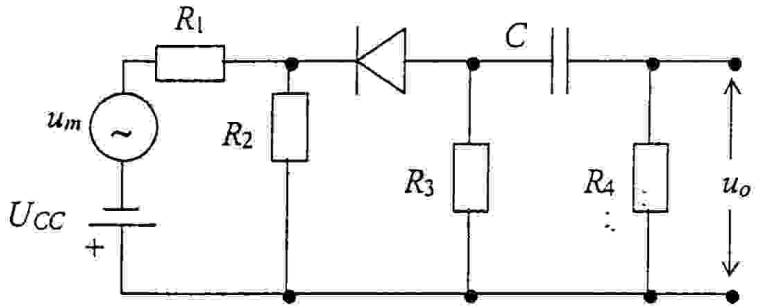
ELEKTRONIKA

(pisni izpit: 3.9.2002)

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

1. naloga (25%)

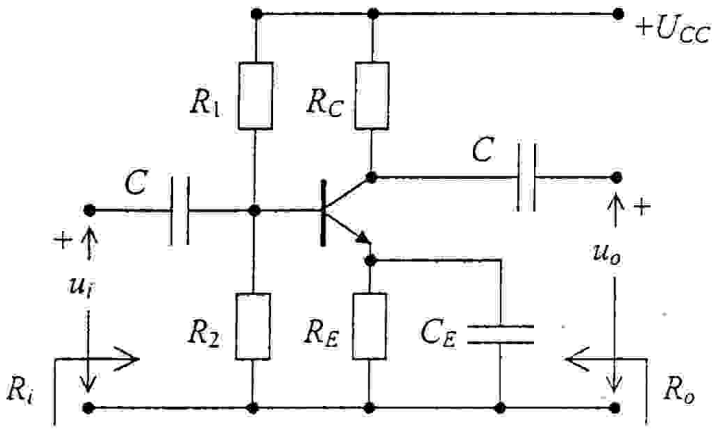
Ob uporabi podane karakteristike diode (priloga) izračunajte amplitudo izmeničnega dela izhodne napetosti podanega vezja.



$R_1 = 8\ \Omega$
$R_2 = 32\ \Omega$
$R_3 = 24\ \Omega$
$R_4 = 180\ \Omega$
$C = 100\ \mu\text{F}$
$U_{CC} = 1{,}5\ \text{V}$
$u_m = U_m \cos \omega t$;
$U_m = 50\ \text{mV}$; $\omega = 10^4\ \text{rad/s}$
$r_D = \dfrac{U_T}{I_{DQ}}$; $U_T = 25\ \text{mV}$

2. naloga (25%)

Za vezje tranzistorskega ojačevalnika s skupnim emitorjem narišite nadomestno shemo za majhne izmenične signale in izračunajte napetostno ojačanje $A_u = \dfrac{u_o}{u_i}$ ter vhodno in izhodno notranjo upornost R_i in R_o.

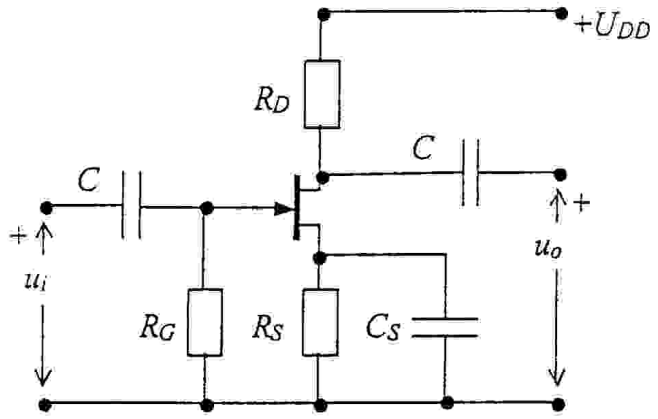


$R_1 = 20\ \text{k}\Omega$
$R_2 = 30\ \text{k}\Omega$
$R_C = 2{,}4\ \text{k}\Omega$
$R_E = 500\ \Omega$
$h_{11e} = 1{,}2\ \text{k}\Omega$
$h_{21e} = 80$
$h_{12e} = h_{22e} = 0$
$C = \infty$
$C_E = \infty$

OBRNITE

3. naloga (25%)

Ojačevalnik z JFET tranzistorjem na sliki naj ima napetostno ojačanje A_u in naj deluje v predvideni delovni točki (I_{DQ}, U_{DSQ}). Narišite nadomestno shemo za majhne izmenične signale ter določite potrebne vrednosti uporov R_D in R_S ter napajalno napetost U_{DD} pri predpostavljenih vrednostih U_p in I_{DSS}.



