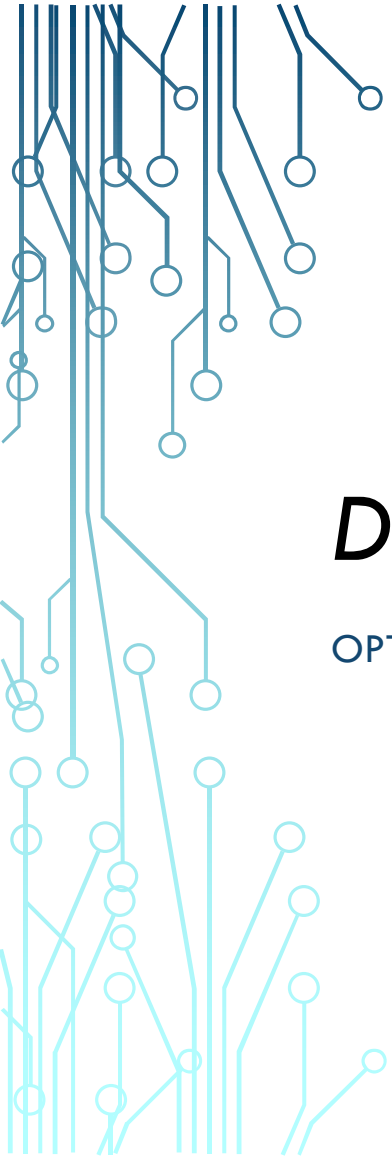
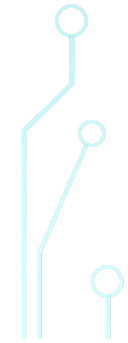




DRIVER ZA LED, LAB. VJEŽBA

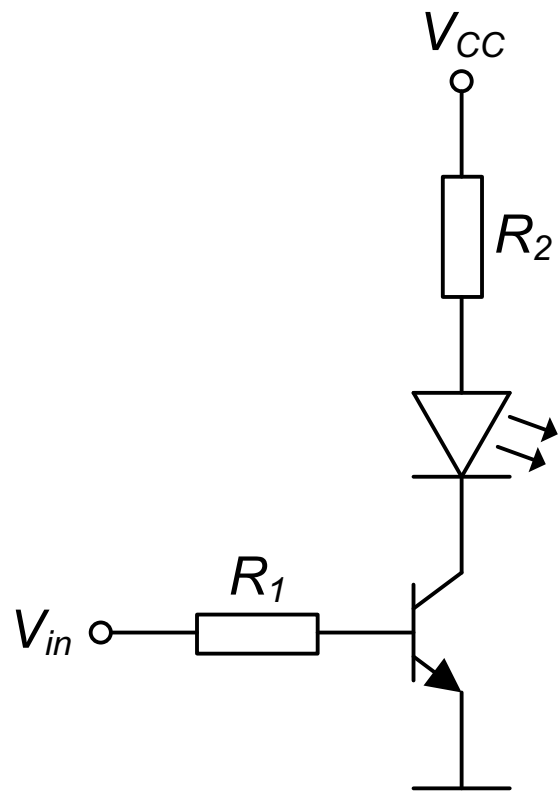
OPTOELEKTRONIKA, ETR, ELEKTRONIKA

DOC. DR MILENA ERCEG

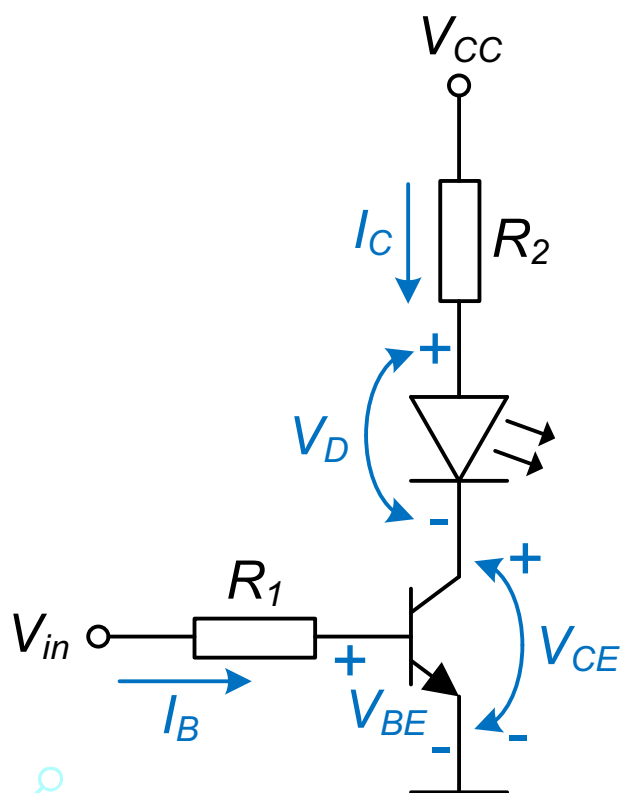


ZADATAK 1

Za kolo prikazano na slici odrediti i grafički prikazati zavisnost struje diode I_D od ulaznog napona V_{IN} , kao i zavisnost napona V_A na anodi LED-a od ulaznog napona V_{IN} , za opseg ulaznog napona $0 < V_{IN} < V_{CC}$. Poznato je: $V_{CC}=5$ V, $R_1=10$ k Ω , $R_2=120$ Ω , strujno pojačanje β bipolarnog tranzistora $\beta=100$, napon $V_{BE}=0.7$ V kada BJT provodi i napon $V_{CES}=0.2$ V. Koristi se LED čija prenosna karakteristika je definisana kao $V=R_s I_d + V_{th}$, pri čemu je $R_s=20$ Ω , dok je napon praga $V_{th}=1.8$ V.



