



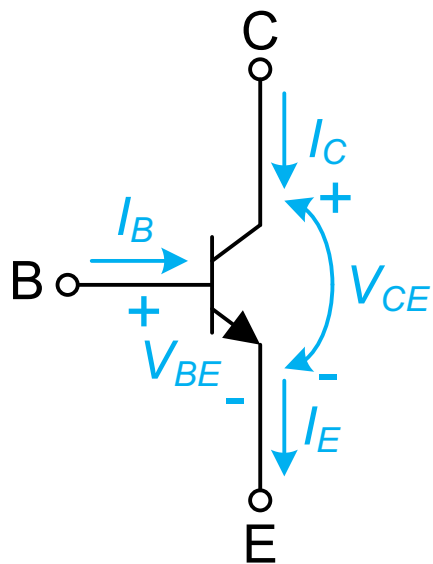
VJEŽBE 2

OSNOVE ELEKTRONIKE, ETR, IV SEMESTAR

DOC. DR. MILENA ERCEG

UVOD

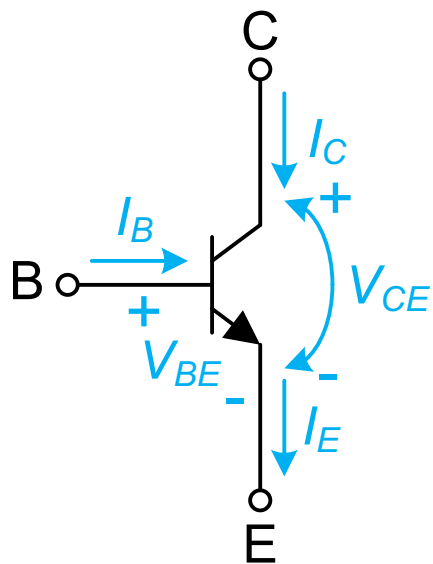
1° BJT ne provodi



$$V_{BE} < 0.7 \text{ V}$$

$$I_B = I_C = I_E = 0$$

UVOD



2° BJT provodi

a) direktan aktivni režim

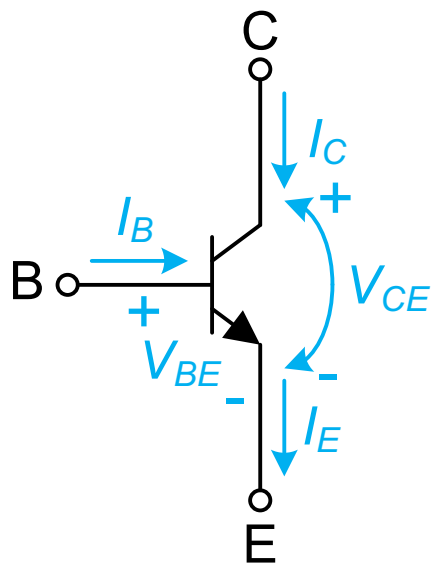
$$I_C = \beta I_B$$

$$I_E = I_B + I_C = (\beta + 1)I_B$$

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

$$V_{CE} > V_{CES} = 0.2 \text{ V}$$

UVOD



b) zasićenje

$$I_C < \beta I_B$$

$$I_E = I_B + I_C$$

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

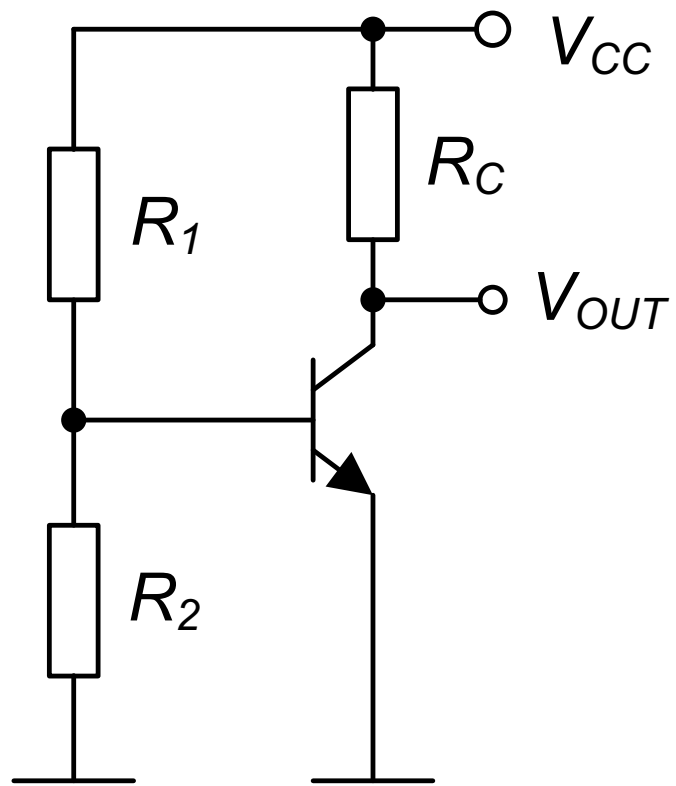
$$V_{CE} = V_{CES} = 0.2 \text{ V}$$

ZADATAK 1

Za kolo prikazano na slici 1 odrediti vrijednosti struja I_B , I_C , I_E i napona V_{OUT} . Poznato je:

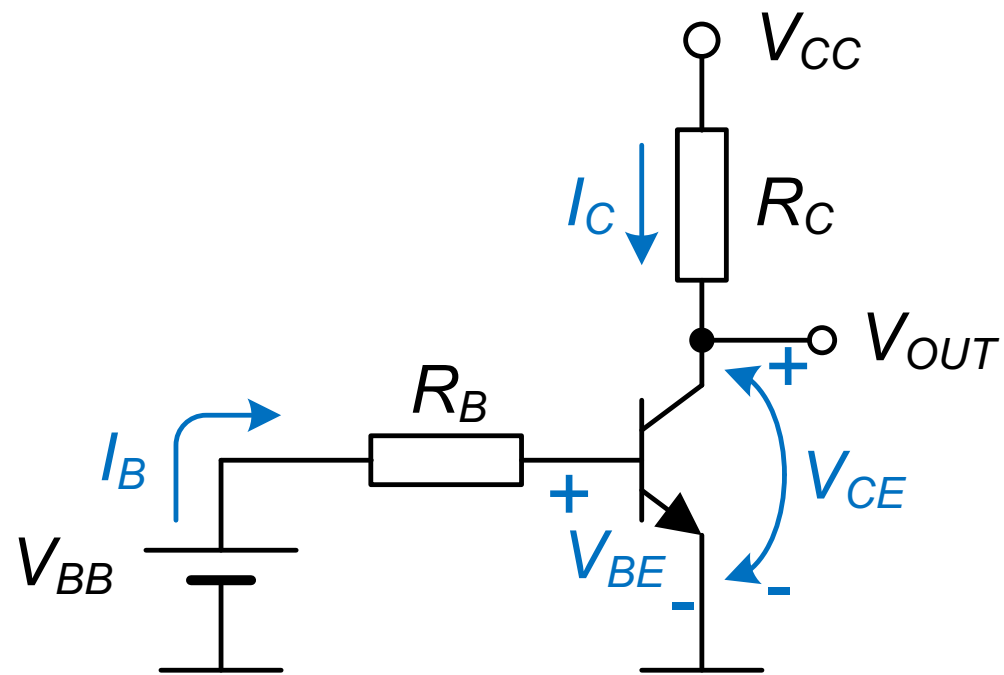
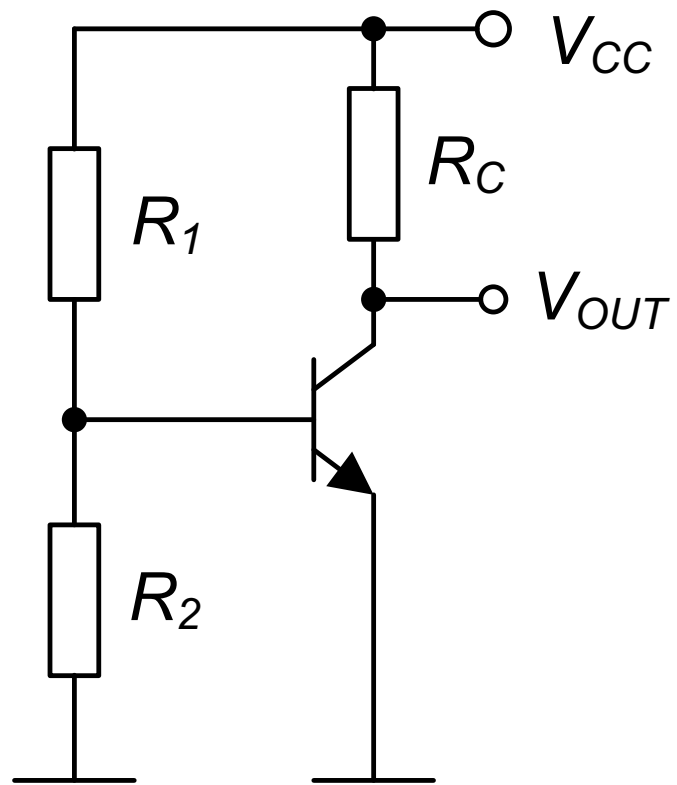
- $V_{CC}=10\text{ V}$, $V_{BE}=0.7\text{ V}$, $V_{CES}=0.2\text{ V}$, $\beta=100$, $R_1=100\text{ k}\Omega$, $R_2=10\text{ k}\Omega$ i $R_C=1.2\text{ k}\Omega$,
- $V_{CC}=10\text{ V}$, $V_{BE}=0.7\text{ V}$, $V_{CES}=0.2\text{ V}$, $\beta=100$, $R_1=10\text{ k}\Omega$, $R_2=10\text{ k}\Omega$ i $R_C=1.2\text{ k}\Omega$,
- $V_{CC}=10\text{ V}$, $V_{BE}=0.7\text{ V}$, $V_{CES}=0.2\text{ V}$, $\beta=500$, $R_1=100\text{ k}\Omega$, $R_2=10\text{ k}\Omega$ i $R_C=1.2\text{ k}\Omega$,
- $V_{CC}=5\text{ V}$, $V_{BE}=0.7\text{ V}$, $V_{CES}=0.2\text{ V}$, $\beta=100$, $R_1=100\text{ k}\Omega$, $R_2=10\text{ k}\Omega$ i $R_C=1.2\text{ k}\Omega$.

