EEE-2103: Electronic Devices and Circuits

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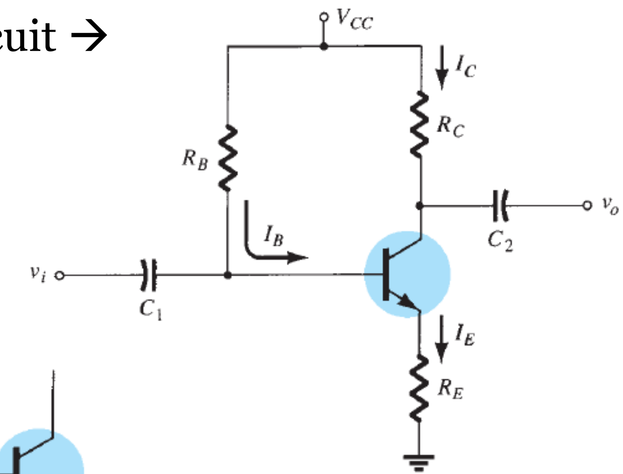
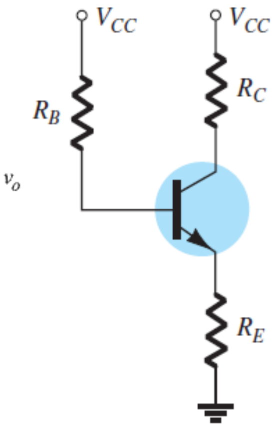
Emitter Bias Configuration