ZADATAK 1



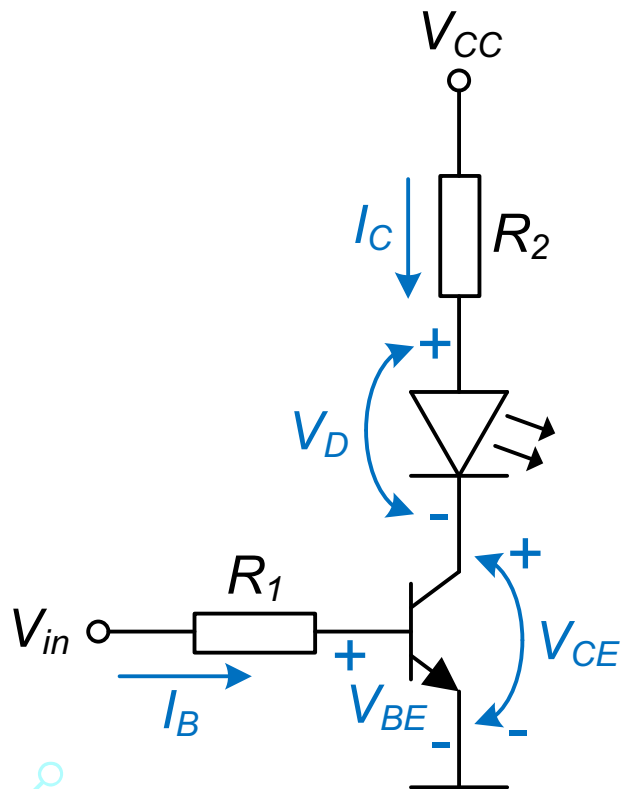
1° BJT zakočen

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

$$I_D = 0$$

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

ZADATAK 1



2° BJT u DAR-u

$$I_D = I_C = \beta I_B = \beta \frac{V_{IN} - V_{BE}}{R_1} > 0 \Rightarrow V_{IN} > V_{BE} = 0.7 \text{ V}$$

$$V_A = V_{CC} - R_2 I_D = V_{CC} - \beta R_2 \frac{V_{IN} - V_{BE}}{R_1}$$

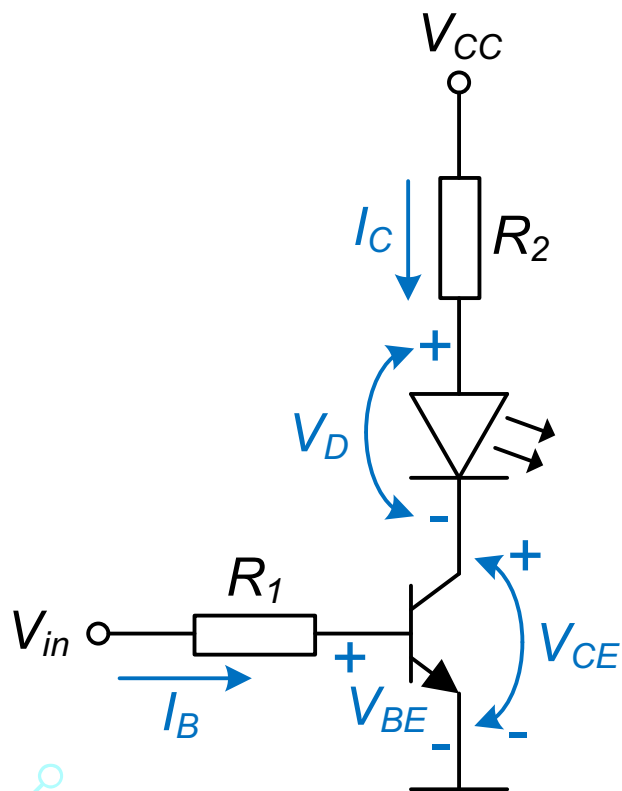
$$V_{CE} = V_{CC} - R_2 I_D - V_D$$

$$V_{CE} = V_{CC} - R_2 I_D - R_s I_D - V_{th}$$

$$V_{CE} = V_{CC} - (R_2 + R_s) I_D - V_{th}$$

$$V_{CE} = V_{CC} - (R_2 + R_s) \beta \frac{V_{IN} - V_{BE}}{R_1} - V_{th} > V_{CES}$$

ZADATAK 1



2° BJT u DAR-u

$$V_{CE} = V_{CC} - (R_2 + R_s) \beta \frac{V_{IN} - V_{BE}}{R_1} - V_{th} > V_{CES}$$

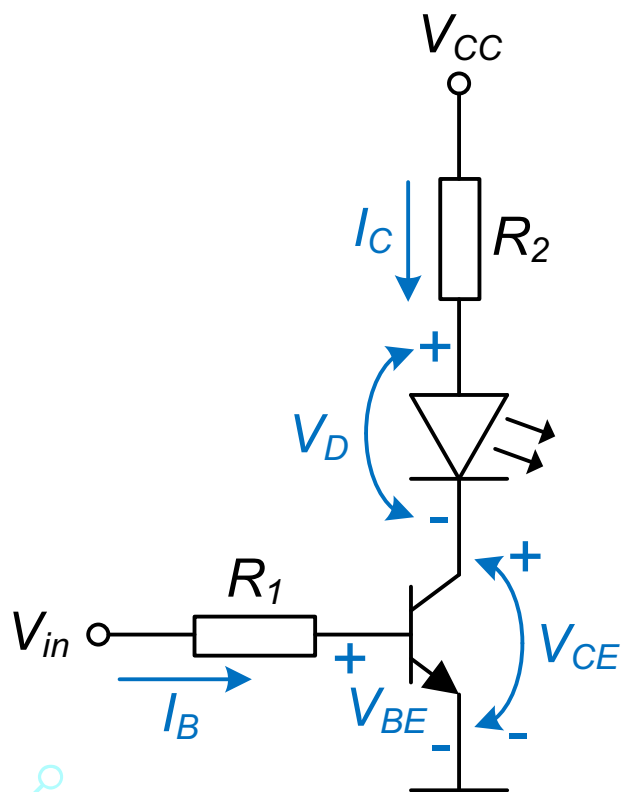
$$(R_2 + R_s) \beta \frac{V_{IN} - V_{BE}}{R_1} < V_{CC} - V_{CES} - V_{th}$$

$$V_{IN} < \frac{R_1}{(R_2 + R_s) \beta} (V_{CC} - V_{CES} - V_{th}) + V_{BE} = 2.84 \text{ V}$$

$$I_D(V_{IN} = 2.84 \text{ V}) = \beta \frac{V_{IN} - V_{BE}}{R_1} = 21.4 \text{ mA}$$

$$V_A(V_{IN} = 2.84 \text{ V}) = V_{CC} - \beta R_2 \frac{V_{IN} - V_{BE}}{R_1} = 2.43 \text{ V}$$

