Bipolar junction Transistor

→ During the period 1904 to 1947, the Vaccum tube was the electronic device.

→ And in 1947 transistor was invented by William Schockley, Brattain & Bardeen at Bell Telephone Laboratories.

→ It was smaller, lightweight, no heater required.

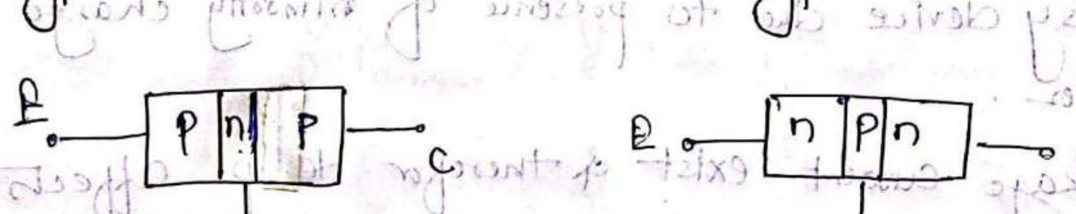
→ requiring no warm-up period & low operating voltage.

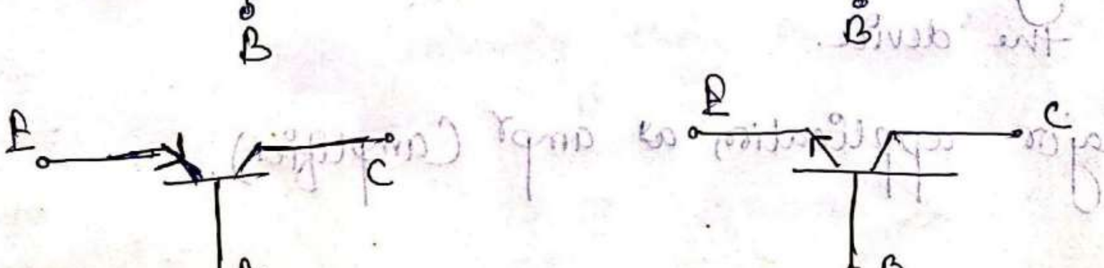
Construction

→ The transistor is a three layer semiconductor device.

→ one type of SC (Semi Conductor) is sandwiched between other type of SC.

→ n type b/w two p type (i.e pnp) or P type is sandwiched b/w two n type





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→ Emitter is highly doped to injects maximum no of charge carriers to Base.

→ Base is lightly doped to reduce the recombination & thus I_c (Collector Current).

→ So, Doping of E > C > B

→ Collector is provided with largest area to reduce heat dessipation.

→ Base with smallest area ~~to~~ to reduce transit time (time taken by charge carrier to moving from E to C).

→ So for Area, C > E > B.

→ Low ~~i/p~~ resistance.

→ High o/p resistance.

→ Bipolar device (Because majority & minority both are responsible for Conduction).

→ Noisy device due to presence of minority charge carrier.

→ Leakage current exist & therefor temp. affects ~~on~~ the device.

→ Major application as ampr (amplifier).

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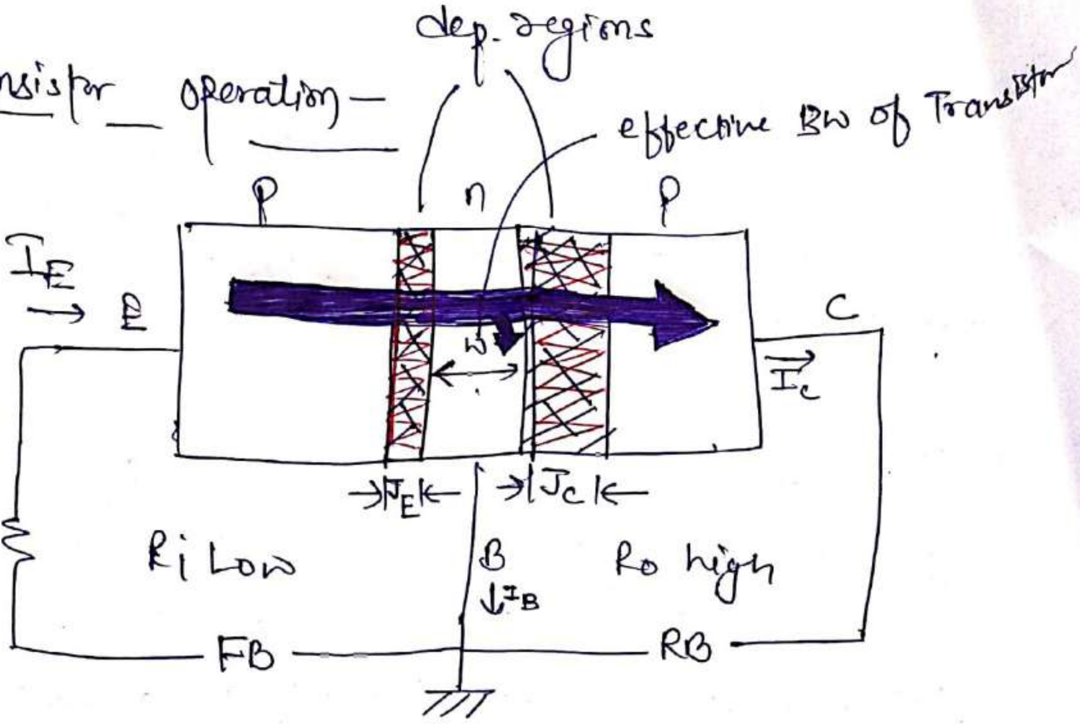
Transistor operation –



