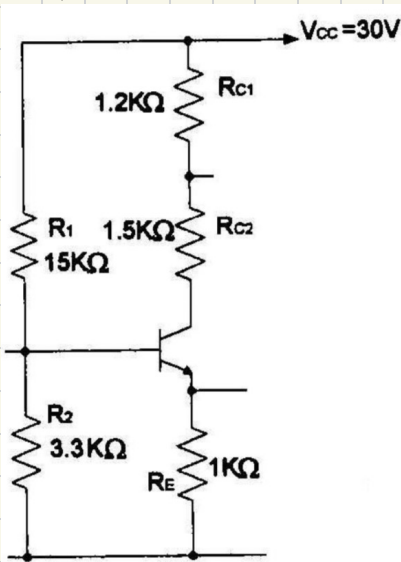


1.

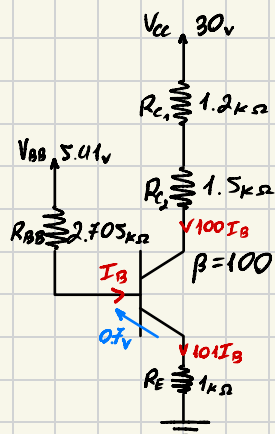


$$V_{BE} = 0.7V$$

$$\beta = 100$$

$$R_{BB} = R_1 \parallel R_2 = 15 \parallel 3.3 = 2.705 k\Omega$$

$$V_{BB} = U_{R_2} = V_{CC} \cdot \frac{R_2}{R_1 + R_2} = 30 \cdot \frac{3.3}{18.3} = 5.41V$$



$$V_{BB} = U_{R_{BB}} + V_{BE} + U_{RE} = 2.705 I_B + 0.7 + 101 \cdot 1 I_B = 5.41$$

$$103.705 I_B = 4.71 \Rightarrow I_B = 45.417 \cdot 10^{-3} mA$$

$$I_C = 100 I_B = 100 \cdot 45.417 \cdot 10^{-3} mA$$

$$I_C = 4.542 mA$$

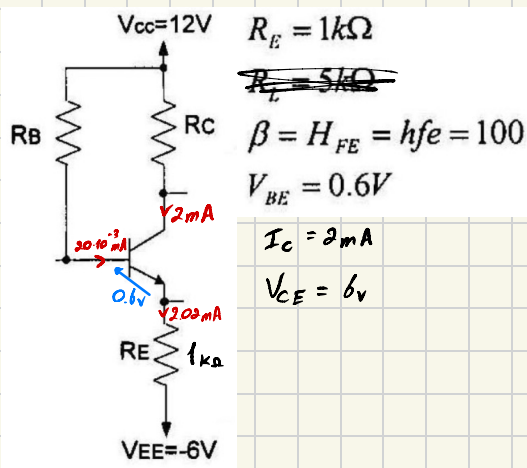
$$V_{CC} = U_{R_{c1}} + U_{R_{c2}} + V_{CE} + U_{RE}$$

$$30 = 100 I_B \cdot 1.2 + 100 I_B \cdot 1.5 + V_{CE} + 101 I_B \cdot 1$$

$$V_{CE} = 13.15V$$

$$(4.542 mA, 13.15V)$$

2.



$$R_E = 1k\Omega$$

$$\cancel{R_E = 5k\Omega}$$

$$\beta = H_{FE} = h_{fe} = 100$$

$$V_{BE} = 0.6V$$

$$I_C = 2mA$$

$$V_{CE} = 6V$$

$$K. \quad V_{CC} - V_{EE} = U_{RB} + V_{BE} + U_{RE}$$

$$I_B = \frac{I_C}{\beta} = \frac{2mA}{100} = 20 \cdot 10^{-3} mA$$

$$12 + 6 = 20 \cdot 10^{-3} R_B + 0.6 + 2.02 \cdot 1$$

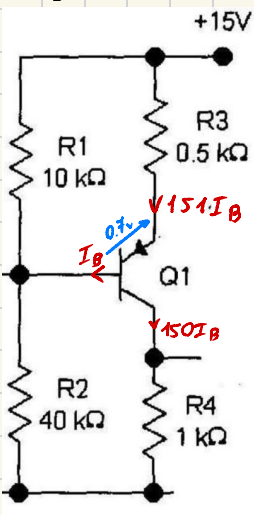
$$R_B = \frac{18 - 0.6 - 2.02}{20 \cdot 10^{-3}} \quad R_B = 0.769 k\Omega$$