Zahteve:
- $A_u = -5$
- $I_{DQ} = 5{,}8$ mA
- $U_{DSQ} = 10$ V

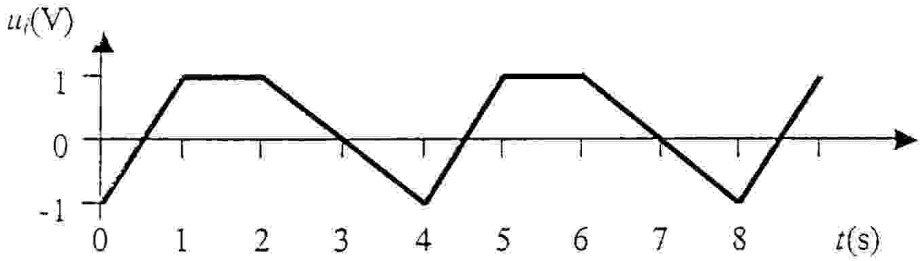
Predpostavke:
- $R_G = 1$ MΩ
- $C = C_S = \infty$
- $r_D >> R_D$
- $U_p = -5$ V
- $I_{DSS} = 10$ mA.

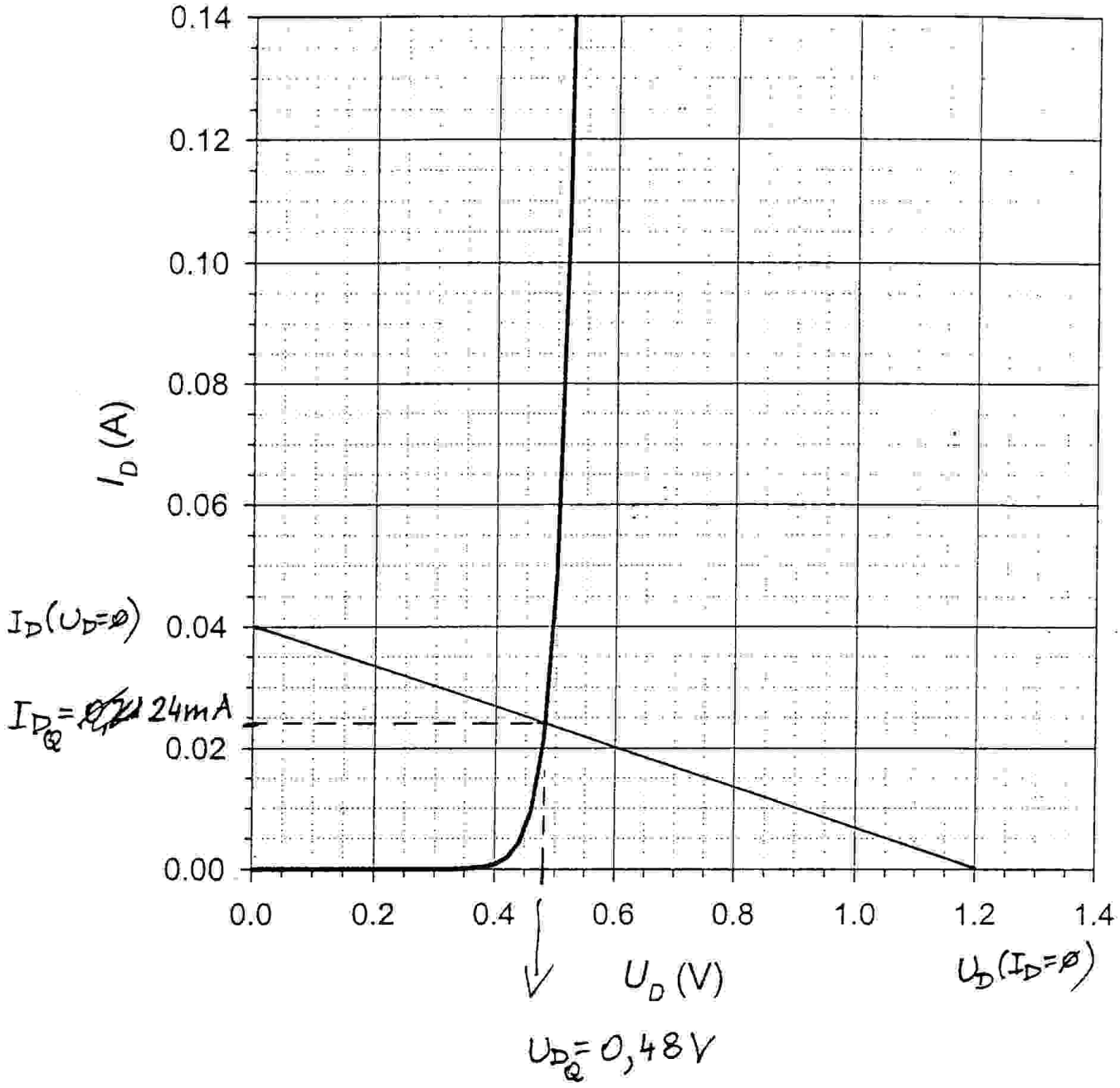
Iščemo: R_D, R_S, U_{DD}

$$i_D = I_{DSS}\left(1-\frac{u_{GS}}{U_p}\right)^2 \qquad g_m = \left.\frac{\partial i_D}{\partial u_{GS}}\right|_Q$$

4. naloga (25%)

Narišite shemo preprostega diferenciatorja (odvajalnika) z operacijskim ojačevalnikom in IZPELJITE izraz za izhodno napetost kot funkcijo vhodne napetosti. Predpostavite, da je operacijski ojačevalnik idealen ($R_i = \infty$, $R_o = 0$, $A = \infty$).
Denimo, da je C = 2 nF. Kakšno vrednost upora R potrebujemo, da amplituda izhodne napetosti u_0 v nobenem trenutku po absolutni vrednosti ne preseže 4 mV, če je vhodni signal tak, kot prikazuje spodnja slika. Skicirajte izhodni signal za izbrano vrednost R (označite amplitude).




0.14
0.12
0.10
0.08
0.06
0.04
0.02
0.00
I_D (A)
$I_D(U_D=0)$
I_{D_Q} = 24mA
0.0
0.2
0.4
0.6
0.8
1.0
1.2
1.4
U_D (V)
$U_D(I_D=0)$
U_{D_Q} = 0,48V

Naloga 1 (3.9.2002)

- Napajalni del nadomestimo s Théveninovim ekvivalentom

$u_T = U'_{cc} + u'_m$