ZADATAK 1



3° BJT u zasićenju

$$V_{IN} > 2.84 \text{ V}$$

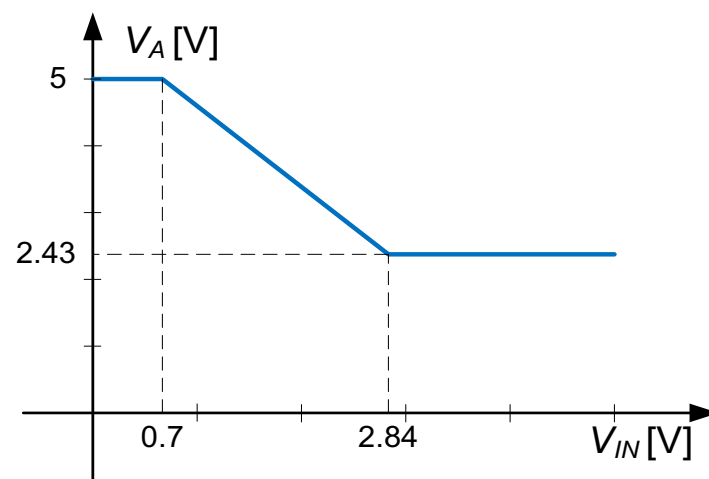
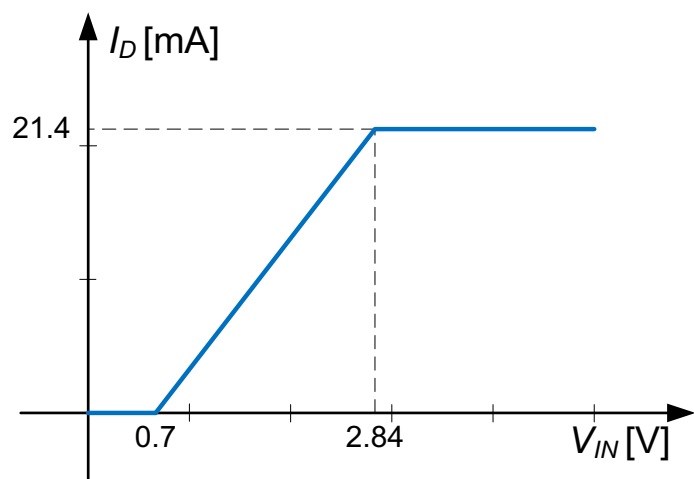
$$V_{CC} - R_2 I_D - V_D - V_{CES} = 0$$

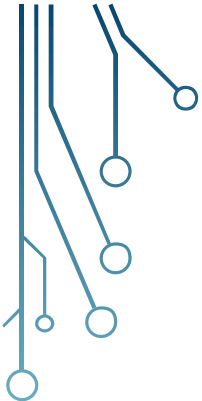
$$V_{CC} - R_2 I_D - R_S I_D - V_{th} - V_{CES} = 0$$

