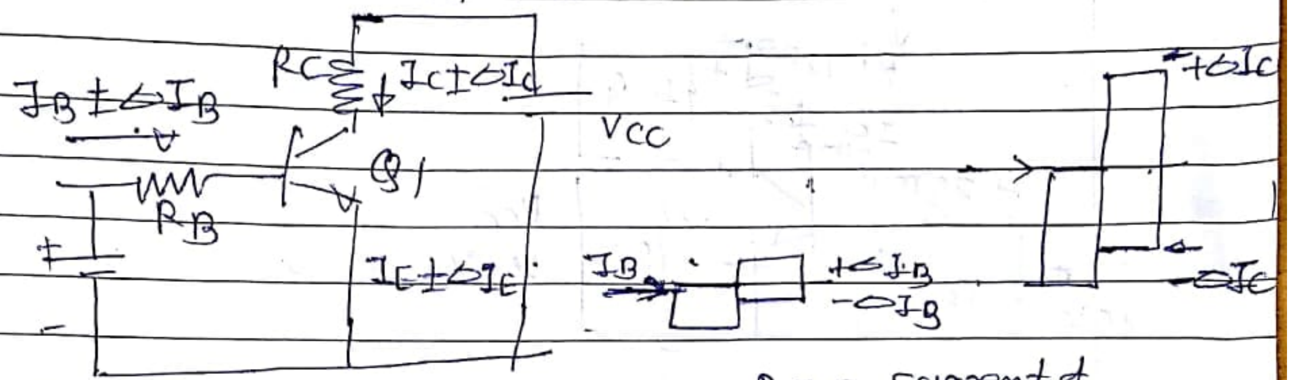
Current Amplification



Current levels & current changes. Base current & collector currents

A small change in base current (ΔI_B) produces a large change in collector current (ΔI_C) and a large change in emitter current (ΔI_E)

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

The increasing & decreasing levels of input & output currents may be defined as alternating quantities. In this case, small letters are used for the subscripts. Thus I_b is an ac base current, I_c is an ac collector current & I_e is an ac emitter current.

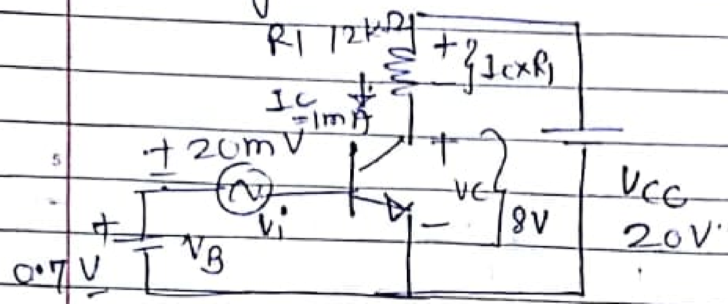
The alternating current gain from base to collector ~~may~~ is

$$\beta_{ac} = \frac{I_c}{I_b}$$

(β_{dc} or h_{fe} given in data sheets)

for common emitter config.

Voltage Amplification.



here V_B is 0.7 V to forward bias base emitter junction. It produces 20 uA base current. This gives

$I_c = \beta_{dc} I_B = 50 \times 20\mu A$

$\boxed{I_c = 1mA}$

dc level of transistor collector voltage is $V_c = V_{cc} - (I_c R_1)$

$= 20 - (1\times10^{-3} \times 12\times10^{3})$

$\boxed{V_c = 8V}$ ~~shown in fig~~

ac I/P voltage is zero Vc is 8V.
Now V_i causes base voltage variation (ΔV_B) of $\pm 20mV$, then base current changes by $\pm 5\mu A$ (Assume) This change produces change in the collector current

$\Delta I_c = \beta_{dc} \Delta I_B = 50(\pm 5\mu A)$

$\boxed{\Delta I_c = \pm 250\mu A}$

This ΔI_c causes change in V.D across R1.