ZADATAK 1



slika 1

ZADATAK 1

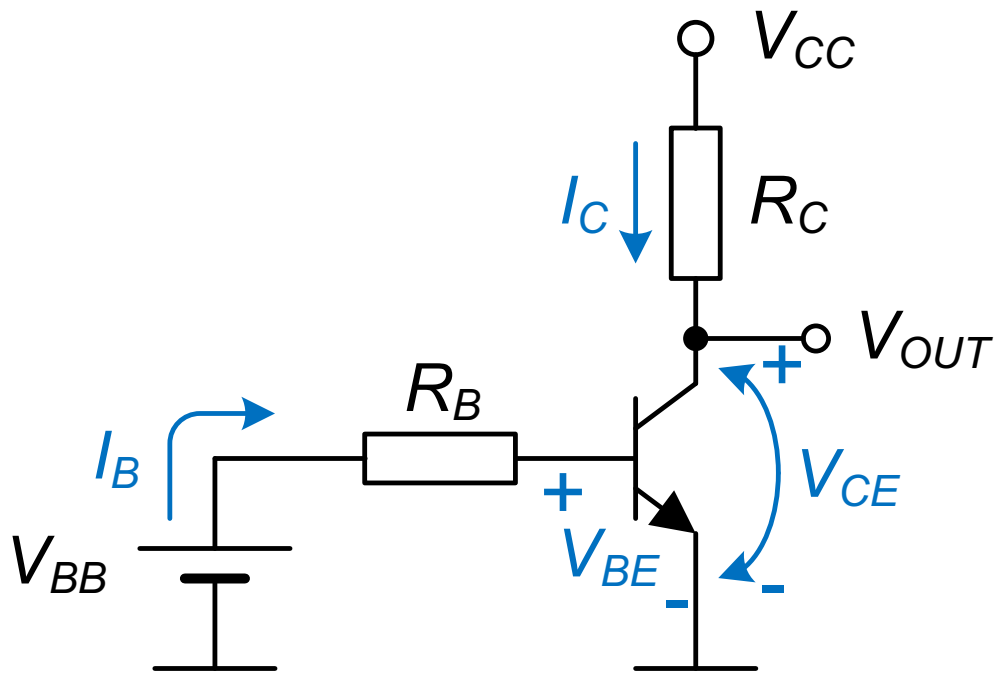


$$R_B = \frac{R_1 R_2}{R_1 + R_2}$$

$$V_{BB} = \frac{R_2}{R_1 + R_2} V_{CC}$$

ZADATAK 1

a)



$$R_B = \frac{R_1 R_2}{R_1 + R_2} = 9.09 \text{ k}\Omega$$

$$V_{BB} = \frac{R_2}{R_1 + R_2} V_{CC} = 0.909 \text{ V}$$

$$I_B = \frac{V_{BB} - V_{BE}}{R_B} = 22.99 \text{ }\mu\text{A} > 0 \Rightarrow \text{BJT provodi}$$

Uvodi se pretpostavka da je BJT u DAR-u

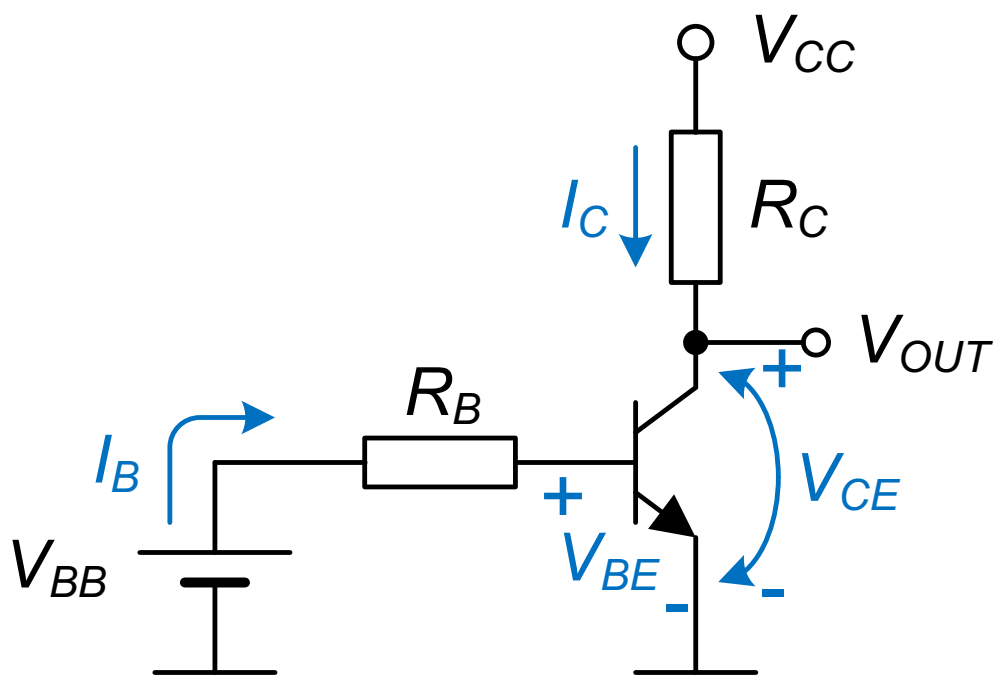
$$I_C = \beta I_B = 2.299 \text{ mA}$$

$$I_E = I_B + I_C = (\beta + 1) I_B = 2.322 \text{ mA}$$

$$V_{CE} = V_{CC} - R_C I_C = 7.2412 \text{ V} > 0.2 \text{ V} \Rightarrow \text{DAR}$$

