Definition of Amplification : The process of transfering the weak signal from low resistance region to high resistance region, which makes the weak signal to strong signal. This process is called amplification.

★

weak signal	→	low amplitude signal.
strong signal	→	high amplitude signal.

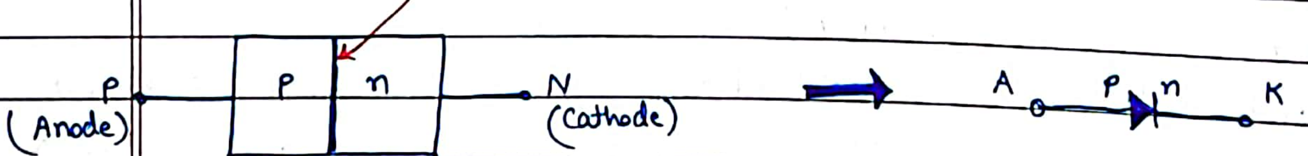
★ $\boxed{\text{Transistor} = \text{Transfer} + \text{resistor}}$

Definition of transistor : Transistor transfers weak signal from low resistance region to high resistance region such that weak signal becomes strong signal.

★

Diode has no amplification property.
Transistor has amplification property.

Construction :

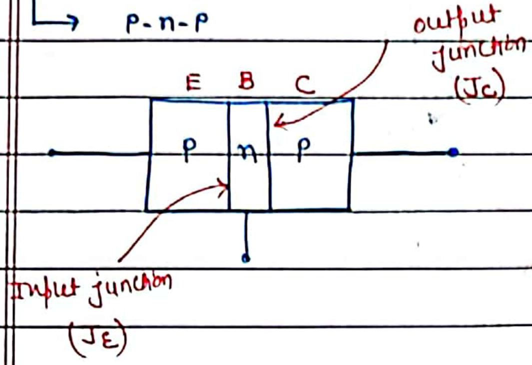


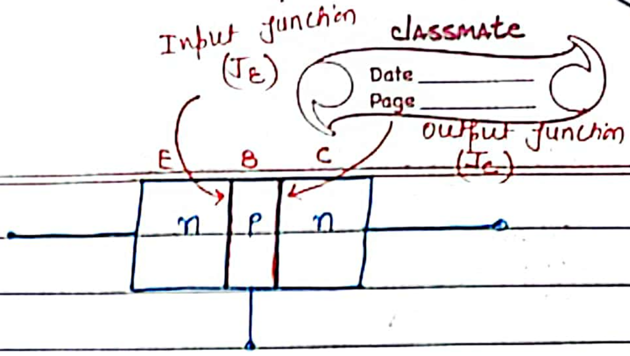
(Diode)
(P-N junction diode)
↓
2- terminal &
1- junction device

(Symbolic representation of diode)

BJT Construction :

BJT → n-p-n
→ p-n-p

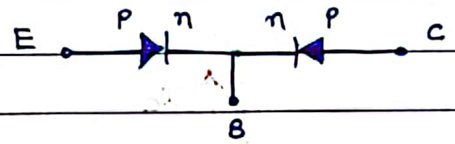




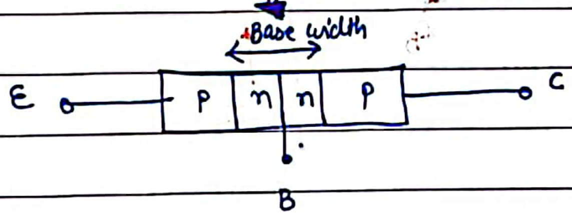
E – Emitter
B – Base
C – Collector

★ **Question :** Can we call transistor as back to back connected diode ?

Sol. : Take example of p-n-p transistor.



This structure cannot behave as transistor structure.



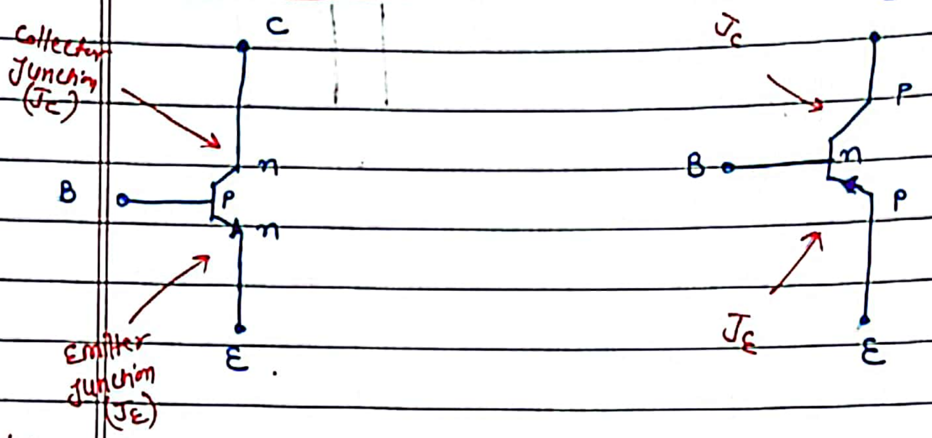
⇒ Here, base width becomes larger, which is not desirable in the designing of a transistor.

