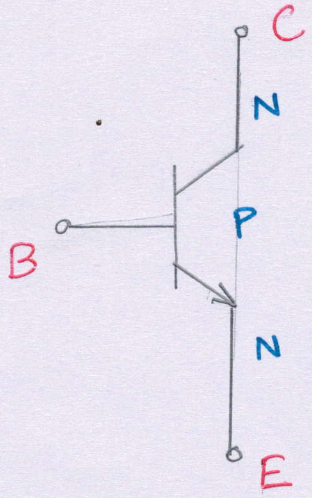
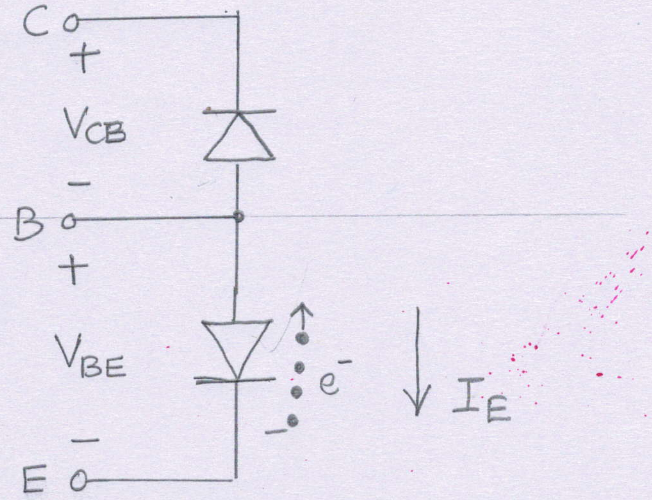
EBER'S MOLL MODEL



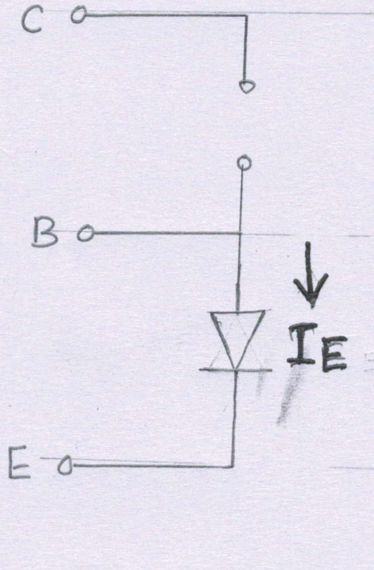


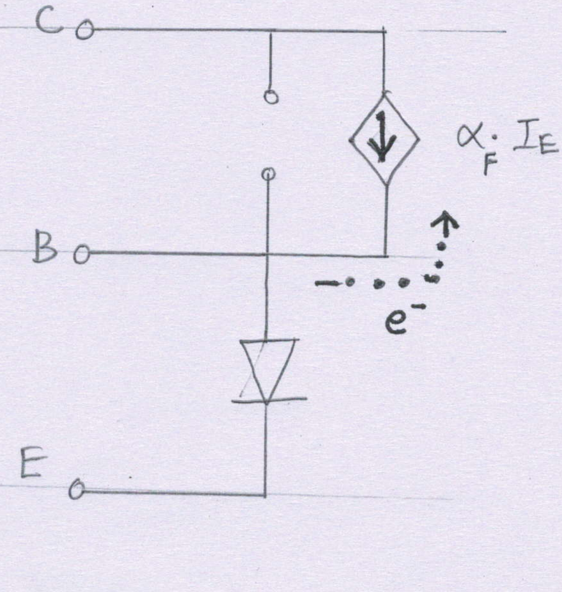
Active mode :- FORWARD

EB Jn — Forward Biased

CB Jn — Reverse Biased.