ZADATAK 1

b)



$$R_B = \frac{R_1 R_2}{R_1 + R_2} = 5 \text{ k}\Omega$$

$$V_{BB} = \frac{R_2}{R_1 + R_2} V_{CC} = 5 \text{ V}$$

$$I_B = \frac{V_{BB} - V_{BE}}{R_B} = 0.86 \text{ mA} > 0 \Rightarrow \text{BJT provodi}$$

Uvodi se pretpostavka da je BJT u DAR-u

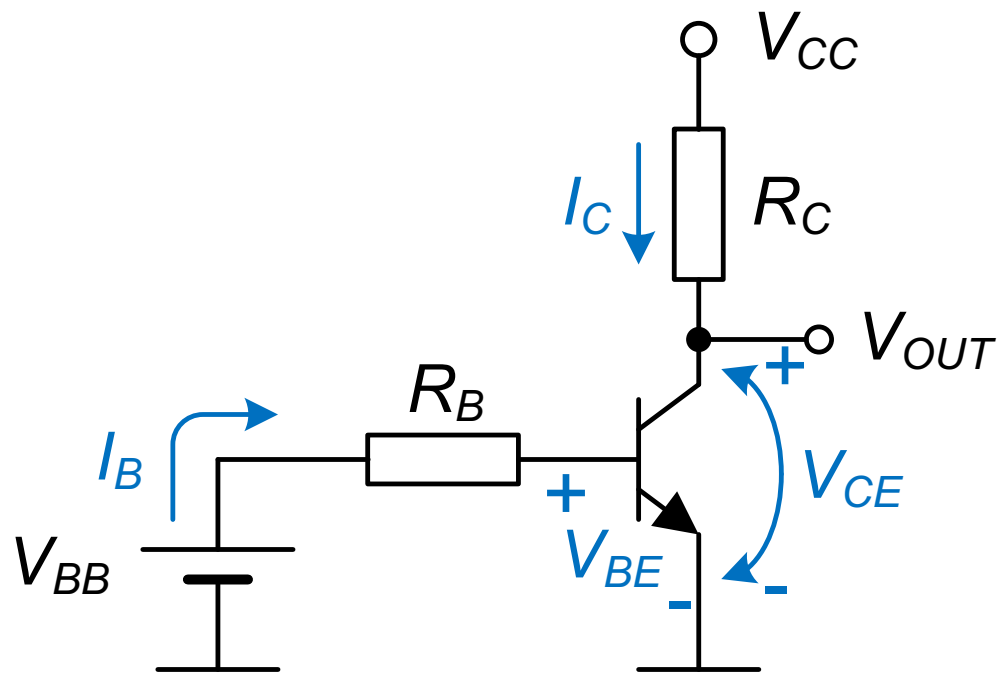
$$I_C = \beta I_B = 86 \text{ mA}$$

$$I_E = I_B + I_C = (\beta + 1) I_B = 86.86 \text{ mA}$$

$$V_{CE} = V_{CC} - R_C I_C = -93.2 \text{ V} < 0.2 \text{ V} \Rightarrow \text{zasićenje}$$

ZADATAK 1

b)



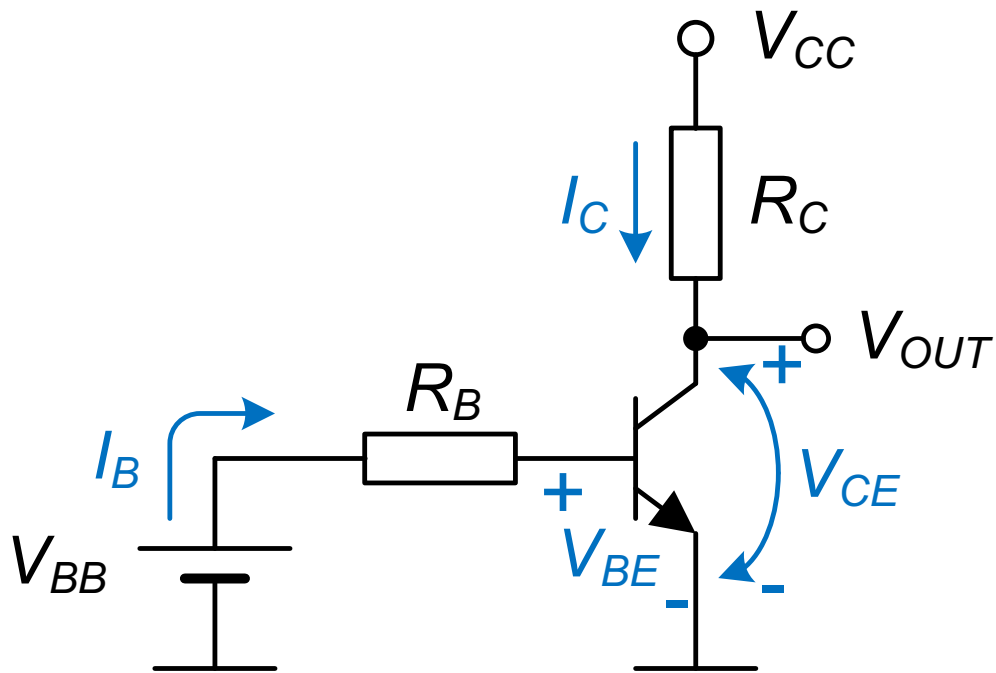
$$V_{CE} = V_{CES} = 0.2 \text{ V}$$

$$I_C = \frac{V_{CC} - V_{CE}}{R_C} = 8.16 \text{ mA}$$

$$I_E = I_B + I_C = 9.02 \text{ mA}$$

ZADATAK 1

c)



$$R_B = \frac{R_1 R_2}{R_1 + R_2} = 9.09 \text{ k}\Omega$$

$$V_{BB} = \frac{R_2}{R_1 + R_2} V_{CC} = 0.909 \text{ V}$$

$$I_B = \frac{V_{BB} - V_{BE}}{R_B} = 22.99 \text{ }\mu\text{A} > 0 \Rightarrow \text{BJT provodi}$$

Uvodi se pretpostavka da je BJT u DAR-u

$$I_C = \beta I_B = 11.495 \text{ mA}$$

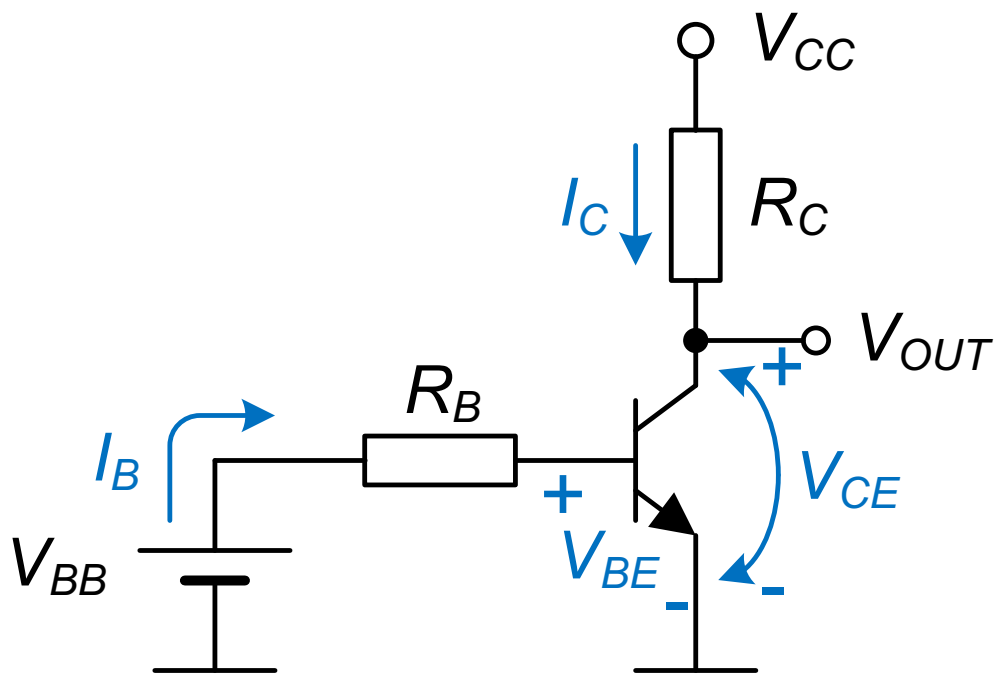
$$I_E = I_B + I_C = (\beta + 1) I_B = 11.518 \text{ mA}$$

$$V_{CE} = V_{CC} - R_C I_C = -3.821 \text{ V} < 0.2 \text{ V} \Rightarrow \text{zasićenje}$$

$$V_{CE} = V_{CES} = 0.2 \text{ V}$$

ZADATAK 1

c)

