1. Given the BJT transistor characteristics below:

a. Draw a load line on the characteristics determined by E = 21 V and R_C = 3 k_ for a fixed-bias configuration.

b. Choose an operating point midway between cutoff and saturation. Determine the value of R_B to establish the resulting operating point.

c. What are the resulting values of I_{CQ} and V_{CEQ}?

d. What is the value of b at the operating point?

e. What is the value of a defined by the operating point?

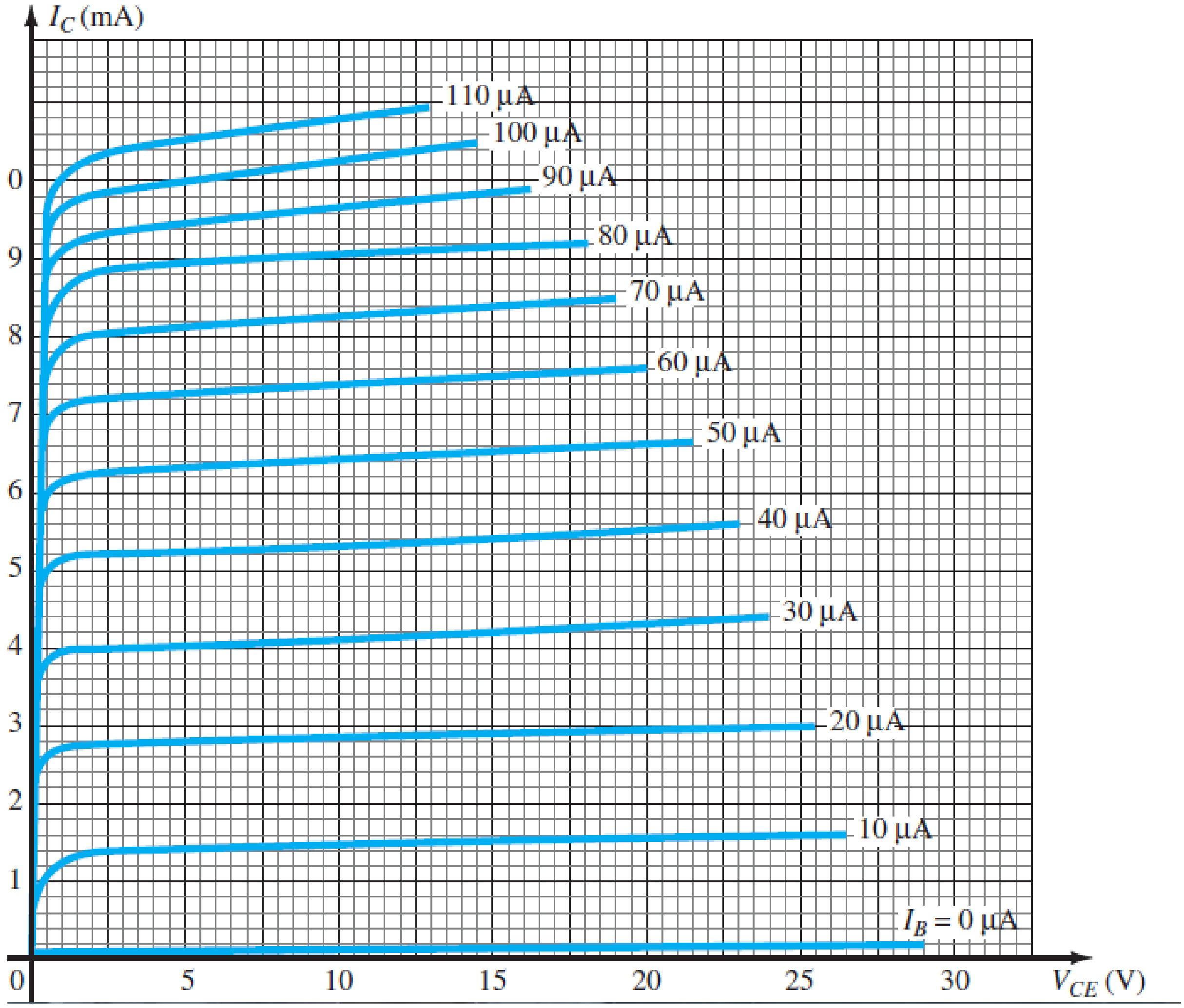
f. What is the saturation current (I_{Csat}) for the design?

g. Sketch the resulting fixed-bias configuration.

h. What is the dc power dissipated by the device at the operating point?

i. What is the power supplied by V_{CC}?

j. Determine the power dissipated by the resistive elements by taking the difference between the results of parts (h) and (i).



