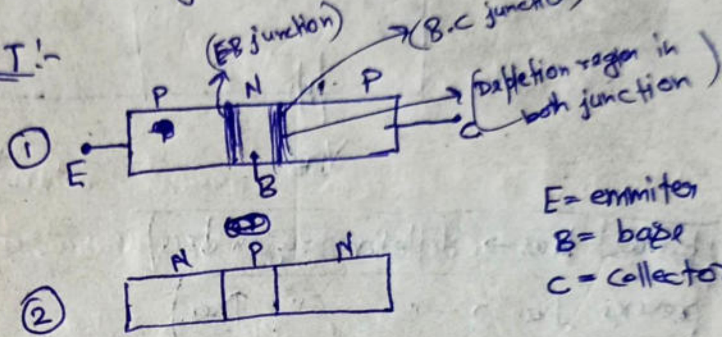
"Unit - 2"

Transistor

BJT (Bipolar junction transistor) :- Bipolar represents that the current is due to both majority and minority both charge carriers.

basic structure of BJT :-

2 types :



E = emmiter
B = base
C = Collector

$\boxed{\text{Size of collector} > E \,\&\, B}$

Size $\boxed{C > E > B}$

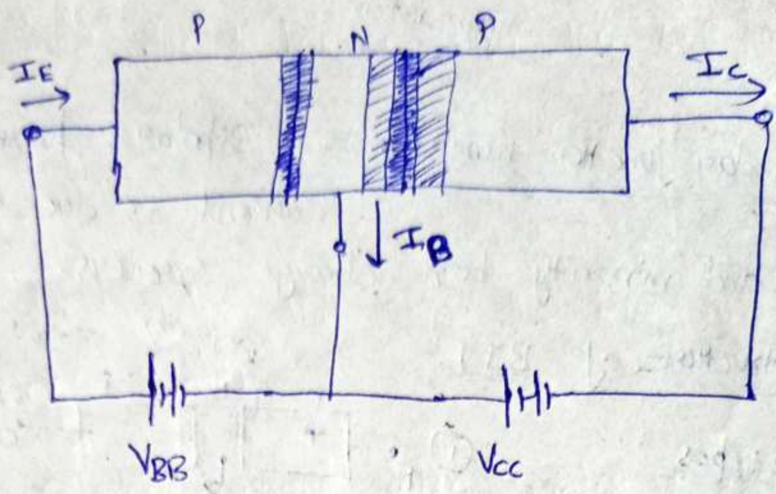
★ Emitter is highly doped, charge carrier is injected by emmiter

★ Base :- width of base is very small compared to emmiter and collector. It is lightly doped i.e. doping conc. of collector is low. It is used to control the flow of majority carrier injected from emmiter

★ Collector :- Size of collector is large compared to emitter & base. because this collector is used to collect majority carriers from emitted. so that may generate the heat so large area required. to ~~disi~~ discipate heat from surface

doping conc. is b/w^n emiter & base
It is used to collect charge carriers generated from emmiter
It discippate the heat.