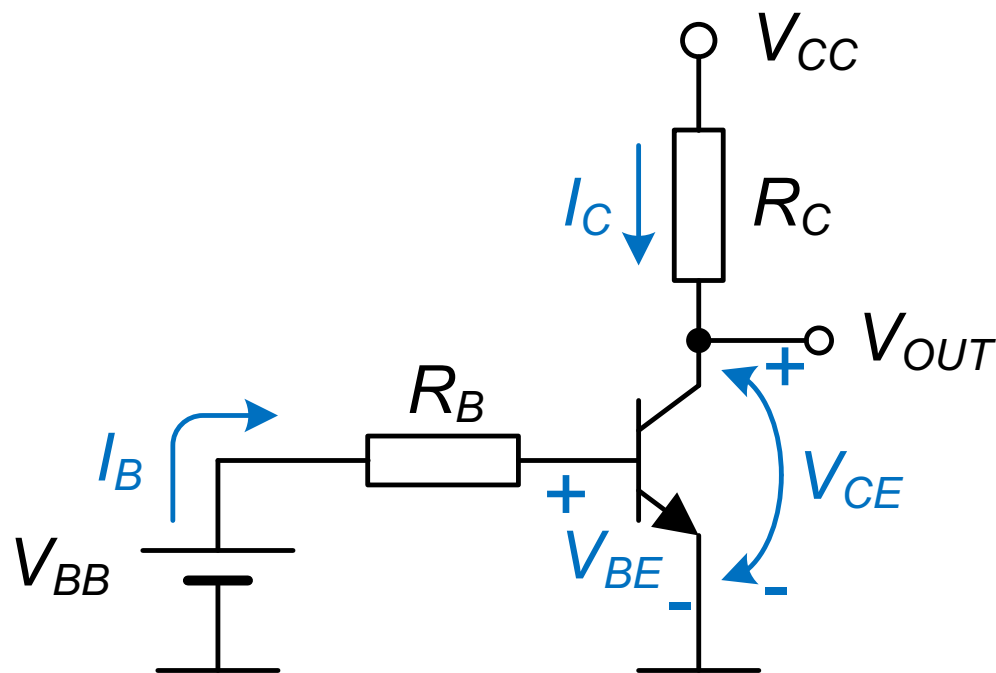


$$I_C = \frac{V_{CC} - V_{CE}}{R_C} = 8.16 \text{ mA}$$

$$I_E = I_B + I_C = 8.183 \text{ mA}$$

ZADATAK 1

d)



$$R_B = \frac{R_1 R_2}{R_1 + R_2} = 9.09 \text{ k}\Omega$$

$$V_{BB} = \frac{R_2}{R_1 + R_2} V_{CC} = 0.454 \text{ V}$$

$$I_B = \frac{V_{BB} - V_{BE}}{R_B} = -27.06 \mu\text{A} < 0 \Rightarrow \text{BJT zakočen}$$

$$I_B = I_C = I_E = 0$$

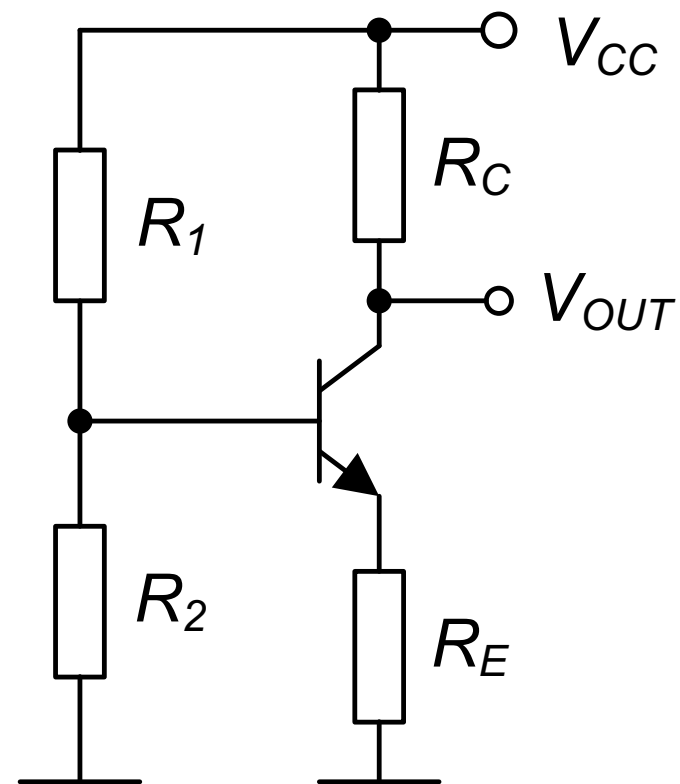
$$V_{CE} = V_{CC} = 5 \text{ V}$$

ZADATAK 2

Za kolo prikazano na slici 3 odrediti vrijednost izlaznog napona V_{OUT} . Poznato je:

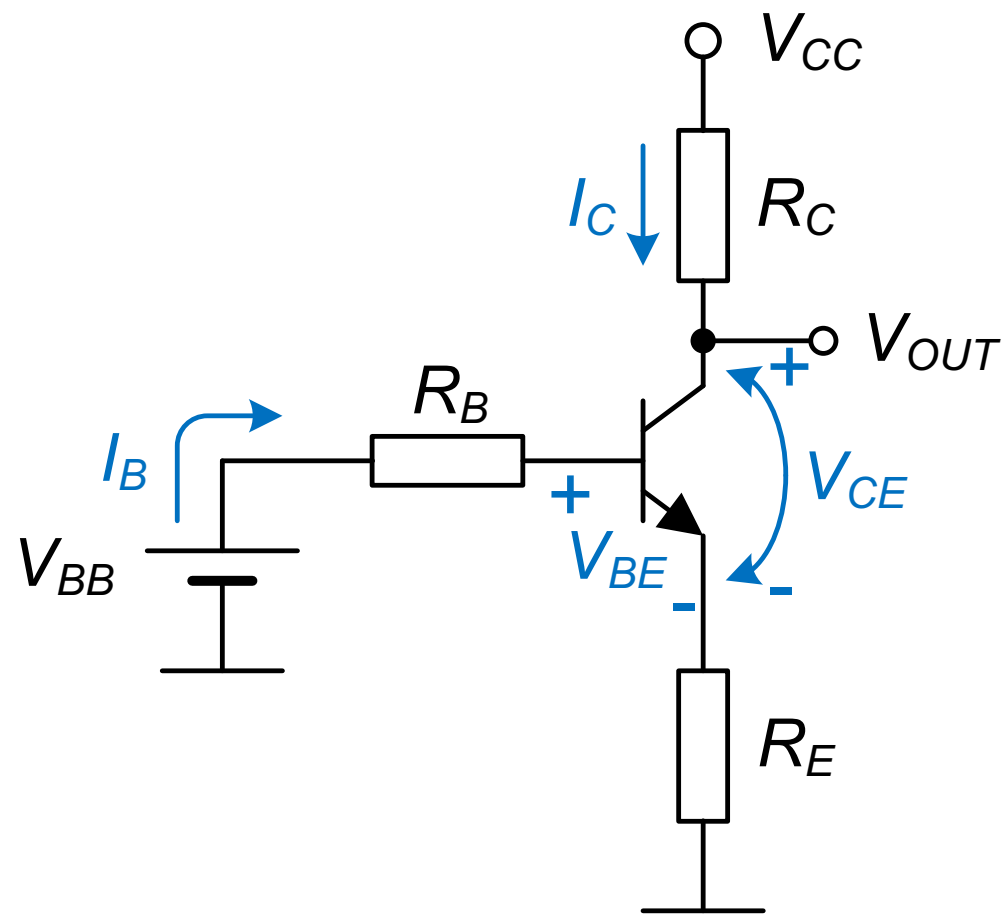
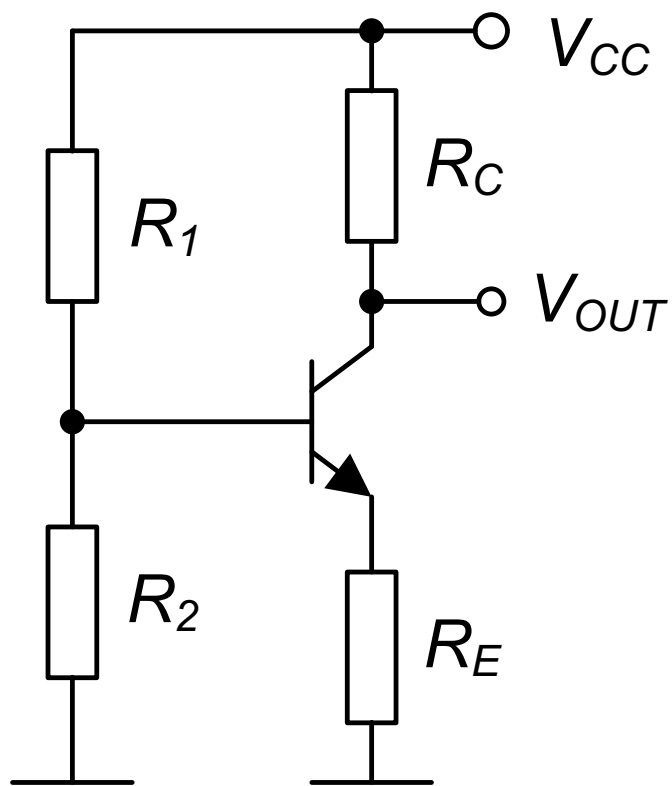
a) $V_{CC}=15$ V, $V_{BE}=0.7$ V, $V_{CES}=0.2$ V, $\beta=100$,
 $R_1=180$ k Ω , $R_2=56$ k Ω , $R_C=5.1$ k Ω i $R_E=1.8$ k Ω ,