$$V_{CC} - V_{EE} = U_{RC} + V_{CE} + U_{RE}$$

$$12 + 6 = 2 \cdot R_C + 6 + 2.02$$

$$R_C = 5k\Omega$$

3.



$$\beta = 150$$

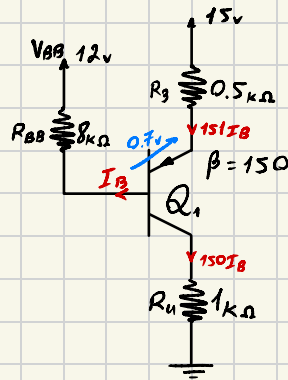
$$h_{fe} = 150$$

$$h_{ie} = 1\text{k}\Omega$$

$$V_{be} = 0.7\text{V}$$

$$R_{BB} = R_2 || R_1 = 40 || 10 = 8\text{k}\Omega$$

$$V_{BB} = U_{R_2} = 15 \cdot \frac{R_2}{R_1 + R_2} = 15 \cdot \frac{40}{50} = 12\text{V}$$



$$15 - V_{BB} = U_{R_3} + V_{EB} + U_{R_{BB}}$$

$$15 - 12 = 0.5 \cdot 151 I_B + 0.7 + 8 I_B$$

$$I_B = 27 \cdot 10^{-3} \text{mA} \quad I_C = 150 I_B$$

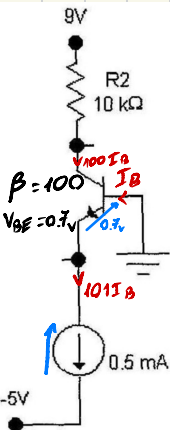
$$I_C = 4.132 \text{mA}$$

$$15 - 0 = U_{R_3} + V_{EC} + U_{R_E}$$

$$15 = 0.5 \cdot 151 I_B + V_{EC} + 1 \cdot 150 I_B \Rightarrow V_{EC} = 8.912\text{V}$$

$$(4.132 \text{mA}, 8.912\text{V})$$

4.



$$I_B = \frac{101 I_B}{101} = \frac{0.5}{101}$$

$$I_B = 4.95 \cdot 10^{-3} \text{mA}$$

$$I_C = 100 I_B$$

$$I_C = 0.495 \text{mA}$$

$$(0.495 \text{mA}, 4.75\text{V}) \Rightarrow 2.12\text{V}$$

$$0 - (-5) = V_{BE} - U_I$$

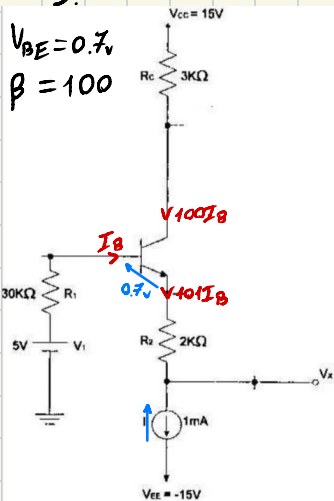
$$5 = 0.7 + U_I$$

$$U_I = 4.3\text{V}$$

$$9 - (-5) = U_{R_2} + V_{CE} + U_I$$

$$14 = 10 \cdot 100 I_B + V_{CE} + 4.3 \Rightarrow V_{CE} = 4.75\text{V}$$

5.



