PH3104 PJ-7

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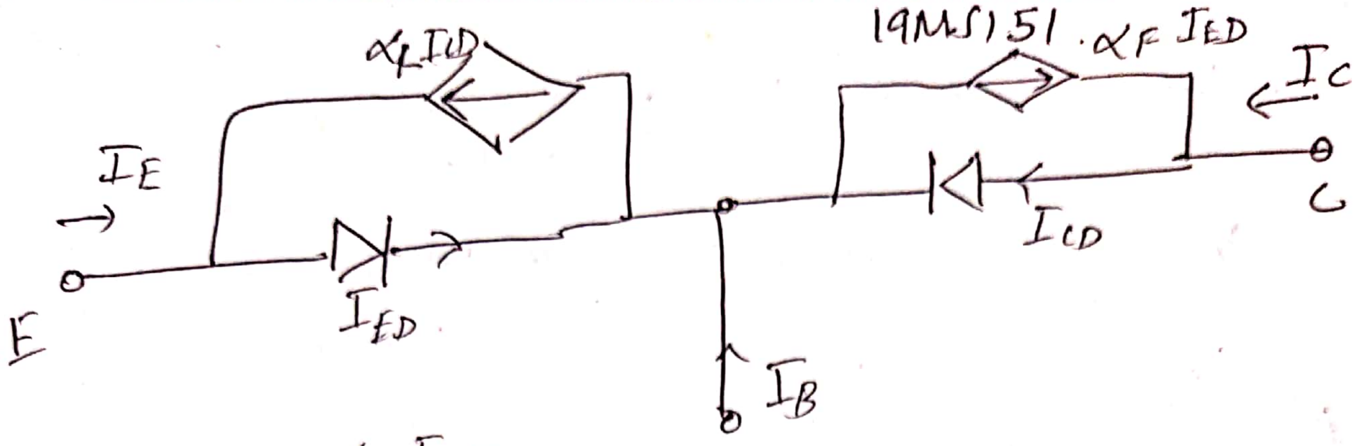
1).



$I_E = I_{ED} - \alpha_R I_{CD}$

$V_T = 0.026$

$I_C = I_{CD} - \alpha_F I_{ED}$

$I_{CD} = I_{CS}\left(\exp\left(\frac{V_{CB}}{V_T}\right) - 1\right)$

$I_{ED} = I_{ES}\left(\exp\left(\frac{V_{EB}}{V_T}\right) - 1\right)$

$\alpha_R I_{CS} = \alpha_F I_{ES}$

$I_{CS} = \frac{0.97}{0.78} \times 10^{-15}$ A.

$I_E = I_{ES}\left(\exp\left(\frac{V_{EB}}{V_T}\right) - 1\right) - \alpha_R I_{CS}\left(\exp\left(\frac{+V_{CB}}{V_T}\right) - 1\right)$

$I_C = I_{CD} - \alpha_F I_{ED}$

$= I_{CS}\left(\exp\left(\frac{V_{CB}}{V_T}\right) - 1\right) - \alpha_F\left(I_{ES}\left(\exp\left(\frac{V_{EB}}{V_T}\right) - 1\right)\right)$

$= I_{CS}(1 - \alpha_R \alpha_F) \cdot \left(\exp\left(\frac{V_{CB}}{V_T}\right) - 1\right) - \alpha_F I_E$

plots in zip.. along with code!

2) $I_E + I_B + I_C = 0$.

