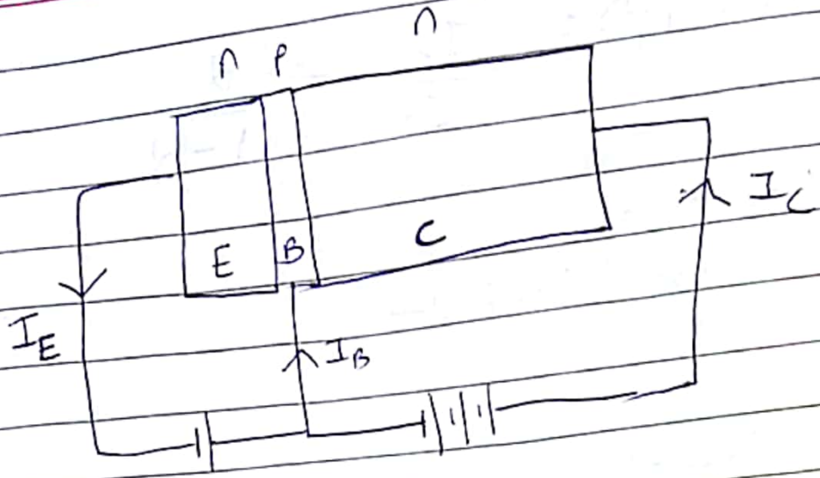
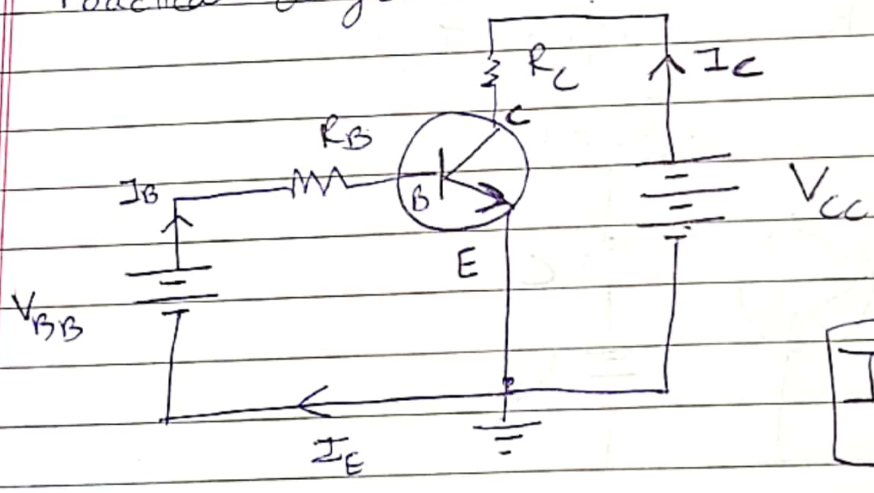


* Transistor works when EB is forward biased & CB is reverse biased

⇒ Emitter ⇒ Heavily doped & moderate size
Base ⇒ light doped & thin
Collector ⇒ Moderately doped & max size

Practical diagram:



Imp:

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

Some Imp formula:

1) $I_C = \alpha I_E$ ⇒ α ⇒ fraction of electron diffuse across Base region
$I_B = (1-\alpha) I_E$

Current gain (β) : $\frac{I_C}{I_B} = \frac{\alpha}{1-\alpha}$

$\Downarrow$

Temperature & voltage dependent

Hybrid Model : (H-parameter Mode)

↳ Equivalent mode of transistor

For Transistor

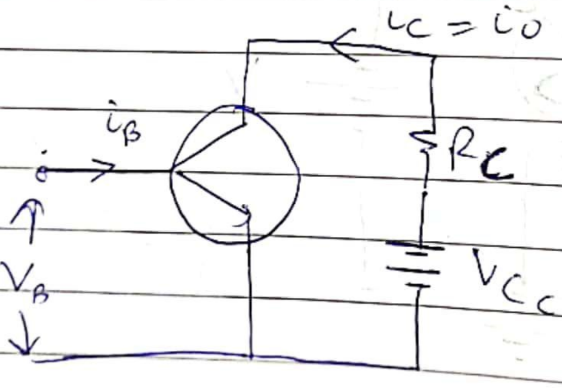
$h_{11} = h_i \Rightarrow$ Input Impedence