Emitter bias configuration and its dc equivalent circuit →





Base-Emitter loop →

$+V_{CC} - I_B R_B - V_{BE} - I_E R_E = 0$

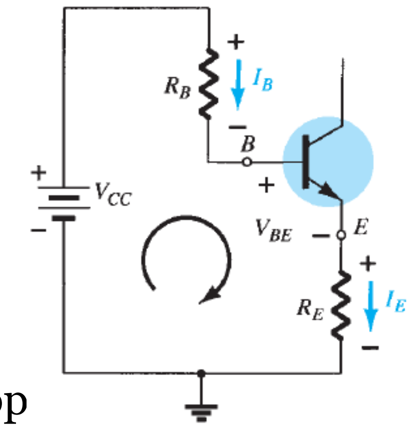
$I_E = (\beta+1) I_B$

$V_{CC} - I_B R_B - V_{BE} - (\beta+1) I_B R_E = 0$

$-I_B(R_B + (\beta+1)R_E) + V_{CC} - V_{BE} = 0$

$I_B(R_B + (\beta+1)R_E) = V_{CC} - V_{BE}$

$$I_B = \frac{V_{CC} - V_{BE}}{R_B + (\beta+1)R_E}$$



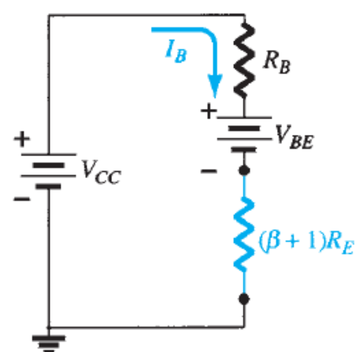
R_E → part of *CE* loop

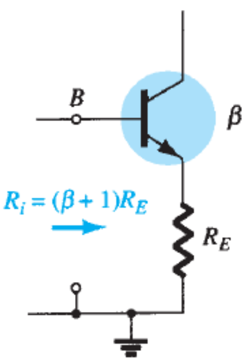
appears as $(\beta+1)R_E$ in *BE* loop

$R_i = (\beta+1)R_E$

Net voltage = $V_{CC} - V_{BE}$

Resistance = $R_B + (\beta+1)R_E$





Emitter Bias Configuration

Collector-Emitter loop →

$$+I_E R_E + V_{CE} + I_C R_C - V_{CC} = 0$$

$$I_E \approx I_C$$

$$V_{CE} - V_{CC} + I_C(R_C + R_E) = 0$$

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

$$V_E = I_E R_E$$

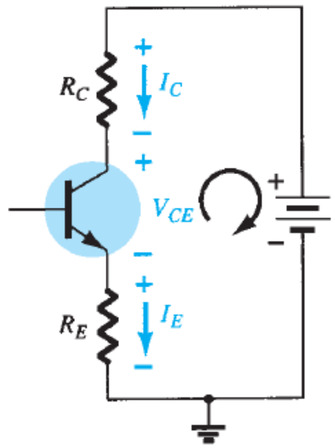
$$V_{CE} = V_C - V_E$$

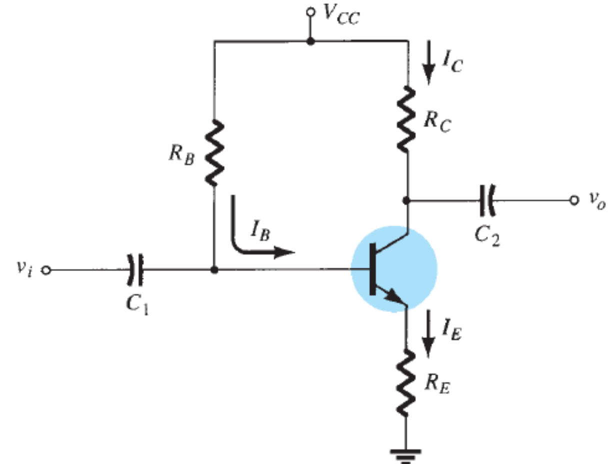
$$V_C = V_{CE} + V_E$$

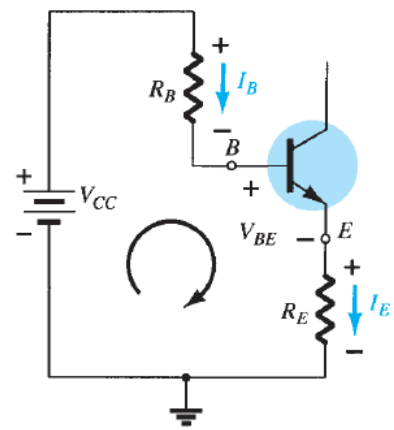
$$V_C = V_{CC} - I_C R_C$$

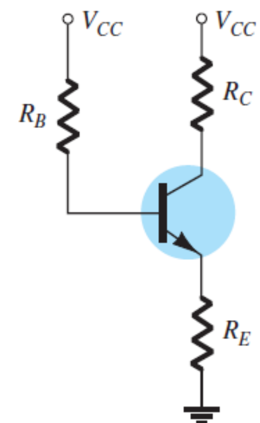
$$V_B = V_{CC} - I_B R_B$$

$$V_B = V_{BE} + V_E$$



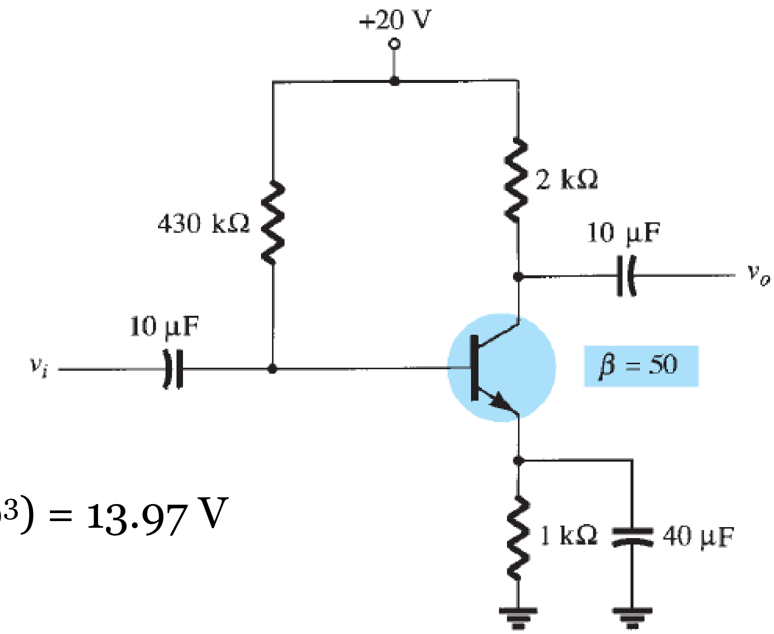






Emitter Bias Configuration

Problem-24:
For the emitter-bias network of Fig. 24, determine
a) I_B. b) I_C. c) V_{CE}. d) V_C. e) V_E. f) V_B. g) V_{BC}.