$\Delta V_c = \Delta I_c R_1 = \pm 250\mu A \times 12k\Omega$

$\boxed{\Delta V_c = \pm 3V}$

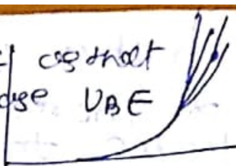
Now $A_V = \frac{\Delta V_C}{\Delta V_B} = \frac{\pm 3V}{\pm 20mV}$

$= 150$

small ac I/P base voltage change (ΔV_B) ($\pm 20mV$)
causes a large ac o/p change (ΔV_C)
to ($\pm 3V$)

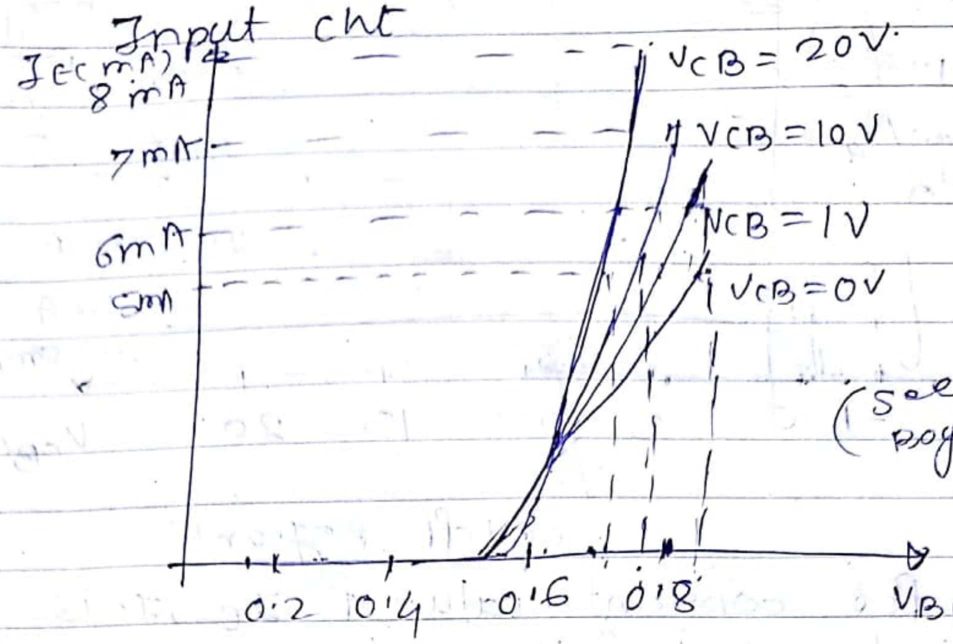
Here we get voltage gain (amplification factor) of 150

To get the same value of I_E as that of for $V_{CB}=0$, you need to decrease V_{BE}



hence curve shifts to left

CB config I/P cht.



(See registered.

Input or driving pt cht for a CB for si transistor ampr

$I_E = I_B + I_C$

When V_{CB} is equal $=0$, emitter base junction is forward biased (FB), junction behaves as diode, I_E ↑ rapidly with small increase in V_{BE}.

* Basewidth reduces which shortens the distance & reduces the resistance b/n Emitter & base and collector base depletion region

When V_{CB} is increased keeping V_{BE} constant the width of base region decrease. This results in increase in I_E *. Therefore curve shifts toward left as V_{CB} ↑. (To get same I_E as that of $V_{CB}=0$, V_{BE} should ↓.)

