ELEKTRONIKA

(pisni izpit: 18.9.2002)

Čas reševanja: 90 minut
Teža nalog: 25+25+25+25=100%

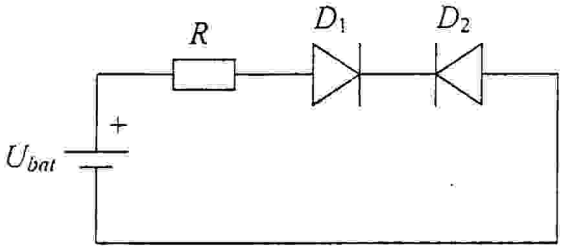
1. naloga (25%)

Slika v prilogi prikazuje zaslon osciloskopa z vhodnim in izhodnim signalom nekega linearnega sistema.

- Določite napetostno ojačanje (v decibelih) in fazni zamik med signaloma.
- Ali pripadata signala členu RC ali CR in kako ste to ugotovili (skicirajte vezje)?
- Izpeljite izraz za prenosno funkcijo tega sistema $H(j\omega)$.
- Če velja, da je $R = 1$ kΩ, določite vrednost kondenzatorja C za podani odziv sistema.
- Določite mejno frekvenco sistema.

2. naloga (25%)

Izračunajte tok v spodnjem vezju in padca napetosti na diodah, če smo uporabili dve enaki germanijevi diodi.



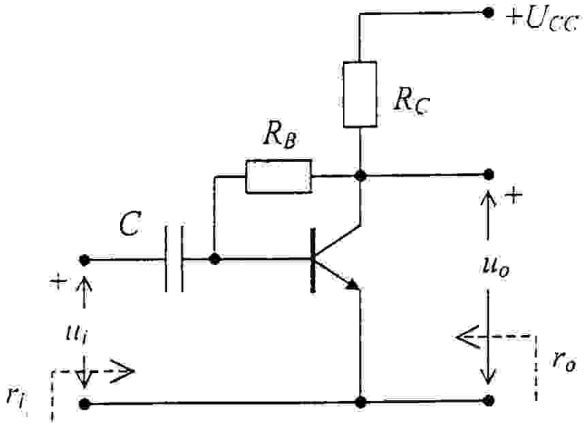
$T = 293$ K
$U_T = 25$ mV
$R = 1{,}2$ kΩ
$U_{bat} = 12$ V
$I_S = 2$ nA

$$I_D = I_S\left(e^{\frac{U_D}{U_T}} - 1\right)$$

OBRNITE

3. naloga (25%)

Prikazano vezje ojačevalnika naj deluje v predpisani delovni točki.



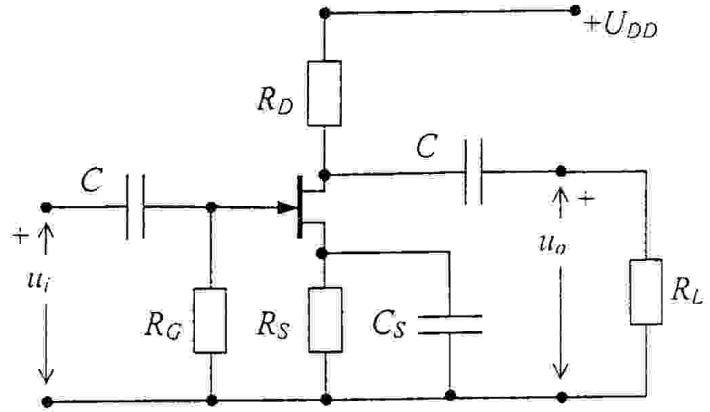
Za delovno točko:
$U_{CEQ} = 12$ V
$I_{CQ} = 20$ mA
$I_{BQ} = 80$ µA
$U_{BEQ} = 0{,}65$ V
$U_{CC} = 24$ V

Parametri tranzistorja:
$h_{ie}(h_{11e}) = 1{,}2$ kΩ
$h_{re}(h_{12e}) = 4 \cdot 10^{-4}$
$h_{fe}(h_{21e}) = 200$
$h_{oe}(h_{22e}) = 333$ µS

- Določite vrednosti uporov v vezju za predpisano delovno točko.
- Narišite nadomestno shemo ojačevalnika za majhne izmenične signale.
- Izračunajte vhodno in izhodno notranjo upornost (r_i in r_o) ter napetostno ojačanje A_u za neobremenjen ojačevalnik. Pri tem izračunu zanemarite vpliv C in R_B na vezje ($C \to \infty$, $R_B \to \infty$).

4. naloga (25%)

Ojačevalnik z JFET tranzistorjem na sliki naj deluje v predvideni delovni točki.