Point : chemically two diodes connected back to back is not referred as transistor because base width becomes largest which is not desirable.

★ Base width must be small for practical transistors.

Note :
★ Use "Ebers-Moll" model to connect two diodes as back to back.
In this model, a an dependent source is connected in parallel with diodes.

★ Symbolic representation of BJT :

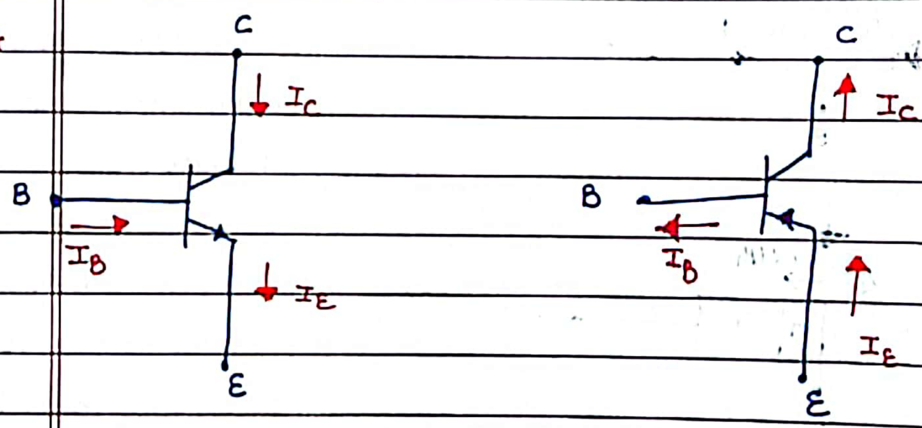


Points :-

★ Arrow represents Emitter terminal.

★ Imp Arrow represents direction of Emitter current when input junction is forward biased.

★★



(n-p-n transistor) ↓ (Arrow direction is outwards)

(p-n-p transistor) ↓ (Arrow direction is inside)

"(Here, assuming that J_E is forward biased)"

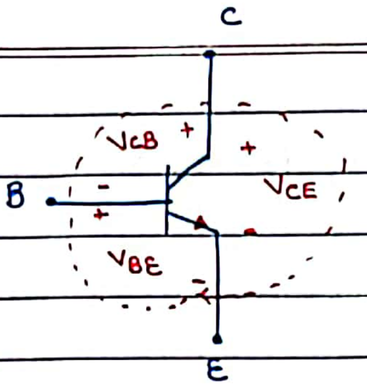
★ $$\boxed{I_E = I_B + I_C}$$ ⇒ Note : capital latters are used for D.C. analysis.

I_E – Emitter current

I_B – Base current

I_C – Collector current

★



V_{CB} = potential difference b/w collector & base.

$$\boxed{\begin{aligned} V_{CB} &= V_C - V_B \\ V_{BE} &= V_B - V_E \\ V_{CE} &= V_C - V_E \end{aligned}}$$

Apply KVL along dotted line,

$$-V_{BE} - V_{CB} + V_{CE} = 0$$

↑ entering at -ve terminal

impr

$$\star\star \quad \boxed{V_{CE} = V_{CB} + V_{BE}} \quad \Rightarrow \text{(Relation b/w voltages.)}$$

$$V_{CE} = V_C - \cancel{V_B} + \cancel{V_B} - V_E$$

$$V_{CE} = V_C - V_E$$

★★ Different combinations of junctions.

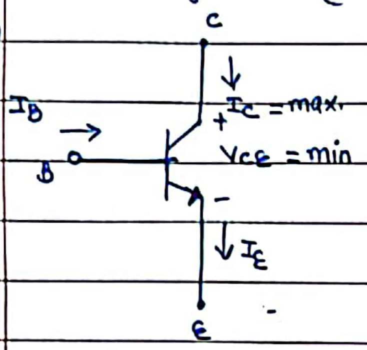
~~J_E (input junction)~~ ~~J_C (output junction)~~

J_E (input junc^n)	J_C (output junct^n)	Regions	Applications	Region Property
(FB) Forward biased (ON)	(RB) Reversed biased (OFF)	Active	Amplification	Amplifier
F.B. (ON)	F.B. (ON)	Saturation (Fully ON)	Switch	ON-switch
R.B. (OFF)	R.B. (OFF)	Cutoff (fully OFF)	Switch	OFF-switch
R.B (OFF)	F.B. (ON)	Inverse active	Attenuator	Attenuation