① PNP



forward bias → depletion region ↓ses
reverse bias → " " ↑ses

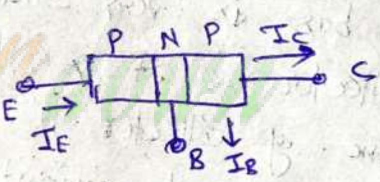
E-B = forward bias
B-C = reverse bias

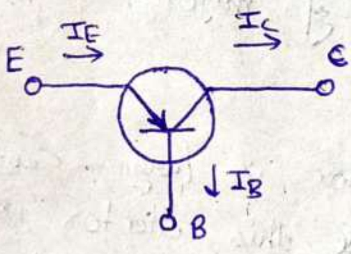
** $\boxed{I_E = I_B + I_C}$

I_B = 2 to 5% of I_E
I_C = 95 to 98% of I_E

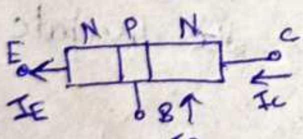
* symbolic representation -

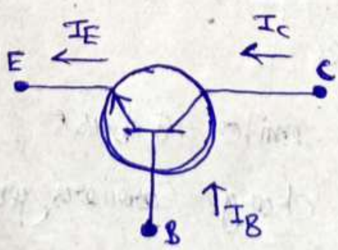
①



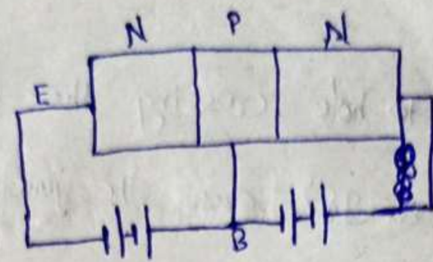


②





② NPN

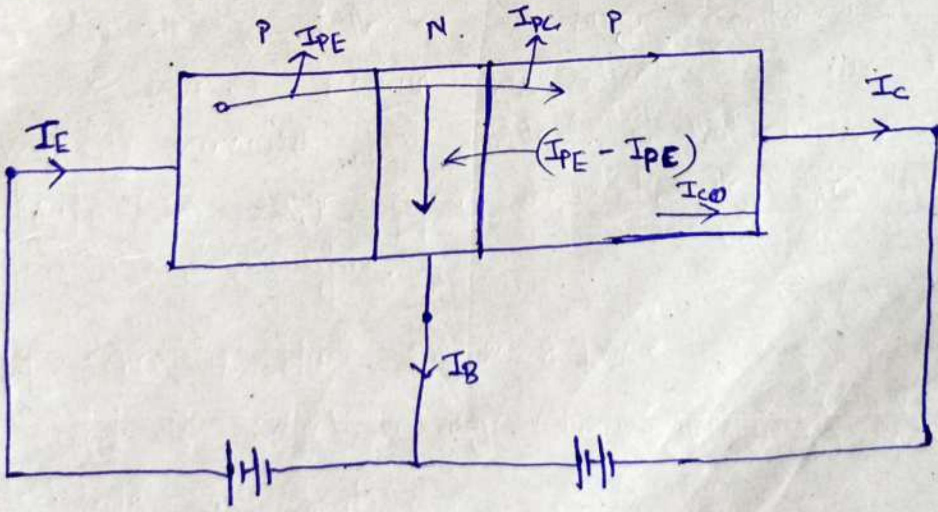


(Transistor as amplifier)

depending upon the different application there are 4 combination of voltage across diodes:

	E-B Junction	B-C junction	Mode of operation
①	forward	Reverse	Active Mode (Amplifier)
②	forward	forward	Saturation ~~region~~ mode (Switch ON)
③	Reverse	Reverse	Cut off mode (OFF)
④	Reverse	forward	Inverted mode ( )

Discuss on different current components -



(a) I_{PE} is current due to hole crossing the E-B junction.

(b) only 2% stops in base & 98% cross the junctions & collected by collector.

(c) I_{PC} is due to holes that cross the base and collected by collector.

(d) I_{CO} is collector current when emmiter is open and is due to thermally generated minority charge carriers

In I_{CO} there are 2 types of minority charge carriers →

① hole crossing base to collector region

② thermally generated e^- in C area passing collector to base region

hence I_{CO} is combo of 2 current.

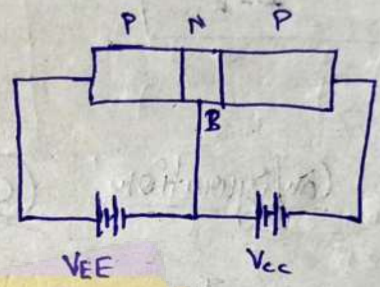
(e)

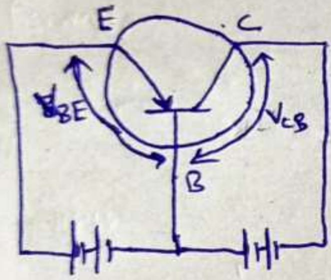
Different Configuration of Transistor !