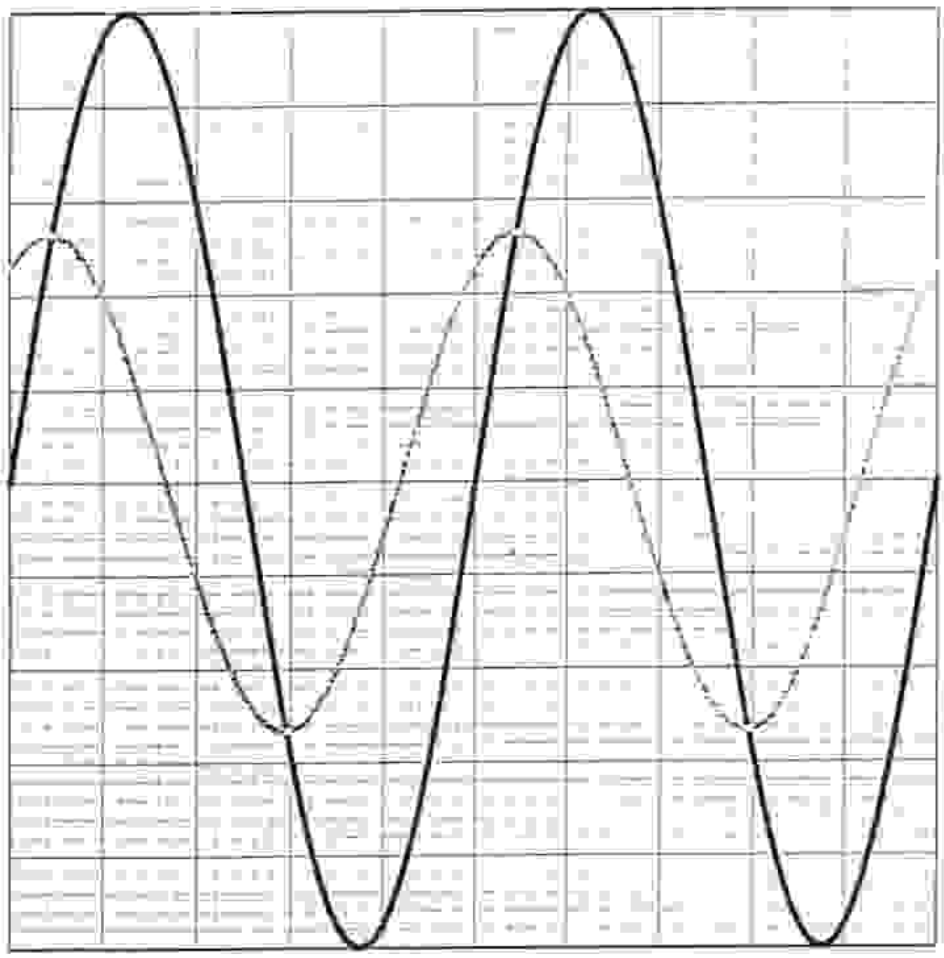


Zahteve za delovno točko:
$I_{DQ} = 2{,}5$ mA
$U_{DSQ} = 10$ V
$U_{GSQ} = -2$ V

Tranzistor:
$r_D = 12$ kΩ
$g_m = 4$ mS

Ostalo:
$U_{DD} = 24$ V
$R_G = 1$ MΩ
$R_L = 500$ Ω
$C = C_S = \infty$

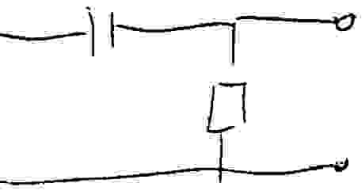
- Določite upora R_D in R_S za zahtevano delovno točko.
- Narišite nadomestno shemo ojačevalnika za majhne izmenične signale.
- Izračunajte napetostno ojačanje obremenjenega ojačevalnika.



dt = 1 ms/div

Ui (2V/div)

Uo (2V/div)



$$H(j\omega) = \frac{U_o(j\omega)}{U_i(j\omega)} = \frac{R}{R + \frac{1}{j\omega C}} = \frac{\omega^2 R^2 C^2 + j\omega RC}{1 + \omega^2 R^2 C^2}$$

$$\varphi = \operatorname{arctg} \frac{Im}{Re} = \operatorname{arctg} \frac{1}{\omega RC} \Rightarrow \underline{C = (tg\varphi \cdot \omega \cdot R)^{-1}}$$

$$= (tg\,59^\circ \cdot 2\pi \cdot 200 \cdot 1000)^{-1} = \underline{\underline{478\ nF}}.$$

