Homework 6 Solutions

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Solution 5.33

$V_{BB} = 0.$

$$\text{Cutoff } V_0 = \left(\frac{R_L}{R_C + R_L}\right)V_{CC} = \left(\frac{10}{10+5}\right)(5)$$

a. $\underline{V_0 = 3.33 \text{ V}}$

$V_{BB} = 1 \text{ V}$

$$I_B = \frac{1-0.7}{50} \Rightarrow 6 \text{ μA}$$

$$I_C = \beta I_B = (75)(6) \Rightarrow I_C = 0.45 \text{ mA}$$

$$\frac{5-V_0}{5} = I_C + \frac{V_0}{10}$$

b. $$1 - 0.45 = V_0\left(\frac{1}{5} + \frac{1}{10}\right) \Rightarrow \underline{V_0 = 1.83 \text{ V}}$$

c. Transistor in saturation $\underline{V_0 = V_{CE}(\text{sat}) = 0.2 \text{ V}}$

Solution 5.57

(a)

$$R_{TH} = 36 \| 68 = 23.5\ \text{k}\Omega$$

$$V_{TH} = \left(\frac{36}{36+68}\right)(10) = 3.46\ \text{V}$$

$$I_{BQ} = \frac{3.46 - 0.7}{23.5 + (51)(30)} = 0.00178\ \text{mA}$$

$$I_{CQ} = 0.0888\ \text{mA}, \quad I_{EQ} = 0.0906\ \text{mA}$$

$$V_{CEQ} = 10 - (0.0888)(42) - (0.0906)(30) \Rightarrow V_{CEQ} = 3.55\ \text{V}$$

(b)

$$R_1 = 22.7, R_2 = 12\ \text{K}, R_C = 14\ \text{K}, R_E = 10\ \text{K}$$

$$R_{TH} = 7.85\ \text{k} \qquad V_{TH} = 3.46$$

$$I_{BQ} = \frac{3.46 - 0.7}{7.85 + (51)(10)} = 0.00533\ \text{mA}$$

$$I_{CQ} = 0.266\ \text{mA} \qquad I_{EQ} = 0.272\ \text{mA}$$

$$V_{CE} = 10 - (0.266)(14) - (0.272)(10)$$

$$\underline{V_{CE} = 3.56\ \text{V}}$$

Solution 5.73

a.

$$R_{TH} = 500 \| 500 \| 70 = 250 \| 70 = 54.7 \text{ k}\Omega$$

$$\frac{5 - V_{TH}}{500} + \frac{3 - V_{TH}}{500} = \frac{V_{TH} - (-5)}{70}$$

$$\frac{5}{500} + \frac{3}{500} - \frac{5}{70} = V_{TH}\left(\frac{1}{500} + \frac{1}{500} + \frac{1}{70}\right) \Rightarrow -0.0554 = V_{TH}(0.0183)$$

$$V_{TH} = -3.03 \text{ V}$$

b.

$$I_{BQ} = \frac{V_{TH} - V_{BE}(\text{on}) - (-5)}{R_{TH} + (1+\beta)R_E}$$

$$= \frac{-3.03 - 0.7 + 5}{54.7 + (101)(5)}$$

$$I_{BQ} = 0.00227 \text{ mA}$$

$$\underline{I_{CQ} = 0.227 \text{ mA}}, \; I_{EQ} = 0.229$$

$$V_{CEQ} = 20 - (0.227)(50) - (0.229)(5)$$

$$\underline{V_{CEQ} = 7.51 \text{ V}}$$

Solution 5.79

$$R_{TH} = R_1 \| R_2 = 100 \| 40 = 28.6\ \text{k}\Omega$$

$$V_{TH} = \left(\frac{R_2}{R_1 + R_2}\right)(10) = \left(\frac{40}{40+100}\right)(10) = 2.86\ \text{V}$$

$$I_{B1} = \frac{V_{TH} - V_{BE}(on)}{R_{TH} + (1+\beta)R_{E1}} = \frac{2.86 - 0.7}{28.6 + (121)(1)}$$

$$I_{B1} = 0.0144\ \text{mA},\ I_{C1} = 1.73\,\text{mA},\quad I_{E1} = 1.75\ \text{mA}$$

$$\frac{10 - V_{B2}}{3} = I_{C1} + I_{B2}$$

$$I_{E2} = \frac{V_{B2} - V_{BE}(\text{on}) - (-10)}{5}$$

$$\frac{10 - V_{B2}}{3} = I_{C1} + \frac{V_{B2} - 0.7 + 10}{(121)(5)}$$

$$\frac{10}{3} - 1.73 - \frac{9.3}{605} = V_{B2}\left(\frac{1}{3} + \frac{1}{(121)(5)}\right)$$

$$1.588 = V_{B2}(0.335) \Rightarrow V_{B2} = 4.74\ \text{V}$$

$$I_{E2} = \frac{4.74 - 0.7 - (-10)}{5} \Rightarrow \underline{I_{E2} = 2.808\ \text{mA}}$$

$$\underline{I_{B2} = 0.0232\ \text{mA}}$$

$$\underline{I_{C2} = 2.785\ \text{mA}}$$

$$V_{CEQ1} = 4.74 - (1.75)(1) \Rightarrow \underline{V_{CEQ1} = 2.99\ \text{V}}$$

$$V_{CEQ2} = 10 - (4.74 - 0.7) \Rightarrow \underline{V_{CEQ2} = 5.96\ \text{V}}$$

Solution 6.1

(a) (i) $g_m = \dfrac{I_{CQ}}{V_T} = \dfrac{0.5}{0.026} = 19.23 \text{ mA/V}$

$$r_\pi = \frac{\beta V_T}{I_{CQ}} = \frac{(180)(0.026)}{0.5} = 9.36\,\text{k}\Omega$$

$$r_o = \frac{V_A}{I_{CQ}} = \frac{150}{0.5} = 300\,\text{k}\Omega$$

(ii) $g_m = \dfrac{2}{0.026} = 76.92\,\text{mA/V}$

$$r_\pi = \frac{(180)(0.026)}{2} = 2.34\,\text{k}\Omega$$

$$r_o = \frac{150}{2} = 75\,\text{k}\Omega$$

(b) (i) $g_m = \dfrac{0.25}{0.026} = 9.615\,\text{mA/V}$

$$r_\pi = \frac{(80)(0.026)}{0.25} = 8.32\,\text{k}\Omega$$

$$r_o = \frac{100}{0.25} = 400\,\text{k}\Omega$$

(ii) $g_m = \dfrac{0.08}{0.026} = 3.077\,\text{mA/V}$

$$r_\pi = \frac{(80)(0.026)}{0.08} = 26\,\text{k}\Omega$$

$$r_o = \frac{100}{0.08} = 1250\,\text{k}\Omega$$