11/10/22

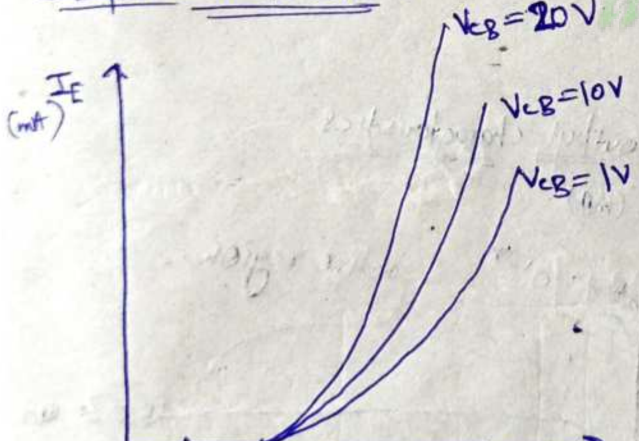
1. CB (common Base Configuration)
2. CE (" emitter confi ")
3. CC (" collector ")

1 CB :-

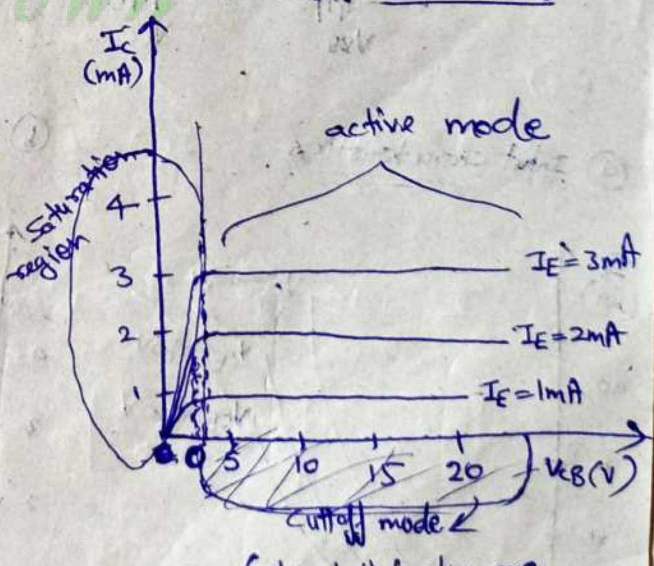




a) Input characteristic :-



b) output characteristics



complete area of active mode is active region

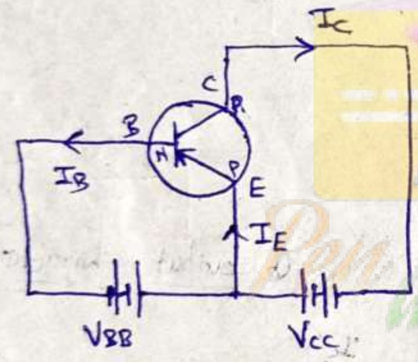
In saturation region both junction forward biased

$I_E = I_C + I_B$

① $\boxed{\alpha_{dc} = \frac{I_C}{I_E}}$ (ratio of output / input current)

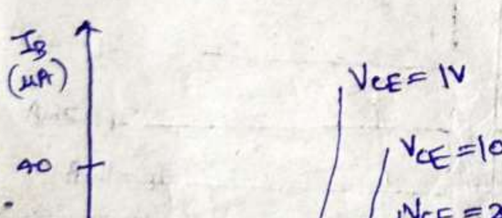
② $\boxed{\alpha_{ac} = \frac{\Delta I_C}{\Delta I_E}}$ (ratio of change of O/I current)

③ Common emitter Configuration: (CE):