$$I_D = \frac{V_{CC} - V_{th} - V_{CES}}{R_2 + R_S} = 21.4 \text{ mA}$$

$$V_A = V_{CC} - R_2 I_D = 2.43 \text{ V}$$

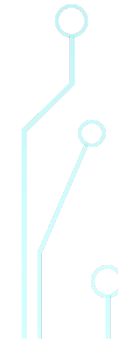
ZADATK 1





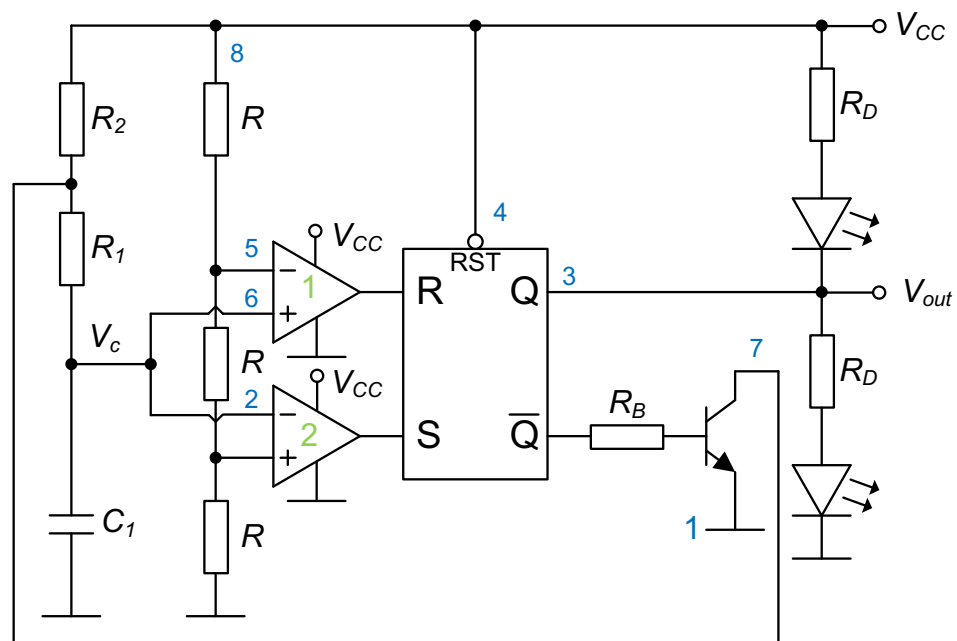
ZADATAK 1

Zadaci laboratorijske vježbe

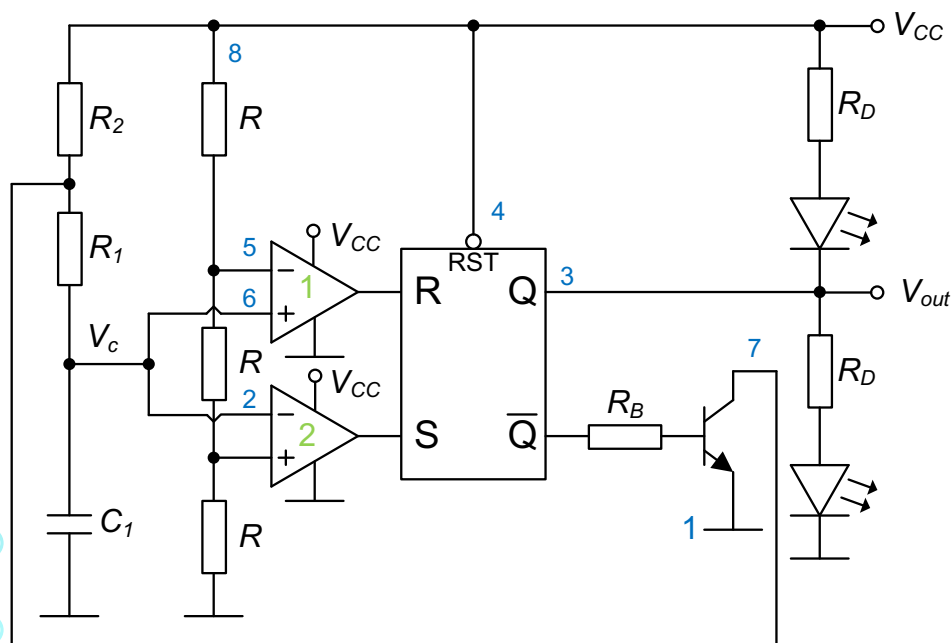
1. Uz pomoć odgovarajućih diskretnih komponenti sastaviti kolo prikazano na slici 1.
 2. Na ulaz kola dovesti rampa funkciju veoma male učestanosti reda 1 Hz, pri čemu napon linearno raste od 0 V do 5 V. Obratiti pažnju na promjenu intenziteta svjetlosti koju emituje LED. Pomoću osciloskopa prikazati talasni oblik ulaznog napona kao i napona na anodi LED-a. Uporediti rezultat sa onim dobijenim računskim putem.
 3. Na ulaz kola dovesti povorku pravougaonih impulsa amplitude 5 V. Učestanost mijenjati od 10 Hz do 100 Hz, sa korakom 10 Hz. Posmatrati LED.
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ZADATAK 2

Za kolo prikazano na slici odrediti i grafički prikazati napon v_{out} kao i napon na krajevima kondenzatora v_c . Odrediti frekvenciju izlaznog napona. Poznato je: $V_{CC}=8\text{ V}$, $R_1=47\text{ k}\Omega$, $R_2=47\text{ k}\Omega$, $C_1=10\text{ }\mu\text{F}$.



ZADATAK 2



1°

$$v_c(0_-) = 0$$

$$v_1^- = \frac{2}{3}V_{CC} > v_1^+ = 0 \Rightarrow R = 0$$

$$v_2^+ = \frac{1}{3}V_{CC} > v_2^- = 0 \Rightarrow S = 1$$

$\Rightarrow Q = 1, v_{out} = V_{CC}$, BJT – zakočen

$$V_{CC} - (R_1 + R_2)i - \frac{1}{C_1} \int i dt = 0$$

$$\frac{di}{i} = - \frac{dt}{(R_1 + R_2)C_1}$$

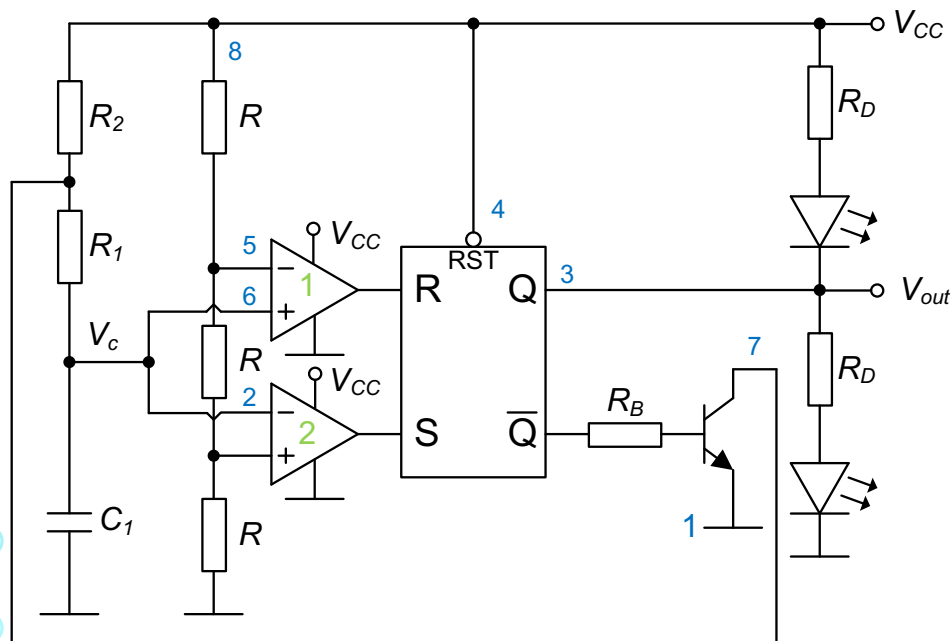
$$\ln i = - \frac{t}{(R_1 + R_2)C_1} + A, A = \ln B$$

$$\ln i - \ln B = - \frac{t}{(R_1 + R_2)C_1}$$

$$i = B e^{-\frac{t}{(R_1 + R_2)C_1}}$$

$$v_c = V_{CC} - (R_1 + R_2)i = V_{CC} - (R_1 + R_2)B e^{-\frac{t}{(R_1 + R_2)C_1}}$$