a) $I_B = \dfrac{V_{CC}-V_{BE}}{R_B+(\beta+1)R_E} = \dfrac{20-0.7}{430\times10^3+(50+1)1\times10^3} = 40.1\ \mu A$

b) $I_C = \beta I_B = (50)(40.1\times10^{-6}) = 2.01\text{ mA}$

c) $V_{CE} = V_{CC} - I_C(R_C + R_E) = 20 - (2.01\times10^{-3})(2\times10^3 + 1\times10^3) = 13.97\text{ V}$

d) $V_C = V_{CC} - I_C R_C = 20 - (2.01\times10^{-3})(2\times10^3) = 15.98\text{ V}$

e) $V_E = V_C - V_{CE} = 15.98 - 13.97 = 2.01\text{ V}$

f) $V_B = V_{BE} + V_E = 0.7 + 2.01 = 2.71\text{ V}$

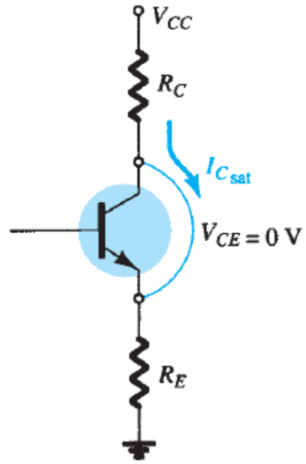
g) $V_{BC} = V_B - V_C = 2.71 - 15.98 = -13.27\text{ V}$

<u>**Emitter Bias Configuration**</u>

Saturation level →

Collector saturation level = max I_C

$$I_{Csat} = \frac{V_{CC}}{R_C + R_E}$$



Load line analysis →

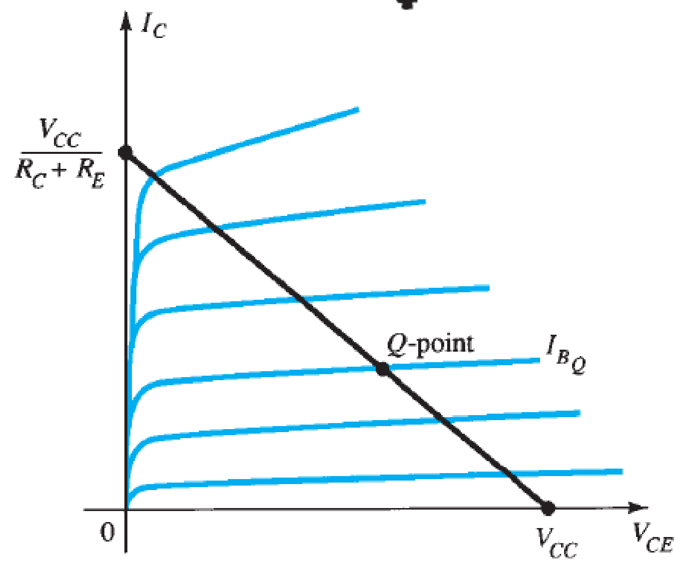
$$V_{CE} = V_{CC} - I_C(R_C + R_E)$$

$I_C = 0$ →

$$V_{CE} = V_{CC}$$

$V_{CE} = 0$ →

$$I_C = \frac{V_{CC}}{R_C + R_E}$$



Emitter Bias Configuration

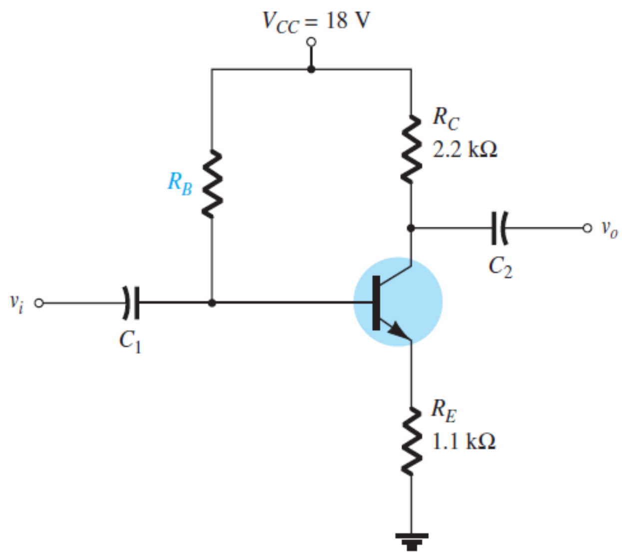
Problem-25:

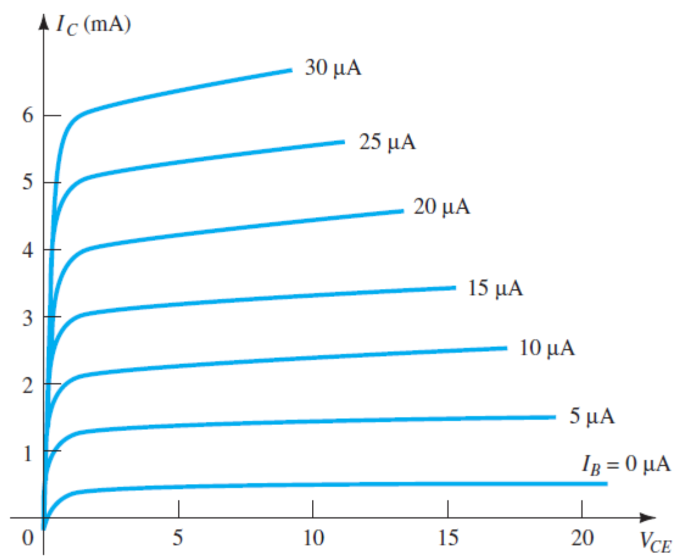
a) Draw the load line for the network of Fig. 25(a) on the characteristics for the transistor appearing in Fig. 25(b).

b) For a Q-point at the intersection of the load line with a base current of 15 µA , find the values of I_{CQ} and V_{CEQ}.

c) Determine the dc beta at the Q-point.

d) Using the beta for the network determined in part c, calculate the required value of R_B and suggest a possible standard value.





Emitter Bias Configuration

Problem-25:

a) At V_{CE} = 0 V: $I_C = \frac{V_{CC}}{R_C + R_E} = \frac{18}{2.2\times10^3 + 1.1\times10^3} = 5.45$ mA

At I_C = 0 mA: $V_{CE} = V_{CC}$ = 18 V

Resulting load line appears in Fig. 25(c).

b) $V_{CEQ} \approx$ 7.5 V, $I_{CQ} \approx$ 3.3 mA

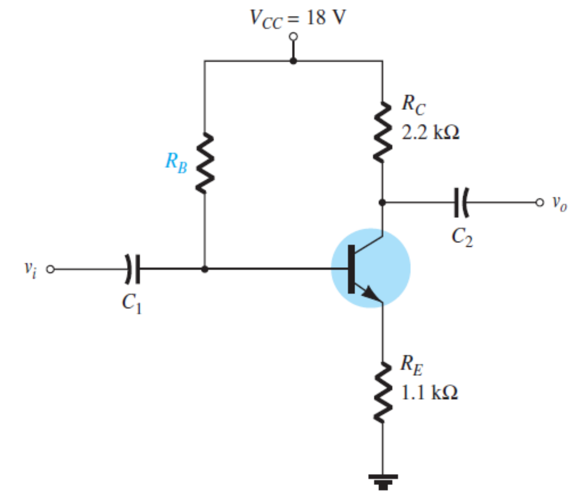
c) $\beta = I_{CQ}/I_{BQ} = 3.3\times10^{-3}/15\times10^{-6} = 220$

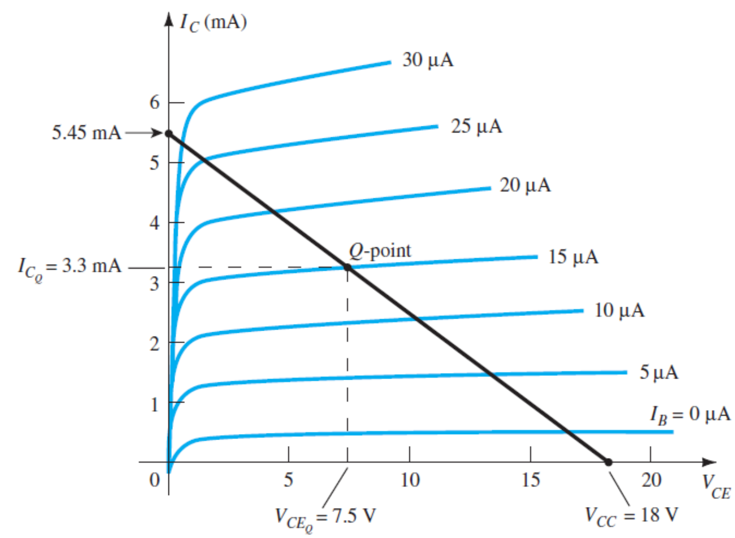
d) $I_B = \frac{V_{CC} - V_{BE}}{R_B + (\beta+1)R_E} = \frac{18 - 0.7}{R_B + (220+1)1.1\times10^3} = 15\times10^{-6}$

