \boxed{I_c = \beta I_B + I_{CEO}}$$