ZADATAK 2



1°

$$v_c(0_-) = 0$$

$$v_c(0_+) = V_{CC} - (R_1 + R_2)B$$

$$\Rightarrow B = \frac{V_{CC}}{R_1 + R_2}$$

$$v_c = V_{CC} - V_{CC}e^{-\frac{t}{(R_1+R_2)C_1}} = V_{CC}\left[1 - e^{-\frac{t}{(R_1+R_2)C_1}}\right]$$

$$\frac{V_{CC}}{3} < v_c < \frac{2}{3}V_{CC}$$

$$v_1^- = \frac{2}{3}V_{CC} > v_1^+ = v_c \Rightarrow R = 0$$

$$v_2^+ = \frac{1}{3}V_{CC} < v_2^- = v_c \Rightarrow S = 0$$

$$\Rightarrow Q = 1, v_{out} = V_{CC}, \text{BJT - zakočen}$$

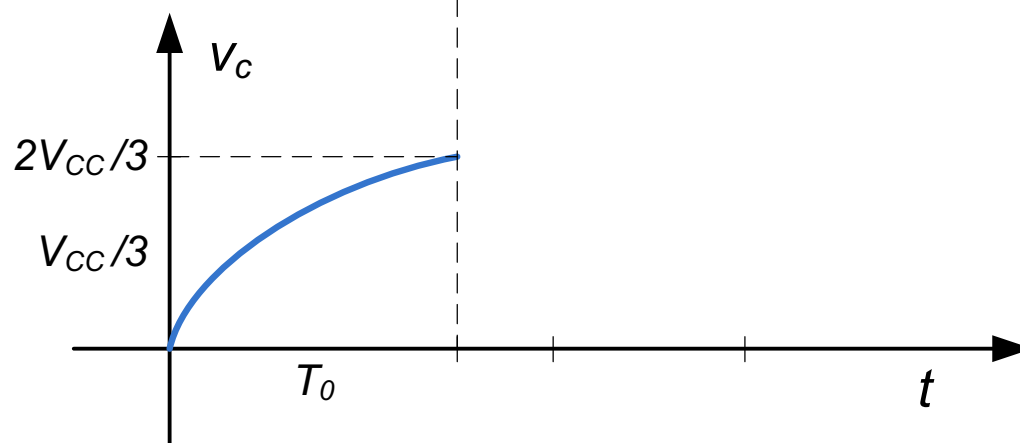
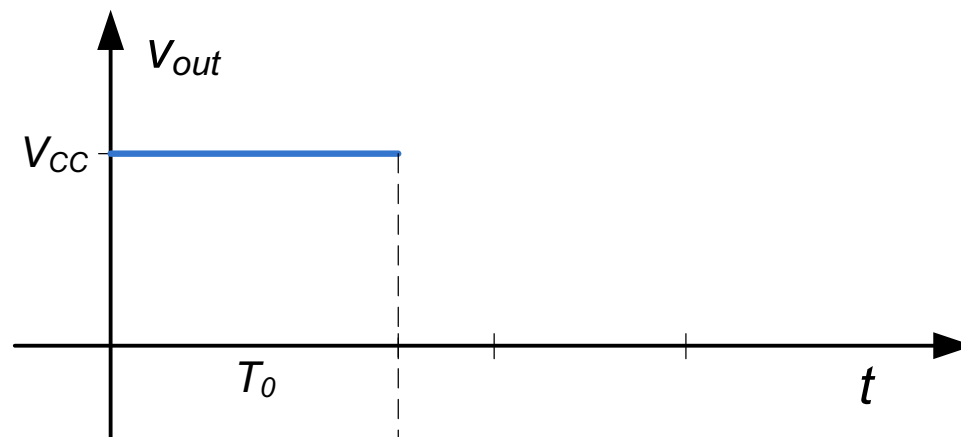
$$v_c < \frac{2}{3}V_{CC}$$

