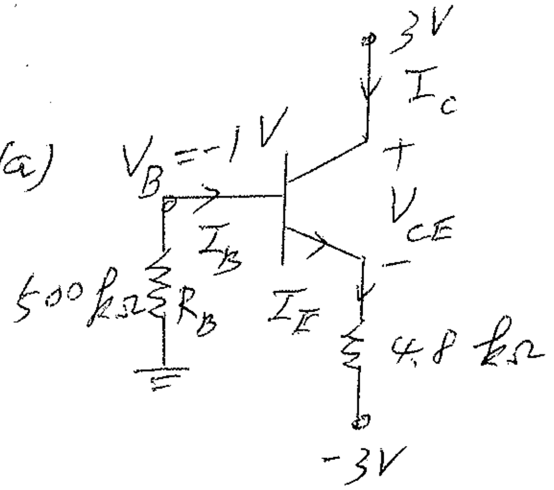
EECE 315 Exercise #3 Solutions

5.23

(a)



Assume the transistor is biased in the active region.

$I_C = \beta I_B$, $V_{BE(on)} = 0.7V$

$$V_B = -1 = V_{BE} + I_E \times 4.8 - 3$$

$$\therefore I_E = \frac{-1+3-0.7}{4.8} = \underline{\underline{0.27\ mA}}$$

$$I_B = \frac{1}{R_B} = \frac{1}{500} = \underline{\underline{2\ \mu A}}$$

$$I_E = I_B + I_C = I_B + \beta I_B = (\beta+1) I_B,\quad \underline{\underline{\beta = 134}}$$

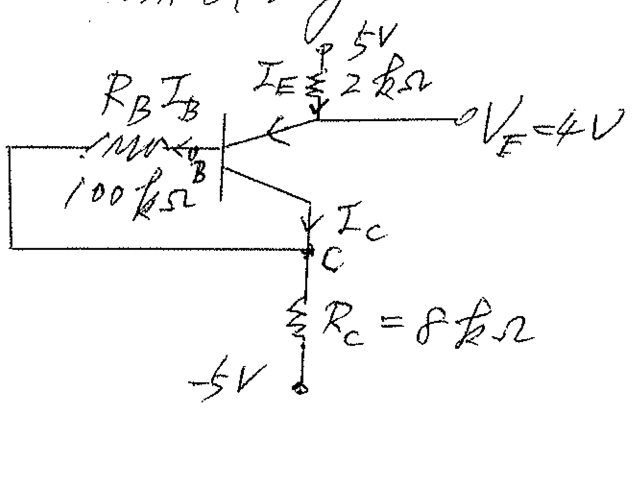
$$\alpha = \frac{\beta}{1+\beta} = \underline{\underline{0.993}}$$

$$V_{CE} = 3 - (4.8 I_E - 3) = 6 - 4.8 \times 0.27 = \underline{\underline{4.704\ V}}$$

$$V_{BC} = V_B - V_C = (-1) - (3) = -4V < 0$$

$\therefore$ Collector junction is reverse biased.

(b)



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

5.23 (b)

Assume active region.

$V_{EB} = 0.7\ V. \quad I_C = \beta I_B$

$$V_E = V_{EB} + I_B \times 100 + (I_B + I_C) \times 8 - 5$$

$$4 = 0.7 + I_B \times 100 + I_E \times 8 - 5$$

$$\therefore I_B = \frac{4 - 0.7 + 5 - 0.5 \times 8}{100} = \frac{4.3}{100} = \underline{\underline{43\ \mu A}}$$

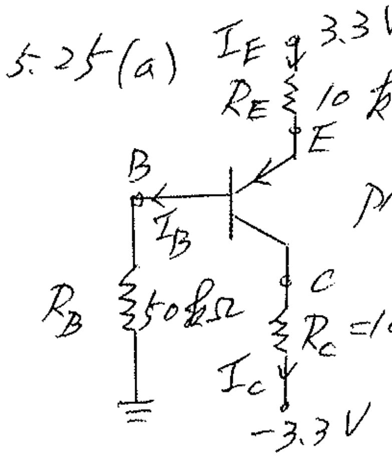
$$I_E = (\beta + 1) I_B, \quad \beta = \frac{I_E}{I_B} - 1 = \underline{\underline{10.63}}$$

$$\alpha = \frac{\beta}{\beta + 1} = \underline{\underline{0.914}}$$

$$V_{CB} = -I_B \times 100 = -4.3\ V < 0$$

Collector junction is reverse biased.

