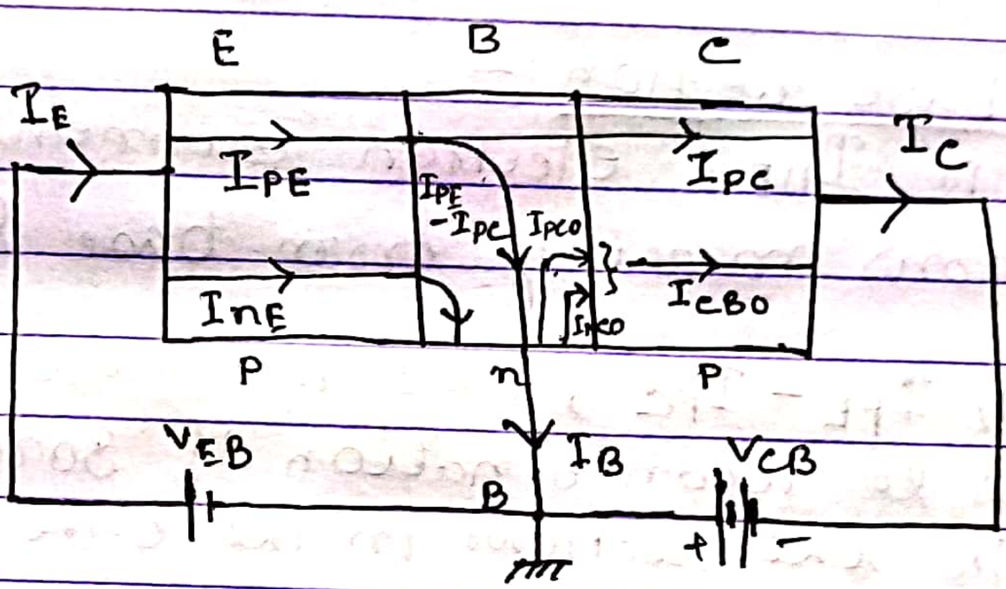
Transistor
PNP → current components

CB mode:-



Transistor current Component of a PNP transistor with emitter junction is forward biased and collector junction is reverse biased. are shown in figure.

In Emitter region :

(i) I_{PE}, hole current ~~density~~ due to holes moving from emitter to base.

(ii) I_{nE}, electron current due to electrons moving from base to emitter.

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Therefore, emitter current

$$I_E = I_{PE} + I_{NE} \quad \text{--- (1)}$$

In base region :-

(I) I_{nE}, electron current due to electrons moving from base to emitter.

(II) $I_{PE} - I_{PC}$, recombination current due to recombination of some holes with the electrons in the base region.

(III) $I_{CBO} = I_{PCO} + I_{nCO}$, leakage current, as the collector junction is reverse bias, we get a current due to drift of minority carriers.

$I_{PCO} \rightarrow$ due to holes from base to collector

$I_{nCO} \rightarrow$ due to electrons from collector to base.

Therefore, base current

$$I_B = I_{nE} + (I_{PE} - I_{PC}) - I_{CBO} \quad \text{--- (2)}$$

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In collector region :-

(I) I_{pc}, hole current, some of the holes recombine at the base region and maximum ~~of~~ number moves to the collector region.

(II) $I_{CBO} = I_{PCO} + I_{nCO}$,

Therefore, collector current,

$$I_C = I_{PC} + I_{CBO} \qquad (3)$$

combining equation (1), (2) and (3) we get

$$I_B + I_C = I_{nE} + I_{PE} - \cancel{I_{PC}} - \cancel{I_{CBO}} + \cancel{I_{PC}} + \cancel{I_{CBO}}$$

Since,

$$I_{nE} + I_{PE} = I_E$$

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

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Current gain of a transistor :- (α and β)

(1) α - of a transistor :- In common base configuration, the d.c current gain of a transistor is denoted as 'α', which is defined as the ratio of the collector current to the emitter current

i.e $\alpha = \frac{I_C}{I_E}$ without leakage current

$\alpha = \frac{I_C - I_{CBO}}{I_E}$ with leakage current.

In common base configuration, the ac current gain is denoted by α_{ac}, which is defined as the ratio of the change in collector current to the change in emitter current

i.e $\alpha_{ac} = \frac{\Delta I_C}{\Delta I_E}$

For a good transistor $\alpha_{ac} = \alpha_{dc} = \alpha$

α - value lies bet^n 0.98 to 0.99

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(2) β of a transistor:- In common emitter configuration, the d.c current gain of a transistor is denoted by β, which is defined as the ratio of the collector to the base current.

i.e $\beta = \frac{I_C}{I_B}$ without leakage current

$\beta = \frac{I_C - I_{CBO}}{I_B}$ with leakage current.

In common emitter configuration, the a.c current gain is denoted by β_{ac}, which is defined as the ratio of the change in collector current to the change in base current.

i.e $\beta_{ac} = \frac{\Delta I_C}{\Delta I_B}$ ~~for a~~

For a good transistor, $\beta_{d.c} = \beta_{a.c} = \beta$

Remember β of a transistor lies bet 22 to 200 (in general)

Relation betn α and β :-

We have $I_E = I_B + I_C$

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

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

or $$\alpha = \frac{\beta}{\beta+1}$$ or $$\beta = \frac{\alpha}{1-\alpha}$$

* Different Relation of collector current in terms of leakage current :-

Relation -1

I_C in term of α (common base configuration)

We have, $$\alpha = \frac{I_C - I_{CBO}}{I_E}$$

Where I_{CBO} = leakage current in CB mode.

Or $$I_C = \alpha I_E + I_{CBO}$$

also

$$\alpha I_E = I_C - I_{CBO}$$

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

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

or $$I_C = \frac{\alpha}{1-\alpha} I_B + \frac{1}{1-\alpha} I_{CBO}$$

Also $\alpha = \frac{\beta}{1+\beta}$ Thus $\frac{\alpha}{1-\alpha} = \beta$ and

$$\frac{1}{1-\alpha} = (\beta + 1)$$

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

Relation - 2

I_C interms of β (common emitter mode)

we have, $\beta = \frac{I_C - I_{CEO}}{I_B}$

where $I_{CEO} \rightarrow$ leakage current in CE mode.

$$I_C = \beta I_B + I_{CEO}$$

Relation - 3

Relation betⁿ two leakage current

i.e $I_{CEO} = (\beta + 1) I_{CBO}$

current gain with leakage in C-B mode.

$$\alpha = \frac{I_C - I_{CBO}}{I_E}$$

$\Rightarrow \alpha I_E = I_C - I_{CBO}$

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

$\Rightarrow I_C = \frac{\alpha}{1-\alpha} I_B + \frac{1}{1-\alpha} I_{CBO}$

$\Rightarrow I_C = \beta I_B + (\beta + 1) I_{CBO}$ ——— (4)

current gain with leakage in CE mode.

$$\beta = \frac{I_C - I_{CEO}}{I_B}$$

$\Rightarrow$ $I_C = \beta I_B + I_{CEO}$ ——— (2)

Compairing eq^n (1) and (2) we get

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