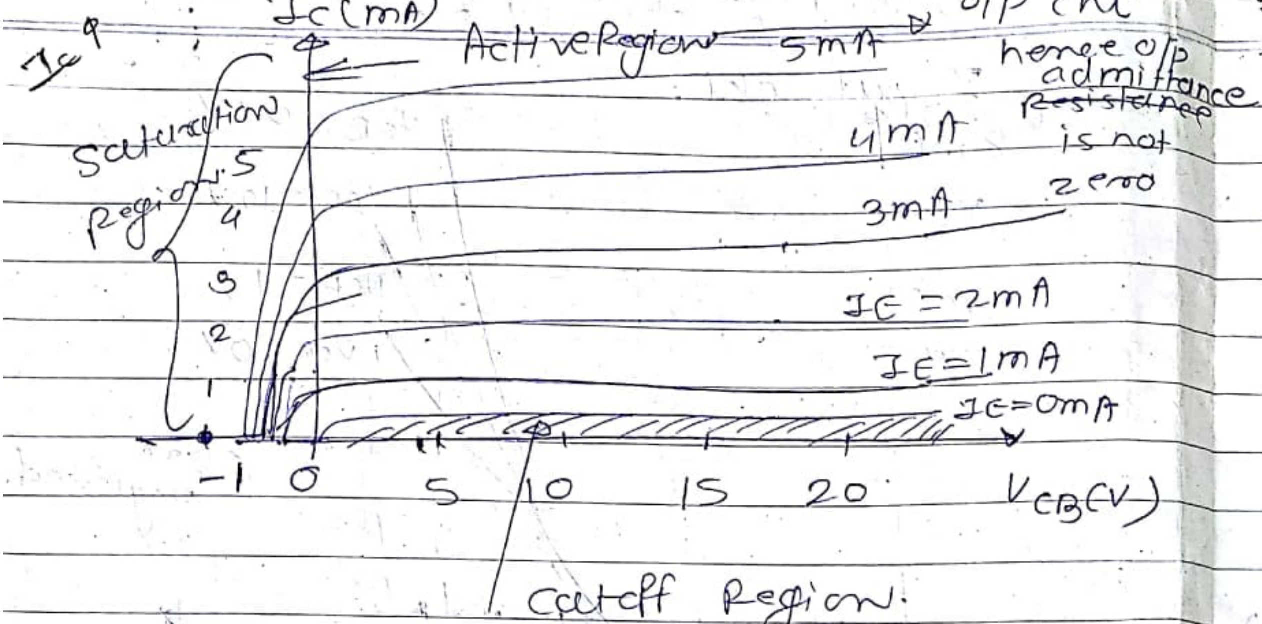
* see previous cht scratched one

output characteristics ↓.

*

Here I_E is kept constant by adjusting V_{EB}. Then V_{CB} is ↑ in suitable equal steps and the collector current I_C is noted for each value of I_E. This is repeated for different fixed values of I_E.

* For higher values of V_{CB} due to Early effect the value of α increases, say α changes from 0.98 to to 0.985. Hence there is very small +ve slope in V_{CB} o/p cht



For constant value of I_E, I_C is independent of V_{CB} and curves are $\parallel^{ar}$ to x axis.

*

even when $V_{CB} = 0$, BE junction is forward biased, majority charge carriers $\bar{e}$ crosses the barrier (depletion region) at CB junction and gives rise to I_C

Saturation ~~Active~~ Region = BE & CB Forward Biased

Cut off region = BE and CB both Reverse biased,

Active Region = BE ju^n FB & BC ju^n Reverse biased

In the cutoff region (or lower end of active region), I_E is zero, the collector current is simply due to reverse saturation collector leakage current I_{CBO}. It is microampers

The slope of CB cht will give following cht. since these parameter have different dimensions, they are commonly called h (hybrid) Parameter

① Input Impedance (hib)

$$hib = \frac{\Delta V_{EB}}{\Delta I_E} \Bigg|_{V_{CB}\ \text{constant}}$$

typical value ranges from 20Ω to 50Ω. This is calculated from CB I/P cht

② ~~Outp~~ Forward Current gain (hfb)

$$h_{fb} = \frac{\Delta I_C}{\cancel{\Delta V_{CB}}\,\Delta I_E} \Bigg|_{V_{CB}\ \text{constant}}$$

typical value 0.9 to 1.0.
This is slope of I_C versus I_E curve (O/P cht)