5.25 (a)



PNP transistor

$V_E = 0.85V$

Assume the BJT is biased in active. $V_{EB} = 0.7\ V$, $I_C = \beta I_B$

$$I_E = \frac{3.3 - V_E}{R_E} = \underline{\underline{0.245\ mA}}$$

$$V_E = V_{EB} + I_B \times R_B, \quad I_B = \frac{V_E - 0.7}{R_B} = 3\ \mu A > 0$$

$$\therefore I_C = I_E - I_B = \underline{\underline{0.242\ mA}}$$

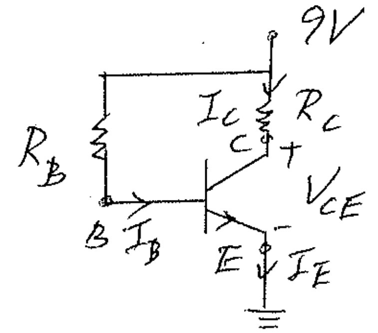
$$\therefore \beta = \frac{I_C}{I_B} = \underline{\underline{80.7}}, \quad \alpha = \frac{\beta}{1 + \beta} = \underline{\underline{0.988}}$$

$$V_{EC} = V_E - V_C = 0.85 - (I_C R_C - 3.3) = \underline{\underline{1.73\ V}}$$

$$V_{BC} = V_B - V_C = (I_B \times R_B) - (I_C R_C - 3.3) = 2.76\ V > 0$$

The collector-base junction is reverse biased.

D5-31



(a) $\beta = 80$

$I_{CQ} = 0.25$ mA

$V_{CEQ} = 4.5$ V

$9 = I_C R_c + V_{CE}$ $\quad \therefore R_c = \dfrac{9-4.5}{0.25} = \underline{\underline{18\ k\Omega}}$

Assume the transistor is biased in active region.

$I_C = \beta I_B$ or $I_B = \dfrac{I_C}{\beta} = 0.003125$ mA $= 3.125\ \mu A > 0$

$9 = I_B R_B + V_{BE}$ where $V_{BE} = 0.7$ V

$\therefore R_B = \dfrac{9-0.7}{I_B} = \underline{\underline{2.656\ M\Omega}}$

$V_{BC} = V_{BE} - V_{CE} = -3.8$ V (The collector-base junction is reverse-biased.)

(b) $\beta = 120$. $R_c = 18\ k\Omega$, $R_B = 2.656\ M\Omega$

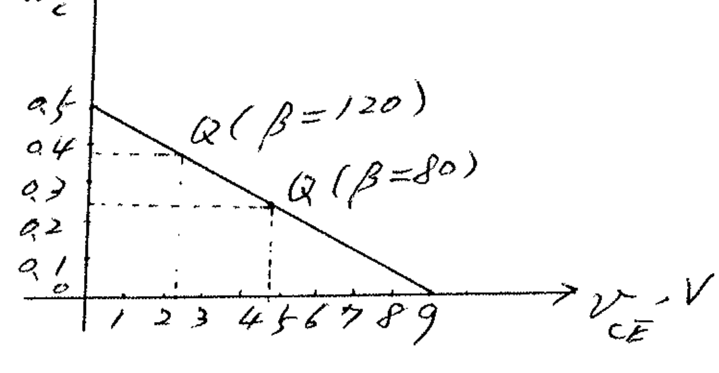
Assume the transistor is still biased in active region. $I_C = \beta I_B = 120 I_B$, $V_{BE} = 0.7$ V