→ The widths of dep layer, indicating clearly which junction is FB & which is RB.

→ A large no of maj charge carriers will diffuse across the FB p-n junction into n-type material.

→ Since the sandwiched n layer is very thin & has law conductivity (less doping), a very small no of charge carrier will recombine with base (at base) results I_B.

→ And now after crossing J_E, majority charge carrier of p layer (i.e holes) became minority at n layer (holes are minority for n layer sc).

→ And now for minority there is no restriction for minority even in R.B.

so they will cross J_C & reachs at collector

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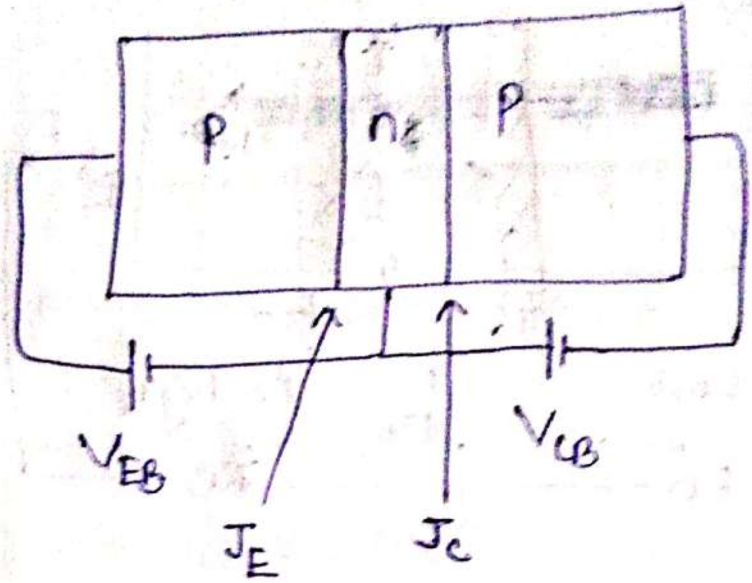
Working of PnP transistor -



→ As holes are majority charge carrier in P(Emitter layer) & pn jn (i.e J_E) is in FB ~~so~~ & holes in Emitter will be repel by V_{EB}.
So they will flow towards J_E. This consitutes the Emitter current I_E.

→ As holes combine with e^- of base. base is lightly doped so only few holes (less then 5%) ~~co~~ combine with e^-. This consitutes the base current I_B.

→ Remaining holes cross the J_C which is in RB. But holes are minority in Base so they (holes) cross J_C & reaches collector consitute I_C.

→ So, Basilly we are contolling current b/w E & C by appling proper I_B.

N6

Biasing of a Transistor

By applying a proper DC voltage across different terminals of transistor, Biasing can be done.

The four possible ways of Biasing

Cases	J_E	J_C	Region of operation
i)	FB	RB	Active
ii)	FB	FB	Saturation
iii)	RB	RB	cut off
iv)	R.B	FB	Inverted

Transistor Configuration -

These are three terminals, (i.e. E, B, C). So we can give i/p in any two terminal & take o/p with other two terminal (with a common terminal b/w i/p & o/p).

So depending upon common terminal b/w i/p & o/p. There are ~~three terminals~~ ways

i) Common Base Configuration

ii) Common Collector "

iii) " Emitter "

A l h i t f i E l R R C S E

i) Common Base Configuration—

Here i/p is applied b/w (between) Emitter (E) & Base (B) & o/p is taken b/w B & Collector (C).

