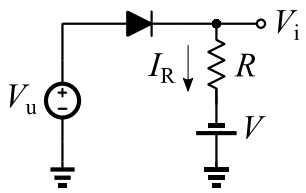
Elektronski fakultet u Nišu
Katedra za Elektroniku
Šifra: OEE3O01, OEM3O01, OET3O01, OEU3O02

Datum: 29. septembar 2023.

OSNOVI ELEKTRONIKE

Zadaci

1. Za diodno kolo sa Sl. 1 odrediti i nacrtati zavisnost:
a) izlaznog napona, V_i, i
b) struje, I_R, u funkciji ulaznog napona V_u.
Poznato je:
R_1=1kΩ, V=2V, –5V ≤ V_u ≤ 5V.
Parametri modela diode su:
V_{D0}=0.6V, r_d=0Ω.

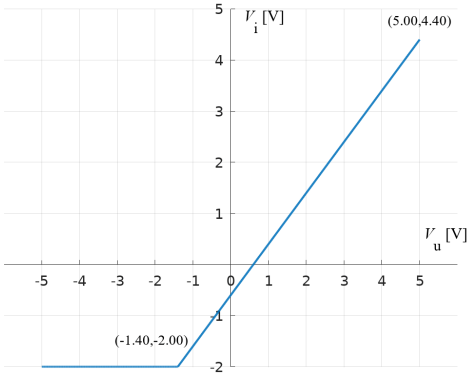


Sl. 1

Za $V_u \geq V_{D0} - V = -1.4V$ dioda vodi. 20%

a) 20%

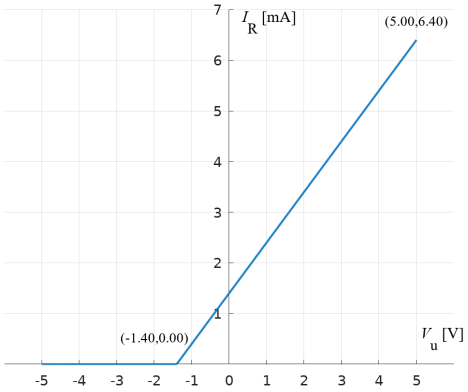
$$V_i = \begin{cases} -2V, & V_u < -1.4V \\ V_u - 0.6V, & V_u \geq -1.4V \end{cases}$$



20%

b) 20%

$$I_R = \begin{cases} 0A, & V_u < -1.4V \\ 1mS \cdot V_u + 1.4mA, & V_u \geq -1.4V \end{cases}$$



20%

2. Za pojačavač sa Sl. 2 odrediti:
a) jednosmerni napon na sorsu tranzistora, M2,
b) parametre modela za male signle, g_m, r_o, i
c) naponsko pojačanje, $A_n=V_i/V_u$.

Poznato je:

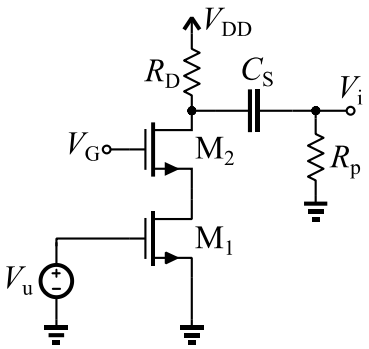
R_D=20kΩ, R_p=10kΩ, V_{DD}=3.3V, V_U=0.6V, V_G=1.3V.

Parametri tranzistora su:

A_1=2.5mA/V^2, A_2=6.25mA/V^2,

$V_{A1}=V_{A2}$=80V, $V_{TH1}=V_{TH2}$=0.4V.

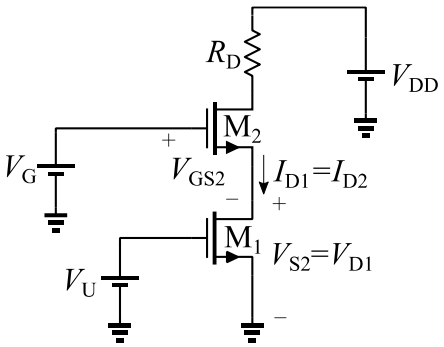
Smatrati da je kapacitivnost sprežnog kondnezatora, C_S, izuzetno velika.