$9 = I_B R_B + V_{BE}$ $\quad I_B = \dfrac{9-0.7}{2.656} = 3.125\ \mu A > 0$

$I_C = \beta I_B = \underline{\underline{0.375\ mA}}$, $V_{CE} = 9 - I_C R_c = \underline{\underline{2.25\ V}}$

$V_{BC} = V_{BE} - V_{CE} = -1.55\ V < 0$

(c)

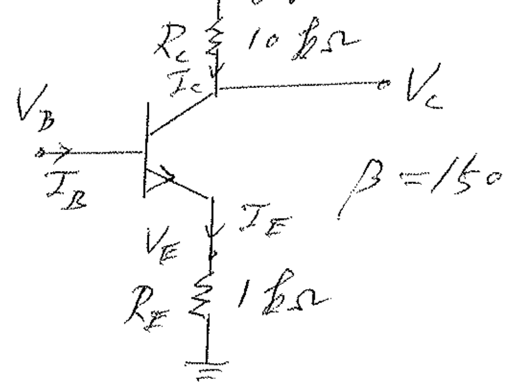


dc load line eq.

$9 = I_c R_c + V_{CE}$

$\begin{cases} I_c = 0, & V_{CE} = 9\ V \\ V_{CE} = 0, & I_c = 0.5\ mA \end{cases}$

5.32



(a) $V_B = 0.2V$

Assume the BJT is off.

$I_B = I_C = I_E = 0$

$V_C = 6V$

$V_{BE} = V_B - V_E = 0.2V < 0.7V$

$V_{BC} = V_B - V_C = -6V < 0$, $V_{CEQ} = V_C - V_E = 6V$

(b) $V_B = 0.9V$

Assume the BJT is active. $V_{BE} = 0.7V$, $I_C = \beta I_B$

$V_{BE} = V_B - V_E = 0.7$, $V_E = V_B - 0.7 = 0.2V$

$\therefore I_E = \frac{V_E}{R_E} = 0.2\,mA$, $I_C = I_E - I_B = I_E - \frac{I_C}{\beta}$

$\therefore I_C = \left(\frac{\beta}{\beta+1}\right) I_E = 0.199\,mA$, $I_B = I_E - I_C = 1\,\mu A > 0$

$V_{BC} = V_B - V_C = 0.9 - (6 - I_C \times 10) = 0.9 - 4.01 = -3.11V < 0$

$V_{CEQ} = V_C - V_E = 4.01 - 0.2 = 3.81V$

(c) $V_B = 1.5V$.

Assume the BJT is still biased in active region.

$V_{BE} = 0.7V$, $I_C = \beta I_B$

$V_E = V_B - 0.7 = 0.8V$, $I_E = \frac{V_E}{R_E} = 0.8\,mA$

$I_C = \left(\frac{\beta}{\beta+1}\right) I_E = 0.795\,mA$, $I_B = I_E - I_C = 5\,\mu A > 0$

$V_{BC} = V_B - V_C = 1.5 - (6 - I_C \times 10) = 1.5 - (-1.95) = 3.45V > 0$

The BJT is NOT biased in active region.

5.32 (c) $V_B = 1.5\,V$

Assume the BJT is biased in saturation region.

$V_{BE} = 0.8\,V, \quad V_{CE} = 0.2\,V$

$V_E = V_B - V_{BE} = 0.7\,V, \quad I_E = \frac{V_E}{R_E} = \underline{\underline{0.7\ mA}}$

$6 = I_c R_c + V_{CE} + V_E \quad \therefore I_c = \frac{6-0.2-0.7}{R_c} = \underline{\underline{0.51\ mA}}$

$I_B = I_E - I_c = 0.19\ mA > 0, \quad \underline{\underline{\beta I_B = 28.5\ mA > I_c}}$

$\therefore \underline{\underline{V_{CEQ} = 0.2\,V}}$

5.32 (d) $V_B = 2.2\,V$

Assume the BJT is biased in saturation region.

