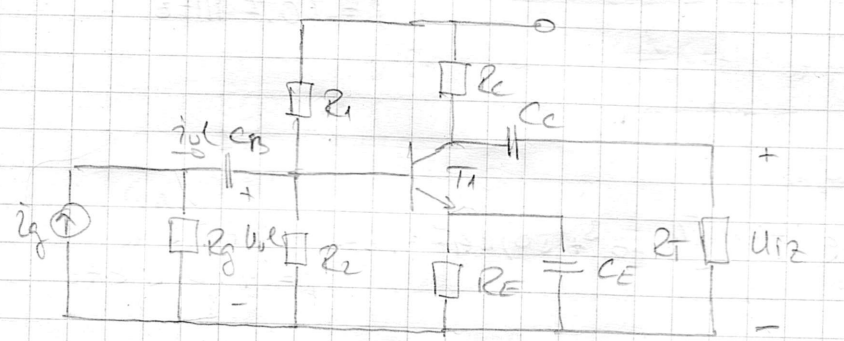
Zadatak 1.

$U_{cc} = 12V$ $R_g = 50\Omega$ $C_B = 4\mu F$ $R_1 = 200\Omega$ $R_2 = 50\Omega$ $R_c = 4\Omega$
$R_E = 500\Omega$ $C_E = 100\mu F$ $C_c = 5\mu F$ $R_T = 1\Omega$ $\beta = 120$ $r_{bb} = 50\Omega$ $C_{be} = 50pF$
$C_{bc} = 3pF$

$A_{Ig} = ?$

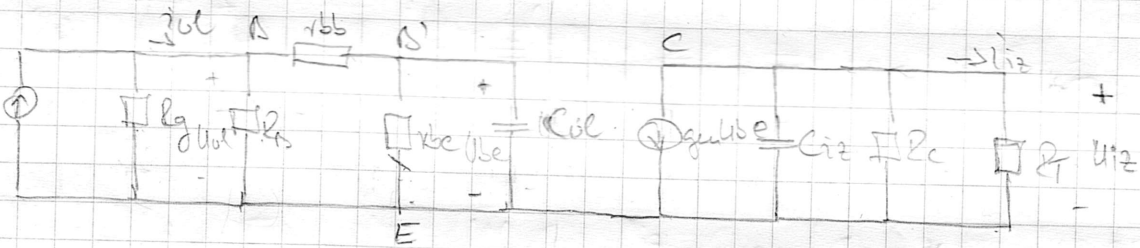


$U_B = \frac{R_2 U_{cc}}{R_1 + R_2} = \frac{50\Omega \cdot 12}{200\Omega + 50\Omega} = 2.4V$ $\quad R_c = R_1 \| R_2 = 40\Omega$

$I_B = \frac{U_B - U_\gamma}{R_B + (1+\beta)R_E} = \frac{2.4 - 0.7}{40\Omega + 121 \cdot 500} = 16.915\mu A$ $\quad I_c = 2.03mA$

$U_{CE} = U_{cc} - I_c(R_c + R_E) = 12 - 2.03^{-3}(4^3 + 500) = 2.86\ V$

$r_{be} = \frac{U_m}{I_B} = 1.478\Omega$ $\quad g_m = \frac{I_c}{U_m} = 81.194\ mA/V$



$A_{vo} = \frac{U_{iz}}{U_{be}} \cdot \frac{U_{be}}{U_{ul}}$

$\frac{U_{iz}}{U_{be}} = K = -g_m \cdot R_c \| R_T = -81.2^{-3} \cdot 4^3 \| 1^3 = -64.95$

$\frac{U_{be}}{U_{ul}} = \frac{r_{be}}{r_{bb} + r_{be}} = \frac{1.478^3}{1.478^3 + 50} = 0.96727$

$\underline{A_{vo} = -62.82}$

$A_{Ig_0} = \frac{i_{iz}}{i_{ul}} \cdot \frac{i_{ul}}{i_g} = A_{vo} \cdot \frac{R_{ul}}{R_T} \cdot \frac{i_{ul}}{i_g}$