$$|H(j\omega)| = \frac{\omega RC}{\sqrt{1 + \omega^2 R^2 C^2}} \Big|^2$$

$$|H|^2 = \frac{(\omega RC)^2}{1 + (\omega RC)^2} \Rightarrow |H|^2 + |H|^2 (\omega RC)^2 = (\omega RC)^2$$

$$|H|^2 = (\omega RC)^2 (1 - |H|^2)$$

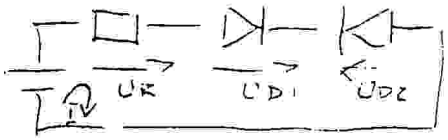
$$\frac{|H|^2}{1 - |H|^2} \cdot \frac{1}{(\omega R)^2} = C^2 \Rightarrow C = \frac{|H|}{\omega R \sqrt{1 - |H|^2}} =$$

$$= \frac{0,53}{1000 \cdot 2\pi\, 200 \sqrt{1 - 0,53^2}} = \underline{\underline{497\ nF}}$$

$$f_0 = \frac{1}{2\pi RC} = \frac{1}{2\pi\, 1000 \cdot 497 \cdot 10^{-9}} = \underline{\underline{320\ Hz}}$$

2. naloga

Za napetosti v vezju velja:



$U_{bat} = U_R + U_{D1} - U_{D2}$ $\quad (U_b = U_R + D_{D1} + U_{D2})$

$I = I_{D1} = -I_{D2}$ $\quad (I = I_{D1} = I_{D2})$

D2 je polarizirana zaporno $\Rightarrow$ $I_{D2} = -I_S = -2\,nA$ $\quad (I_{D2} = I_S = 2\,nA)$

D1 je polarizirana prevodno, a teče isti tok

$$I_{D1} = I_S\left(e^{\frac{U_{D1}}{U_T}} - 1\right) = I_S$$

$$e^{U_{D1}/U_T} = 2$$

$$U_{D1} = U_T \cdot \ln 2 = 25\,mV \cdot \ln 2 = 17{,}33\,mV$$

$$U_{bat} - I \cdot R - U_{D1} = -U_{D2}$$

$$12 - 2 \cdot 10^{-4} \cdot 1{,}2 \cdot 10^{3} - 17{,}33 \cdot 10^{-3} =$$

$$= 12 - 2{,}4 \cdot 10^{-6} - 17{,}33 \cdot 10^{-3} = 11{,}983\,V = -U_{D2}$$

$(U_{D2} = U_{bat} - IR - U_{D1} = 11{,}983\,V)$

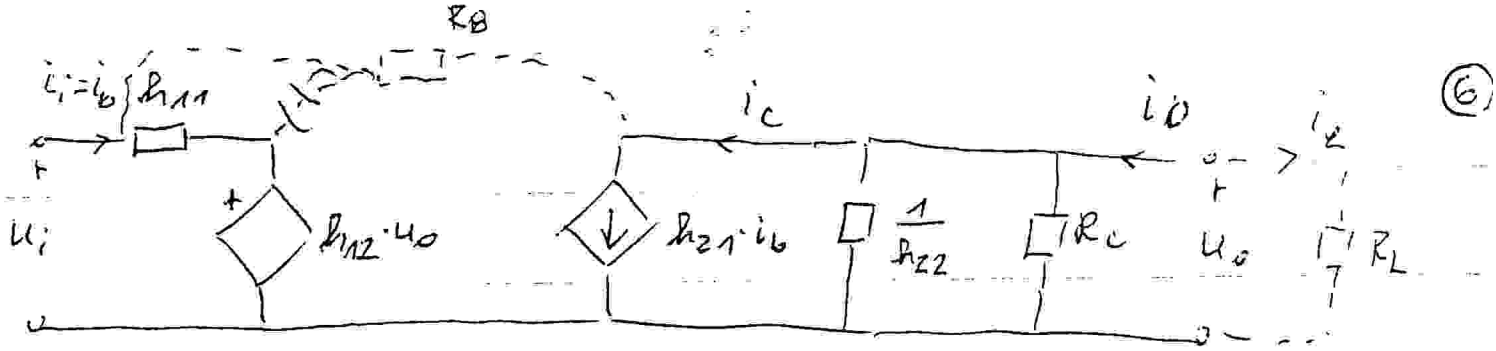
3. naloga

Delovna točka:

$$R_C = \frac{U_{RC}}{I_{RC}} = \frac{U_{CC} - U_{CEQ}}{I_{CQ} + I_{BQ}} = \frac{24 - 12}{(20 + 0{,}08)\cdot 10^{-3}} = \underline{598\ \Omega}$$ (2)

$$R_B = \frac{U_{RB}}{I_{RB}} = \frac{U_{CEQ} - U_{BEQ}}{I_{BQ}} = \frac{12 - 0{,}65}{80\cdot 10^{-6}} = \underline{141{,}875\ k\Omega}$$ (3)

