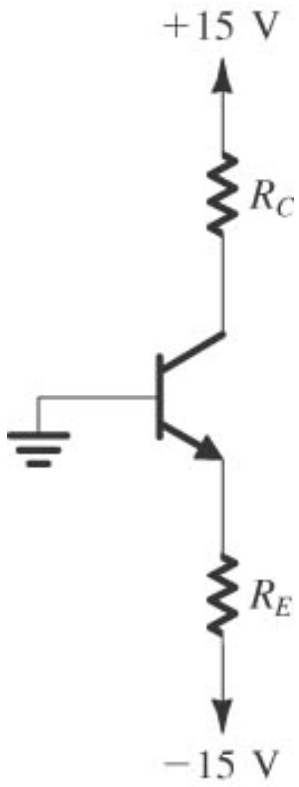
Lect. 11: BJT Circuits at DC



β=100, $v_{BE,ON}$=0.7V, $V_{CE,sat}$ =0.3V.
Design the circuit so that I_C=2mA and V_C=5V in the active region.

(1) What is R_c?

(2) What is I_E?

(3) What is V_E?

(4) What is R_E?

(5) Is it in active region?

(1) $R_C = \dfrac{10\ \text{V}}{2\ \text{mA}} = 5\ \text{k}\Omega$

(2) $I_E = I_B + I_C = \dfrac{2}{100} + 2 = 2.02\ \text{mA}$

(3) $V_E = -0.7V$

(4) $R_E = \dfrac{V_E - (-15)}{2.02} = 7.08\ \text{k}\Omega$

(5) $V_{CE} = 5 - (-0.7) = 5.7 > V_{CE,sat}$

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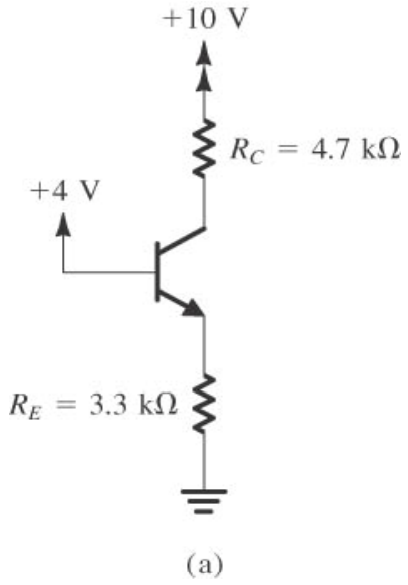
Using $V_{BE,ON}$=0.7V, β = 100, $V_{CE,sat}$=0.2V



1. V_E = ?
2. I_E = ?
3. I_C= ?
4. V_C=?
5. I_B=?

$$V_E = 4 - V_{BE} = 4 - 0.7 = 3.3\ \text{V}$$

$$I_E = \frac{V_E - 0}{R_E} = \frac{3.3}{3.3} = 1\ \text{mA}$$

$$I_C = \alpha I_E$$

$$\alpha = \frac{\beta}{\beta + 1} = \frac{100}{101} \sim 0.99$$

$$I_C = 0.99 \times 1 = 0.99\ \text{mA}$$

$$V_C = 10 - I_C R_C = 10 - 0.99 \times 4.7 \sim 5.3\ \text{V}$$

$$I_B = \frac{I_E}{\beta + 1} = \frac{1}{101} \sim 0.01\ \text{mA}$$

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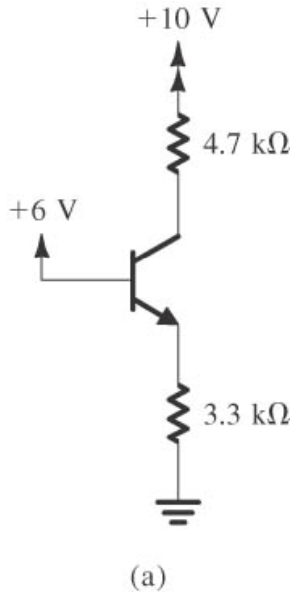
Using $V_{BE,ON}$=0.7V, β = 100, $V_{CE,sat}$=0.2V



(a)