$R_{ul} = (R_B \| r_{be} + r_{bb}) = 40^3 \| (1.478^3 + 50) = 1.4717^3\Omega$

$\frac{i_{ul}}{i_g} = \frac{R_g}{R_g + R_{ul}} = \frac{50^3}{50^3 + 1.4718^3} = 0.9714$

$C_{ul} = C_{be} + C_{bc}(1 - K) = 247.85pF$
$C_{iz} = C_{bc}\frac{(K-1)}{K} = 3.04pF$

$A_{Ig_0} = -62.82 \cdot \frac{1.4718^3}{1^3} \cdot 0.9714 = \underline{-89.82}$

$\tau_{ul} = C_{ul}\left[(R_g \| R_B) + r_{bb}) \| r_{be}\right] = 247.85^{-12}\left[(50^3 \| 40^3) + 50) \| 1.478^3\right] = 343.52ns$
$\omega = 2.91 \cdot 10^6\ rad/s$
$f = 463.3\ kHz$

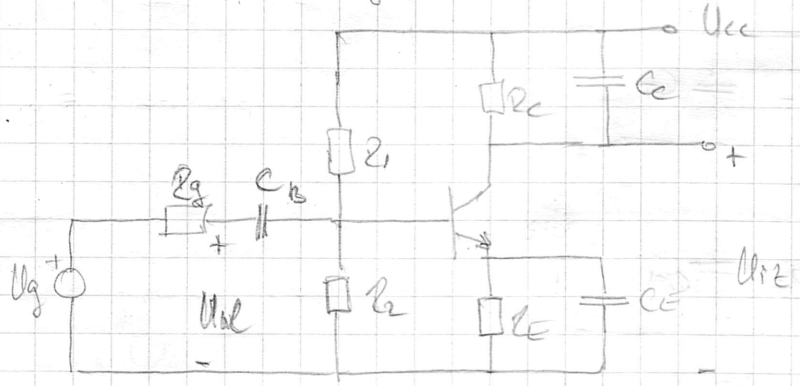
$\tau_{iz} = C_{iz}\left[R_c \| R_T\right] = 3.04^{-12}\left[4^3 \| 1^3\right] = 2.432ns$ $\quad \omega = 411.18 \cdot 10^6\ rad/s$ $\quad f = 65.44\ MHz$

$f_g = 463.3\ kHz$

Zadatak 2.

$U_{cc} = 15V$ $R_g = 500\,\Omega$ $C_B = 4\mu F$ $R_1 = 200\,k\Omega$ $R_2 = 100\,k\Omega$ $R_E = 400\,\Omega$
$C_E = 100\mu F$ $R_i = 2.5\,k\Omega$ $C_T = 300pF$ $\beta = 100$ $r_{bb} = 50\,\Omega$ $C_{be} = 40pF$
$C_{bc} = 1.2pF$

$A_{vg} = ?$

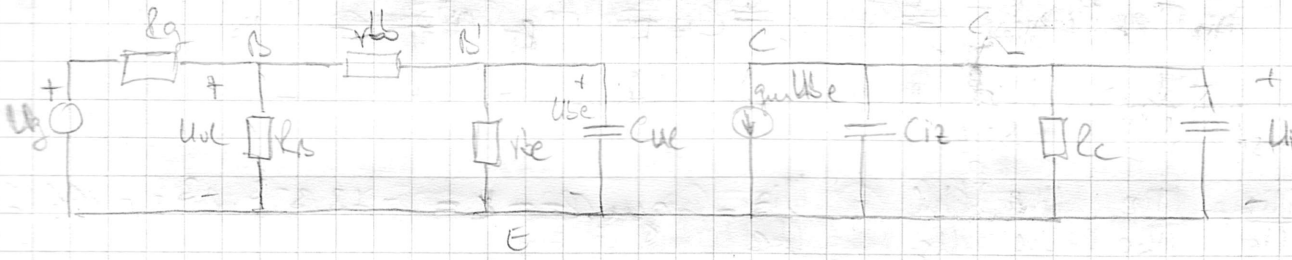


$$U_B = \frac{R_2 \cdot U_{cc}}{R_1 + R_2} = \frac{100^3 \cdot 15}{200^3 + 100^3} = 5V \qquad R_B = R_1 \| R_2 = 100^3 \| 200^3 = 66.6\,k\Omega$$