$15\times10^{-6}R_B + (15\times10^{-6})(243.1\times10^3) = 17.3$

$15\times10^{-6}R_B = 13.65$

$R_B = 13.65/15\times10^{-6} = 910$ kΩ

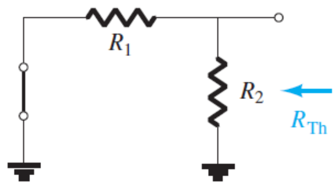




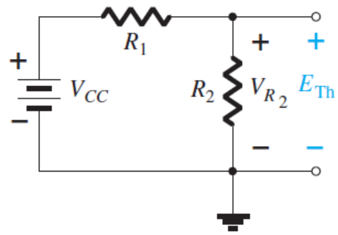
Voltage Divider Bias Configuration

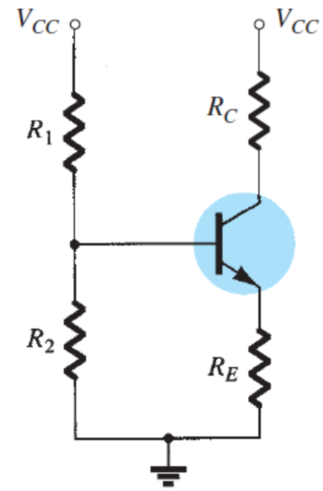
Exact analysis:

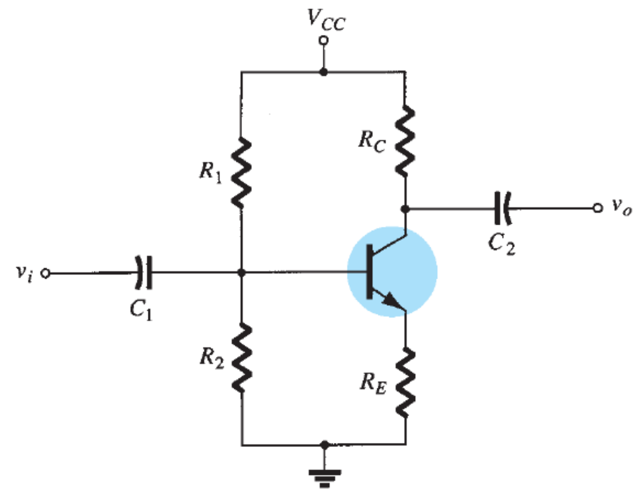
$R_{Th} = R_1 || R_2$

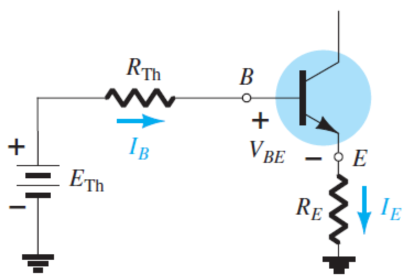


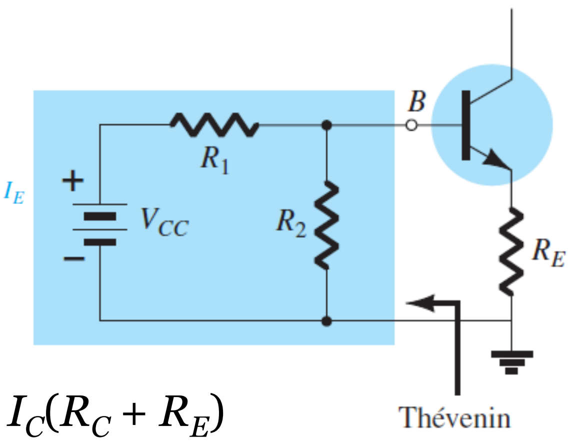
$$E_{Th} = V_{R2} = \frac{R_2 V_{CC}}{R_1 + R_2}$$