Base is common to both i/p & o/p circuits.

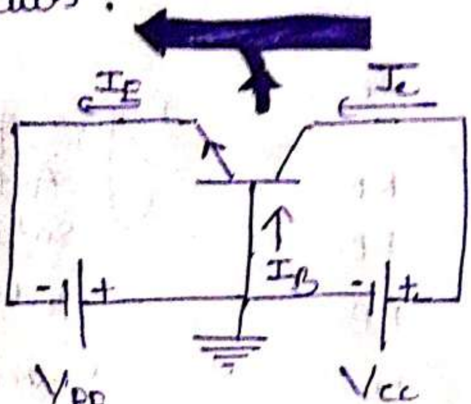
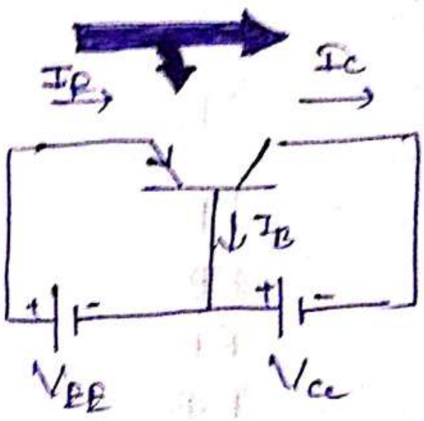


fig (A)



a CB (Common Base) npn transistor (tr) shown in figure (A) & CB, pnp tr in fig (B).

Current amplification factor

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

where ΔI_C = change in I_C
ΔE = chang in I_E.

α is the ratio of o/p current to the i/p current.

In case of CB, I_E is i/p current & I_C is o/p current.

α ranges from 0.90 to 0.99

Expression for Collector Current –

→ As we all know whole I_E does't the collector.

→ Because some of its charge carrier neutralize at base region due to e^--hole recombination gives rise to base current.

→ Since the J_C is RB so a leakage current will also flow from C to B (due to ~~majority~~ minority)

So, from above discussion it is clear,

→ $$I_E = I_B + I_C \quad \text{— (1)}$$

Some of Emitter charge carrier recombine with base

the Charge carrier of E which remain after recombination.

$$I_C = \alpha I_E + I_{CBO} \quad \text{— (2)}$$

Leakage current due to minority charge carrier.

from eqn (1) & (2)

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

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

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

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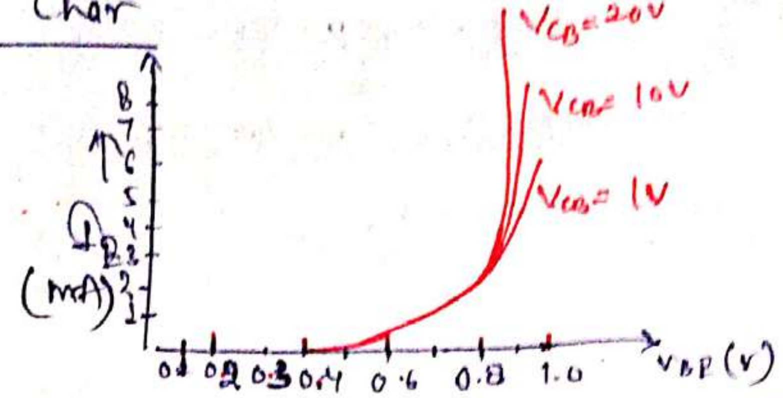
Characteristics of CB:—

– i/p Char



→ It actually relates i/p current I_E to i/p voltage V_{BE} for various level of o/p vol. V_{CB}.

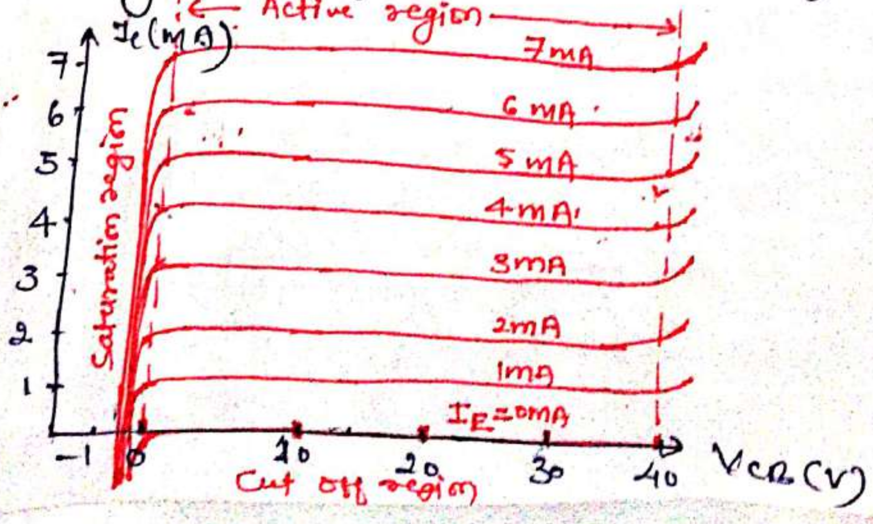
→ from above graph we can conclude that –