$$I_B = \frac{U_B - U_\gamma}{R_B + (1+\beta) R_E} = \frac{5 - 0.7}{66.6^3 + 101 \cdot 400} = 40.187\,\mu A \qquad I_C = 4.018\,mA$$

$$U_{CE} = U_{cc} - I_C (R_i + R_E) = 3.345\,V$$

$r_{be} = 622.09\,\Omega$ $\qquad g_m = \frac{I_C}{U_m} = 160.74\,mA/V$



$$A_{vg} = \frac{U_{iz}}{U_{ul}} = \frac{U_{iz}}{U_{be}} \cdot \frac{U_{be}}{U_{ul}} \cdot \frac{U_{ul}}{U_g}$$

$$\frac{U_{iz}}{U_{be}} = -g_m R_c = k = -160.74^{-3} \cdot 2.5^3 = -401.85$$

$$\frac{U_{be}}{U_{ul}} = \frac{r_{be}}{r_{bb} + r_{be}} = \frac{622.09}{622.09 + 50} = 0.9256$$

$$R_{UL} = R_B \| (r_{bb} + r_{be}) = 66.6^3 \| (50 + 622.09) = 665.375\,\Omega$$

$$\frac{U_{ul}}{U_g} = \frac{R_{UL}}{R_g + R_{UL}} = \frac{665.37}{500 + 665.37} = 0.5709$$

$A_{vg} = -212.36$

$$C_{UL} = C_{be} + C_{bc}(1+k) = 523.42\,pF$$

$$C_{iz} = C_{bc}\left(\frac{k-1}{k}\right) + C_c = 1.203pF + 300^{-12} = 301.203pF$$

$$\tau_{UL} = C_{UL}\left[(R_g \| R_B) + r_{bb}\right] \| r_{be} = 523.42^{-12}\left[\left((500 \| 66.6^3) + 50\right) \| 622.09\right] = 152.24ns$$

$\omega = 6.568 \cdot 10^6$ rad/s $\qquad f = 1.045\,MHz$

$$\tau_{iz} = C_{iz}\left[R_c\right] = 301.203^{-12} \cdot 2.5^3 = 753ns \qquad \omega = 1.328 \cdot 10^6\ rad/s$$

$f = 211.36\,kHz$

$f_g = 211.36\,kHz$

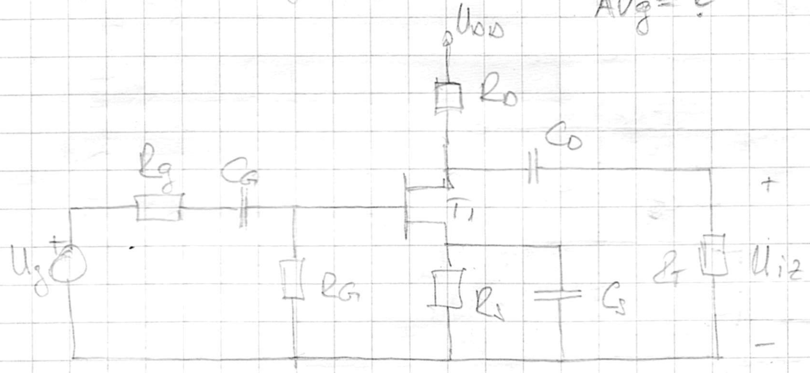
Zadatak 3)