③ O/P ~~Impedance~~ admittance

$$h_{ob} = \frac{\Delta I_C}{\Delta V_{CB}} \Bigg|_{I_E\ \text{constant}}$$

This is slope of I_C versus V_{CB} from O/P cht
Typical value is 0.1 to 10 µ mhos

or O/P Resistance is high
typical value 1 MΩ

④ Reverse voltage gain

$$h_{rb} = \frac{\Delta V_{EB}}{\Delta V_{CB}} \Bigg|_{I_E\ \text{constant}}$$

slope of V_{EB} Vs V_{CB}, from I/P cht
Typical value 10^{-5} to 10^{-4}

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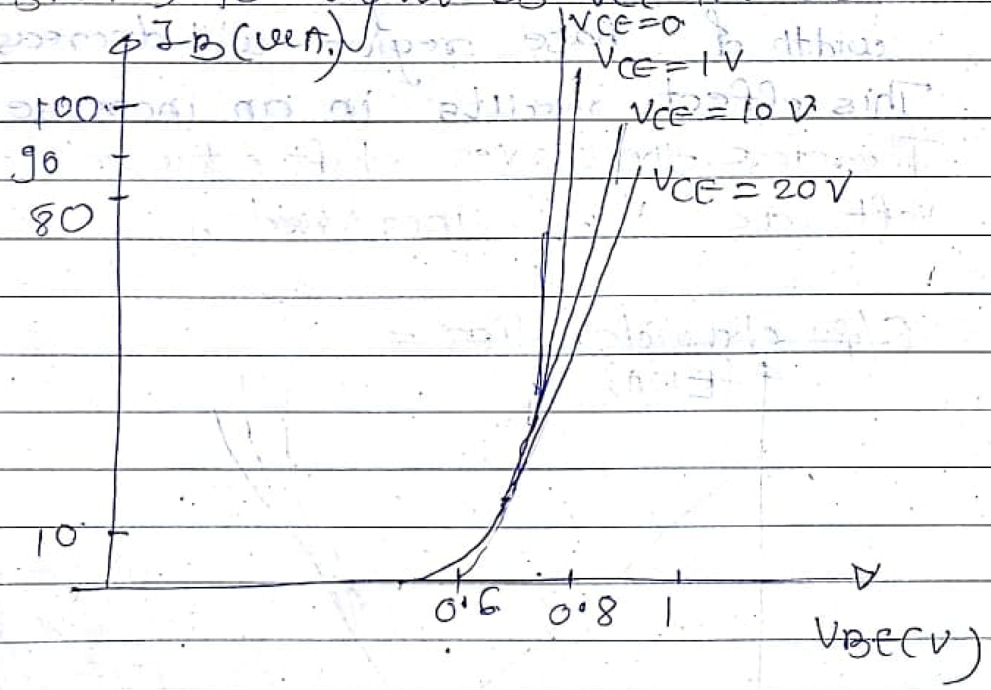
CE configuration

I/P cht - V_{CE} is kept constant say $V_{CE} = 0V$, then I_B is plotted by increasing V_{BE} in equal steps. Then V_{CE} is ~~repeate~~ changed and procedure is repeated.