$$101 I_B = 1\text{mA}$$

$$I_B = 9.9 \cdot 10^{-3} \text{mA}$$

$$V_{CC} - V_X = U_{R_C} + V_{CE} + U_{R_2}$$

$$\Rightarrow 15 - 2.003 = 3 \cdot 100 I_B + V_{CE} + 2 \cdot 101 I_B$$

$$V_I - V_{EE} = U_{R_1} + V_{BE} + U_{R_2} + U_I$$

$$V_{CE} = 8.027\text{V}$$

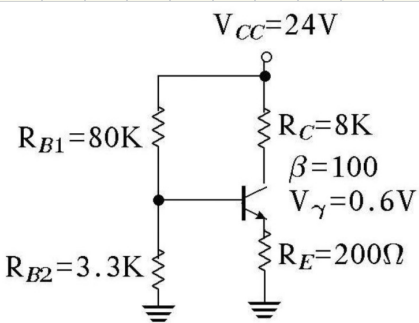
$$5 + 15 = 30 I_B + 0.7 + 2 \cdot 101 I_B + U_I$$

$$U_I = 17.003\text{V}$$

$$U_I = V_X - V_{EE}$$

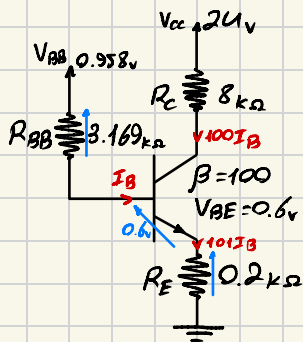
$$V_X = U_I + V_{EE} = 17.003 - 15$$

$$V_X = 2.003\text{V}$$



$$K. R_{BB} = R_{B_1} \parallel R_{B_2} = 80 \parallel 9.3 = 3.169 k\Omega$$

$$V_{BB} = U_{R_{B_2}} = U_{CC} \cdot \frac{R_{B_2}}{R_{B_1} + R_{B_2}} = 24 \cdot \frac{3.3}{83.3} = 0.958 \text{ V}$$



$$V_{BB-0} = U_{R_{BB}} + V_{BE} + U_{R_E}$$

$$0.958 = 3.169 I_B + 0.6 + 0.2 \cdot 10 I_B$$

$$I_B = 15.32 \cdot 10^{-3} \text{ mA}$$

$$I_C = 100 I_B \Rightarrow I_C = 1.532 \text{ mA}$$

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

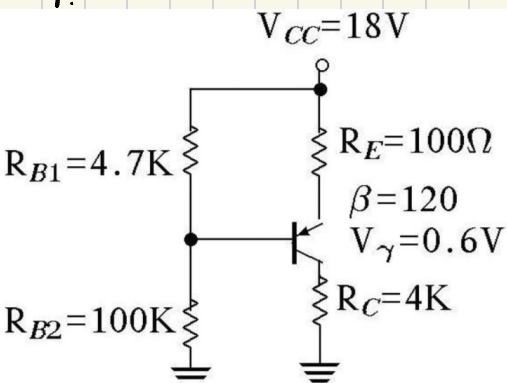
$$24 = 8 \cdot 100 I_B + V_{CE} + 0.2 \cdot 10 I_B$$

$$V_{CE} = 8.027_v$$

$$(1.532 \text{ mA}, 8.027 \text{ V}) \rightarrow 2128 \text{ J}$$

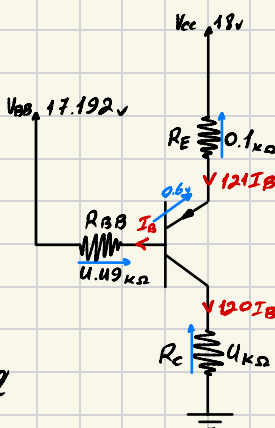
מטרת הנסך RE היא
לנוסח את המפרטות
הנכס כק β - ϵ תשתנה.