$U_{DD}=15V$ $R_g=1k\Omega$ $C_G=50\mu F$ $R_G=2M\Omega$ $R_D=4k\Omega$

$R_S=500\Omega$ $C_S=20\mu F$ $C_D=1\mu F$ $R_T=6k\Omega$ $I_{DSS}=8mA$ $U_p=-2V$

$C_{gs}=3pF$ $C_{gd}=2pF$

$A_{vg}=?$



$0=U_{GS}+I_D R_S$ $\qquad I_D=I_{DSS}\left(1-\frac{U_{GS}}{U_p}\right)^2$

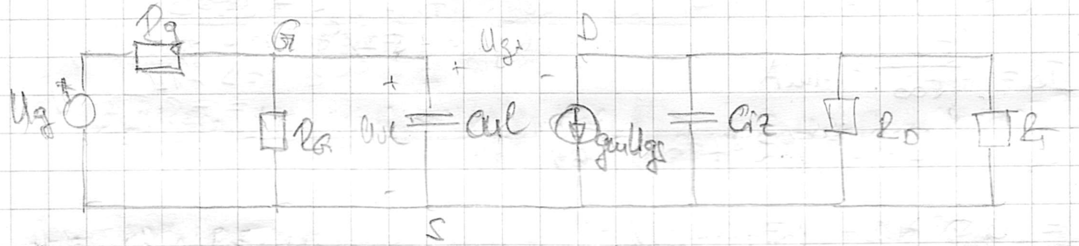
$-\frac{U_{GS}}{R_S}=I_{DSS}-2I_{DSS}\frac{U_{GS}}{U_p}+I_{DSS}\frac{U_{GS}^2}{U_p^2}$

$U_{GS}^2\left(\frac{I_{DSS}}{U_p^2}\right)+U_{GS}\left(\frac{1}{R_S}-\frac{2I_{DSS}}{U_p}\right)+I_{DSS}=0$ $\qquad U_{GS}^2\left(\frac{8^{-3}}{4}\right)+U_{GS}\left(\frac{1}{500}+\frac{16^{-3}}{2}\right)+8^{-3}$

$U_{GS}^2(2^{-3})+U_{GS}(10^{-3})+8^{-3}=0$ $\qquad U_{GS}^2+U_{GS}(5)+4=0$ $\qquad U_{GS1,2}=\frac{-5\pm3}{2}$ $=-1$, $=-4$

$U_{GS}=-1V$ $\qquad I_D=\frac{1}{500}=2mA$

$U_{DS}=U_{DD}-I_D(R_D+R_S)=15-2^{-3}(4^3+500)=6V$ $\qquad g_m=\frac{2I_{DSS}}{U_p}\left(1-\frac{U_{GS}}{U_p}\right)=4mA/V$



$A_{vg}=\frac{U_{iz}}{U_g}=\frac{U_{iz}}{U_{gs}}\cdot\frac{U_{gs}}{U_{ul}}\cdot\frac{U_{ul}}{U_g}$ $\qquad \frac{U_{iz}}{U_{gs}}=-g_m R_D\|R_T=K=-4^{-3}\,4^3\|6^3=-9.6$

$\frac{U_{gs}}{U_{ul}}=\frac{U_{gs}}{U_{gs}}=1$ $\qquad \frac{U_{ul}}{U_g}=\frac{R_G}{R_G+R_g}=\frac{2^6}{1^3+2^6}=0.9995$

$A_{vg0}=-9.5952\approx-9.6$

$C_{ul}=C_{gs}+C_{gd}(1-K)=24.2pF$ $\qquad C_{iz}=C_{gd}\left(\frac{K-1}{K}\right)=2.2pF$

$\tau_{ul}=C_{ul}(R_G\|R_g)=24.188ns$ $\qquad \omega=41.34\cdot10^6 rad/s$ $\qquad f=6.58MHz$