$h_{12} = h_r \Rightarrow$ Reverse Transfer

$h_{21} = h_f \Rightarrow$ forward Transfer

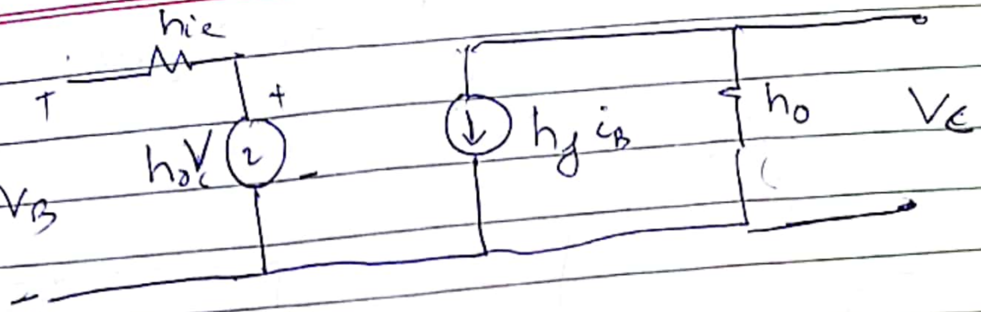
$h_{22} = h_o \Rightarrow$ Output Impedance

Can b… used fo… low … as hig… freq…



For Transistor

$$V_B = h_i i_b + h_r V_C$$
$$i_C = h_f i_b + h_o V_C$$



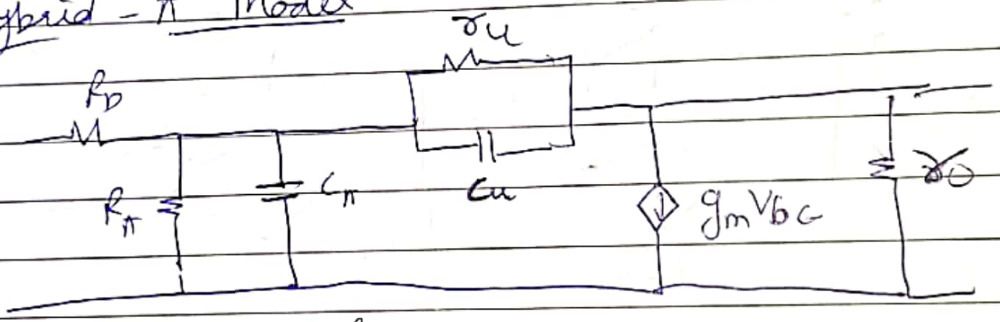
So, Here

$i_1 \to i_B$
$V_1 \to V_{BE}$
$i_2 \to i_C$
$V_2 \to V_{CE}$

(For used higher frequency)

Hybrid - π Model

Can be used for low as well as high frequency



↳ For high frequency

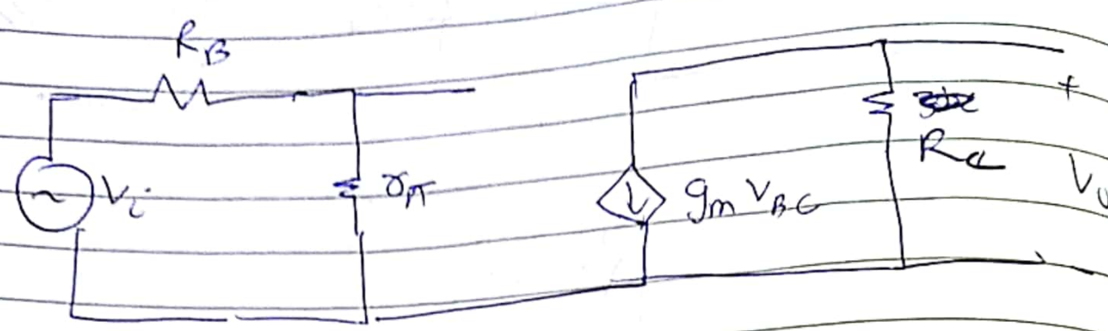
$$g_m \text{ (trans Conductance)} = \left.\frac{I_{out}}{V_{in}}\right|_{V_{out}} = \left.\frac{i_C}{V_{BE}}\right|_{V_{CE}=0}$$

