Homework 5 Solutions

Sanjay Krishna: University of New Mexico

HW 5, ECE 322L

Solution 5.9

(a) $V_C = I_C(5) - 10$

$-1.2 = I_C(5) - 10 \Rightarrow I_C = 1.76\,\text{mA}$

$I_E = \dfrac{I_C}{\alpha} = \dfrac{1.76}{0.986} = 1.785\,\text{mA}$

$I_B = I_E - I_C = 1.785 - 1.76 \Rightarrow I_B = 25\,\mu\,\text{A}$

(b) $I_E = I_{Eo}\exp\left(\dfrac{V_{EB}}{V_T}\right)$

$1.785\times10^{-3} = 2\times10^{-15}\exp\left(\dfrac{V_{EB}}{V_T}\right)$

$V_{EB} = (0.026)\ln\left(\dfrac{1.785\times10^{-3}}{2\times10^{-15}}\right) = 0.7154\,\text{V}$

Solution 5.17

(a)

$$I_E = \frac{-0.7-(-10)}{5} = 1.86 \text{ mA}$$

$$I_C = (1.86)\left(\frac{75}{76}\right) = 1.836 \text{ mA}$$

$$V_C = -0.7 + 4 = 3.3 \text{ V}$$

$$R_C = \frac{10-3.3}{1.836} \Rightarrow R_C = 3.65 \text{ K}$$

(b)

$$I_B = \frac{0.5}{76} = 0.00658 \text{ mA}$$

$$V_B = I_B R_B = (0.00658)(25) \Rightarrow V_B = 0.164 \text{ V}$$

$$I_C = (0.5)\left(\frac{75}{76}\right) = \underline{0.493 \text{ mA}}$$

$$R_C = \frac{-1-(-5)}{0.493} \Rightarrow R_C = 8.11 \text{ K}$$

(c)

$$O = \frac{I_E}{76}(10) + 0.7 + I_E(4) - 8$$

$$7.3 = I_E(4 + 0.132) \Rightarrow I_E = 1.767 \text{ mA}$$

$$I_C = (1.767)\left(\frac{75}{76}\right) = \underline{1.744 \text{ mA}}$$

$$V_{CE} = 8 - (1.744)(4) - \left[(1.767)(4) - 8\right]$$

$$= 16 - 6.972 - 7.068 \Rightarrow V_{CE} = 1.96 \text{ V}$$

(d)

$$5 = I_E(10) + \left(\frac{I_E}{76}\right)(20) + 0.7 + I_E(2) \qquad = I_E(10 + 0.263 + 2) + 0.7$$

$$I_E = 0.3506 \text{ mA} \Rightarrow \underline{I_B = 4.61\ \mu\text{A}} \qquad V_C = 5 - (0.3506)(10)$$

$$\underline{V_C = 1.49 \text{ V}}$$

Solution 5.19

(a) $V_{CC} = I_C R_C + V_{CE}$

$$I_C = \frac{2.5 - 1.1}{4} = 0.35\,\text{mA}$$

$$I_C = I_S \exp\left(\frac{V_{BE}}{V_T}\right)$$

$$V_{BE} = V_{BB} = (0.026)\ln\left(\frac{0.35\times10^{-3}}{5\times10^{-16}}\right) = 0.7091\,\text{V}$$

(b) $I_E = \dfrac{V_{CC} - V_{CE}}{R_E} = \dfrac{2.5 - 1.1}{2} = 0.7\ \text{mA}$

$$I_C = \left(\frac{\beta}{1+\beta}\right)\cdot I_E = \left(\frac{90}{91}\right)(0.70) = 0.6923\,\text{mA}$$

$$V_{BE} = (0.026)\ln\left(\frac{0.6923\times10^{-3}}{5\times10^{-16}}\right) = 0.7269\,\text{V}$$

$$V_{BB} = V_{BE} + I_E R_E = 0.7269 + (0.7)(2) = 2.127\,\text{V}$$

Solution 5.21

(a) $I_E = \dfrac{2-(0.7+0.2)}{1.5} = 0.7333\,\text{mA}$

$I_C = \left(\dfrac{\beta}{1+\beta}\right)\cdot I_E = \left(\dfrac{120}{121}\right)(0.7333) = 0.7273\,\text{mA}$

$V_{EC} = V_E = 0.9\,\text{V}$

(b) $I_C = \beta I_B = (120)(15) \Rightarrow I_C = 1.8\,\text{mA}$ - Not possible

Transistor in saturation

$V_{EC} = 0.2\,\text{V}$

$I_E = \dfrac{2-0.2}{1.5} = 1.2\,\text{mA}$

$I_C = I_E - I_B = 1.2 - 0.015 = 1.185\,\text{mA}$

(c) Transistor cutoff

$I_C = 0$, $V_{EC} = 2\,\text{V}$

Solution 5.23

(a)

$$V_B = -I_B R_B \Rightarrow I_B = \frac{-V_B}{R_B} = \frac{-(-1)}{500}$$

$$I_B = 2.0\ \mu\text{A}$$

$$V_E = -1 - 0.7 = -1.7\ \text{V}$$

$$I_E = \frac{V_E - (-3)}{R_E} = \frac{-1.7 + 3}{4.8} = 0.2708\ \text{mA}$$

$$\frac{I_E}{I_B} = (1+\beta) = \frac{0.2708}{0.002} = 135.4 \Rightarrow \underline{\beta = 134.4}$$

$$\alpha = \frac{\beta}{1+\beta} \Rightarrow \underline{\alpha = 0.9926}$$

$$I_C = \beta I_B \Rightarrow \underline{I_C = 0.269\ \text{mA}}$$

$$V_{CE} = 3 - V_E = 3 - (-1.7) \Rightarrow \underline{V_{CE} = 4.7\ \text{V}}$$

(b)

$$I_E = \frac{5-4}{2} \Rightarrow I_E = 0.5\ \text{mA}$$

$$4 = 0.7 + I_B R_B + (I_B + I_C) R_C - 5$$

$$I_B + I_C = I_E$$

$$I_B + I_C = I_E$$

$$4 = 0.7 + I_B(100) + (0.5)(8) - 5$$

$$I_B = 0.043 \Rightarrow \frac{I_E}{I_B} = (1+\beta) = \frac{0.5}{0.043} = 11.63$$

$$\underline{\beta = 10.63},\ \alpha = \frac{\beta}{1+\beta} \Rightarrow \underline{\alpha = 0.9140}$$