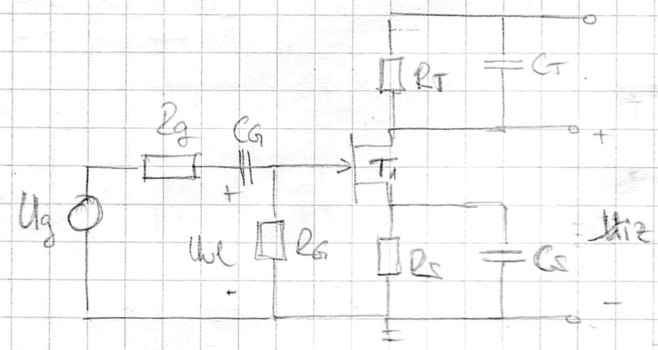
$\tau_{iz}=C_{iz}(R_D\|R_T)=5.28ns$ $\qquad \omega=189.4\cdot10^6 rad/s$ $\qquad f=30.143MHz$

$f_g=6.58MHz$

Zadatak 4.1

$U_{DD}=15V$ $R_g=12\Omega$ $C_G=50\mu F$ $R_G=1M\Omega$ $R_T=2,5k\Omega$ $R_S=400\Omega$
$C_T=50pF$ $C_S=20\mu F$ $I_{DSS}=15mA$ $U_p=-3V$ $C_{gs}=2,5pF$ $C_{gd}=1,5pF$

$A_V=?$

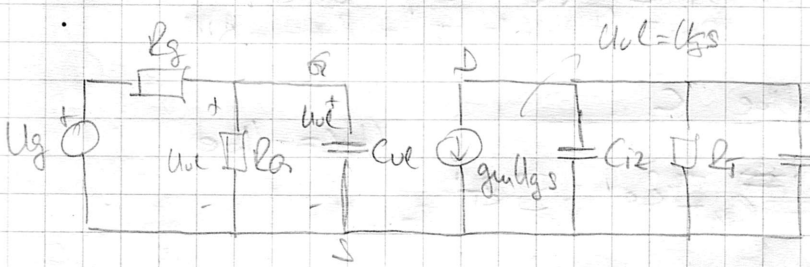


$0=U_{gs}+I_D R_S$ $I_D=I_{DSS}\left(1-\frac{U_{gs}}{U_p}\right)^2$ $U_{gs}^2\left(\frac{I_{DSS}}{U_p^2}\right)+U_{gs}\left(\frac{1}{R_S}-\frac{2I_{DSS}}{U_p}\right)+I_{DSS}=0$

$U_{gs}^2\left(\frac{15^{-3}}{3}\right)+U_{gs}\left(\frac{1}{400}+\frac{30^{-3}}{3}\right)+15^{-3}=0$ $U_{gs}^2(1)+U_{gs}(7,5)+9=0$

$U_{gs1,2}=\frac{-7,5\pm 4,5}{2}=-1,5$ $=-6$ $(U_{gs}=-1,5)$

$I_D=\frac{1,5}{400}=3,75mA$ $g_m=-\frac{2I_{DSS}}{U_p}\left(1-\frac{U_{gs}}{U_p}\right)=5mA/V$



$C_{ul}=C_{gs}+C_{gd}(1-k)=22,75pF$
$C_{iz}=C_T+C_{gd}\left(\frac{k-1}{k}\right)=51,62pF$

$A_V=\frac{U_{iz}}{U_{ul}}=\frac{U_{iz}}{U_{gs}}\cdot\frac{U_{gs}}{U_{ul}}=\frac{U_{iz}}{U_{gs}}=-g_m R_T=-5^{-3}\cdot 2,5^3=-12,5 \Rightarrow k=-12,5$