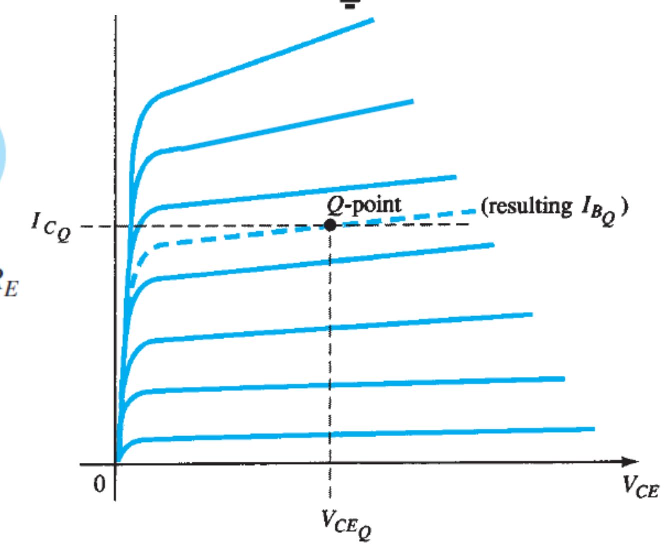












$E_{Th} - I_B R_{Th} - V_{BE} - I_E R_E = 0$

$I_E = (\beta + 1) I_B$

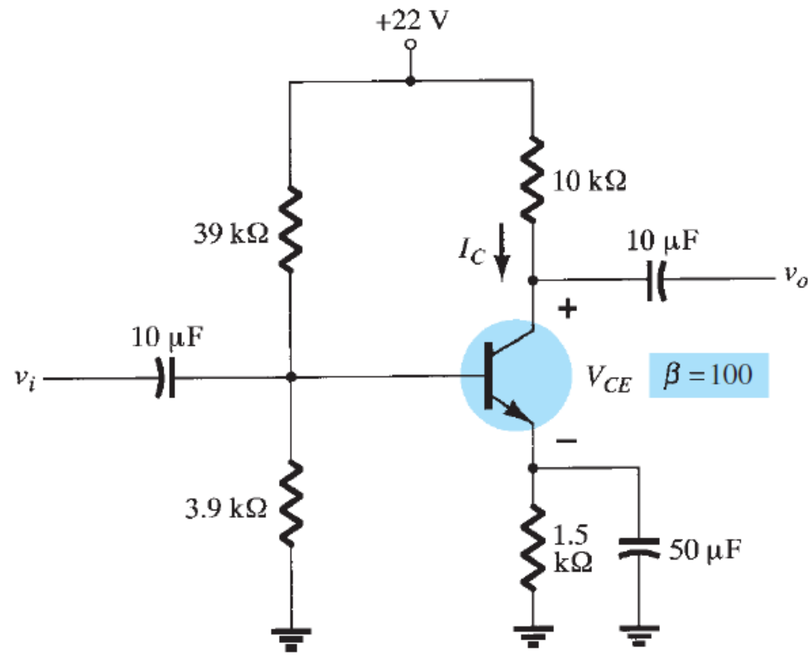
$$I_B = \frac{E_{Th} - V_{BE}}{R_{Th} + (\beta+1) R_E}$$

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

Voltage Divider Bias Configuration

Problem-26:

Determine the dc bias voltage V_{CE} and the current I_C for the voltage divider configuration of Fig. 26.



$$R_{Th} = R_1 \parallel R_2 = \frac{(39\times10^3)(3.9\times10^3)}{39\times10^3+3.9\times10^3} = 3.55\text{ k}\Omega$$

$$E_{Th} = V_{R2} = \frac{R_2V_{CC}}{R_1+R_2} = \frac{(3.9\times10^3)(22)}{39\times10^3+3.9\times10^3} = 2\text{ V}$$

$$I_B = \frac{E_{Th}-V_{BE}}{R_{Th}+(\beta+1)R_E} = \frac{2-0.7}{3.55\times10^3+(101)(1.5\times10^3)} = 8.38\ \mu\text{A}$$

$$I_{CQ} = \beta I_B = (100)(8.38\times10^{-6}) = 0.84\text{ mA}$$

$$\begin{aligned} V_{CEQ} &= V_{CC} - I_C(R_C + R_E) \\ &= 22 - (0.84\times10^{-3})(10\times10^3 + 1.5\times10^3) \\ &= 12.34\text{ V} \end{aligned}$$