Nadomestna shema



(6)

$$A_u = \frac{u_0}{u_i} =$$

$$u_0 = -h_{21} i_b \cdot \frac{1}{h_{22}} \| R_C = \dots$$

$$\frac{1}{h_{22}} \| R_C = \frac{3003 \cdot 598}{3601} = \underline{497\ \Omega}$$

$$u_i = i_b \cdot h_{11} + h_{12} \cdot u_0 = i_b \left(h_{11} - h_{12} h_{21} \frac{1}{h_{22}} \| R_C \right)$$

$$= \dots$$

$$A_u = \frac{u_0}{u_i} = \frac{-\frac{1}{h_{22}} \| R_C}{h_{12} \cdot \frac{1}{h_{22}} \| R_C \cdot h_{21}} = \frac{497}{4\cdot 10^{-4} \cdot 497}$$ (5)

$$= \frac{-h_{21} \cdot \frac{1}{h_{22}} \| R_C}{h_{11} - h_{12} h_{21} \frac{1}{h_{22}} \| R_C} = \frac{-200 \cdot 497}{1200 - 4\cdot 10^{-4} \cdot 200 \cdot 497} = \underline{-85{,}7}$$

$$r_i = \frac{u_i}{i_i} = \frac{i_b\left(h_{11} - h_{12}h_{21}\left(\frac{1}{h_{22}} \| R_c\right)\right)}{i_b} = h_{11} - h_{12}h_{21}\frac{1}{h_{22}} \| E$$

$$= 1200 - 4\cdot 10^{-4}\cdot 200 \cdot 497 = \underline{1160\,\Omega} \quad (5)$$

$$r_o = \left.\frac{u_o}{i_o}\right|_{u_i=0} = \frac{i_o \cdot \frac{1}{h_{22}} \| R_c}{i_o} = \frac{1}{h_{22}} \| R_c = \underline{497\,\Omega} \quad (3)$$

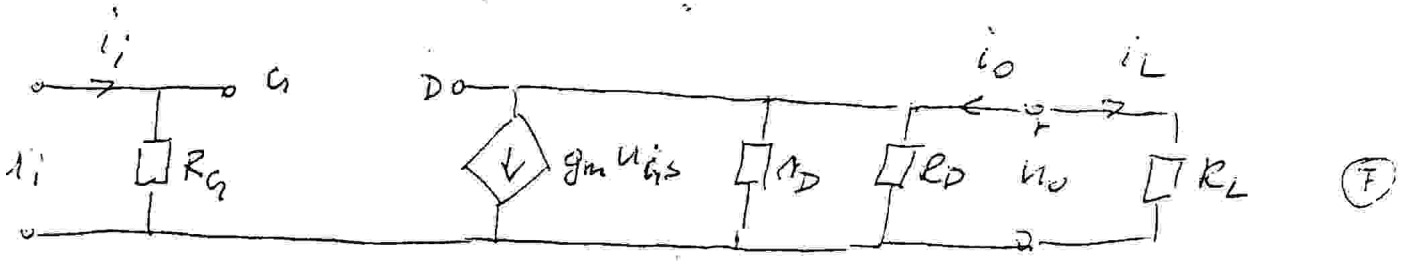
4. naloga

klena točka:

$$R_3 = \frac{U_{R3Q}}{I_{R3Q}} = \frac{-U_{GSQ}}{I_{DQ}} = \frac{2}{2{,}5\cdot 10^{-3}} = 800\,\Omega \quad (5)$$

$$R_D = \frac{U_{RDQ}}{I_{RDQ}} = \frac{U_{DD} - U_{DSQ} - U_{R3Q}}{I_{DQ}} = \frac{U_{DD} - U_{DSQ} + U_{GSQ}}{I_{DQ}} =$$

$$= \frac{24 - 10 - 2}{2{,}5\cdot 10^{-3}} = 4800\,\Omega \quad (4)$$



(7)

$$A_u = \frac{u_o}{u_i} = \qquad R' = \left(\frac{1}{12k} + \frac{1}{4k8} + \frac{1}{500}\right)^{-1} = 436\,\Omega$$

$$u_o = -g_m \cdot u_{GS} \cdot r_D \| R_D \| R_L =$$

$$u_i = u_{GS}$$

(10)

$$A_u = -g_m \cdot r_D \| R_D \| R_L = -4\cdot 10^{-3} \cdot 436 = -1{,}744$$