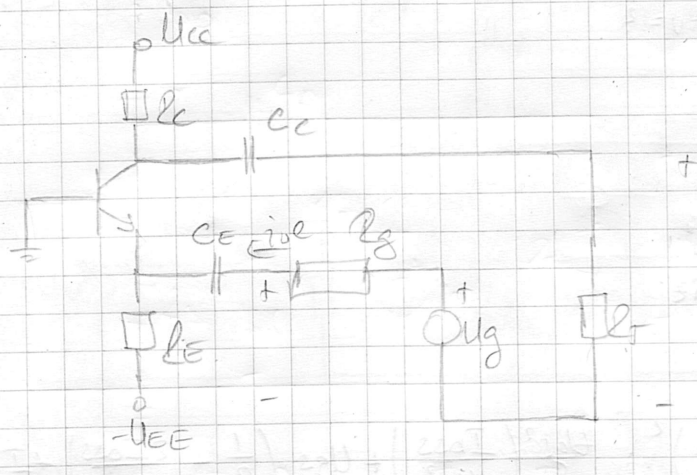
$\frac{U_{gs}}{U_{ul}}=1$ $A_V=-12,5$

$\tau_{ul}=C_{ul}(0)=0$ $\omega=\infty$ $\tau_{iz}=C_{iz}[R_T]=129,05ns$ $\omega=7,75\cdot 10^6 rad/s$
$f=1,23MHz$

$f_g=1,23MHz$

Zadatak 5.

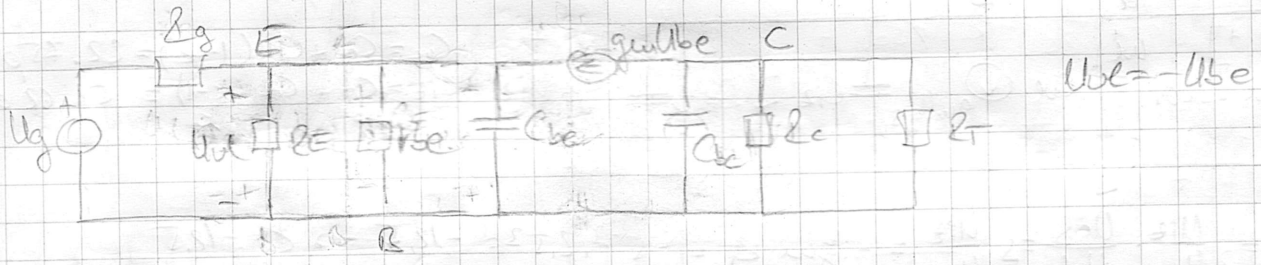
$U_{CC} = U_{EE} = 12V$ $R_g = 50\Omega$ $C_E = 150\mu F$ $R_E = 43\Omega$ $R_C = 22\Omega$
$C_C = 2\mu F$ $R_T = 33\Omega$ $\beta = 100$ $C_{be} = 50pF$ $C_{bc} = 3pF$ $V_{BB} = 0$
$A_{Vg} = ?$



$U = U_\gamma + I_B(1+\beta)R_E - U_{EE}$ $I_B = \frac{U_{EE} - U_\gamma}{(1+\beta)R_E} = \frac{12 - 0.7}{101 \cdot 43} = 27.93\mu A$ $I_C = 2.793$ mA

$g_m = \frac{I_C}{U_{be}} = 111.88 mA/V$ $r_{be} = 893.8\ \Omega$

$U_{CE} = U_{CC} + U_{EE} - I_C(R_C + R_E) = 24 - 2.793 \cdot 10^{-3}(23 + 43) = 7.215\ V$



$A_{Vg} = \frac{U_{iz}}{U_g} = \frac{U_{iz}}{U_{be}} \cdot \frac{U_{be}}{U_{ul}} \cdot \frac{U_{ul}}{U_g} = \frac{U_{iz}}{U_{be}} = -g_m R_C \| R_T = -134.25$

$A_V = 134.25$ $\frac{U_{be}}{U_{be}} = \frac{U_{be}}{-U_{be}} = -1$

$\frac{U_{ul}}{U_g} = \frac{R_{ul}}{R_{ul} + R_g}$ $R_{UL} = R_E \| \frac{r_{be}}{1+\beta} = 43 \| \frac{893.8}{101} = 8.83\ \Omega$

$= \frac{8.83}{8.83 + 50} = 150.1 \cdot 10^{-3} \Rightarrow A_{Vg0} = 134.25 \cdot 150.1^{-3} = 20.15$