$$= \frac{I_C}{V_T} = \frac{I_C}{26mV} \to \text{At } 300K$$

$$r_\pi = \frac{\beta}{g_m} = \frac{V_T}{I_B} = \frac{26mV}{I_B}$$

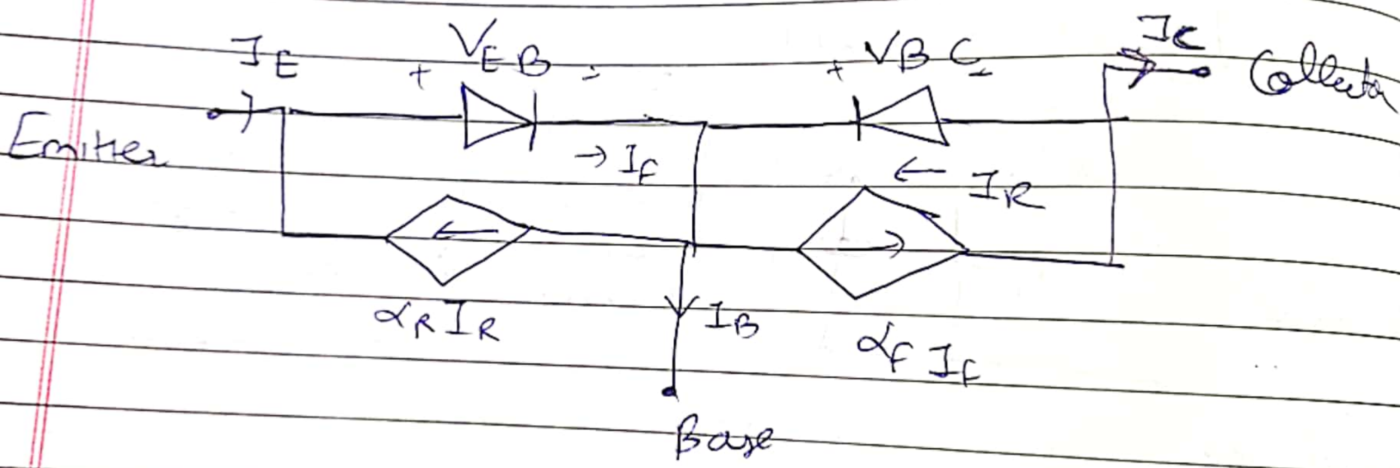
$r_o = \cancel{V_A}$

For Transistor at low frequency



Acc. to Mam

Eber-Moll's model → Not Imp for Exam



$$I_E = I_F - \alpha_R I_R = I_E^0\left(e^{\frac{V_{BE}}{V_T}} - 1\right) - \alpha_R I_C^0\left(e^{\frac{V_{CB}}{V_T}} - 1\right)$$

$$I_C = \alpha_F I_F - I_R = \alpha_F I_E^0\left(e^{\frac{V_{BE}}{V_T}} - 1\right) - I_{C0}\left(e^{\frac{V_{CB}}{V_T}} - 1\right)$$