Napetostni delilnik : $\frac{R_2}{R_1+R_2}$

$$u_T = u_{R2} = i \cdot R_2 = \frac{U_{cc} + u_m}{R_1 + R_2} \cdot R_2 = U'_{cc} + u'_m$$

$$\underline{U'_{cc}} = \frac{R_2}{R_1+R_2} U_{cc} = \frac{32}{8+32} 1{,}5 = \underline{1{,}2V}$$

$$\underline{U'_m} = \frac{R_2}{R_1+R_2} U_m = \frac{32}{40} \cdot 50mV = \underline{40mV} \quad (u'_m = U'_m \cos\omega t)$$

$$\underline{R_T} = R_1 \| R_2 = \frac{32 \cdot 8}{40} = \underline{6{,}4\Omega}$$

- Delovna točka (DC) : linearizacija diodne karakteristike, ker je $U'_m << U'_{cc}$ => superpozicija

DC: $U'_{cc} = U_D + I_D(R_T + R_3)$

premica: $U_D(I_D = 0) = U'_{cc} = \underline{1{,}2V}$

$I_D(U_D = 0) = \frac{U'_{cc}}{R_T+R_3} = \frac{1{,}2}{6{,}4+24} = \underline{39{,}5mA}$ ($\doteq 40mA$)

Odčitamo : $\underline{U_{DQ}} = \underline{0{,}48V}$

$\underline{I_{DQ}} = \underline{24mA}$

Upornost diode v delovni točki (linearizacija)

$$\underline{r_D} = \frac{U_T}{I_{DQ}} = \frac{25mV}{24mA} = \underline{1{,}042\Omega} \quad (\doteq 1\Omega)$$

Izmenične razmere (odziv na u'_m)

Z_C zanemarljiv proti R_4

$$\left.\begin{aligned} \frac{1}{\omega C} &= \frac{1}{10^4 \cdot 10^{-4}} = 1\,\Omega \ll 180\,\Omega \end{aligned}\right\} \Rightarrow u_0 \doteq u_{R3}$$