$I_C = 0 \Rightarrow \cancel{I_E} = -I_B$

$\cancel{Ec}$, $I_C = I_{CS}(1-\alpha_R\alpha_F)\left(\exp\left(\frac{V_{CB}}{V_T}\right)-1\right) + \alpha_F I_B$

$\boxed{\text{from Q1}}$

$$\Rightarrow 1 - \frac{\alpha_F I_B}{(1-\alpha_R\alpha_F)I_{CS}} = \exp\left(\frac{V_{CB}}{V_T}\right)$$

$$I_{CS}\left(\exp\left(\frac{V_{CB}}{V_T}\right)-1\right) = \alpha_F I_{ES}\left(\exp\left(\frac{V_{EB}}{V_T}\right)-1\right)$$

$$= \alpha_R I_{CS}\left(\exp\left(\frac{V_{EB}}{V_T}\right)-1\right)$$

$$\Rightarrow \exp\left(\frac{V_{CB}}{V_T}\right)-1 = \alpha_R\left(\exp\left(\frac{V_{EB}}{V_T}\right)-1\right)$$

$I_C = -I_B = I_{EB} - \alpha_R I_{CD}$.

$$I_{ES}\left(\exp\left(\frac{V_{EB}}{V_T}\right)-1\right) - \alpha_R I_{CS}\left(\exp\left(\frac{V_{CB}}{V_T}\right)-1\right) = -I_B$$

$$\Downarrow$$

$$(\alpha_R\alpha_F - 1)\left(\exp\left(\frac{V_{EB}}{V_T}\right)-1\right) = \frac{I_B}{I_{ES}}.$$

$$\Downarrow$$

$$\Rightarrow \frac{V_{EB}}{V_T} = \ln\left(1 + \frac{I_B}{I_{ES}(\alpha_R\alpha_F - 1)}\right)$$

$$\frac{I_{CS}}{\alpha_F}\left(\exp\left(\frac{V_{CB}}{V_T}\right)-1\right) - \alpha_R I_{CS}\left(\exp\left(\frac{V_{CB}}{V_T}\right)-1\right) = -I_B.$$

$$\frac{(1-\alpha_R\alpha_F)}{\alpha_F}\left(\exp\left(\frac{V_{CB}}{V_T}\right)-1\right) = \frac{-I_B}{I_{CS}}$$

$$\Rightarrow \frac{V_{CB}}{V_T} = \ln\left(1 + \frac{\alpha_F I_B}{(\alpha_R\alpha_F - 1)I_{CS}}\right)$$

(a). $I_B = -10\,\mu A$

$V_{EB} = 0.026 \ln\left(1 + \frac{10^{-5}}{(0.97 \times 0.78 - 1)\, 10^{-15}}\right)$

$V_{CB} = 0.026 \ln\left(1 + \frac{-0.97 \times 10^{-5}}{(0.97 \cdot 0.78 - 1) \times \frac{0.97}{0.78} \times 10^{-15}}\right)$

$V_{CE} = V_{CB} - V_{EB} = -6.48 \times 10^{-3}\ V.$

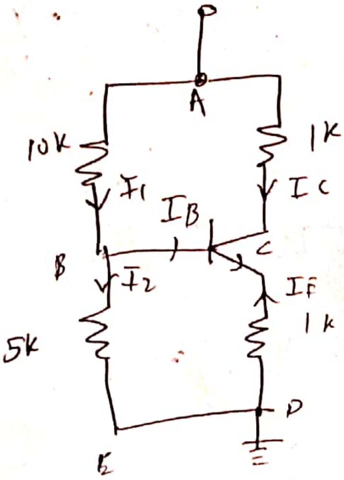
(B) $I_B = -50\,\mu A$.

$V_{EB} = 0.026 \ln\left(1 + \frac{-5 \times 10^{-5}}{(0.97 \times 0.78 - 1)\, 10^{-15}}\right)$

$V_{CB} = 0.026 \ln\left(1 + \frac{-0.97 \times 5 \times 10^{-5}}{(0.97 \cdot 0.78 - 1)\, \frac{0.97}{0.78} \times 10^{-15}}\right)$

$\Rightarrow V_{CE} = -6.46 \times 10^{-3}\ V$

3)