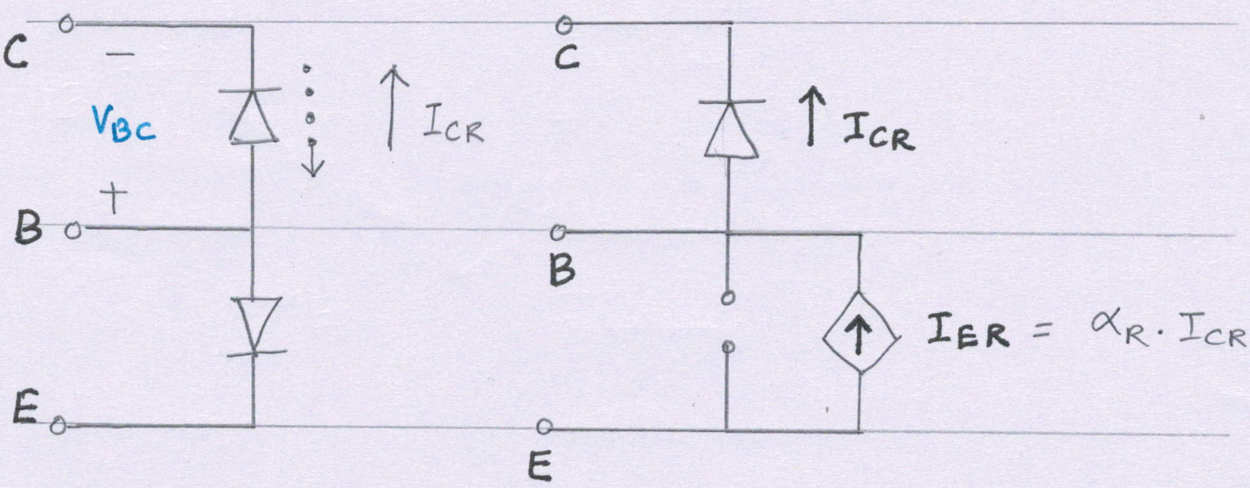
$$I_{EF} = I_{SE}\left[e^{\frac{V_{BE}}{V_T}} - 1\right] \quad \text{—— (B)}$$



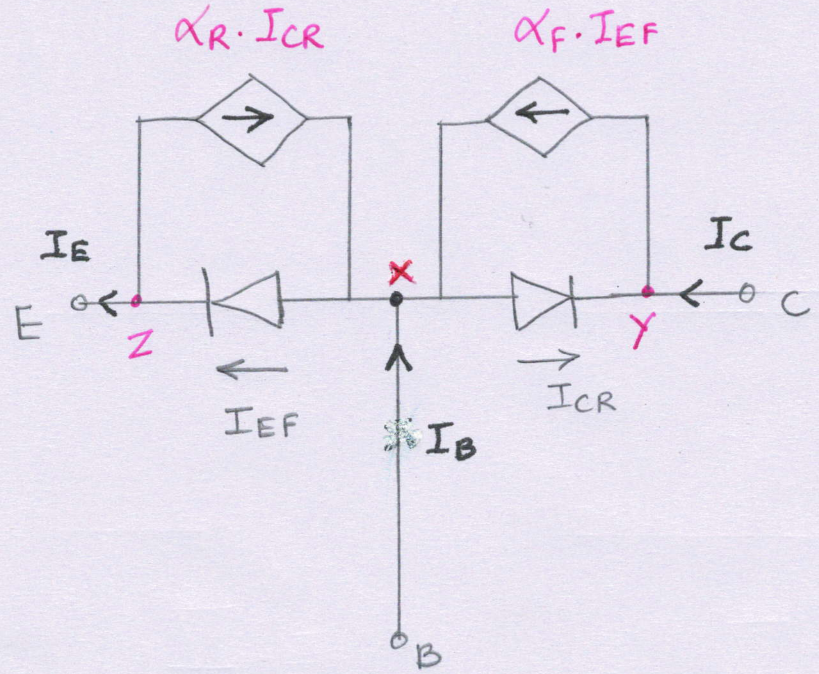


Active mode :- – REVERSE.

CB Jn :- Forward biased
EB Jn :- Reverse biased.



$$I_{CR} = I_{SC} \cdot \left[e^{\frac{V_{BC}}{V_T}} - 1 \right] \quad \text{—— (A)}$$



KCL at X :-

$$I_B + I_{EF} \cdot \alpha_F + \alpha_R \cdot I_{CR} - I_{EF} - I_{CR} = 0$$

$$\therefore \quad I_B = (1 - \alpha_F) I_{EF} + (1 - \alpha_R) I_{CR} \quad \text{—— (1)}$$