ANSWER:

(a) Load line intersects vertical axis at $I_C = \dfrac{21\text{ V}}{3\text{ k}\Omega} = 7\text{ mA}$

and horizontal axis at $V_{CE} = 21$ V.

(b) $I_B = 25\ \mu\text{A}$: $R_B = \dfrac{V_{CC} - V_{BE}}{I_B} = \dfrac{21\text{ V} - 0.7\text{ V}}{25\ \mu\text{A}} = \mathbf{812\ k\Omega}$

(c) $I_{C_Q} \cong \mathbf{3.4\ mA}$, $V_{CE_Q} \cong \mathbf{10.75\ V}$

(d) $\beta = \dfrac{I_C}{I_B} = \dfrac{3.4\text{ mA}}{25\ \mu\text{A}} = \mathbf{136}$

(e) $\alpha = \dfrac{\beta}{\beta+1} = \dfrac{136}{136+1} = \dfrac{136}{137} = \mathbf{0.992}$

(f) $I_{C_{\text{sat}}} = \dfrac{V_{CC}}{R_C} = \dfrac{21\text{ V}}{3\text{ k}\Omega} = \mathbf{7\ mA}$

(g) –

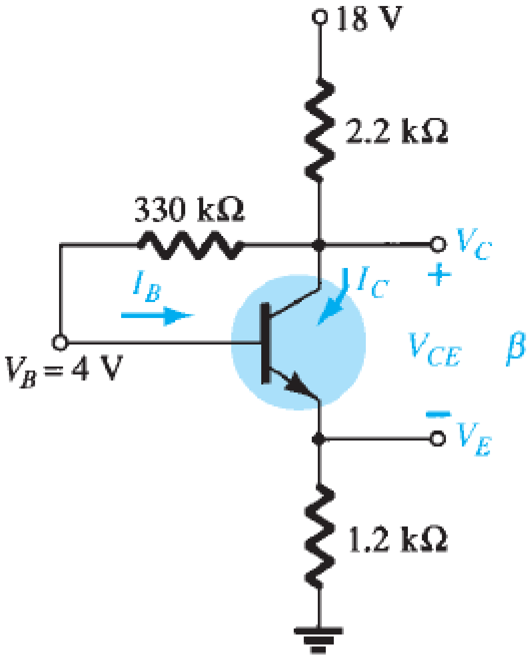
(h) $P_D = V_{CE_Q} I_{C_Q} = (10.75\text{ V})(3.4\text{ mA}) = \mathbf{36.55\ mW}$

(i) $P_s = V_{CC}(I_C + I_B) = 21\text{ V}(3.4\text{ mA} + 25\ \mu\text{A}) = \mathbf{71.92\ mW}$

(j) $P_R = P_s - P_D = 71.92\text{ mW} - 36.55\text{ mW} = \mathbf{35.37\ mW}$

2. Given $V_B = 4$ V for the network below , determine:

a. V_E.
b. I_C.
c. V_C.
d. V_{CE}.
e. I_B.
f. β.



ANSWER:

(a) $V_E = V_B - V_{BE} = 4\text{ V} - 0.7\text{ V} = \mathbf{3.3\ V}$

(b) $I_C \cong I_E = \dfrac{V_E}{R_E} = \dfrac{3.3\text{ V}}{1.2\text{ k}\Omega} = \mathbf{2.75\ mA}$

(c) $V_C = V_{CC} - I_C R_C = 18\text{ V} - (2.75\text{ mA})(2.2\text{ k}\Omega)$