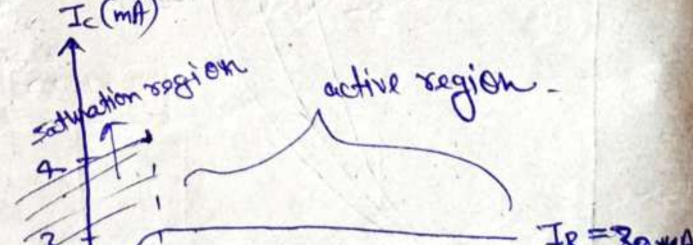


$I_E = I_C + I_B$

ⓐ Input characteristics



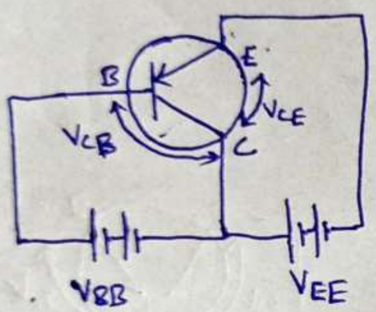
ⓑ output characteristics:



Current gain (β)

① $\boxed{\beta_{DC} = \frac{I_C}{I_B}}$ ② $\boxed{\beta_{AC} = \frac{\Delta I_C}{\Delta I_B}}$

③ CC:-



Current gain (γ)

① $\gamma_{DC} = \frac{I_E}{I_B}$

② $\gamma_{AC} = \frac{\Delta I_E}{\Delta I_B}$

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

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

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

rel^n b/w^n α, β & γ

$$\alpha = \frac{I_C}{I_E} = \frac{I_C}{I_C + I_B} \qquad (I_E = I_C + I_B)$$

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

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

so $\boxed{\alpha = \dfrac{\beta}{1+\beta}}$

Similarly,

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

Now

$$\gamma = \frac{I_E}{I_B} = \frac{I_C + I_B}{I_B} = 1 + \frac{I_C}{I_B}$$

$\cancel{1+\beta}$ $\qquad \boxed{\gamma = 1+\beta}$

hence $\boxed{\gamma = \dfrac{1}{1-\alpha}}$

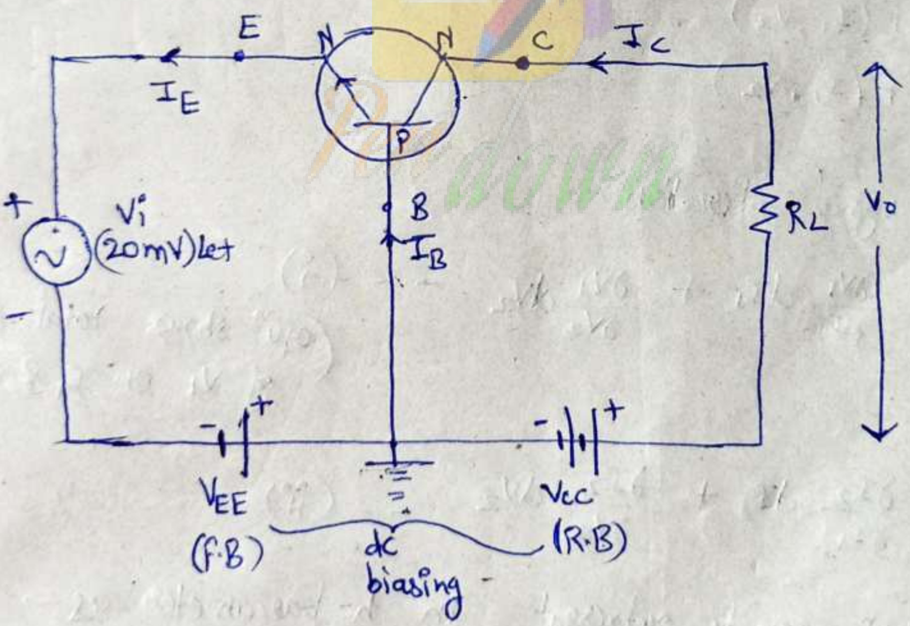
$\boxed{I_C = \alpha I_E + I_{CBO}}$ → for common base