$$V_{CC}\left[1 - e^{-\frac{t}{(R_1+R_2)C_1}}\right] < \frac{2}{3}V_{CC}$$

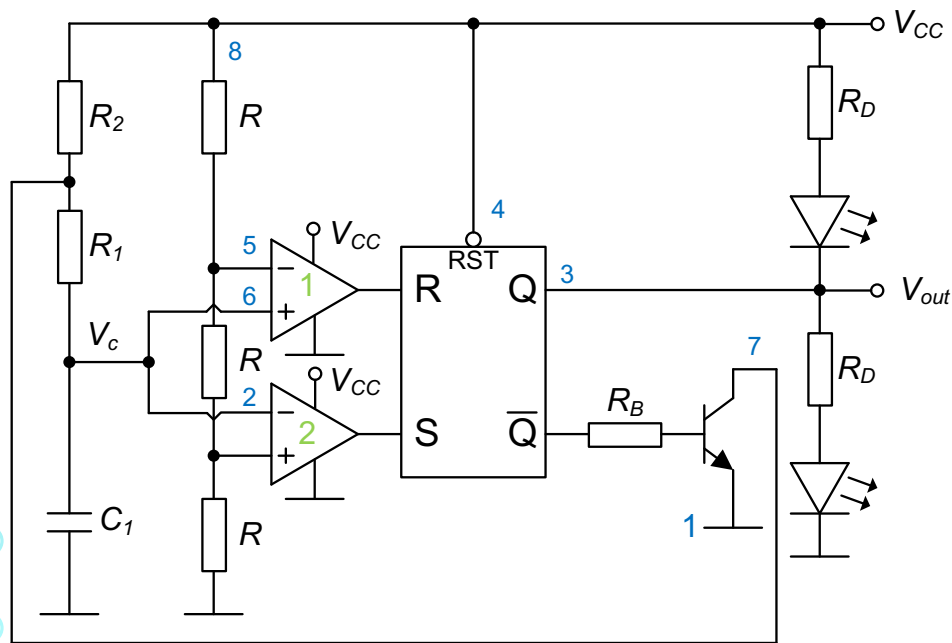
$$t < (R_1 + R_2)C_1 \ln 3 = T_0$$

$$T_0 = 1.03 \text{ s}$$

ZADATAK 2



ZADATAK 2



2°

$$v_c(0_-) = \frac{2}{3}V_{CC}$$

$$v_1^- = \frac{2}{3}V_{CC} < v_1^+ = v_c \Rightarrow R = 1$$

$$v_2^+ = \frac{1}{3}V_{CC} < v_2^- = v_c \Rightarrow S = 0$$

$\Rightarrow Q = 0, v_{out} = 0$, BJT – provodi u zasićenju

$$R_1 i + \frac{1}{C_1} \int i dt = 0$$

$$i = B e^{-\frac{t}{R_1 C_1}}$$

$$v_c = -R_1 i$$

$$v_c = -R_1 B e^{-\frac{t}{R_1 C_1}}$$

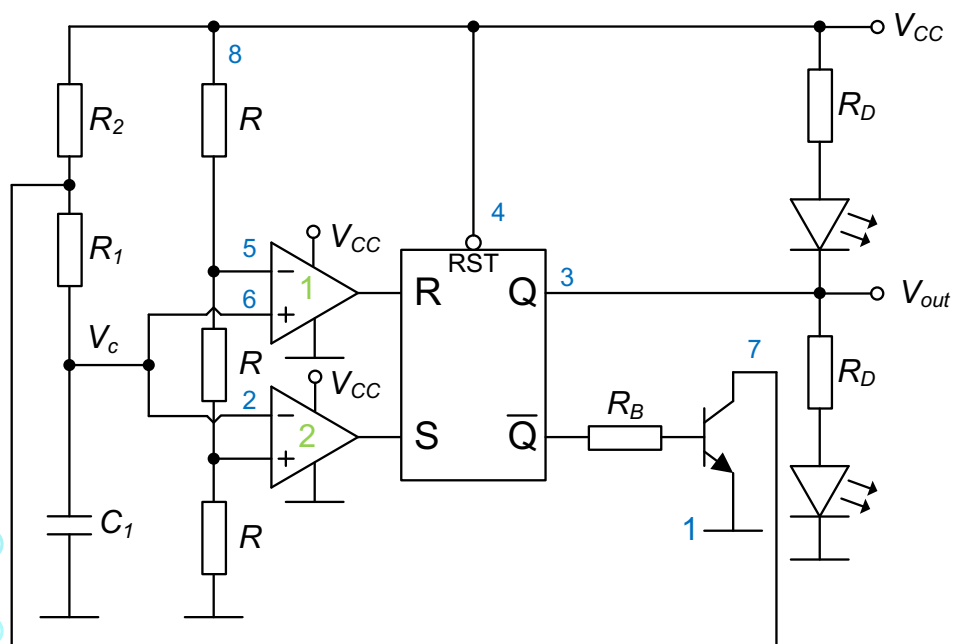
$$v_c(0_-) = \frac{2}{3}V_{CC}$$

$$v_c(0_+) = -R_1 B$$

$$\Rightarrow B = -\frac{2}{3} \frac{V_{CC}}{R_1}$$

$$v_c = \frac{2}{3}V_{CC} e^{-\frac{t}{R_1 C_1}}$$

ZADATAK 2



2°

$v_c \searrow$

$$\frac{V_{CC}}{3} < v_c < \frac{2}{3}V_{CC}$$