7.



$$K. R_{BB} = R_{B1} \parallel R_{B2} = 4.7 \parallel 100 = 4.49 k\Omega$$

$$V_{BB} = U_{RB_2} = V_{CC} \cdot \frac{R_{B_2}}{R_{B_1} + R_{B_2}} = 18 \cdot \frac{100}{104.7} = 17.192 \text{ V}$$



$$V_{CC} - V_{BB} = V_{RE} + V_{EB} + V_{RBB}$$

$$18 - 17.192 = 0.1 \cdot 121 I_B + 0.7 + 4.49 I_B$$

$$I_B = 6.51 \cdot 10^{-3} \text{ mA}$$

$$I_C = 120 I_B \Rightarrow I_C = 0.781 \text{ mA}$$

$$V_{CC} - 0 = U_{R_E} + V_{EB} + U_{R_C}$$

$$18 = 0.1 \cdot 121 I_B + V_{EB} + 4 \cdot 120 I_B$$

$$V_{EB} = 14.875_v$$

ד' 2821 (14.875V, 0.781mA)

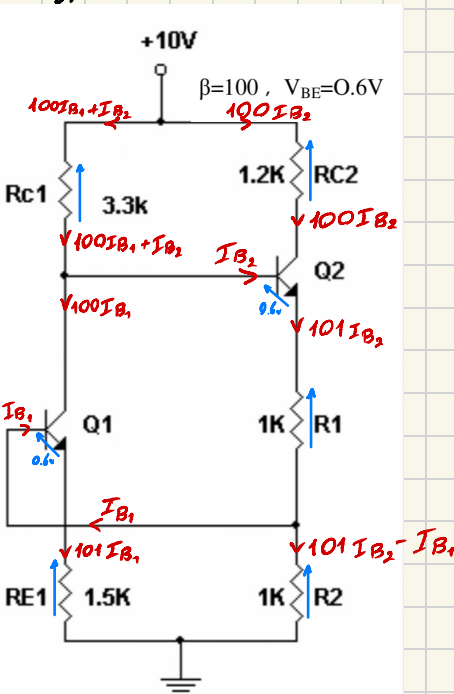
2. $R_B \uparrow \Rightarrow V_{BE} \downarrow, I_C \uparrow$ fine tuning
 $R_B \downarrow \Rightarrow V_{BE} \uparrow, I_C \downarrow$

$R_{B2} \uparrow \Rightarrow V_{BE} \uparrow, I_c \downarrow$ tuning
 $R_{B2} \downarrow \Rightarrow V_{BE} \downarrow, I_c \downarrow$

$R_c \uparrow \Rightarrow V_{BE} \downarrow, I_c \downarrow$
 $R_c \downarrow \Rightarrow V_{BE} \uparrow, I_c \uparrow$

$\beta \nearrow \Rightarrow V_{BE} \downarrow, I_C \nearrow$
 $\beta \searrow \Rightarrow V_{BE} \downarrow, I_C \searrow$

8.

 $Q_1:$

$$U_{R_2} - 0 = V_{BE} + U_{RE_1}$$

$$1 \cdot (101 I_{B_2} - I_{B_1}) = 0.6 + 1.5 \cdot 101 I_{B_1}$$

$$152.5 I_{B_1} - 101 I_{B_2} = -0.6$$

 $Q_2:$

$$10 = U_{RC_1} + V_{BE} + U_{R_1} + U_{R_2}$$

$$10 = 3.3(100 I_{B_1} + I_{B_2}) + 0.6 + 1 \cdot 101 I_{B_2} + 1(101 I_{B_2} - I_{B_1})$$

$$10 = 203.3 I_{B_2} + 329 I_{B_1} + 0.6$$

$$329 I_{B_1} + 205.3 I_{B_2} = 9.4$$

$$\begin{pmatrix} 152.5 & -101 \\ 329 & 205.3 \end{pmatrix} \begin{pmatrix} I_{B_1} \\ I_{B_2} \end{pmatrix} = \begin{pmatrix} -0.6 \\ 9.4 \end{pmatrix}$$

$$I_{B_1} = 12.8 \cdot 10^{-3} \text{ mA}$$

$$I_{B_2} = 25 \cdot 10^{-3} \text{ mA}$$

$$I_{C_1} = 12.8 \cdot 10^{-3} \cdot 100 = 1.28 \text{ mA}$$

$$I_{C_2} = 25 \cdot 10^{-3} \cdot 100 = 2.5 \text{ mA}$$

 $Q_1:$

$$10 = U_{RC_1} + V_{CE} + U_{RE_1} \Rightarrow 10 = 3.3(100 I_{B_1} + I_{B_2}) + V_{CE_1} + 1.5 \cdot 101 I_{B_1}$$