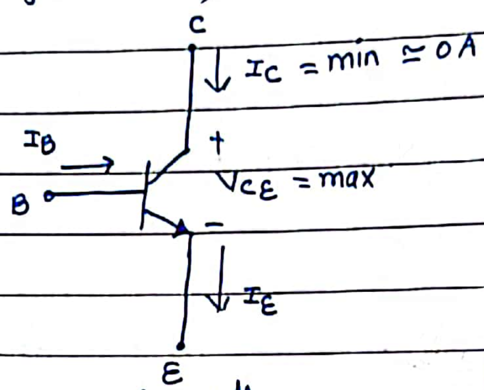
Note: Generally, we do not prefer use of transistor for attenuation purpose. It can be done by using voltage divider bias.

Conclusion:

1) when transistor works in active region, it behaves as amplifier (max. gain region)
2) In digital circuits, transistor works in saturation or cutoff regions. (eg, logic families)
3)



(Saturation region)



(cutoff region)

P_T = Power dissipation

$P_T = V_{CE} \times I_C$

★ Saturation region → $I_C = max.$
$V_{CE} = min$
$P_{T(sat)} = V_{CE(min)} \times I_{C(max)} \simeq 0$ watts

★ Cutoff region → $I_C = min.$
$V_{CE} = max.$
$P_T(cutoff) = V_{CE(max)} \times I_{C\,min} \simeq 0$ watts.

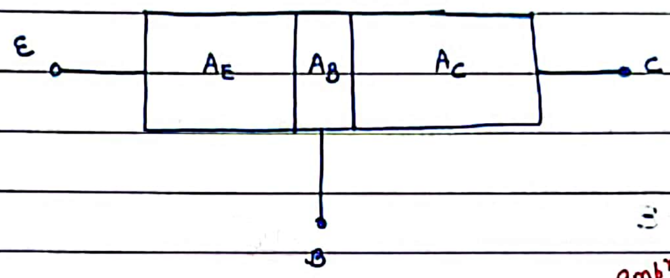
★ Active region → V_{CE} = medium
I_C = medium
$P_T(active) \simeq$ high

Points:

4) In digital circuitary, power consumption is very low.
5) In case of amp^r, power consumption is highest.
6) Among BJT, MOSFET, JFET, OP-Amp, the power consumption of BJT is high.

6) BJT is a noisy device.
7) (V_{CE}, I_C) is also referred as Q-point or operating point.
8) The product of Q-point is called power dissipation.

"order of cross-sectional area"



A_E – cross-sectional area of emitter
A_C – " " " " collector
A_B – " " " " base

gmp^r

$\boxed{A_C > A_E > A_B}$

(order of cross sectional area)

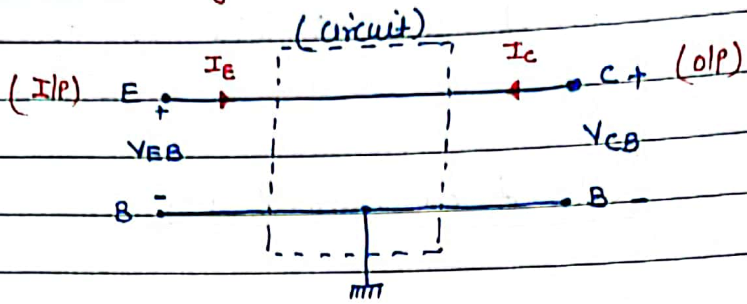
$R = \frac{\rho l}{A}$ (Resistance) $\Rightarrow$ $\boxed{R \propto \frac{1}{A}}$

$\boxed{R_B > R_E > R_C}$ (order of resistances)

"(BJT configurations)"

1) Common-Base configuration. (CB)
2) Common-Emitter configuration. (CE)
3) Common-Collector configuration. (CC)

1) Common-Base configuration :- (CB) :-



** α_{dc} = common-base dc current gain

$\alpha_{dc} = \frac{I_C}{I_E} = \frac{I_C}{I_E}$

$I_E = I_C + I_B$

gmp

Generally, $\boxed{\begin{array}{l} I_C = 98\% \text{ of } I_E \\ I_B = 2\% \text{ of } I_E \end{array}}$

** $\boxed{\alpha_{DC} \sim (0.95 - 0.99)}$

$\alpha_{dc} = \frac{98\% \text{ of } I_E}{I_E} \Rightarrow \alpha_{dc} = \frac{0.98 \cancel{I_E}}{\cancel{I_E}}$

gmp

** $\boxed{\alpha_{dc} \simeq 0.98}$

gmp

** $\boxed{0.9 < \alpha < 1}$

** $\boxed{\alpha_{dc}(max) = 1}$ $\Rightarrow$ * $\boxed{I_C = I_E}$ $\Rightarrow$ gmp $\boxed{I_B \simeq 0}$

* The value of α_{dc} equals to 1 indicates that the base current (I_B) is 0A and $I_C = I_E$.

gmp

* $\boxed{\alpha_{dc} > 1}$ (not possible)

→ So, the value of α_{dc} cannot be greater than unity.