b) $V_{CC}=15$ V, $V_{BE}=0.7$ V, $V_{CES}=0.2$ V, $\beta=100$,
 $R_1=180$ k Ω , $R_2=56$ k Ω , $R_C=100$ k Ω i $R_E=1.8$ k Ω .



slika 3

ZADATAK 2

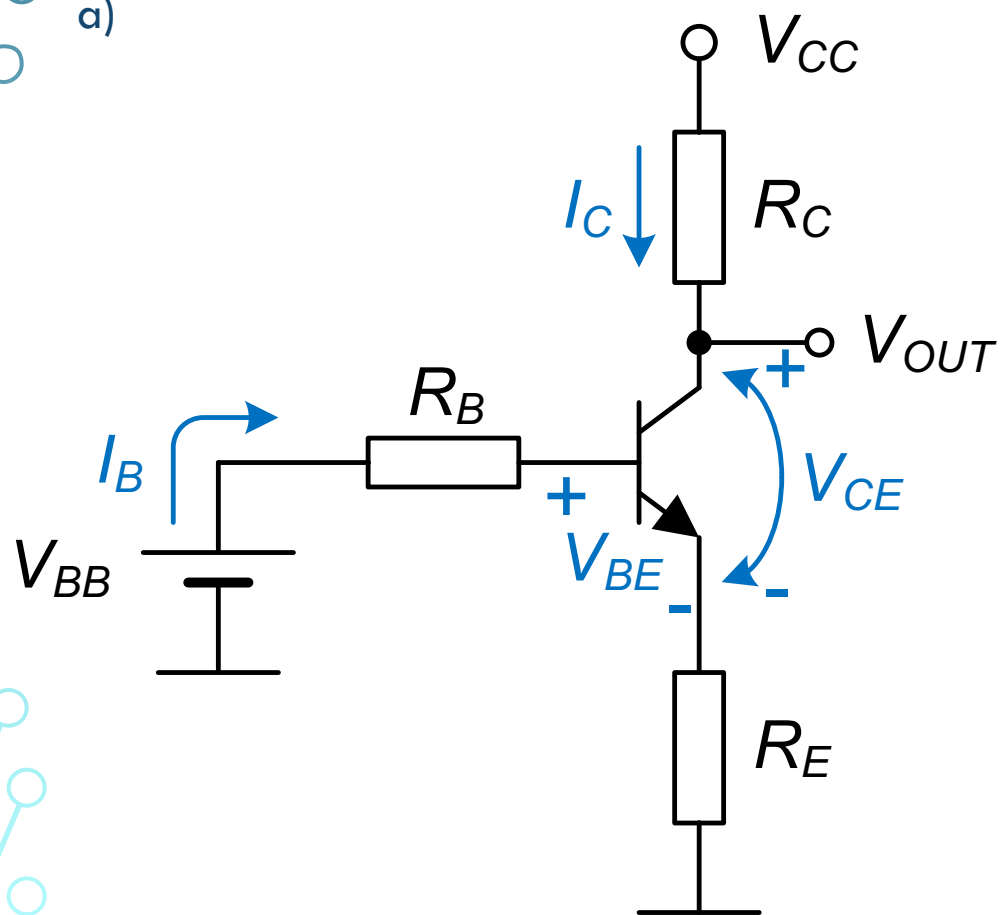


$$R_B = \frac{R_1 R_2}{R_1 + R_2}$$

$$V_{BB} = \frac{R_2}{R_1 + R_2} V_{CC}$$

ZADATAK 2

a)



$$R_B = \frac{R_1 R_2}{R_1 + R_2} = 42.71 \text{ k}\Omega$$

$$V_{BB} = \frac{R_2}{R_1 + R_2} V_{CC} = 3.559 \text{ V}$$

Uvodi se pretpostavka da je BJT u DAR-u

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

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

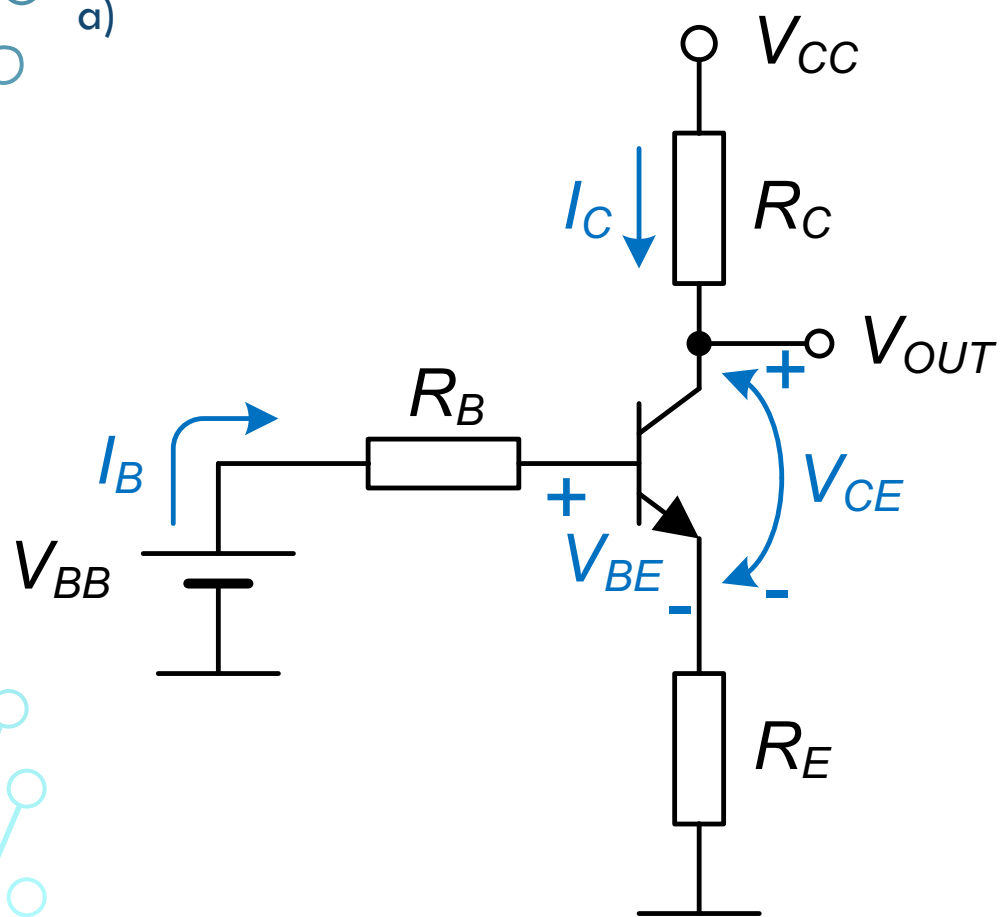
$$I_B = \frac{V_{BB} - V_{BE}}{R_B + (\beta + 1) R_E} = 12.73 \text{ }\mu\text{A} > 0 \Rightarrow \text{BJT provodi}$$

$$I_C = \beta I_B = 1.273 \text{ mA}$$

$$I_E = I_B + I_C = (\beta + 1) I_B = 1.286 \text{ mA}$$

ZADATAK 2

a)