1. V_E = ?
2. V_C=?
3. I_B=?

$$V_E = +6 - V_{BE} = 6 - 0.7 = 5.3 \text{ V}$$

$$I_E = \frac{5.3}{3.3} = 1.6 \text{ mA}$$

$$V_C = 10 - 4.7 \times I_C = 10 - 7.52 = 2.48 \text{ V}$$

V_{CE} = 2.48-5.3= -2.82 **(not possible)**

$$V_C \sim V_E + V_{CEsat} = 5.3 + 0.2 = +5.5 \text{ V}$$

$$I_C = \frac{+10 - 5.5}{4.7} = 0.96 \text{ mA}$$

$$I_B = I_E - I_C = 1.6 - 0.96 = 0.64 \text{ mA}$$

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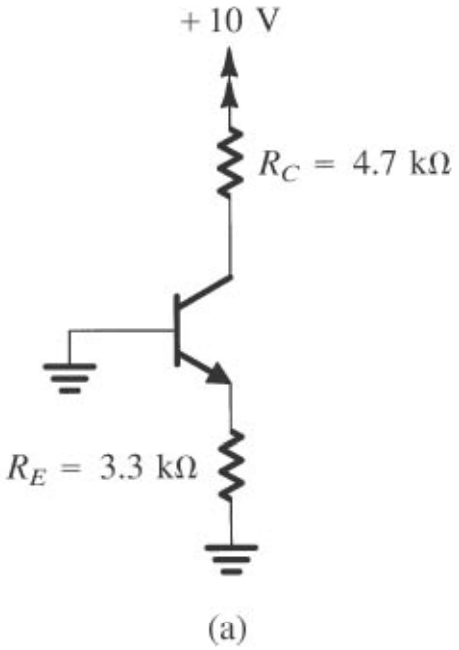

(a)

1. V_E = ?

2. V_C=?

3. I_B, I_C, I_E=?

Transistor is cut-off!

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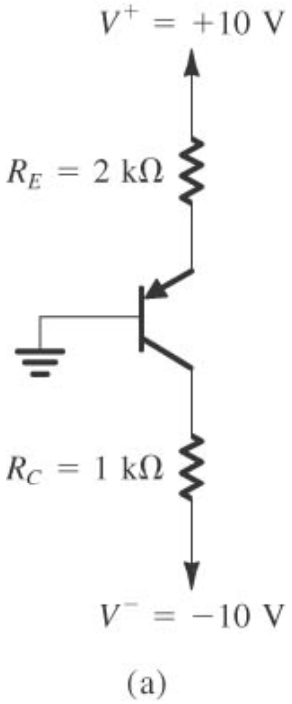

(a)

β=100

1. V_E = ?
2. I_C=?
3. V_C=?
4. I_B=?

$$V_E = V_{EB} = 0.7 \text{ V}$$

$$I_E = \frac{V^+ - V_E}{R_E} = \frac{10 - 0.7}{2} = 4.65 \text{ mA}$$

$$I_C = \alpha I_E = 0.99 \times 4.65 = 4.6 \text{ mA}$$

$$V_C = V^- + I_C R_C$$
$$= -10 + 4.6 \times 1 = -5.4 \text{ V}$$

$$I_B = \frac{I_E}{\beta + 1} = \frac{4.65}{101} = 0.05 \text{ mA}$$

$$V_{EC} = 0.7 - (-5.4) > V_{EC,sat}$$

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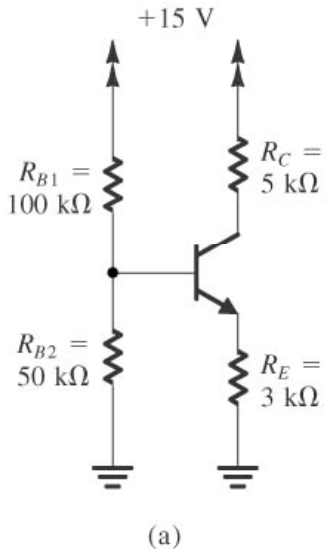


(a)

β=100

1. I_E = ?
2. V_C=?

$$V_{BB} = +15\frac{R_{B2}}{R_{B1}+R_{B2}} = 15\frac{50}{100+50} = +5\ \text{V}$$