$\boxed{I_C = \beta I_B + I_{CEO}}$ → for common emitter

$I_{CBO} = I_{CO}$ is the collector to base current when emitter is open
α is the factor will collected by collector
i.e α is amount of majority carriers cross barrier

Transistor as amplifier :- (in Active region)

J_1 = Forward bias
J_2 = Reverse bias



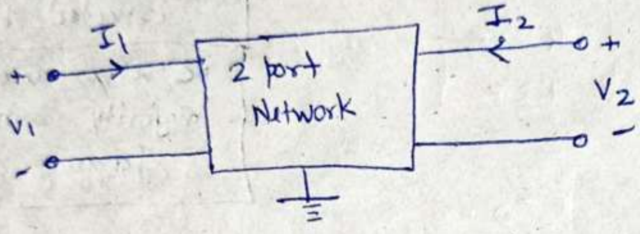
★ Voltage Amplification factor :- $\boxed{A_V = \frac{V_o}{V_i}}$

★ Current Amplification factor = $\alpha \in (0.95 \text{ to } 0.98)$

$(\mu =$

Hybrid Parameter (H- Parameter) :-

h-parameter are applicable to any 2- port Network



V_1 and I_2 are dependable variables
V_2 and I_1 are Independent variables

so

$$V_1 = f(I_1, V_2)$$
$$I_2 = f(I_1, V_2)$$

for small signal operation

$$dV_1 = \frac{\partial V_1}{\partial I_1} dI_1 + \frac{\partial V_1}{\partial V_2} dV_2 \quad --- (i)$$

(equ^n shows total dependence of V_1 on I_1 & V_2)

$$dI_2 = \frac{\partial I_2}{\partial I_1} dI_1 + \frac{\partial I_2}{\partial V_2} dV_2 \quad --- (ii)$$

these 2 equ^n can be represent in h-parameter as—

$$\boxed{\begin{aligned} V_1 &= h_{11} i_1 + h_{12} V_2 \\ i_2 &= h_{21} i_1 + h_{22} V_2 \end{aligned}}$$

Calculation of h-parameter -

step (i) short ckt output i.e $\boxed{V_2 = 0}$ for a.c.

then equ^n (i)

$$\boxed{h_{11} = \left.\frac{V_1}{i_1}\right|_{V_2=0}} = \text{Input impedence } (h_i)$$

in equ^n (ii)

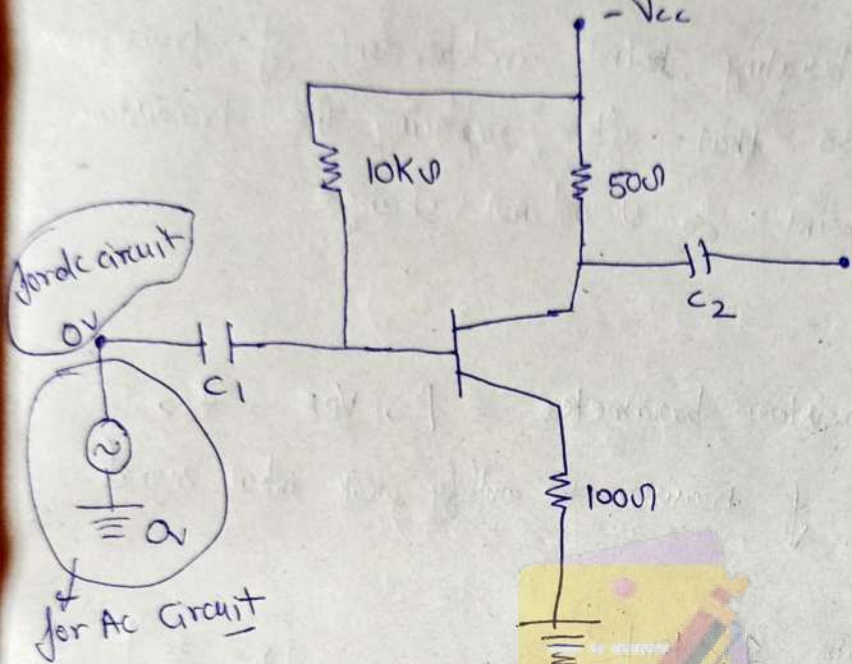
$$\boxed{h_{21} = \left.\frac{i_2}{i_1}\right|_{V_2=0}} = \text{forward current gain } (h_f)$$