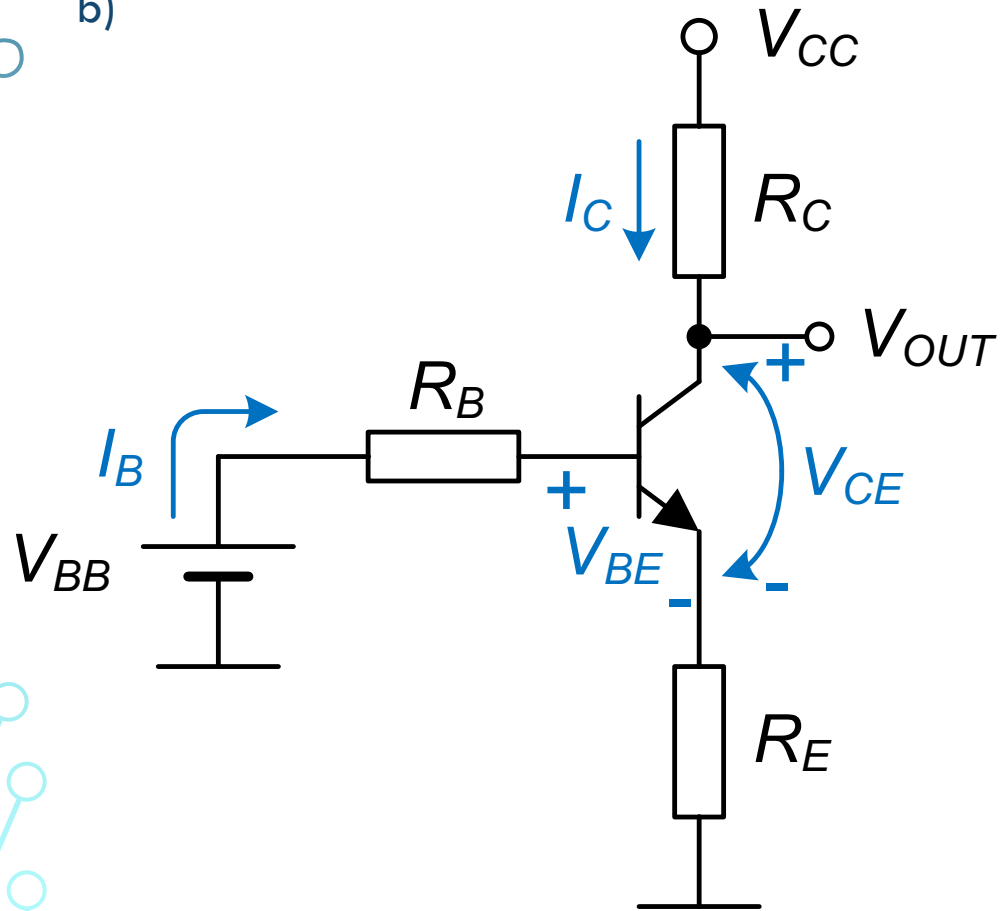


$$V_{CE} = V_{CC} - R_C I_C - R_E I_E = 6.193 \text{ V} > 0.2 \text{ V} \Rightarrow \text{DAR}$$

$$V_{OUT} = V_{CC} - R_C I_C = 8.508 \text{ V}$$

ZADATAK 2

b)



$$R_B = \frac{R_1 R_2}{R_1 + R_2} = 42.71 \text{ k}\Omega$$

$$V_{BB} = \frac{R_2}{R_1 + R_2} V_{CC} = 3.559 \text{ V}$$

Uvodi se pretpostavka da je BJT u DAR-u

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

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

$$I_B = \frac{V_{BB} - V_{BE}}{R_B + (\beta + 1) R_E} = 12.73 \text{ }\mu\text{A} > 0 \Rightarrow \text{BJT provodi}$$

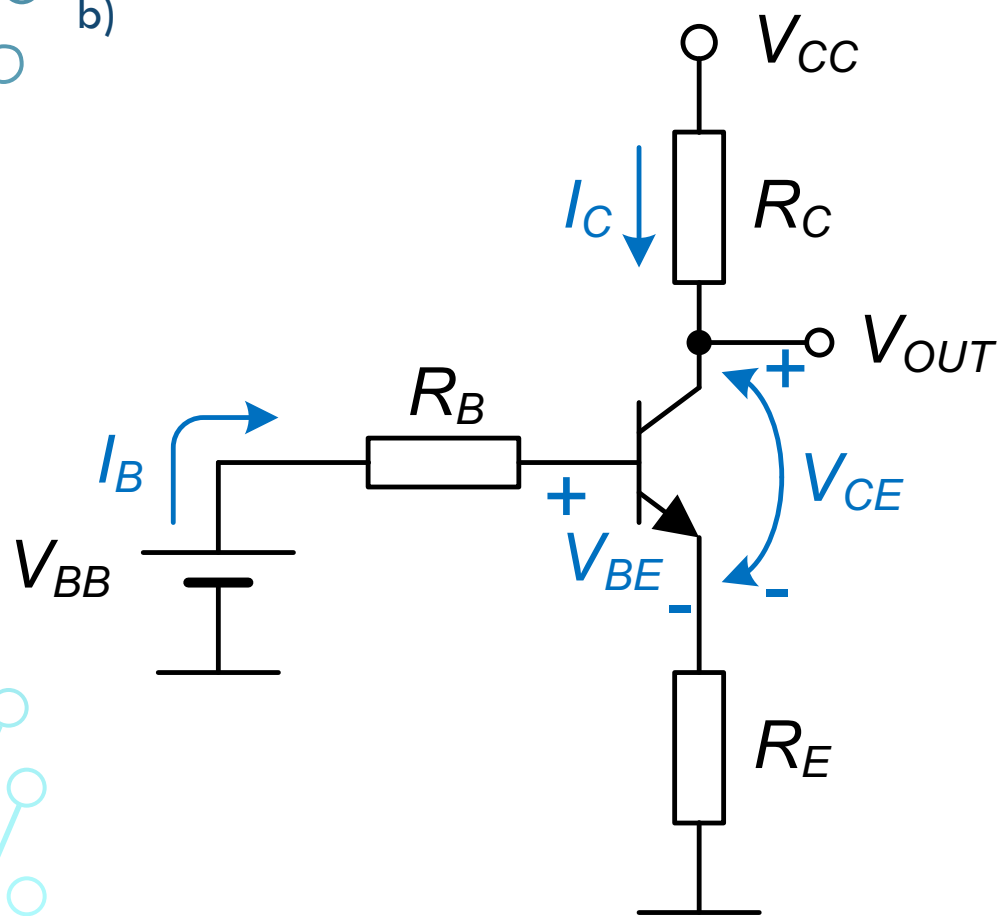
$$I_C = \beta I_B = 1.273 \text{ mA}$$

$$I_E = I_B + I_C = (\beta + 1) I_B = 1.286 \text{ mA}$$

$$V_{CE} = V_{CC} - R_C I_C - R_E I_E = -114.615 \text{ V} < 0.2 \text{ V} \Rightarrow \text{zasićenje}$$