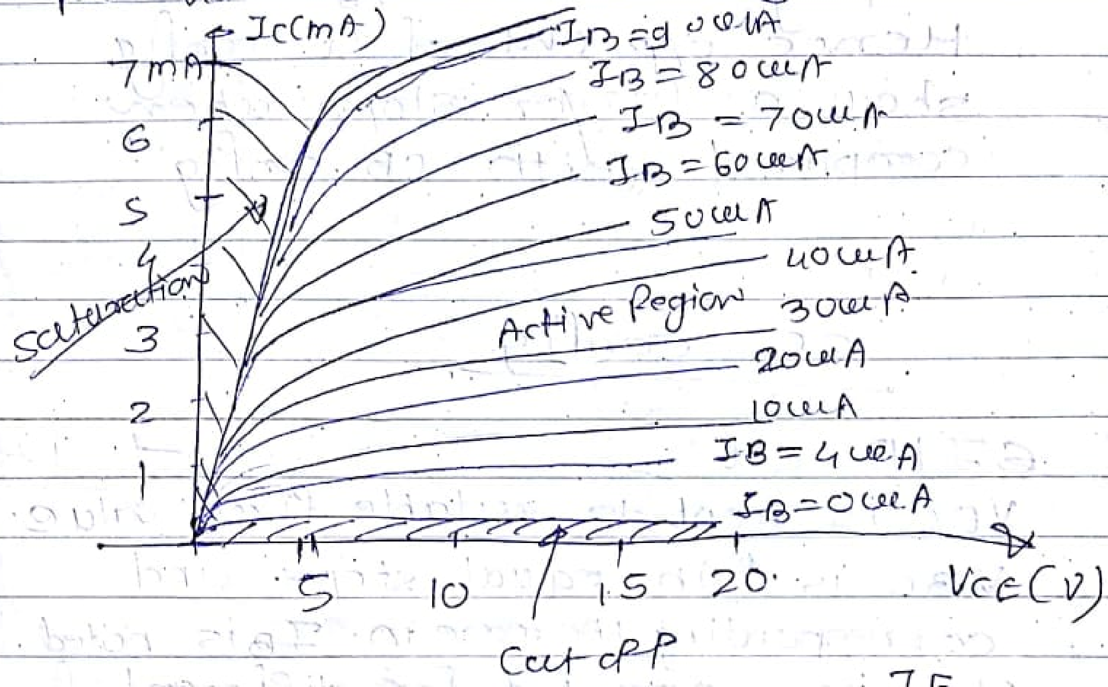
At $V_{CE} = 0$ EB jn forward biased & behaves like a diode & hence we get I_B. Now when V_{CE} is increased, the width of depletion region goes on increasing hence effective width of Base decreases. Hence less recombination of holes & electrons take place and $I_B \downarrow$. (Hence to get the same value of I_B as that for $V_{CE} = 0$, V_{BE} should be increased.) Therefore curve shifts to right as V_{CE} increases.

early effect



o/p cht for CE config

I_B is kept constant by adjusting V_{BE}. V_{CE} is increased in suitable equal steps from zero and I_C is noted for each value of V_{BE} and plotted for various values of I_B



I_B is in μA as compared to I_C in mA ($\frac{I_E}{q}$)

& curve for I_B is not horizontal as those obtained for I_E in CB config indicating collector to emitter voltage will influence the magnitude of collector current

For larger values of V_{CE} due to Early effect, a very small change in α reflected in a very large change in β. for e.g $\alpha = 0.98$

$$\beta = \frac{\alpha}{1-\alpha} = \frac{0.98}{1-0.98} = 49$$

If α increases to 0.985 then

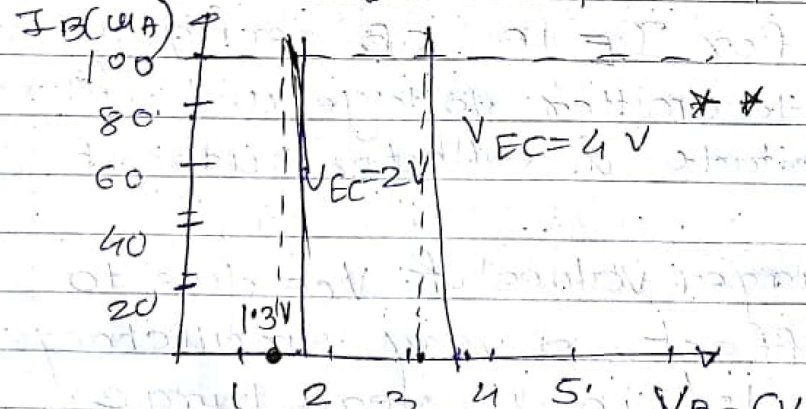
$$\beta = \frac{0.985}{1-0.985} = 66.$$

Here slight increase in α by about 0.5% results in an increase in β by about 34%. Hence Hence o/p cht of CE config show a larger slope when compared with CB config.