$$V_{CE_1} = 3.753 \text{ V}$$

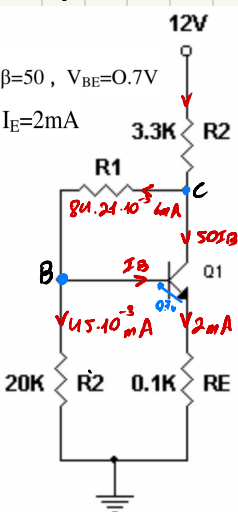
$$10 = U_{RC_2} + V_{CE_2} + U_{R_1} + U_{R_2} \Rightarrow 10 = 1.2 \cdot 100 I_{B_2} + V_{CE_2} + 1 \cdot 101 I_{B_2} + 1(101 I_{B_2} - I_{B_1})$$

$$V_{CE_2} = 1.97 \text{ V}$$

$$Q_1(1.28 \text{ mA}, 3.753 \text{ V})$$

$$Q_2(2.5 \text{ mA}, 1.97 \text{ V})$$

9.



$$I_B = \frac{I_E}{\beta + 1} = \frac{2}{51} = 39.216 \cdot 10^{-3} \text{ mA}$$

$$V_B = V_{BE} + U_{RE} = 0.7 + 0.1 \cdot 2$$

$$V_B = 0.9 \text{ V}$$

$$I_{R_2} = \frac{V_C}{R_2} = \frac{0.9}{20} = 45 \cdot 10^{-3} \text{ mA}$$

$$I_{R_2} = I_{R_1} + I_C = 50 I_B + I_B + 45 \cdot 10^{-3} = 2.069 \text{ mA}$$

$$V_C = V_{CC} - U_{R_2} = V_{CC} - I_{R_2} \cdot R_2 = 12 - 2.069 \cdot 3.3$$

$$V_C = 5.173 \text{ V}$$

$$U_{R_1} = V_C - V_B = 5.173 - 0.9 = 4.273 \text{ V}$$

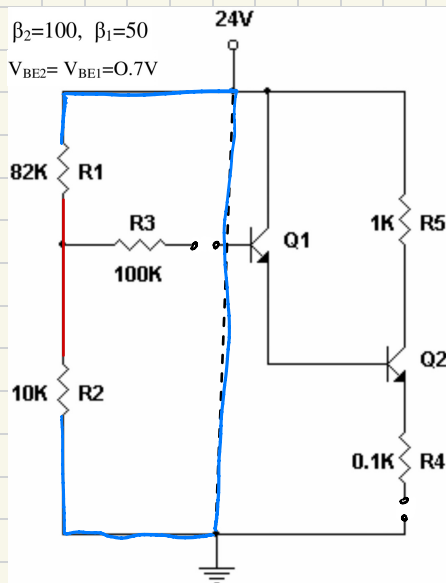
$$R_1 = \frac{U_{R_1}}{I_1} = \frac{4.273}{84.21 \cdot 10^{-3}}$$

$$R_1 = 50.748 \text{ k}\Omega$$

10.

$$\beta_2=100, \beta_1=50$$

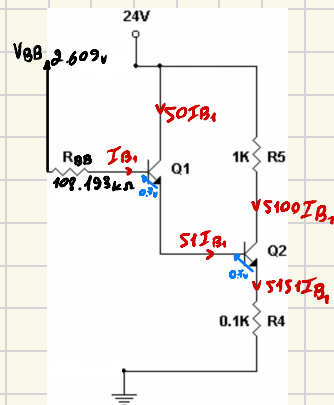
$$V_{BE2}=V_{BE1}=0.7V$$



Q1:

$$V_{BB1} = U_{R2} = 24 \cdot \frac{10}{92} = 2.609V$$

$$R_{BB1} = R_1 || R_2 + R_3 = 82 || 10 + 100 = 108.913k\Omega$$



$$V_{BB} - 0 = U_{R_{BB}} + V_{BE1} + V_{BE2} + U_{R_4}$$

$$2.609 = 108.193I_{B1} + 0.7 + 0.7 + 0.1 \cdot 5151I_{B1}$$

$$I_{B1} = 1.94 \cdot 10^{-3} mA$$

$$I_{C1} = 50I_{B1} = 0.1mA$$

$$I_{C2} = 5100I_{B1} = 10.2mA$$

$$24 = U_{R_5} + V_{CE} + U_{R_4}$$

$$24 = 1 \cdot 5100I_{B1} + V_{CE} + 0.1 \cdot 5151I_{B1}$$

$$V_{CE2} = 12.77V \quad \text{נפתר במסגרת solve}$$

$$24 = V_{CE1} + V_{BE} + U_{R_4}$$

$$24 = V_{CE1} + 0.7 + 0.1 \cdot 5151I_{B1}$$

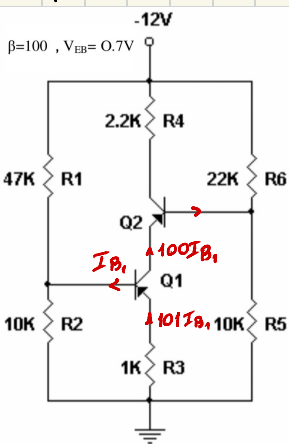
$$V_{CE1} = 22.27V$$

.solve נפתר עם

$$Q_1(0.1mA, 22.27V)$$

$$Q_2(10.2mA, 12.77V)$$

11.

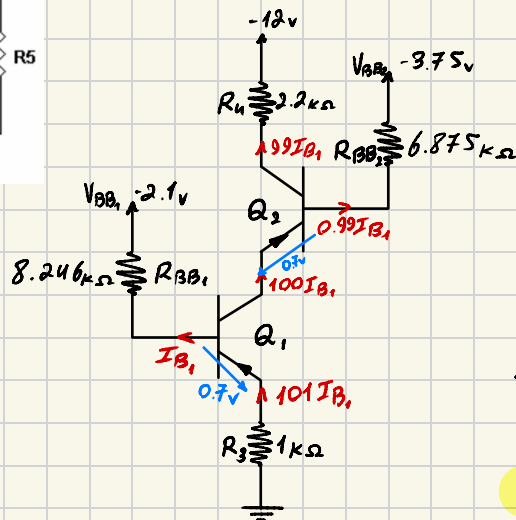


$$R_{BB1} = R_1 \parallel R_2 = 47 \parallel 10 = 8.246 \text{ k}\Omega$$

$$V_{BB1} = U_{R_2} = -12 \cdot \frac{R_2}{R_1 + R_2} = -12 \cdot \frac{10}{57} = -2.1 \text{ V}$$

$$R_{BB2} = R_5 \parallel R_6 = 22 \parallel 10 = 6.875 \text{ k}\Omega$$

$$V_{BB2} = U_{R_5} = -12 \cdot \frac{R_5}{R_5 + R_6} = -12 \cdot \frac{10}{32} = -3.75 \text{ V} \Rightarrow V_{BB2} = -3.75 \text{ V}$$