→ I_E ↑ (increases) rapidly with small ↑ in V_{EB}. which means R_i (i/p resistance is low).

→ I_E is almost independent to V_{CB}.

O/p Char

It actually relates o/p current I_C to the O/p voltage V_{CB} for various level of I_E.



→ In active region the J_E is FB, whereas the J_C is RB.

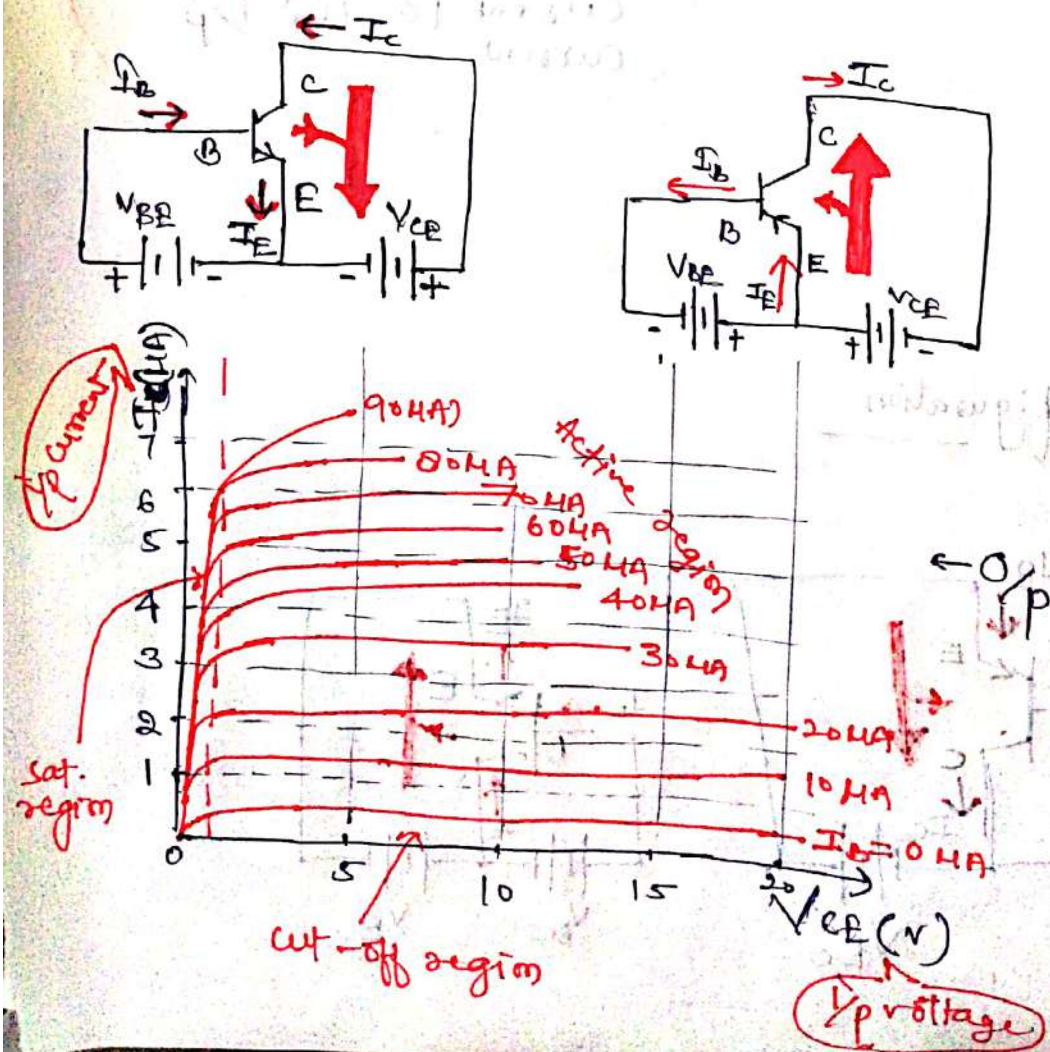
→ In the cut-off region both the jn (junction) are RB.