$$R_{BB} = (R_{B1} \,//\, R_{B2}) = (100\,//\,50) = 33.3\ \text{k}\Omega$$

$$V_{BB} = I_B R_{BB} + V_{BE} I_E R_E$$

$$I_B = \frac{I_E}{\beta+1}$$

$$I_E = \frac{V_{BB}-V_{BE}}{R_E + [R_{BB}/(\beta+1)]}$$

$$I_E = \frac{5-0.7}{3+(33.3/101)} = 1.29\ \text{mA}$$

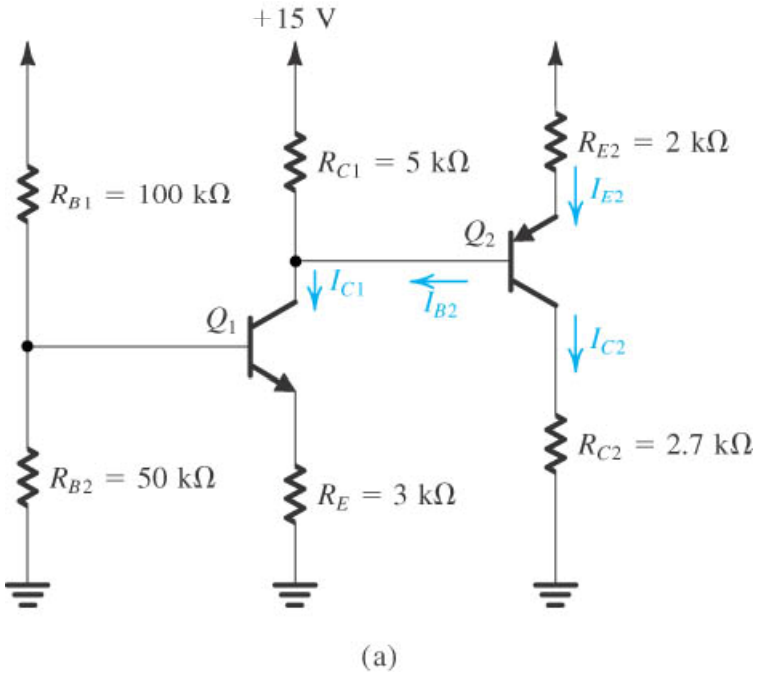
$$I_C = \alpha I_E = 1.28\ \text{mA}$$

$$V_C = +15 - I_C R_C = 15 - 1.28\times 5 = 8.6\ \text{V}$$

$$I_B = \frac{1.29}{101} = 0.0128\ \text{mA}$$

$$V_B = V_{BE} + I_E R_E = 0.7 + 1.29\times 3 = 4.57\ \text{V}$$

$$V_E = V_B - V_{BE} = 4.57 - 0.7 = 3.87\ \text{V}$$



(a)

β=100

1. $V_{C,1}$=?
2. I_{B2} =?

Ignoring I_{B2}

$$V_{C1} = +15 - I_{C1}R_{C1}$$
$$= 15 - 1.28 \times 5 = +8.6 \text{ V}$$

$$V_{E2} = V_{C1} + V_{EB}\big|_{Q_2} = 8.6 + 0.7 = +9.3 \text{ V}$$

$$I_{E2} = \frac{+15 - V_{E2}}{R_{E2}} = \frac{15 - 9.3}{2} = 2.85 \text{ mA}$$

$$I_{B2} = \frac{I_{E2}}{\beta_2 + 1} = \frac{2.85}{101} = 0.028 \text{ mA}$$

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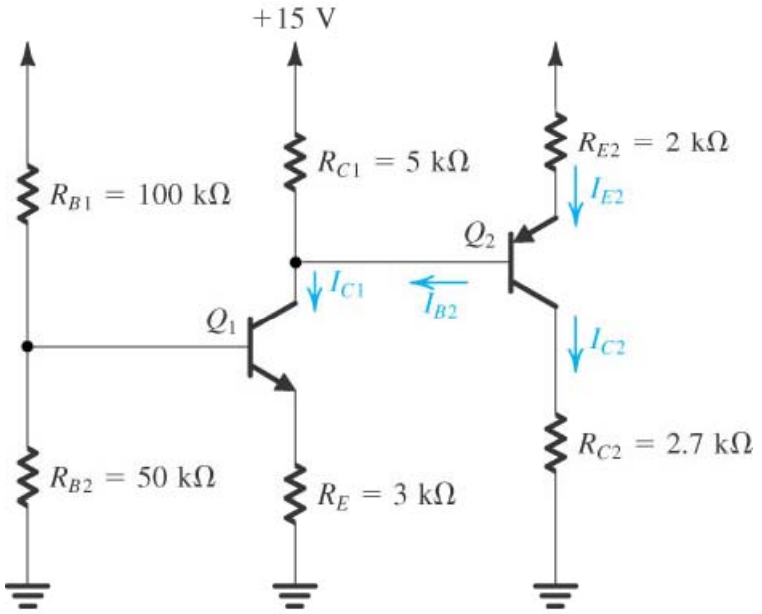

β=100

1. $V_{C,1}$=?
2. I_{B2} =?

Considering I_{B2},

Does V_{C1} go up or down?

Current in $R_{C1} = I_{C1} - I_{B2} = 1.28 - 0.028 = 1.252$ mA

$$\mathbf{V_{C1} = 15 - 5 \times 1.252 = 8.74\ V}$$ (Before, 8.6V)

$$\mathbf{V_{E2} = 8.74 + 0.7 = 9.44\ V}$$

$$\mathbf{I_{E2} = \frac{15 - 9.44}{2} = 2.78 mA}$$

$$\mathbf{I_{B2,new} = \frac{2.78}{101} = 0.0275\ mA}$$ (Before, 0.028mA)