$\tau_{UL} = C_{be} \cdot \left[R_g \| R_E \| \frac{r_{be}}{1+\beta} \right] = 50^{-12} \left[(50 \| 43) \| 8.85 \right] = 375.2\ ps$ $\omega = 2.66 \cdot 10^9$ rad/s
$f = 421.13$ MHz

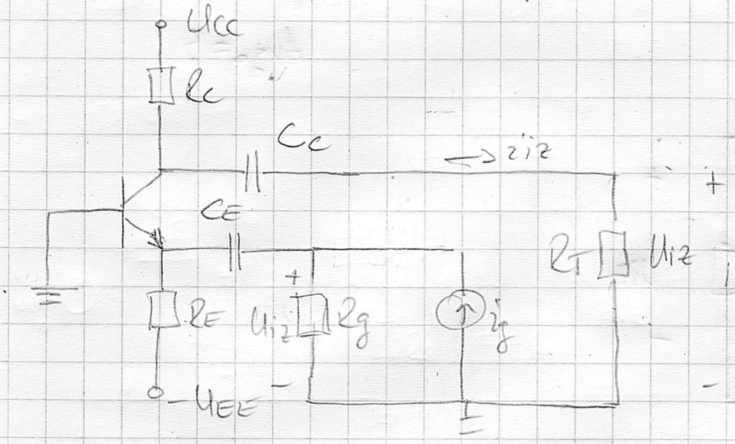
$\tau_{iz} = C_{bc} \left[R_C \| R_T \right] = 3^{-12} \left[23 \| 33 \right] = 3.6\ ns$ $\omega = 277.7 \cdot 10^6$ rad/s
$f = 44.21$ MHz

$f_g = 44.21$ MHz

Zadatak 6.

$U_{CC} = U_{EE} = 10V$ $R_g = 52\Omega$ $C_E = 120\mu F$ $R_E = 52\Omega$ $R_C = 42\Omega$
$C_C = 1{,}5\mu F$ $R_T = 1{,}52\Omega$ $\beta = 150$ $C_{be} = 40pF$ $C_{bc} = 3pF$

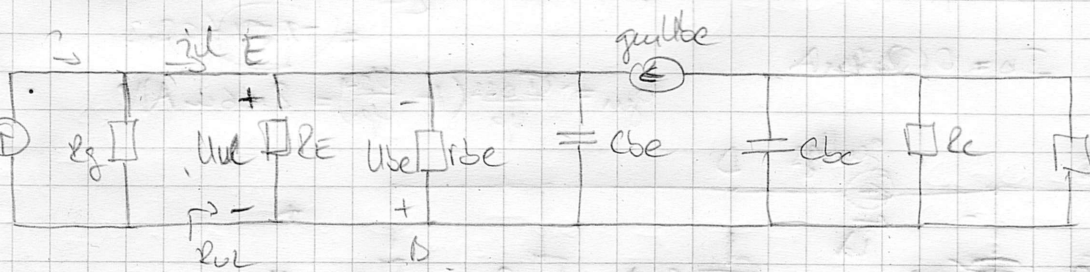
$A_{Ig} = ?$



$0 = U_\gamma - U_{EE} + I_B(1+\beta)R_E$ $I_B = \frac{U_{EE} - U_\gamma}{(1+\beta)R_E} = \frac{10 - 0{,}7}{151 \cdot 53} = 12{,}318\mu A$

$r_{be} = 2{,}03\,k\Omega$ $I_C = 1{,}847\,mA$ $g_m = 73{,}91\,mA/V$

$U_{CE} = U_{CC} + U_{EE} + I_C(R_C + R_E) = 20 - 1{,}847^{-3}(53 + 43) = 3{,}377V$



$A_V = \frac{U_{iz}}{U_{ul}} = \frac{U_{iz}}{U_{be}} \cdot \frac{U_{be}}{U_{ul}}$ $\frac{U_{iz}}{U_{be}} = -g_m R_C \| R_T = -73{,}91^{-3} \, 43 \| 1{,}5^3 = -80{,}63$