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

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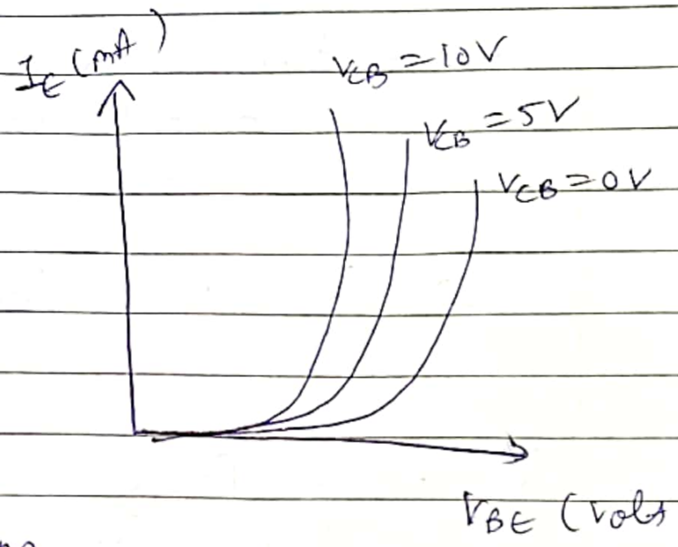
~~Vce~~

Common Emitter Configuration : Power gain
Common Base Config : Voltage gain
Common Collector config : Current gain

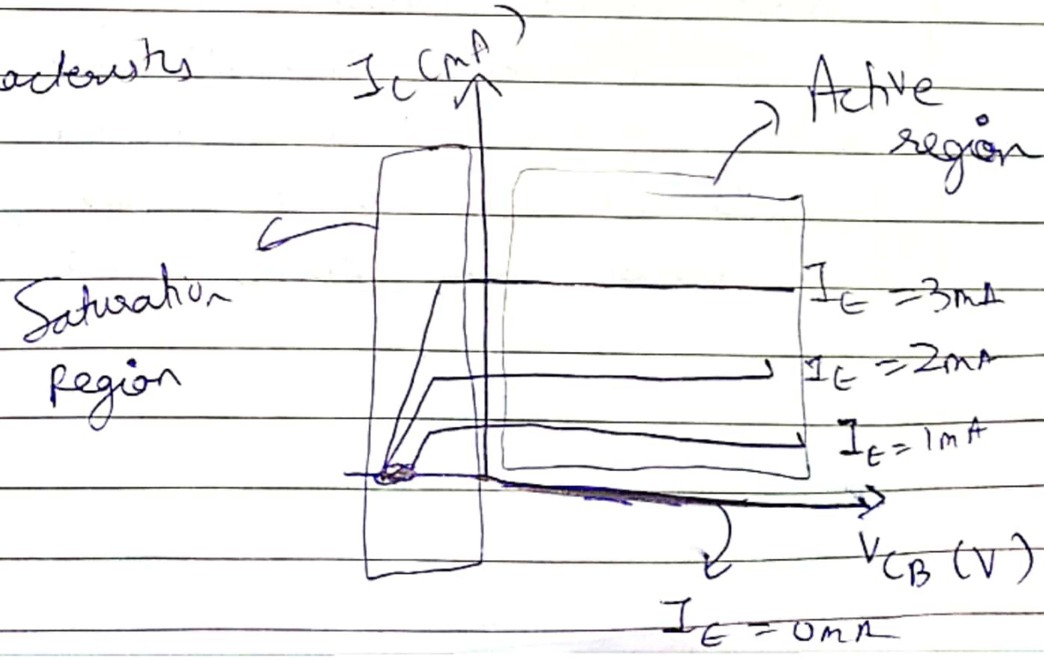
Common base Configuration

Input Characteristics:



Reason:
As V_{CB} increases so, it becomes more reverse biased at CB so, depletion region increases making the size of B more smaller So, know $\boxed{\text{less voltage}}$ is required to forward bias emitter-base junction thus increasing I_E & shifting the graph towards left

Output Characteristics



Active Region: here I_C remains constant even on increase in V_{CB}

So, here $\boxed{I_C = \alpha I_E}$

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

So, in this region Collector current act like a constant current source

↳ So, used for Amplification

Saturation Region: here ~~both~~ as $V_{CB} = -ve$
so, it is like both BE & CB are forward biased