Sl. 2

a)

$$I_{D1} = A_1(V_{GS1} - V_{TH1})^2 = 100\mu A = I_{D2} \Rightarrow$$
$$V_{GS2} = V_{TH2} + \sqrt{\frac{I_{D2}}{A_2}} = 0.526V, \text{ 15\%}$$
$$V_{S2} = V_{D1} = V_G - V_{GS2} = 0.774V \text{ 15\%}$$

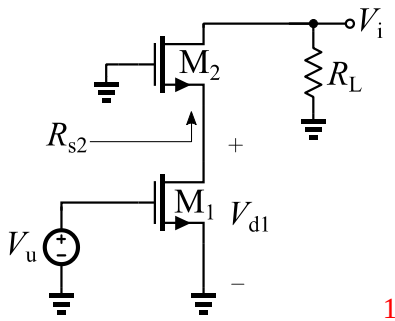


b)

$$g_{m1} = \frac{2I_{D1}}{V_{GS1}-V_{TH1}} = 1mS, r_{o1} = \frac{V_{A1}}{I_{D1}} = 800k\Omega \text{ 10\%}$$
$$g_{m1} = \frac{2I_{D2}}{V_{GS2}-V_{TH2}} = 1.581mS, r_{o2} = \frac{V_{A1}}{I_{D1}} = 800k\Omega \text{ 10\%}$$

c)

$$\mu_1 = g_{m1}r_{o1} = 800, \mu_2 = g_{m2}r_{o2} = 1265$$
$$R_L = R_D||R_p = 6.667k\Omega \text{ 20 10\%}$$
$$R_{s2} = \frac{R_L+r_{o2}}{1+\mu_2} = 636.7\Omega \text{ 10\%}$$
$$A_n = \frac{V_i}{V_u} = \frac{V_i}{V_{d1}} \cdot \frac{V_{d1}}{V_u} = \frac{(1+\mu_2)R_L}{R_L+r_{o2}} \cdot \frac{-\mu_1 R_{s2}}{R_{s2}+r_{o1}} = -10.533 \text{ 20\%}$$



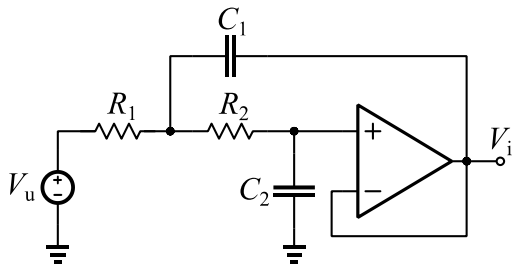
10%

3. Za filtar sa Sl. 3 odrediti:

a) prenosnu funkciju, $T(s) = V_i/V_u$,
b) polove funkcije prenosa i
c) tip filtra.

Poznato je:
$R_1=R_2=10k\Omega$, $C_1=C_2=1nF$.

Operacioni pojačavač ima sledeće karakteristike:
$A\rightarrow \infty V/V$, $R_{ul} \rightarrow \infty\Omega$, $R_{iz} \rightarrow 0\Omega$.

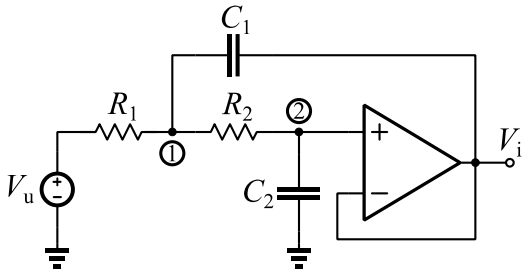


Sl. 3

a)