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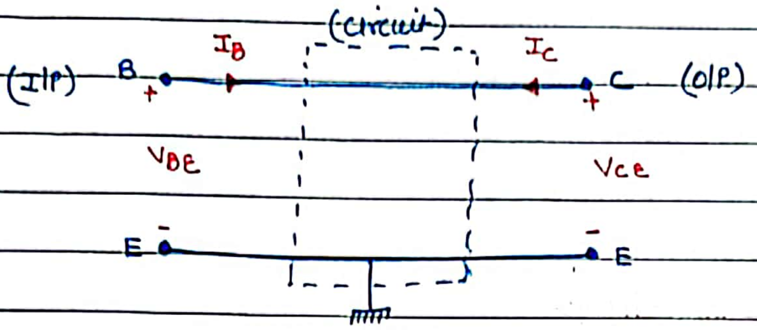
2) Common-Emitter (CE) Configuration



★ β_{dc} – Common-emitter dc current gain

(Approximate eqn)

★ $\beta_{dc} = \frac{\text{output current}}{\text{Input current}} = \frac{I_C}{I_B} \Rightarrow$ ★★ $\boxed{\beta_{dc} = \frac{I_C}{I_B}} \Rightarrow \boxed{I_C = \beta_{dc} I_B}$

$\beta_{dc} = \frac{98\% \text{ of } I_E}{2\% \text{ of } I_E} = \frac{0.98}{0.02} = 49$

Impr

$\beta_{dc} = 49 \Rightarrow \boxed{\beta_{dc} >> 1} \Rightarrow (\beta \text{ is very high})$

★★ $\boxed{\text{Practically, } \beta_{DC} \sim (20-200)}$

★ $I_E = I_C + I_B$

$\beta = \frac{I_C}{I_B}$, $\alpha = \frac{I_C}{I_E}$

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

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

Impr ★ $\boxed{\beta = \frac{\alpha}{1-\alpha}}$ (OR) Impr ★ $\boxed{\alpha = \frac{\beta}{1+\beta}}$

$\Rightarrow$ If $\alpha_{dc} = 1 \Rightarrow \beta_{dc} = \frac{\alpha_{dc}}{1-1} = \infty \Rightarrow$ ★ $\boxed{\beta_{dc} = \infty}$

It indicates that $\boxed{I_B \simeq 0 A}$

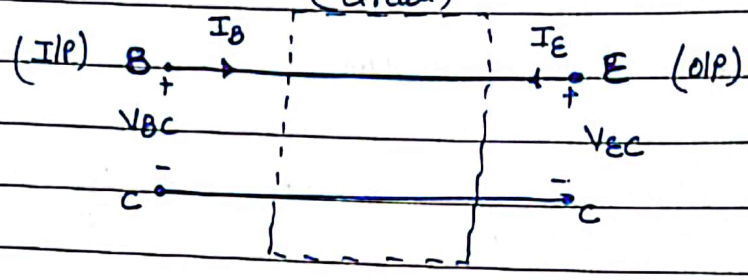
★ Generally, the value of β_{dc} is high. If value of β_{dc} is not given, then assume $\beta_{dc} = \infty$, which means $I_B \simeq 0 A$.

Exact relation b/w I_C & I_B :

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

3) Common-collector(CC) configuration :-

(circuit)



★ γ_{dc} – common collector d.c. current gain.

★ $\gamma_{dc} = \dfrac{I_E}{I_B} = \dfrac{I_E}{2\% \text{ of } I_E} = \dfrac{I_E}{0.02 I_E} = 50$

$$\star \quad \boxed{\gamma_{dc} = 50}$$

gmp^r

$$\star\star \quad \boxed{\gamma_{dc} > \beta_{dc} > \alpha_{dc}}$$

★ $\gamma_{dc} = \dfrac{I_E}{I_B} = \dfrac{I_C + I_B}{I_B} = 1 + \dfrac{I_C}{I_B} = 1 + \beta_{dc}$

$$\star\star \quad \boxed{\gamma_{dc} = 1 + \beta_{dc}}$$

★ $\gamma_{dc} = 1 + \dfrac{\alpha_{dc}}{1-\alpha_{dc}} = \dfrac{1-\alpha_{dc}+\alpha_{dc}}{1-\alpha_{dc}} = \dfrac{1}{1-\alpha_{dc}} \Rightarrow \boxed{\gamma_{dc} = \dfrac{1}{1-\alpha_{dc}}}$