In this region as the V_{CB} becomes more negative i.e. BC region becomes more forward biased
I_C (Collector current) decreases
as electrons enter into base junction (for npn) will not able to cross base junction due to forward bias nature across CB

Cut off Region

↳ When $I_E = 0 \Rightarrow I_C \simeq 0$

even in increase of V_{CB} there is no I_C

when $I_E = 0$

The only current will be Reverse Saturation current (I_S) or I_{CO}

due to minority carrier in BC

flowed across Reverse bias reg

So, For Common base

$$I_C = I_E + I_S$$

→ Reverse saturation current i.e. found when $I_E = 0$

But as $I_E \uparrow$ So, $I_C \simeq I_E$

Early Effect

↳

It's simply the thing we discussed in input characteristics

i.e. if we increase V_{CB} making BC more reverse biased

So, depletion region along Base & Collector increases

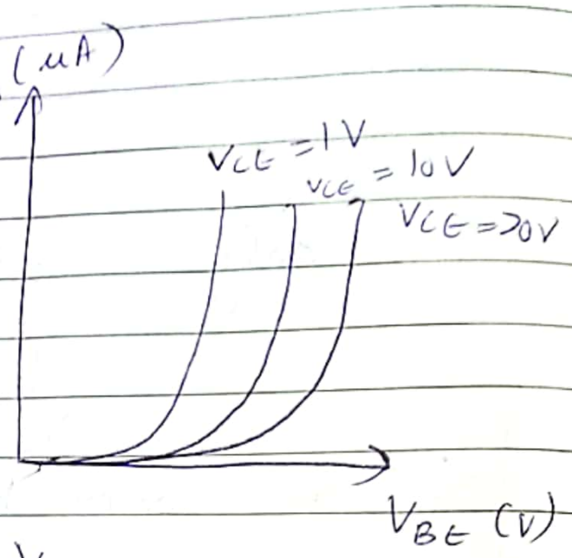
leading to decrease in size of Base, making it more thin