ZADATAK 2

b)



$$V_{CE} = V_{CES} = 0.2 \text{ V}$$

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

$$V_{CC} - V_{CES} - (R_C + R_E) I_C - R_E I_B = 0 \quad (*)$$

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

$$V_{BB} - R_B I_B - V_{BE} - R_E (I_B + I_C) = 0$$

$$V_{BB} - V_{BE} - (R_B + R_E) I_B - R_E I_C = 0 \quad (**)$$

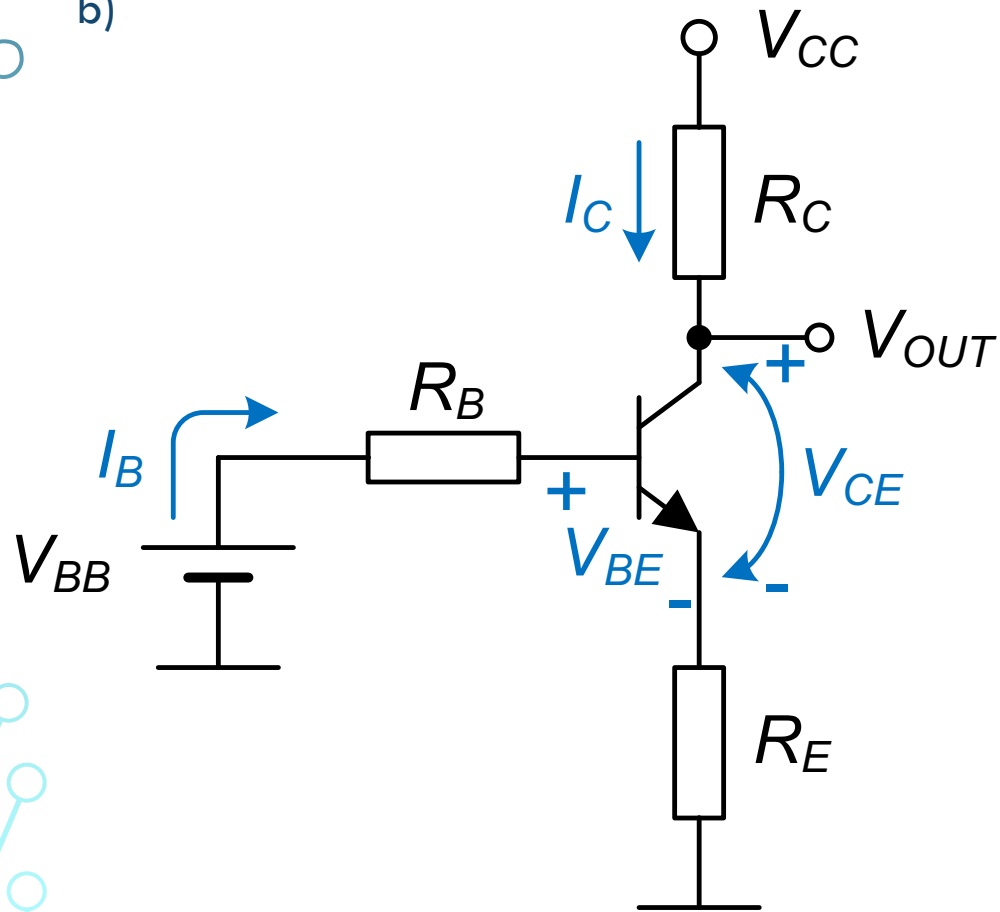
$$I_B = \frac{V_{CC} - V_{CES} - (R_C + R_E) I_C}{R_E} \quad (*)$$

$$I_B = \frac{V_{BB} - V_{BE} - R_E I_C}{R_B + R_E} \quad (**)$$

$$\frac{V_{CC} - V_{CES} - (R_C + R_E) I_C}{R_E} = \frac{V_{BB} - V_{BE} - R_E I_C}{R_B + R_E}$$

ZADATAK 2

b)



$$\frac{V_{CC} - V_{CES} - (R_C + R_E)I_C}{R_E} = \frac{V_{BB} - V_{BE} - R_E I_C}{R_B + R_E}$$

$$(R_B + R_E)[V_{CC} - V_{CES} - (R_C + R_E)I_C] = R_E(V_{BB} - V_{BE} - R_E I_C)$$

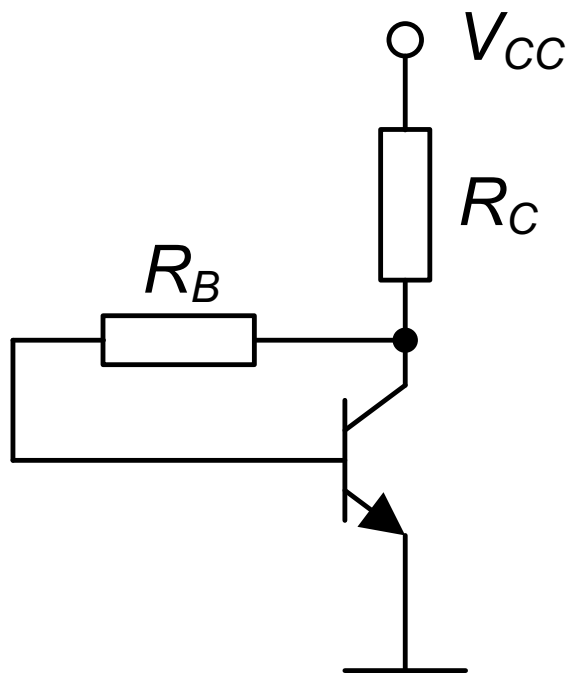
$$I_C = \frac{R_E(V_{BB} - V_{BE}) - (R_B + R_E)(V_{CC} - V_{CES})}{R_E^2 - (R_B + R_E)(R_C + R_E)} = 0.144 \text{ mA}$$

$$I_B = \frac{V_{BB} - V_{BE} - R_E I_C}{R_B + R_E} = 0.053 \text{ mA}$$

$$V_{OUT} = V_{CC} - R_C I_C = 0.565 \text{ V}$$

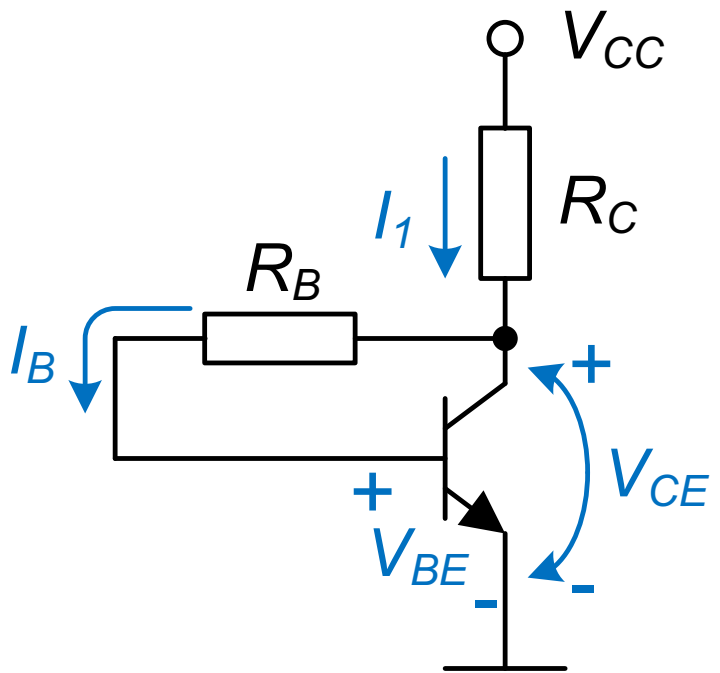
ZADATAK 3

Za kolo prikazano na slici 5 odrediti vrijednost struja I_B , I_C , I_E kao i napona V_{CE} .
Poznato je: $V_{CC}=5$ V, $V_{BE}=0.7$ V, $V_{CES}=0.2$ V, $\beta=100$, $R_C=1$ k Ω i $R_B=5$ k Ω .