$$I_{B2} = \frac{100 I_{B1}}{100 + 1}$$

$$I_{B2} = 0.99 I_{B1}$$

$$0 - V_{BB1} = U_{R_3} + V_{EB} + U_{R_{BB1}}$$

$$2.1 = 1 \cdot 101 I_{B1} + 0.7 + 8.246 I_{B1}$$

$$I_{B1} = 12.815 \cdot 10^{-3} \text{ mA} \text{ נפתר בצורה פשוטה}$$

$$I_{C1} = 100 I_{B1}$$

$$I_{C1} = 1.286 \text{ mA}$$

$$I_{C2} = 99 I_{B1}$$

$$I_{C2} = 1.269 \text{ mA}$$

$$0 - V_{BB2} = U_{R_3} + V_{EC1} + V_{EB} + U_{R_{BB2}}$$

$$3.75 = 101 I_{B1} + 0.7 + V_{EC1} + 6.875 \cdot 0.99 I_{B1}$$

$$V_{EC1} = 1.668 \text{ V} \text{ נפתר בצורה פשוטה}$$

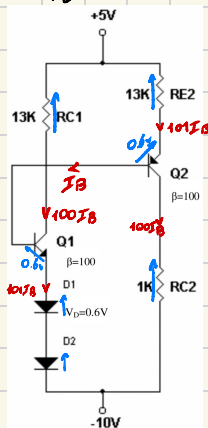
$$-12 - 0 = U_{R_4} + V_{CE2} + V_{CE1} + U_{R_3}$$

$$12 = 2.2 \cdot 99 I_{B1} + V_{CE2} + 1.668 + 1 \cdot 101 I_{B1}$$

$$\Rightarrow V_{CE2} = 6.247 \text{ V}$$

.solve for V_{CE2}

12.



$$5 - (-10) = U_{RE2} + V_{EB2} + V_{BE1} + 2V_D$$

$$15 = 13 \cdot 101 I_B + 0.6 + 0.6 + 1.2$$

$$I_B = 9.596 \cdot 10^{-3} \text{ mA} \text{ פשוט נפתר}$$

$$I_{C1} = I_{C2} = 0.96 \text{ mA}$$

$$5 - (-10) = U_{RC1} + V_{CE} + 2V_D$$

$$15 = 13 \cdot 100 I_B + V_{CE} + 1.2$$

$$V_{CE1} = 1.324 \text{ V} \text{ פשוט נפתר}$$

$$5 - (-10) = U_{RE2} + V_{CE2} + U_{RC2}$$

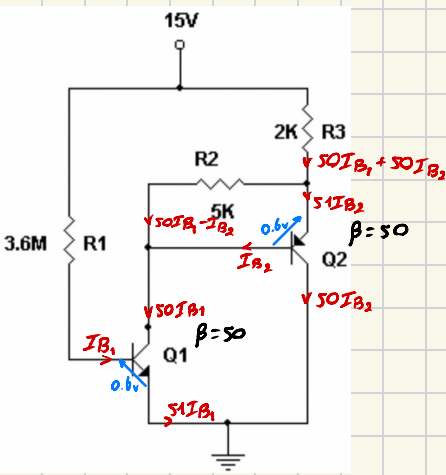
$$15 = 13 \cdot 101 I_B + V_{CE2} + 1 \cdot 100 I_B$$

$$V_{CE2} = 1.44 \text{ V}$$

$$Q_1 (0.96 \text{ mA}, 1.324 \text{ V})$$

$$Q_2 (0.96 \text{ mA}, 1.44 \text{ V})$$

13.



$$15 - 0 = U_{R1} + V_{BE}$$

$$15 = 3.6 \cdot 10^3 I_{B1} + 0.6$$

$$I_{B1} = 4 \cdot 10^{-3} \text{ mA}$$

$$I_{C1} = 50 I_{B1}$$

$$I_{C1} = 0.2 \text{ mA}$$

$$U_{R2} = V_{EB} = 0.6 \text{ V}$$

$$I_{R2} = \frac{U_{R2}}{R2}$$

$$50 I_{B1} - I_{B2} = \frac{0.6}{5} \quad \text{7.5 mA}$$

$$I_{B2} = 80 \cdot 10^{-3} \text{ mA} \quad \text{solve}$$

$$I_{C2} = 50 I_{B2}$$

$$I_{C2} = 4 \text{ mA}$$

$$15 - 0 = U_{R3} + V_{EC2}$$

$$15 = (50 I_{B1} + 50 I_{B2}) \cdot 2 + V_{EC2}$$

$$V_{EC2} = 6.6 \text{ V}$$

$$15 - 0 = U_{R3} + U_{R2} + V_{CE1}$$

$$15 = 8.4 + 0.6 + V_{CE1}$$

$$V_{CE1} = 6 \text{ V}$$

$$Q_1 (0.2 \text{ mA}, 6 \text{ V})$$

$$Q_2 (4 \text{ mA}, 6.6 \text{ V})$$