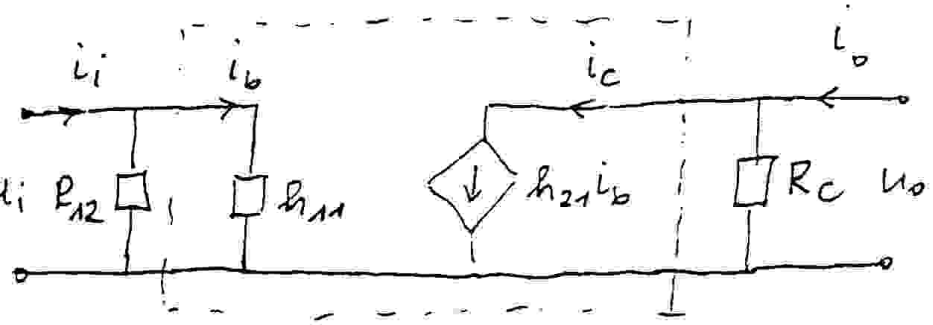
$$\underline{u_0 \doteq U_{R3}} = I \cdot R_3 \| R_4 = U'_m \cdot \frac{R_3 \| R_4}{(R_T + r_D + R_3 \| R_4)}$$

$$U'_m = I \cdot (R_T + r_D + R_3 \| R_4)$$

$$= 0{,}04 \cdot \frac{\frac{24 \cdot 180}{204}}{6{,}4 + 1{,}042 + \frac{24 \cdot 180}{204}} = \underline{29{,}6\ mV} \quad (30\ mV)$$

...logge 2 (3.9.2002)

$C_E = \infty$



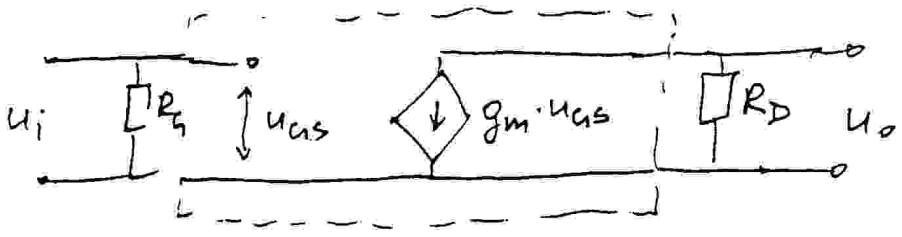
$$\underline{R_{12}} = R_1 \| R_2 = \frac{20 \cdot 30}{50} = \underline{12\,k\Omega}$$

$$\left.\begin{aligned} u_i &= i_b \cdot h_{11} \\ u_o &= -i_b \cdot h_{21} \cdot R_C \end{aligned}\right\} \quad \underline{A_u} = \frac{u_o}{u_i} = -\frac{h_{21} \cdot R_C}{h_{11}} = -\frac{80 \cdot 2400}{1200} = \underline{-160}$$

$$\underline{R_i} = \frac{u_i}{i_i} = \frac{i_b \cdot h_{11}}{i_b + \frac{i_b \cdot h_{11}}{R_{12}}} = h_{11} \| R_{12} = \frac{1{,}2 \cdot 12}{13{,}2} = \underline{1{,}09\,k\Omega}$$

$$\underline{R_o} = \left.\frac{u_o}{i_o}\right|_{\text{pri } i_b = 0} = \frac{i_o \cdot R_C}{i_o} = R_C = \underline{2{,}4\,k\Omega}$$

Naloge 3 (3.9.2002)



- Delovna točka (DC režim) → R_S

$$I_{DQ} = I_{DSS}\left(1 - \frac{U_{GSQ}}{U_P}\right)^2 \Rightarrow$$

$$\underline{U_{GSQ}} = U_P\left(1 - \sqrt{\frac{I_{DQ}}{I_{DSS}}}\right) = -5\left(1 - \sqrt{\frac{5,8}{10}}\right) \doteq \underline{-1,19V}$$

ker $U_{RSQ} \doteq -U_{GSQ}$

$$\Rightarrow \underline{R_S} = \frac{U_{RSQ}}{I_{DQ}} = \frac{-U_{GSQ}}{I_{DQ}} = \frac{1,19}{0,0058} \doteq \underline{206\Omega}$$

- R_D računamo za AC režim (R_D določa ojačanje)

$$\left.\begin{aligned} u_i &= u_{GS} \\ u_o &= -g_m u_{GS} R_D \end{aligned}\right\} A_u = \frac{u_o}{u_i} = -g_m R_D = -5 \Rightarrow$$

$$\underline{g_m} = \frac{\partial i_D}{\partial u_{GS}}\bigg|_Q = -\frac{2I_{DSS}}{U_P}\left(1 - \frac{U_{GSQ}}{U_P}\right) = \frac{0,02}{5}\left(1 - \frac{1,19}{5}\right) = \underline{3,048mS}$$

$$\Rightarrow \underline{R_D} = \frac{A_u}{-g_m} = \frac{-5}{-3,048mS} = \underline{1,64\,k\Omega}$$