step (ii) $\boxed{i_1 = 0}$ (input is open ckt)

$$\boxed{h_{12} = \left.\frac{V_1}{V_2}\right|_{i_1=0}} = \text{Reverse voltage gain } (h_r)$$

$$\boxed{h_{22} = \left.\frac{i_2}{V_2}\right|_{i_1=0}} = \text{output Admittance } (h_o)$$

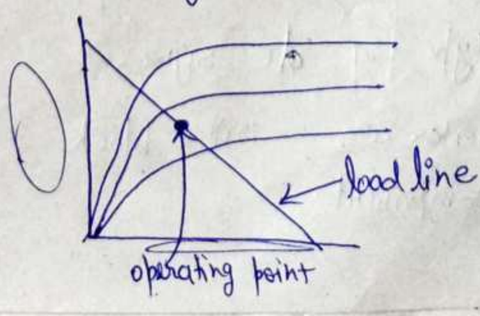
Transistor biasing -



① Why biasing required?

Ans) To active an transistor. so that we can apply input signal the operating point doesnot move either in Saturation or Cuttoff mode.
i.e we make Q-point independent of device parameters variation so that it doesnot shift.

(i) stablize operating point in center of active region



(ii) stablise the collector current against the temperature variation. ($10°C \uparrow$ in temp doubles the current)

(iii) make the operating point independent of transistor parameters so that after replacing the transistor operational point ~~to~~ should not change.

(2) what are transistor parameter β, V_{BE}, I_{CO}?

Ans) β = capability of transistor to amplify weak input signal

(3) why $\beta \uparrow$ with $\uparrow$ in temp?

Ans) as $T \uparrow$ $\quad \beta \uparrow$, $V_{BE} \downarrow$; $I_{CO} \uparrow$

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

so we try to make it temp Independent

as on $\uparrow$ temp, the transport factor reduces in turn causing decrease in base current therefore increase in β

(4) what is the rate of C_1 & C_2 in given Ques Circuit?

Ans) we get AC input (C_1) then amplified AC signal at output (C_2) and capacitor (C_1) block any input type of dc signal
Similarly capacitor C_2 will block any output DC signal component

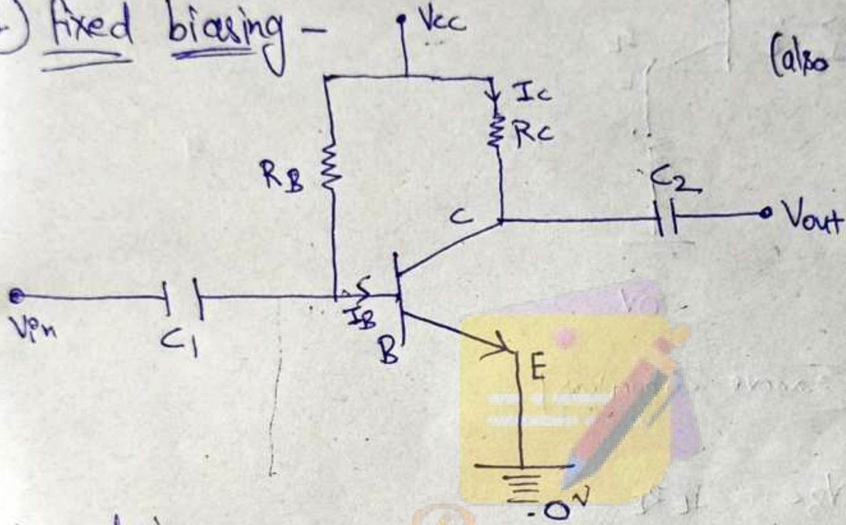
for AC Component both C_1 & C_2 will behave as Conducting wire

