* Low-frequency Common-Base current gain:-

- Basic principle of operation of BJT is the control of I_C by V_{BE}.
- Collector current is a function of number of majority carrier reaching the collector after being injected from emitter across B-E junction.

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

Ideally, $\alpha \rightarrow 1$

- Flow of various charged carriers leads to definitions of particular currents in the device, which are used to define the current gain of the transistor.

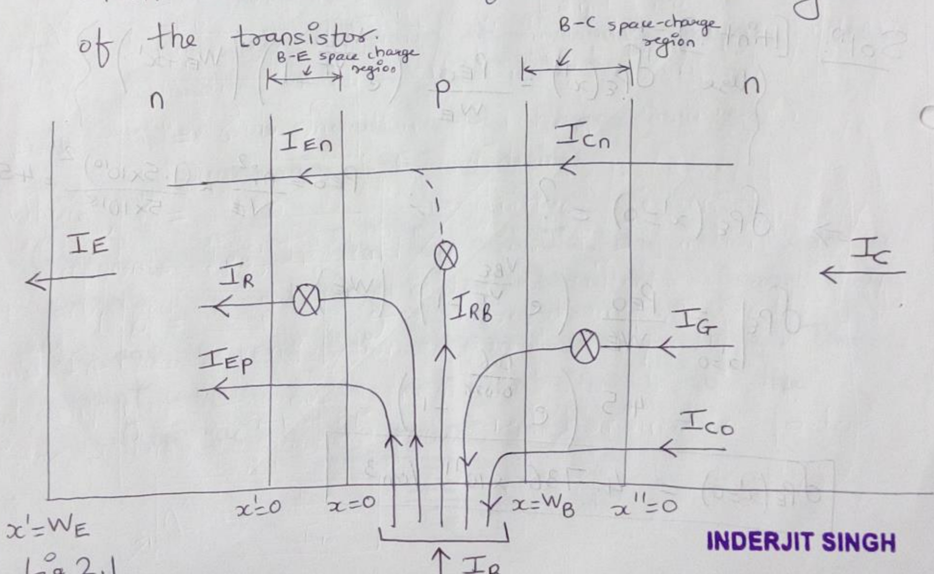

fig 2.1

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fig 1.2 describes the current components in npn BJT for forward active mode.

I_{En} → due to diffusion of minority carrier electrons in the base (at $x = 0$)

I_{Cn} → due to diffusion of minority carrier electrons in the base (at $x = W_B$)

I_{RB} → difference between I_{En} and I_{Cn}, which is due to recombination of excess minority carrier electron with majority carrier holes in the base.

I_{Ep} → due to diffusion of minority carrier holes in the emitter at $x' = 0$

I_R → due to recombination of charge carriers in the forward-bias B-E junction.

I_{C0} → due to diffusion of minority carrier holes in the collector at $x' = 0$

I_G → due to generation of charge carriers in reverse-bias B-C junction.

Current components I_{RB}, I_{Ep} and I_R are B-E junction currents only and do not contribute to collector current. I_{C0} and I_G are B-C junction currents only. These current components do not contribute to the transistor action or current gain.

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

CB current gain

If cross-sectional area of emitter and collector is same, then

$$\alpha = \frac{I_C}{I_E} = \frac{I_{En} + I_G + I_{Co}}{I_{En} + I_R + I_{Ep}} \quad \text{— (1)}$$

But we are interested in finding how I_C will change with a change in I_E.

Thus, small-signal common base ~~current~~ gain is

$$\alpha = \frac{\partial I_C}{\partial I_E} = \frac{I_{Cn}}{I_{En} + I_R + I_{Ep}} \quad \text{— (2)}$$

The reverse bias B-C junction currents I_G and I_{Co} are not the function of I_E.

$$\boxed{\alpha = \left(\frac{I_{En}}{I_{En} + I_{Ep}}\right)\left(\frac{I_{Cn}}{I_{En}}\right)\left(\frac{I_{En} + I_{Ep}}{I_{En} + I_R + I_{Ep}}\right)} \quad \text{— (3)}$$

ie $\boxed{\alpha = \gamma\, b\, \delta}$

where,

$$\boxed{\gamma = \frac{I_{En}}{I_{En} + I_{Ep}}} \rightarrow \text{Emitter injection efficiency}$$

$$\boxed{b = \frac{I_{Cn}}{I_{En}}} \rightarrow \text{Base transport factor}$$

$$\boxed{\delta = \frac{I_{En} + I_{Ep}}{I_{En} + I_R + I_{Ep}}} \rightarrow \text{Recombination factor}$$

— (4)

Goal overall is to make α as close to one as possible.

ie $\alpha \approx \frac{I_C}{I_E} \rightarrow 1$

- To achieve this goal, we must make each term in equation (3) and (4) as close to one as possible, since each factor is less than unity.

- $\gamma = \frac{I_{En}}{I_{En} + I_{Ep}}$ → Emitter injection efficiency (γ) takes into account the minority carrier hole diffusion current in the emitter. (This current is part of emitter current, but does not contribute to the transistor action in that I_{Ep} is not part of collector current)

ie $\gamma = \frac{I_{En}}{I_{En} + I_{Ep}} \approx \frac{1}{\left(1 + \frac{I_{Ep}}{I_{En}}\right)}$ ⇝ tends to 1 (As W_B is reduced)

- $b = \frac{I_{Cn}}{I_{En}} = \frac{I_{En} - I_{RB}}{I_{En}} = \left(1 - \frac{I_{RB}}{I_{En}}\right)$ → tends to 1 (As W_B is reduced)

b → base transport factor takes into account any recombination of minority carrier electrons in the base. (Ideally, we want no recombination in the base ie $I_{RB} \rightarrow 0$)

b → represents what fraction of currents (still retained) (or recombines), when carriers are transported across the base.

ie $\boxed{I_{RB} \approx 0 \approx I_{En} - I_{Cn}}$ ← (Ideally)

ie $I_{En} \approx I_{Cn}$

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$\delta = \frac{I_{En}+I_{Ep}}{I_{En}+I_R+I_{Ep}}$ → Recombination factor takes into account the recombination in the forward-bias B-E junction. Current I_R contributes to the emitter current, but does not contribute to collector current.

$$\alpha = \gamma b \delta \to 1 \quad \text{as} \quad W_B l_B << 1$$

Alpha of BJT → (Tranfer of current from Emitter to collector is almost complete for these conditions.)

1) $I_{Ep} << I_{En}$
2) Base width (W_B) should be v.small
   ie I_{RB} is v.small.

ie Entire I_{En} reaches I_{Cn}.

Under these two conditions {'Collector' will collect almost entire 'Emitter' current}

So, this tranfer of current F.B B-E junct^n to a R.B B-C junction is called

"**BJT Transistor Action**"

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