slika 5

ZADATAK 3



Uvodi se pretpostavka da je BJT u DAR-u

$$V_{CC} - R_C I_1 - R_B I_B - V_{BE} = 0$$

$$V_{CC} - R_C (I_B + I_C) - R_B I_B - V_{BE} = 0$$

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

$$I_B = \frac{V_{CC} - V_{BE}}{(\beta + 1) R_C + R_B} = 40.56 \mu\text{A} > 0 \Rightarrow \text{BJT provodi}$$

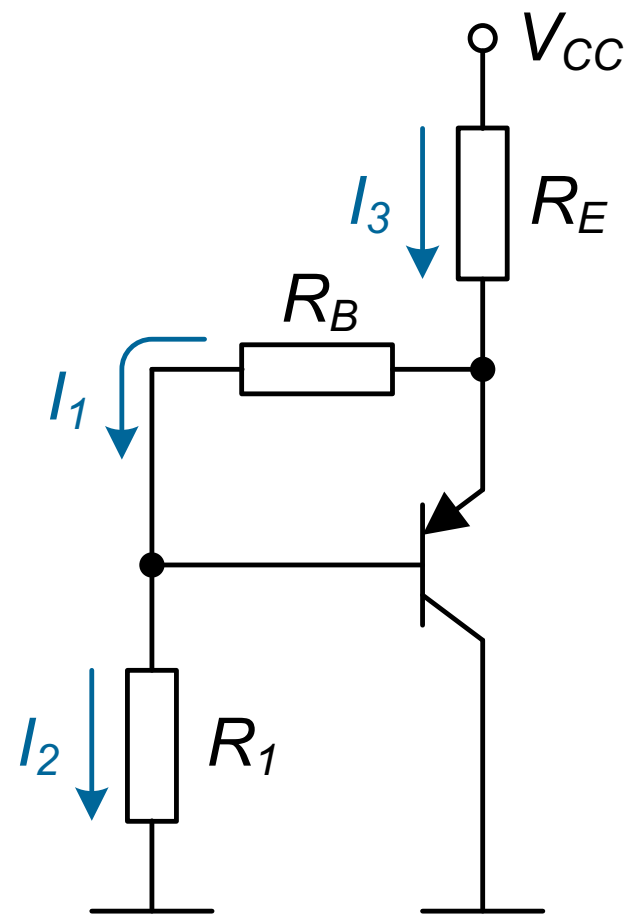
$$I_C = \beta I_B = 4.056 \text{ mA}$$

$$I_E = I_B + I_C = (\beta + 1) I_B = 4.097 \text{ mA}$$

$$V_{CE} = V_{CC} - R_C (I_B + I_C) = 0.903 \text{ V} > 0.2 \text{ V} \Rightarrow \text{DAR}$$

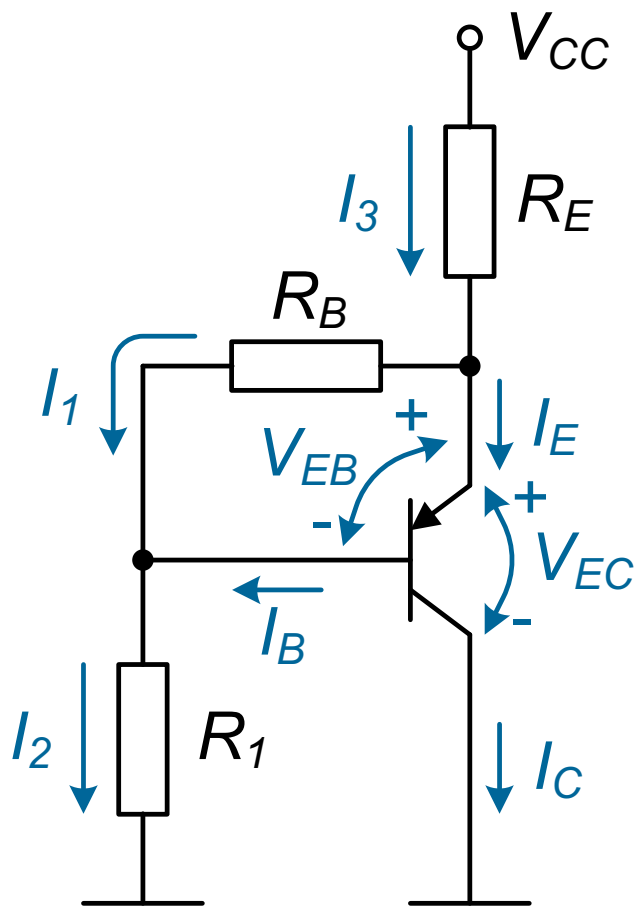
ZADATAK 4

Za kolo prikazano na slici 7 odrediti struje I_1 , I_2 , I_3 , I_B , I_C , I_E i napon V_{EC} . Poznato je $R_I=1 \text{ k}\Omega$, $R_B=1 \text{ k}\Omega$, $R_E=100 \text{ }\Omega$, $V_{CC}=5 \text{ V}$, $V_{EB}=0.7 \text{ V}$, $V_{ECS}=0.2 \text{ V}$ i $\beta=100$.



slika 7

ZADATAK 4



Uvodi se pretpostavka da je BJT u DAR-u

$$I_3 = I_1 + I_E = I_1 + (\beta + 1)I_B$$

$$I_2 = I_1 + I_B$$

$$I_1 = \frac{V_{EB}}{R_B} = 0.7 \text{ mA}$$

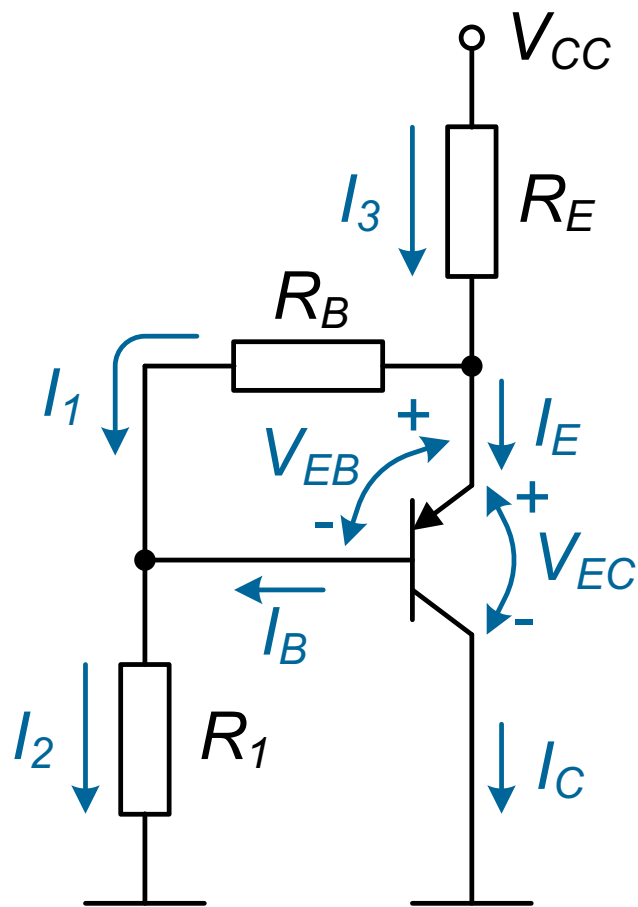
$$V_{CC} = R_E I_3 + R_B I_1 + R_1 I_2$$

$$I_B = \frac{V_{CC} - I_1 (R_E + R_B + R_1)}{(\beta + 1)R_E + R_1} = 0.318 \text{ mA} \Rightarrow \text{BJT provodi}$$

$$I_C = \beta I_B = 31.8 \text{ mA}$$

$$I_E = (\beta + 1)I_B = 32.12 \text{ mA}$$

ZADATAK 4



$$I_2 = I_1 + I_B = 1.018 \text{ mA}$$

$$I_3 = I_1 + I_E = 32.82 \text{ mA}$$

$$V_{EC} = V_{CC} - R_E I_3 = 1.718 \text{ V} \Rightarrow \text{DAR}$$