$$v_1^- = \frac{2}{3}V_{CC} > v_1^+ = v_c \Rightarrow R = 0$$

$$v_2^+ = \frac{1}{3}V_{CC} < v_2^- = v_c \Rightarrow S = 0$$

$\Rightarrow Q = 1, v_{out} = 0$, BJT – provodi u zasićenju

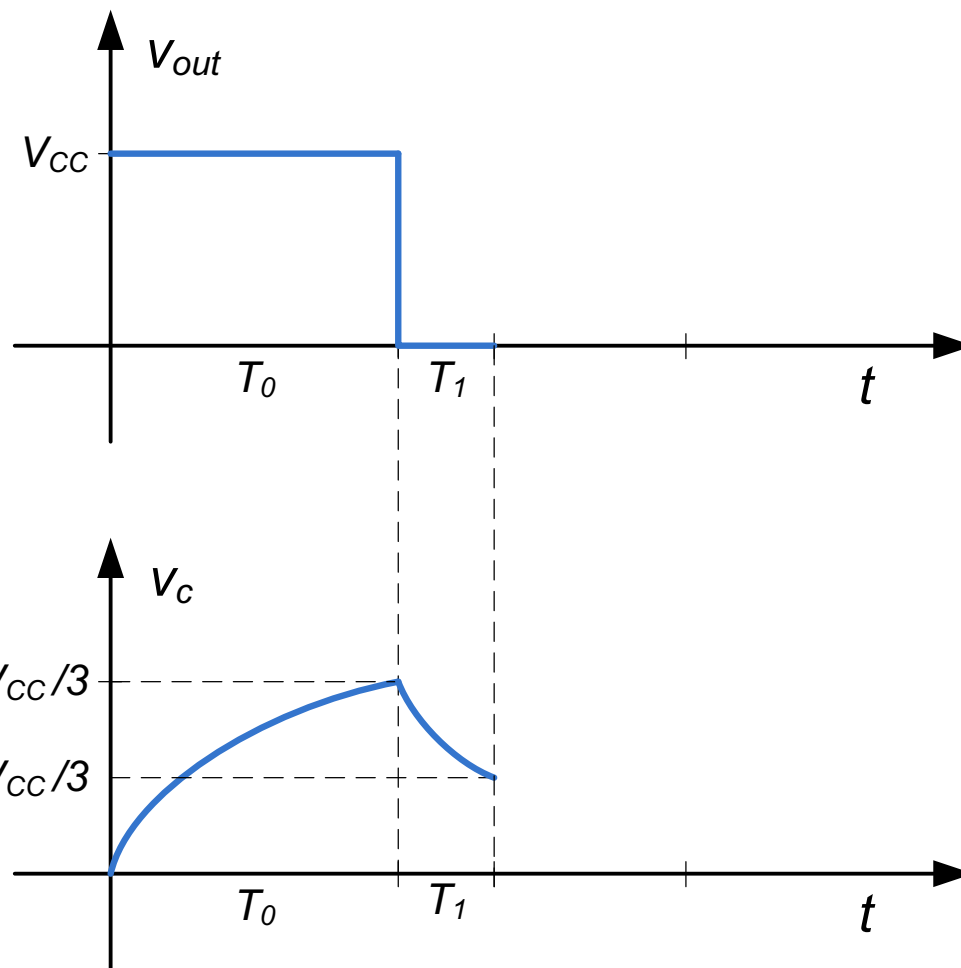
$$v_c > \frac{1}{3}V_{CC}$$

$$\frac{2}{3}V_{CC}e^{-\frac{t}{R_1C_1}} > \frac{1}{3}V_{CC}$$

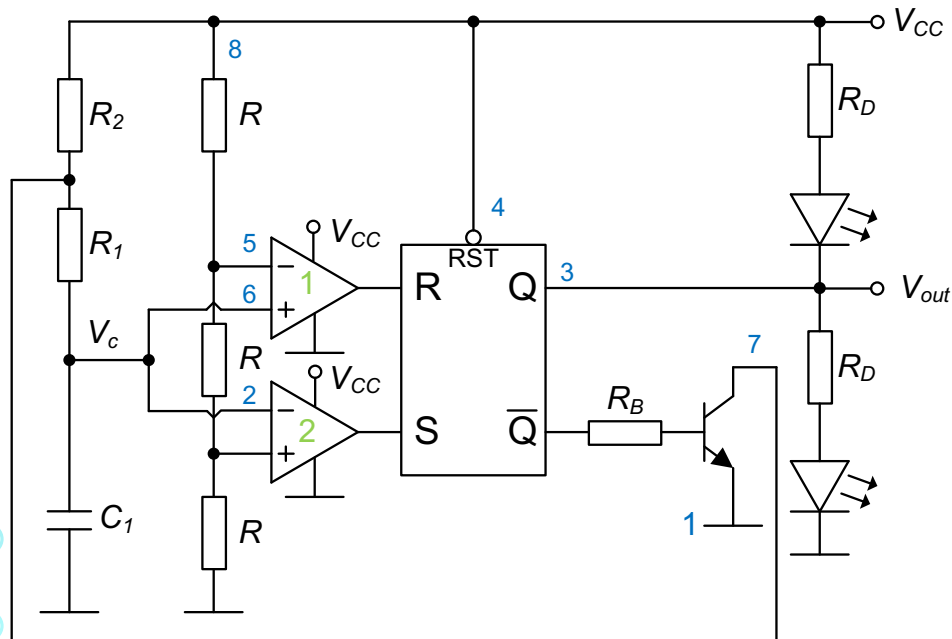
$$t < R_1C_1 \ln 2 = T_1$$

$$T_1 = 0.33 \text{ s}$$

ZADATAK 2



ZADATAK 2



3°

$$v_c(0_-) = \frac{1}{3}V_{CC}$$

$$v_1^- = \frac{2}{3}V_{CC} > v_1^+ = v_c \Rightarrow R = 0$$

$$v_2^+ = \frac{1}{3}V_{CC} > v_2^- = v_c \Rightarrow S = 1$$

$\Rightarrow Q = 1, v_{out} = V_{CC}$, BJT – zakočen

$$V_{CC} - (R_1 + R_2)i - \frac{1}{C_1} \int i dt = 0$$

$$i = B e^{-\frac{t}{(R_1+R_2)C_1}}$$

$$v_c = V_{CC} - (R_1 + R_2)i = V_{CC} - (R_1 + R_2)B e^{-\frac{t}{(R_1+R_2)C_1}}$$