KCL at 'Y' :-

$$I_C + I_{CR} - \alpha_F I_{EF} = 0$$

$$\therefore \quad I_C = \alpha_F I_{EF} - I_{CR} \quad \text{——} \quad (2)$$

KCL at 'Z' :-

$$I_{EF} - \alpha_R I_{CR} - I_E = 0$$

$$I_E = I_{EF} - \alpha_R I_{CR} \quad \text{——} \quad (3)$$

Substituting (A) and (B) in (3),

$$I_E = I_{SE}\left[e^{\frac{V_{BE}}{V_T}} - 1\right] - \alpha_R \cdot \left\{I_{SC}\left[e^{\frac{V_{BC}}{V_T}} - 1\right]\right.$$

$$\therefore \; I_E = I_{SE}\, e^{\frac{V_{BE}}{V_T}} - \alpha_R I_{SC}\, e^{\frac{V_{BC}}{V_T}} - I_{SE} + \alpha_R I_{SC}$$

Let, $\alpha_R I_{SC} = \alpha_F I_{SE} = I_S$

$$\therefore \; I_E = \frac{I_S}{\alpha_F} \cdot e^{V_{BE}/V_T} - I_S \cdot e^{V_{BC}/V_T} - \frac{I_S}{\alpha_F} + I_S$$

$$I_E = \frac{I_S}{\alpha_F}\left[e^{\frac{V_{BE}}{V_T}} - 1\right] - I_S\left[e^{\frac{V_{BC}}{V_T}} - 1\right]$$

(4)

From (2),

$$I_C = \alpha_F I_{EF} - I_{CR}$$

$$= \alpha_F\left[I_{SE}\left(e^{\frac{V_{BE}}{V_T}} - 1\right)\right] - I_{SC}\left[e^{\frac{V_{BC}}{V_T}} - 1\right]$$

$$= \alpha_F I_{SE}\left(e^{V_{BE}/V_T} - 1\right) - I_{SC}\left[e^{\frac{V_{BC}}{V_T}} - 1\right]$$

$$I_C = I_S\left(e^{V_{BE}/V_T} - 1\right) - \frac{I_S}{\alpha_R}\left[e^{\frac{V_{BC}}{V_T}} - 1\right]$$

(5)

From (1),

$$I_B = (1-\alpha_F) I_{EF} + (1-\alpha_R) I_{CR}.$$

$$= (1-\alpha_F) I_{SE}\left(e^{\frac{V_{BE}}{V_T}} - 1\right) + (1-\alpha_R)\left(e^{\frac{V_{BC}}{V_T}} - 1\right) \cdot I_{SC}$$

$$I_B = (1-\alpha_F)\frac{I_S}{\alpha_F}\left(e^{\frac{V_{BE}}{V_T}} - 1\right) + (1-\alpha_R)\frac{I_S}{\alpha_R}\left(e^{\frac{V_{BC}}{V_T}}\right.$$

(6)

W.K.T $\quad \alpha = \dfrac{\beta}{1+\beta}$

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

$$\Rightarrow \quad \alpha_F = \frac{\beta_F}{1+\beta_F} \quad ; \quad \alpha_R = \frac{\beta_R}{1+\beta_R}$$

$$\beta_F = \frac{\alpha_F}{1-\alpha_F} \quad ; \quad \beta_R = \frac{\alpha_R}{1-\alpha_R}.$$

6 becomes,

$$\boxed{I_B = \frac{I_s}{\beta_F}\left(e^{\frac{V_{BE}}{V_T}} - 1\right) + \frac{I_s}{\beta_R}\left(e^{\frac{V_{BC}}{V_T}} - 1\right)} \quad -7$$

~~5 becomes~~,

4, 5 and 7 are currents in all possible modes of operation

W.K.T $\alpha = \frac{\beta}{1+\beta}$

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

$$\Rightarrow \quad \alpha_F = \frac{\beta_F}{1+\beta_F} \quad ; \quad \alpha_R = \frac{\beta_R}{1+\beta_R}$$

$$\beta_F = \frac{\alpha_F}{1-\alpha_F} \quad ; \quad \beta_R = \frac{\alpha_R}{1-\alpha_R}.$$

6 becomes,

$$\boxed{I_B = \frac{I_s}{\beta_F}\left(e^{\frac{V_{BE}}{V_T}} - 1\right) + \frac{I_s}{\beta_R}\left(e^{\frac{V_{BC}}{V_T}} - 1\right)} \quad - (7)$$

~~5 becomes~~,

4, 5 and 7 are currents in all possible modes of operation