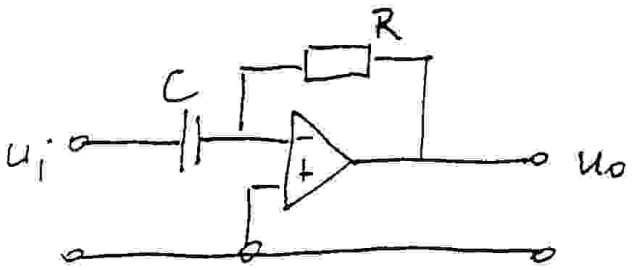
- U_{DD}:

$$\underline{U_{DD}} = I_{DQ} \cdot R_D + U_{DSQ} + I_{DQ} \cdot R_S$$

$$= I_{DQ}(R_D + R_S) + U_{DSQ} = 5,8mA(1640 + 206) + 10$$

$$= \underline{20,7V}$$

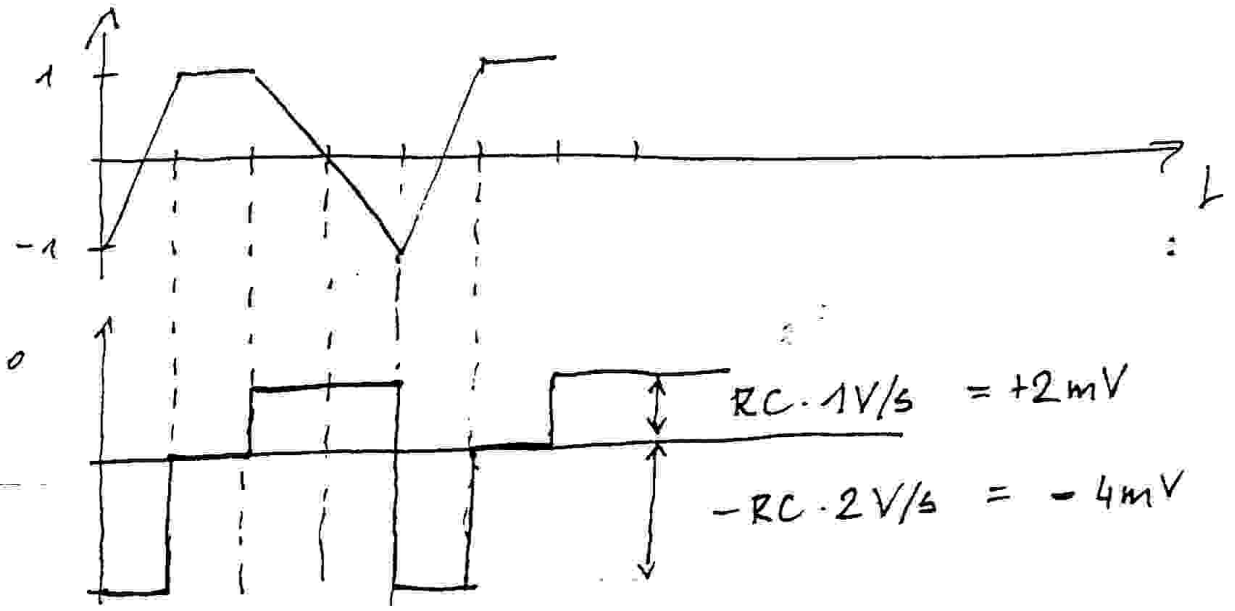
Naloga 4 (3.9.02)



$$\sum i = 0 \Rightarrow i_C + i_R = 0$$

$$C\frac{du_i}{dt} + \frac{u_o}{R} = 0$$

$$\boxed{u_o = -RC\frac{du_i}{dt}}$$



$t = 0 \to 1$: $\quad u_o = -RC \cdot \frac{\Delta u_i}{\Delta t} = -RC \cdot 2\,V/s$

$t = 1 \to 2$: $\quad u_o = 0$

$t = 2 \to 4$: $\quad u_o = -RC \cdot \frac{\Delta u_i}{\Delta t} = RC \cdot 1\,V/s$

Največja amplituda:

$$|-RC \cdot 2\,V/s| = 4mV \Rightarrow \underline{\underline{R}} = \frac{4\,mV}{2\,V/s \cdot 2nF} = \frac{4 \cdot 10^{-3}}{2 \cdot 2 \cdot 10^{-9}} = 1M$$

$$i_C = C\frac{du_C}{dt}$$

$$u_C = \frac{1}{C}\int_0^t i_C\,dt + u_C(0)$$