CC config

· E I/P cht

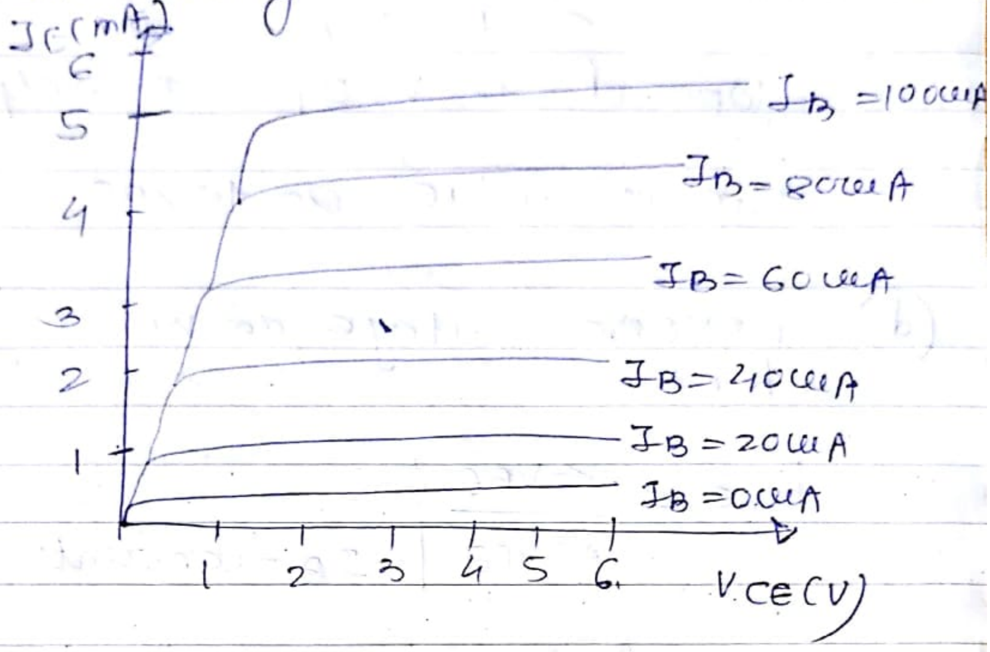
V_{EC} is kept to suitable fixed value. V_{BC} is ↑ in equal steps and corresponding increase in I_B is noted. This is repeated for different fixed values of V_{EC}. Plots of V_{BC} versus I_B for different V_{EC} is plotted



*** CC config is known as emitter follower o/p is taken across emitter. Since voltage gain is unity, we get same o/p as that I/P. Hence we can say that emitter follows I/P hence called emitter follower

O/P cht

O/P chts of CC are same as that of CE config.



—x—

CE config

I/P Imp

(a) $hie = \dfrac{\Delta V_{BE}}{\Delta I_B}\Big|_{V_{CE} = \text{constant}}$

slope of I_B Vs V_{BE} for I/P cht

Typical value 500 to 2000 Ω

(b) output admittance hoe

$hoe = \dfrac{\Delta I_C}{\Delta V_{CE}}\Big|_{I_B = \text{constant}}$

slope of I_C Vs V_{CE} for O/P cht

Typical value 0.1 to 10 μ ohms.

(c) Forward current gain (hfe).

$$h_{fe} = \frac{\Delta I_C}{\Delta I_B} \Big| V_{CE} \text{ constant}$$

slope of I_C Vs I_B. from o/p

Typical value 20 to 200.

(d) Reverse voltage gain.
h_{re}

$$h_{re} = \frac{\Delta V_{BE}}{\Delta V_{CE}} \Big| I_B = \text{constant}$$

slope of V_{BE} Vs V_{CE} from ~~I~~/p cht
Typical value is 10^{5} to 10^{4}.

** The CC I/P cht is quite different ~~Vee~~ from either CB or CC cht I/P
The difference is due to the fact that I/P voltage (V_{BC}) is largly determined by o/p voltage (V_{EC})

$$V_{EC} = V_{EB} + V_{BC}$$

or $V_{EB} = V_{EC} - V_{BC}$

Increasing the level of V_{BC} with V_{EC} held constant and thus reduces I_B. hence cht is not almost vertical slightly slope around.

($V_{EC} = 2 - 1.3V = 0.7$ ~~ara~~ BE goes in Forward bias for less than 1.3V above 1.3V BE less forward bias so $I_B \downarrow$.)

lly 3.3 V V_{BC}, $4 - 3.3 = 0.7$