→ In sat. (saturation) region both the jn are in FB.

CE Configuration –

→ It is called CE configuration because the E is common in both i/p & o/p.

→ Two set of char are again necessary to describe fully the behaviour of CE configuration.



← O/p Char

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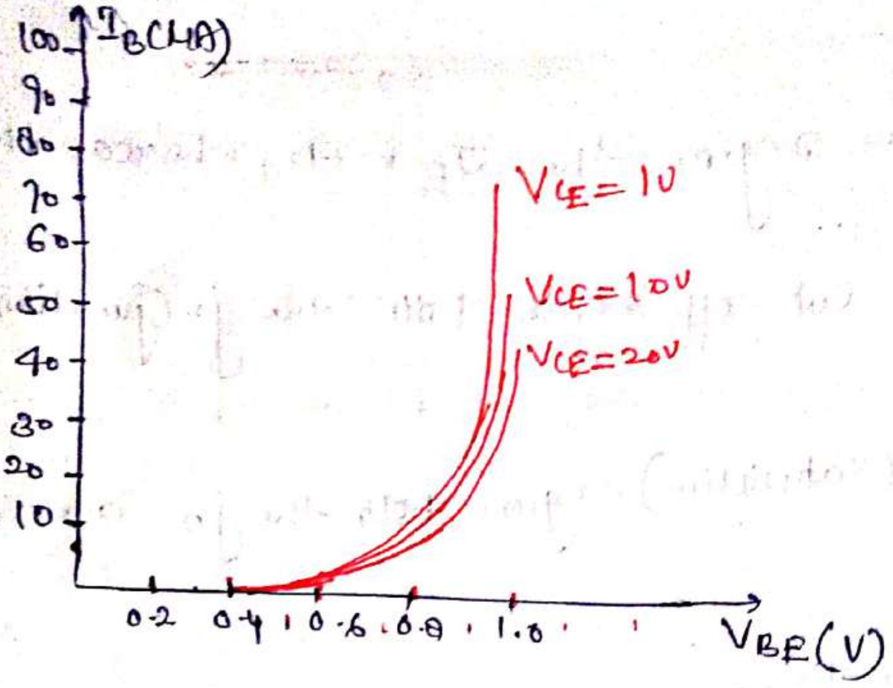


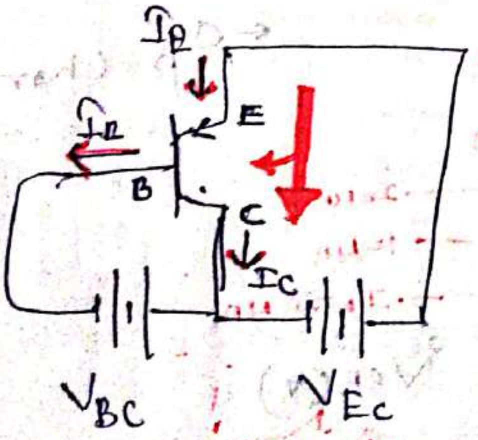
i/p char

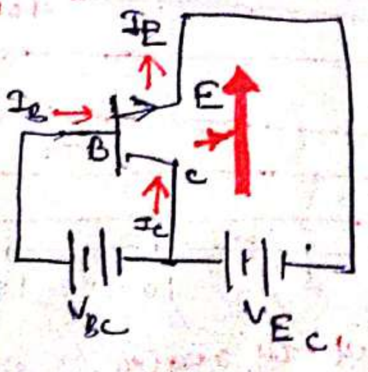
amplification factor for CE

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

Similar as α for CB both are ratio of o/p current to the i/p current.

CC Configuration





→ The third & final configuration is CC.

→ Collector is connected in same manner as Emitter, so from design point of view there is no need of set of CC char.

→ It can be designed using CE configuration.

→ for all the practical purpose, the o/p char of the CC configuration are same as CE.

→ the o/p char will be plot of I_E Vs V_{CE} for range of I_B.

→ the i/p char will be plot of I_B Vs V_{BC}.

~~Ch~~

Amplification factor –

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

— Chapter over — — —

H.W

→ try to find out the relation b/w amplification factor of CB, CE & CC (i.e relation b/w α, β & γ).

R. Goklani