$V_\gamma = 0.7V,\ \beta = 100,\ I_E = I_C\left(-\frac{\beta+1}{\beta}\right)$

$12 = I_C \times 1k + V_{CE} - I_E \times 1$

$I_1 = I_2 + I_B$

$I = I_1 + I_C$

$I_1 = I - \beta I_B$

$I_2 = I - (\beta+1) I_B$

$I_B + I_C + I_E = 0$

$\Rightarrow (\beta+1) I_B = -I_E$

$12 = (10 \times 1)(I - \beta I_B) + (5 \times 1)(I - (\beta+1) I_B)$

$12 = 15 I k \quad 15 \beta I_\beta k - 5 I_B k$

$\Rightarrow I = \frac{(12 \times 10^{-3}) + (15\beta + 5) I k}{15 k}$

$10k(I - \beta I_B) + 0.7 - I_E k = 12V.$

$(10k)\left(\frac{12 + (15\beta + 5) I_B}{15} - \beta I_B\right) + I_B (\beta+1) k = 11.3$

$8 + \frac{10}{3} I_B + I_B(101) = 11.3$

$I_B = \frac{3.3 \times 3 \times 10^{-3}}{313} = 31.63\ \mu A$.

$V_{BE} = V_\gamma = 0.7$

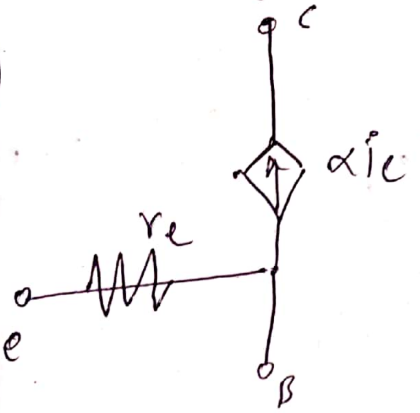
$\Rightarrow I_C = \beta I_B = 100 \times 31.63 \Rightarrow 3.163$ mA.

$12 = (I_C)k + V_{CE} - I_B(k)$

$\Rightarrow 12 = (3.163 \times 10^{-3})\, 10^{3} + V_{CE} + (101)(31.63 \times 10^{-6} \times 10^{-3})$

$V_{CB} = (12 - 3.163 - 3.194) = 5.642$ V.

4)



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

$i_c = -\alpha i_e.$

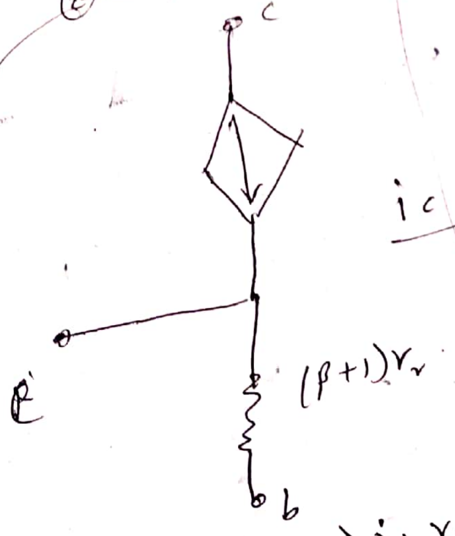
$i_e + i_b = \alpha i_e$

$i_b = (\alpha - 1)\, i_e$

$\Rightarrow i_b = \frac{-i_e}{1+\beta}$

(1) $i_c = -\alpha i_e = +\left(\frac{\beta}{1+\beta}\right) i_b (\beta+1)$

$V_{EB} = r_e i_e$ (2) , $i_c = \beta i_b$ (3)



$i_c = \beta i_b$ (3)

and $i_e + \beta i_b + i_b = 0$

$\Rightarrow i_b = \frac{-i_e}{\beta+1}$ (1)

$V_{EB} = -(\beta+1)\, i_b r_\pi = +(\beta+1)\frac{i_e}{\beta+1} = i_e r_\pi$ (2)

Parameters match.

~~Both models~~ Approximat AC models are both equivalent.

Scanned with CamScanner