$= \mathbf{11.95\ V}$

(d) $V_{CE} = V_C - V_E = 11.95\text{ V} - 3.3\text{ V} = \mathbf{8.65\ V}$

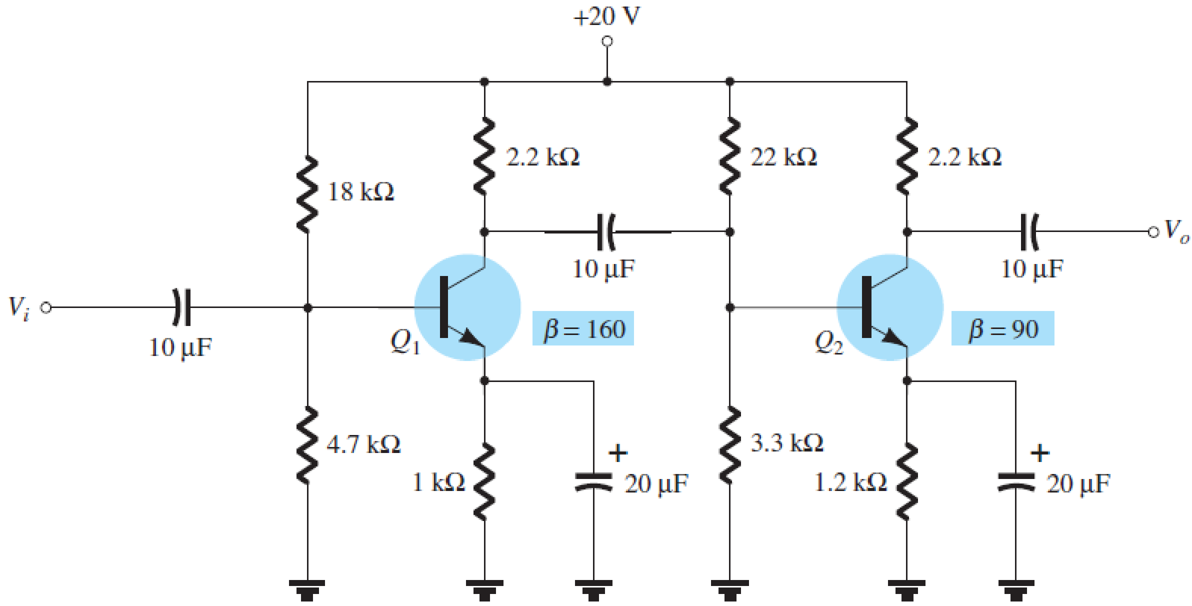
(e) $I_B = \dfrac{V_{R_B}}{R_B} = \dfrac{V_C - V_B}{R_B} = \dfrac{11.95\text{ V} - 4\text{ V}}{330\text{ k}\Omega} = \mathbf{24.09\ \mu A}$

(f) $\beta = \dfrac{I_C}{I_B} = \dfrac{2.75\text{ mA}}{24.09\ \mu\text{A}} = \mathbf{114.16}$

3. For the *R–C*-coupled amplifier of below determine

a. the voltages V_B, V_C, and V_E for each transistor.

b. the currents I_B, I_C, and I_E for each transistor



ANSWER:

(a)

$$V_{B_1} = \frac{4.7\text{ k}\Omega(20\text{ V})}{4.7\text{ k}\Omega + 18\text{ k}\Omega} = \mathbf{4.14\text{ V}}$$

$$V_{E_1} = 4.14\text{ V} - 0.7\text{ V} = \mathbf{3.44\text{ V}}$$

$$I_{C_1} \cong I_{E_1} = \frac{3.44\text{ V}}{1\text{ k}\Omega} = 3.44\text{ mA}$$

$$V_{C_1} = 20\text{ V} - (3.44\text{ mA})(2.2\text{ k}\Omega) = \mathbf{12.43\text{ V}}$$

$$V_{B_2} = \frac{3.3\text{ k}\Omega(20\text{ V})}{3.3\text{ k}\Omega + 22\text{ k}\Omega} = \mathbf{2.61\text{ V}}$$

$$V_{E_2} = 2.61\text{ V} - 0.7\text{ V} = \mathbf{1.91\text{ V}}$$

$$I_{E_2} \cong I_{C_2} = \frac{1.91\text{ V}}{1.2\text{ k}\Omega} = \mathbf{1.59\text{ mA}}$$