Types of biasing in Transistors -

1. fixed
2. self bias
3. voltage divider biasing

1) fixed biasing -

(also known as base-bias ckt)



$V_{cc} = I_B R_B$

$V_{CE} = V_{cc} - I_c R_c$

dc analysis -

$$V_{cc} = I_B R_B + V_{BE}$$

$$I_B = \frac{V_{cc} - V_{BE}}{R_B}$$

$$V_{BE} \simeq 0$$

$$\boxed{I_B = \frac{V_{cc}}{R_B}}$$

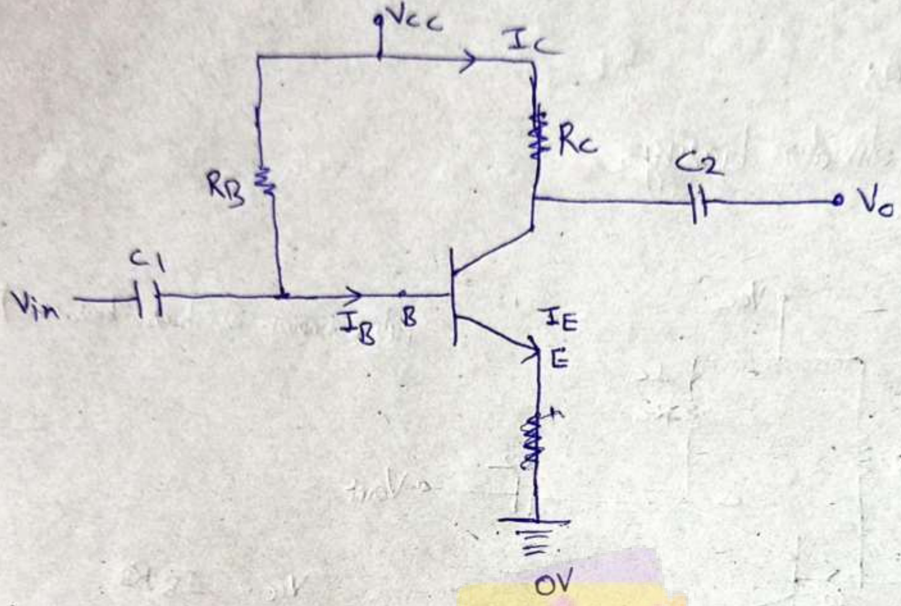
This is called fixed biasing because the value of I_B is fixed.

$V_{cc} = I_c R_c + V_{CE}$ → Terminal voltage

$$\boxed{V_{CE} = V_{cc} - I_c R_c}$$

$$\boxed{I_c = \beta I_B}$$

② Emitter or self biasing –



dc analysis → $\boxed{\text{remove capacitors}}$

$$V_{CC} = I_B R_B + V_{BC} + I_E R_E$$

$$\boxed{I_E = (1+\beta) I_B}$$

$$V_{CC} = I_B R_B + V_{BE} + (1+\beta) I_B R_E$$

$$\boxed{I_B = \frac{V_{CC} - V_{BE}}{R_B + (\beta+1) R_E}}$$ → To calculate value of I_B

then

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

if I_{CBO} not given $\boxed{I_{CBO} = 0}$

$$V_{CC} = I_C R_C + V_{CE} + I_E R_E$$

$$V_{CE} = V_{CC} - R_C I_C - I_E R_E$$

If $I_C \simeq I_E$

$$\boxed{V_{CE} = V_{CC} - I_C R_C + R_E}$$

then the role of feedback is to provide output from input.

$$I_E = (1+\beta) I_B$$

$$I_B = \frac{V_{CC} - V_{BE}}{R_B + (1+\beta) R_C}$$

$$V_{CC} = I_B R_B + I_E R_E$$

$$V_{CE} = V_{CC} - I_C R_C - I_E R_E$$

$$R = \frac{V_{CC} - V_{BE}}{R_B + R_E (1+\beta)}$$