$V_{BE} = 0.8\,V, \quad V_{CE} = 0.2\,V$

$V_E = V_B - V_{BE} = 1.4\,V, \quad I_E = \frac{V_E}{R_E} = \underline{\underline{1.4\ mA}}$

$6 = I_c R_c + V_{CE} + V_E$

$\therefore I_c = \frac{6-0.2-1.4}{R_c} = \underline{\underline{0.44\ mA}}$

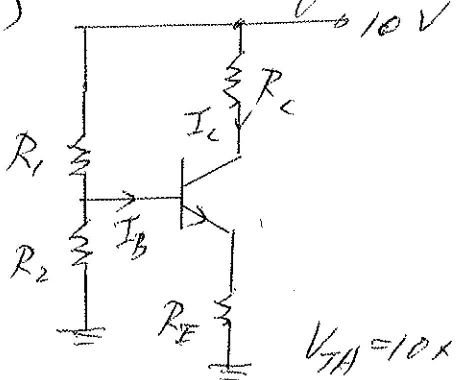
$I_B = I_E - I_c = 0.96\ mA > 0$

$\beta I_B = 144\ mA. \quad \therefore \underline{\underline{\beta I_B > I_c}}$

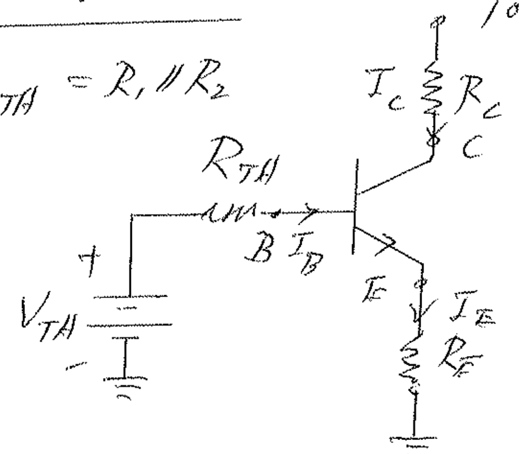
$V_{CEQ} = \underline{\underline{0.2\,V}}$

5.59 dc equivalent circuit

(a)



or



$R_{TH} = R_1 \parallel R_2$

$V_{TH} = 10 \times \frac{R_2}{R_1 + R_2}$

(a) $\beta = 100$, $I_{CQ} = 0.8$ mA, $V_{CEQ} = 5$ V. $R_E = 0.5$ kΩ

Assume the BJT is biased in active region.

$I_C = \beta I_B$. $V_{BE} = 0.7$ V

$I_B = \frac{I_C}{\beta} = 8\ \mu A > 0$. $I_E = I_B + I_C = 0.808$ mA

Let $R_E = \frac{10}{\beta + 1} \times R_{TH}$. ∴ $R_{TH} = (101 \times R_E)/10 = 5.05$ kΩ

$V_{TH} = I_B \times R_{TH} + V_{BE} + I_E \times R_E = 1.1444$

$V_{TH} = 10 \times \frac{R_2}{R_1 + R_2} = 10 \times \frac{R_1 R_2}{R_1 + R_2} \times \frac{1}{R_1} = 10 \times \frac{R_{TH}}{R_1} = 1.1444$

∴ $R_1 = \frac{10 \times R_{TH}}{1.1444} = 44.13$ kΩ

$\frac{R_1 R_2}{R_1 + R_2} = R_{TH}$ ∴ $R_2 = \frac{R_1 \times R_{TH}}{R_1 - R_{TH}} = 5.703$ kΩ

$10 = I_C R_C + V_{CE} + I_E R_E$. ∴ $R_C = \frac{10 - 5 - I_E R_E}{I_C} = 5.745$ kΩ

$V_{BC} = V_{BE} - V_{CE} = 0.7 - 5 = -4.3\text{V} < 0$