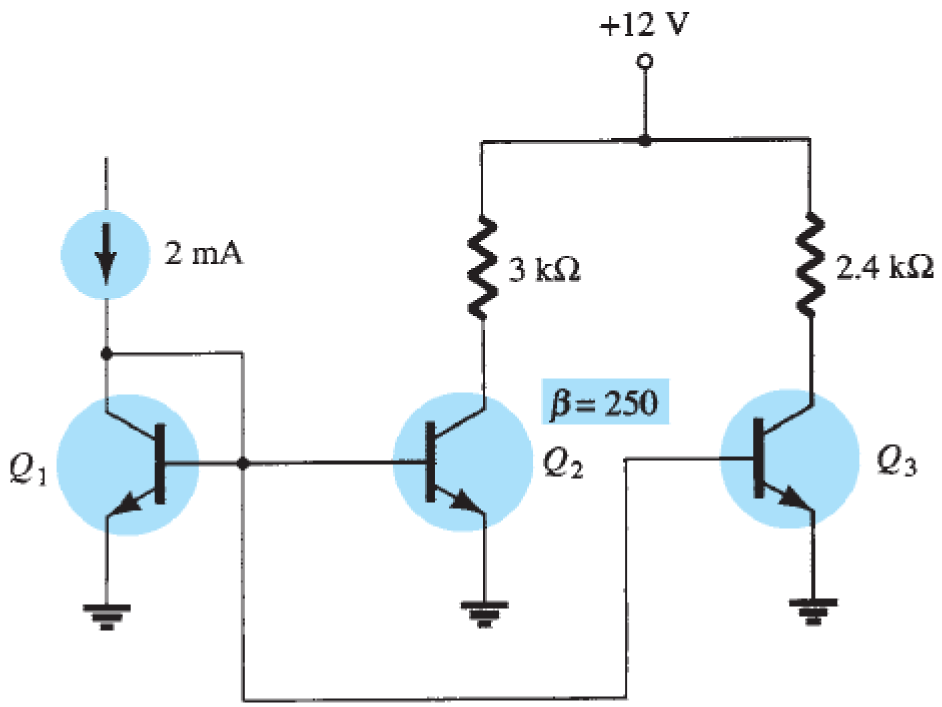
$$V_{C_2} = 20\text{ V} - (1.59\text{ mA})(2.2\text{ k}\Omega) = \mathbf{16.5\text{ V}}$$

(b)

$$I_{B_1} = \frac{I_{C_1}}{\beta} = \frac{3.44\text{ mA}}{160} = \mathbf{21.5\ \mu A},\ I_{C_1} \cong I_{E_1} = \mathbf{3.44\text{ mA}}$$

$$I_{B_2} = \frac{I_{C_2}}{\beta} = \frac{1.59\text{ mA}}{90} = \mathbf{17.67\ \mu A},\ I_{C_2} \cong I_{E_2} = \mathbf{1.59\text{ mA}}$$

4. Calculate collector currents for Q_1 and Q_2 in figure below



ANSWER:

For current mirror:

$$I(3\ \text{k}\Omega) = I(2.4\ \text{k}\Omega) = I = 2\ \text{mA}$$

5. Answer the following questions about the circuit below :

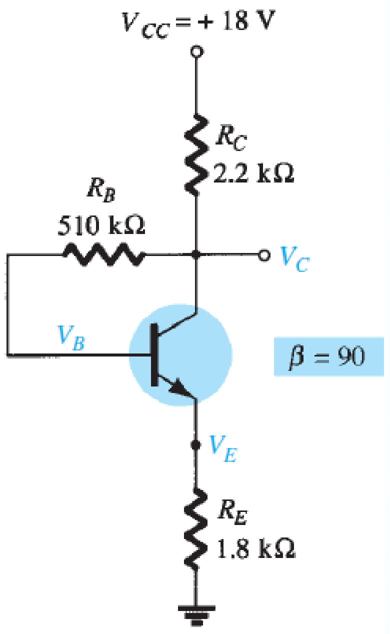
a. What happens to the voltage V_C if the resistor R_B is open?

b. What should happen to V_{CE} if b increases due to temperature?

c. How will V_E be affected when replacing the collector resistor with one whose resistance is at the lower end of the tolerance range?

d. If the transistor collector connection becomes open, what will happen to V_E ?

e. What might cause V_{CE} to become nearly 18 V?



ANSWER:

(a) R_B open, $I_B = 0\ \mu$A, $I_C = I_{CEO} \cong 0$ mA
and $V_C \cong V_{CC} = \mathbf{18\ V}$

(b) $\beta\uparrow$, $I_C\uparrow$, $V_{R_C}\uparrow$, $V_{R_E}\uparrow$, $V_{CE}\downarrow$

(c) $R_C\downarrow$, $I_B\uparrow$, $I_C\uparrow$, $V_E\uparrow$

(d) Drop to a relatively low voltage $\cong 0.06$ V

(e) Open in the base circuit