which is called Early Effect or Base-Width Modulation

& I_B current decreases

Common Emitter Configuration

Input Characteristics

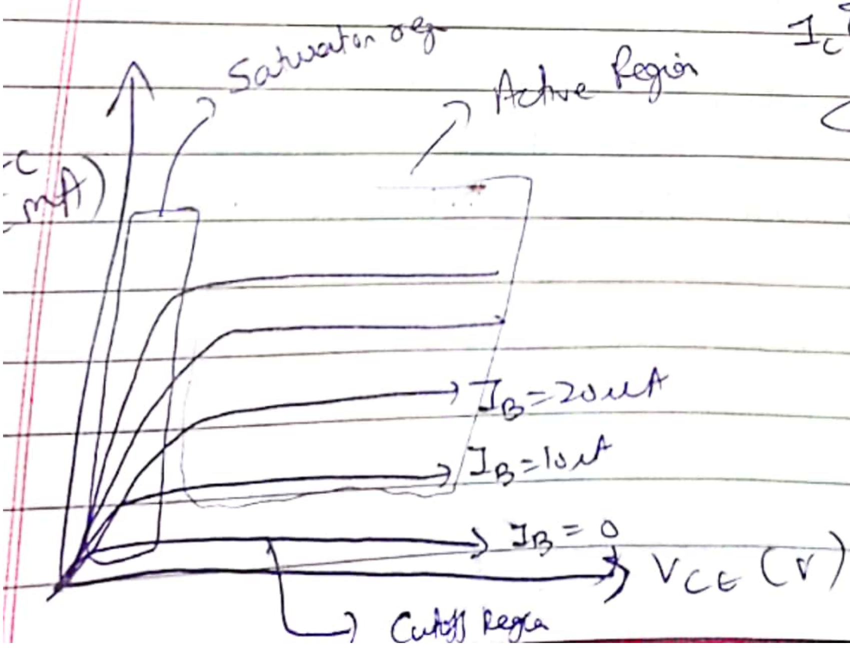


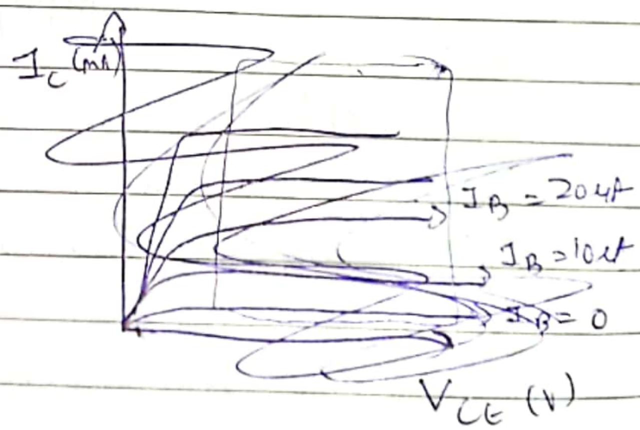
Reason:

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

Now, if we will see for fixed value of V_{BE} if increase V_{CE} then V_{CB} will also increase
So, reverse bias along BC increase so, depletion region along BC will increases leading to smaller size of Base again
So, thereby reducing I_B
Hence,
With increase in V_{CE} I_B decreases for a particular value of V_{BE}

Output Characteristics





Active Region

for, $I_B > 0$

$$\beta_{dc} = \frac{\Delta I_C}{\Delta I_B}$$

As $I_B \uparrow$ I_C also $\uparrow$

& also with increase in V_{CC}, $I_C \uparrow$

as
$$V_{CC} = V_{CB} + V_{BE}$$

So, if V_{CC} increases $\Rightarrow$ V_{CB} also increases along BC leading to increase in depletion region and base region getting thin so, I_C increases

Saturation Region

Now, as the V_{CC} is close to zero Collector Base region becomes forward biased

Cut off Region

↳ Here for $I_B = 0$

$\Downarrow$

$I_C \neq 0 \Rightarrow$ That is due to Reverse Saturation current I_{CO}

↓

Here unlike Common base configuration I_C value is large due to:

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

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

classmate

Date

Page

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

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

$$I_C = \beta I_B + \left(\frac{1}{1-\alpha}\right) I_{CO}$$

Now for cut off region $I_B = 0$

$$I_C = \left(\frac{1}{1-\alpha}\right) I_{CO}$$

$$\simeq (\beta + 1) I_{CO}$$

So, there is large I_C even $I_B = 0$

So, Early effect in CE is more

Early Voltage → more significant in Common Emi

↳ Same as we discussed in Input characteristics of Common Emitter

~~Some Imp Points~~

Some Imp points of ~~Volta~~ Common Emmiter Curve

* Saturation region is below ~~0.2V~~ ~~V_{CE}~~. $V_{CE} = 0.2V$

So, Saturation region $\Rightarrow$ 0 ~~V_{CE}~~

$$0 < V_{CE} < 0.2V$$

↳ Remember

* Slope of output characteristics of Common Emitter Configuration is more than for common base as

Early effect is more significant in Common Emmiter

* load line $\Rightarrow$ Straight line joining two points

where first point is value of V_{CE} at $I_C = 0$

& second point when $V_{CE} = 0 \Rightarrow I_C$

↓

It contains every possible operating point for the circuit

Imp formula for BJT

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

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

$$\beta+1 = \frac{1}{1-\alpha} = A_i \text{ (Current gain)}$$

$$I_E = I_C + I_B$$

$$I_C = \alpha I_E = \beta I_B + I_{CO}$$

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

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

$$V_{CE} = V_{CC} - I_C R_C = V_{CE} - V_{RC}$$

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

$$\Rightarrow I_C = \beta I_B = \beta\left(\frac{V_{BB} - V_{BE}}{R_B}\right)$$

$$V_{RB} = V_{BB} - V_{BE}$$

$$I_C = \frac{V_{CC} - V_{CE}}{R_C}$$

Base voltage $V_B = V_E + V_{BE}$