$V_2 = V_i$

$$\begin{bmatrix} \frac{1}{R_1}+\frac{1}{R_2}+sC_1 & -sC_1-\frac{1}{R_2} \\ -\frac{1}{R_2} & \frac{1}{R_2}+sC_2 \end{bmatrix} \begin{bmatrix} V_1 \\ V_i \end{bmatrix} = \begin{bmatrix} \frac{V_u}{R_1} \\ 0 \end{bmatrix}$$ 30%



$$\Delta = \frac{1}{R_1R_2} + sC_2\left(\frac{1}{R_1}+\frac{1}{R_2}+sC_1\right)$$ 10%

$$\Delta_{V_i} = \frac{V_u}{R_1R_2}$$ 10%

$$T(s) = \frac{V_i}{V_u} = \frac{\Delta_{V_i}}{\Delta}\cdot\frac{1}{V_u} = \frac{1}{1+sC_2(R_1+R_2)+s^2R_1R_2C_1C_2}$$ 10%

b)

$R_1 = R_2 = R, C_1 = C_2 = C, \tau = RC = 10\mu s$

$$T(s) = \frac{D(s)}{N(s)} \Rightarrow N(s) = 1+sC_2(R_1+R_2)+s^2R_1R_2C_1C_2 = 1+s(2\tau)+s^2\tau^2 = 0$$

$s_{1,2} = -\frac{1}{\tau} = -10^5 rad/s$ 20%

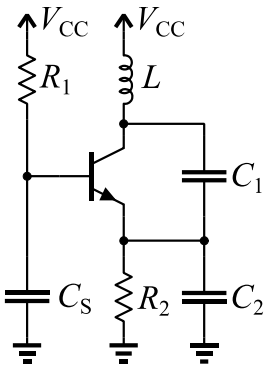
c) Propusnik niskih frekvencija (low pass). 20%

4. Za oscilator sa Sl. 4 odrediti:
a) frekvenciju oscilovanja i
b) otpornost baze za mali signal, r_π, pri kojoj je ispunjen uslov ocilovanja.

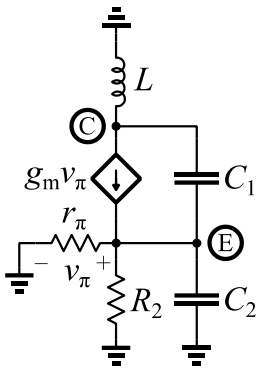
Poznato je:
R_1=400kΩ, R_2=100Ω, C_1=400nF, C_2=200nF, L=500nH, V_{CC}=3.3V.

Tranzistr ima sledeće karakteristike:
β = 80, $V_T=kT/q \approx$ 25mV.

Smatrati da kapacitivnost CS ima izuzetno veliku vrednost.



Sl. 4



10%

$v_\pi = v_b - v_e = -v_e$ (10%)

$$\begin{bmatrix} \frac{1}{R_2} + \frac{1+\beta}{r_\pi} + s(C_1+C_2) & -sC_1 \\ -\frac{\beta}{r_\pi} - sC_1 & \frac{1}{sL} + sC_1 \end{bmatrix} \begin{bmatrix} v_e \\ v_c \end{bmatrix} = \begin{bmatrix} 0 \\ 0 \end{bmatrix}$$ (20%)

$$\Delta = \frac{1}{L}\left(\frac{1}{R_E} + \frac{1+\beta}{r_\pi}\right) + s\frac{(C_1+C_2)}{L} + s^2 C_1\left(\frac{1}{R_2} + \frac{1}{r_\pi}\right) + s^3 C_1 C_2$$ (20%)

a) 20%

$$Im\{\Delta\} = \omega_0 \frac{(C_1+C_2)}{L} - \omega_0^3 C_1 C_2 \Rightarrow C_{ek} = \frac{C_1 C_2}{C_1+C_2} = 133.33nF, \omega_0 = \frac{1}{\sqrt{LC_{ek}}} = 3.873 \cdot 10^6 rad/s$$

$$f_o = \frac{\omega_o}{2\pi} = 616.40kHz$$

b) 20%

$$Re\{\Delta\} = \frac{1}{L}\left(\frac{1}{R_2} + \frac{1+\beta}{r_\pi}\right) - \omega_0^2 C_1\left(\frac{1}{R_2} + \frac{1}{r_\pi}\right) \Rightarrow r_\pi = R_2\left(\beta\frac{C_1}{C_2} - 1\right) = 3.9k\Omega$$