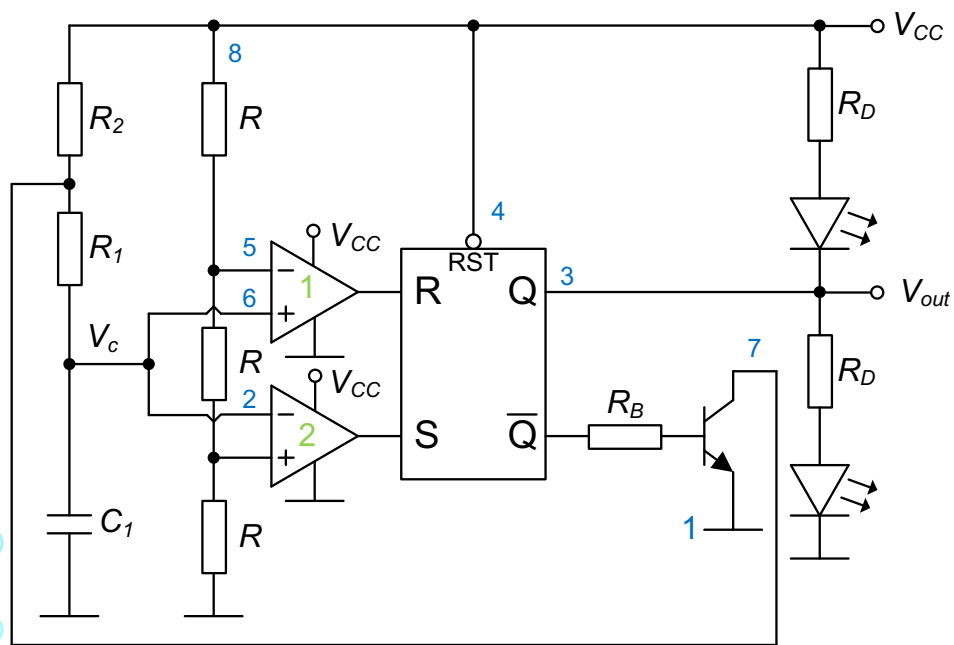
$$v_c(0_-) = \frac{1}{3}V_{CC}$$

$$v_c(0_+) = V_{CC} - (R_1 + R_2)B$$

$$\Rightarrow B = \frac{2}{3} \frac{V_{CC}}{R_1 + R_2}$$

$$v_c = V_{CC} - \frac{2}{3}V_{CC} e^{-\frac{t}{(R_1+R_2)C_1}}$$

ZADATAK 2



3°

$v_c \nearrow$

$$\frac{V_{CC}}{3} < v_c < \frac{2}{3}V_{CC}$$

$$v_1^- = \frac{2}{3}V_{CC} > v_1^+ = v_c \Rightarrow R = 0$$

$$v_2^+ = \frac{1}{3}V_{CC} < v_2^- = v_c \Rightarrow S = 0$$

$\Rightarrow Q = 1, v_{out} = V_{CC}, \text{BJT} - \text{zakočen}$

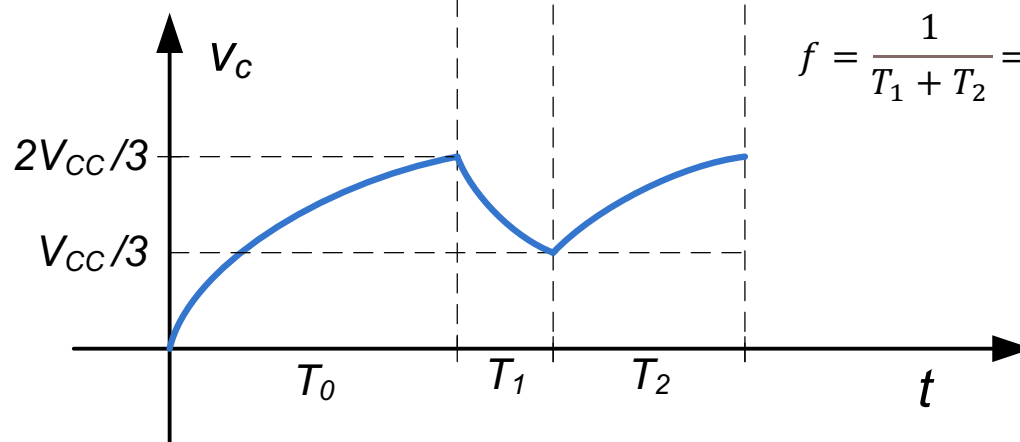
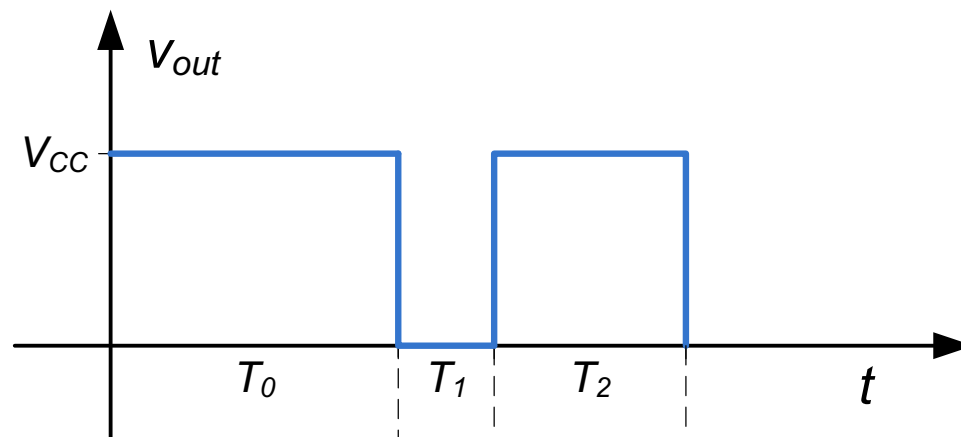
$$v_c < \frac{2}{3}V_{CC}$$

$$V_{CC} - \frac{2}{3}V_{CC}e^{-\frac{t}{(R_1+R_2)C_1}} < \frac{2}{3}V_{CC}$$

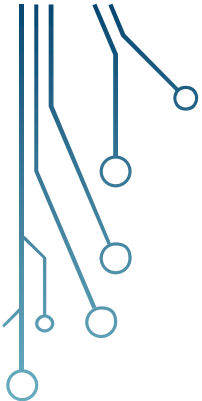
$$t < (R_1 + R_2)C_1 \ln 2 = T_2$$

$$T_2 = 0.65 \text{ s}$$

ZADATAK 2



$$f = \frac{1}{T_1 + T_2} = \frac{1}{(2R_1 + R_2)C_1 \ln 2} = 1.02 \text{ Hz}$$



ZADATAK 2

Zadaci laboratorijske vježbe

1. Uz pomoć odgovarajućih diskretnih komponenti sastaviti kolo prikazano na slici 5. Koristiti *Timer* 555, $R_D=1\text{ k}\Omega$.
 2. Pomoću osciloskopa prikazati talasni oblik napona v_{out} i napona v_c . Odrediti frekvenciju izlaznog napona. Uporediti rezultat sa onim dobijenim računskim putem. Posmatrati LED.
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