$\frac{U_{be}}{U_{ul}} = -1$ $A_V = 80{,}63$

$A_{Ig} = \frac{i_{iz}}{i_{ul}} \cdot \frac{i_{ul}}{i_g} = \frac{\frac{U_{iz}}{R_T}}{\frac{U_{ul}}{R_{ul}}} = A_V \cdot \frac{R_{ul}}{R_T}$ $R_{ul} = R_E \| \frac{r_{be}}{1+\beta} = 53 \| \frac{2{,}03^3}{151} = 13{,}4\,\Omega$

$R_{ul} = 0{,}720.$

$\tau_{ul} = C_{be}\left[(R_E \| R_g) \| \frac{r_{be}}{151}\right] = 534{,}87\,ps$; $\omega = 1{,}87 \cdot 10^9\,rad/s$ $f = 297{,}5\,MHz$

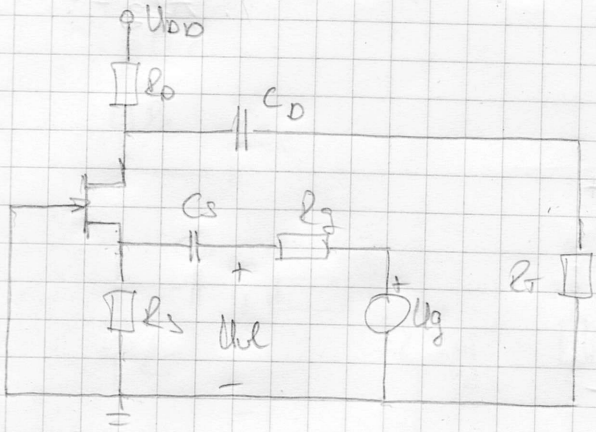
$\tau_{iz} = C_{bc}[R_C \| R_T] = 3{,}27\,ns$ $\omega = 305{,}5 \cdot 10^6\,rad/s$ $f = 48{,}63\,MHz$

$f_g = 48{,}63\,MHz$

Zadatak 7.

$U_{DD} = 20V$ $R_g = 500$ $C_S = 50\mu F$ $R_S = 750\Omega$ $R_D = 62\Omega$
$C_D = 5\mu F$ $R_T = 10k\Omega$ $I_{DSS} = 8mA$ $U_P = -3V$ $C_{gs} = 3pF$ $C_{gd} = 2pF$

$A_{vg_0} = ?$



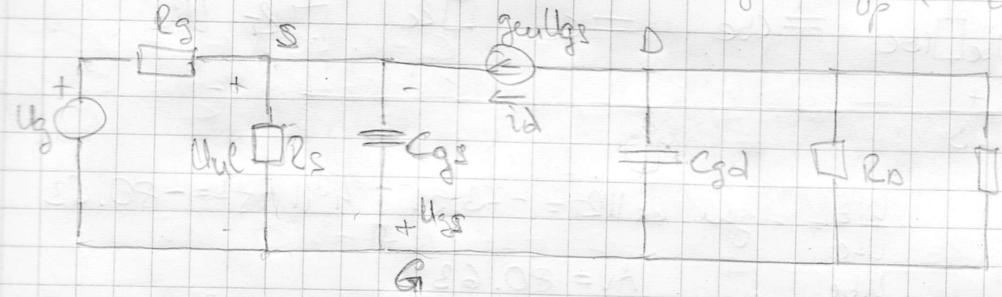
$0 = U_{gs} + I_D R_S$ $\quad I_D = I_{DSS}\left(1 - \frac{U_{gs}}{U_P}\right)^2$

$U_{gs}^2\left(\frac{I_{DSS}}{U_P^2}\right) + U_{gs}\left(\frac{1}{R_S} - \frac{2I_{DSS}}{U_P}\right) + I_{DSS} = 0$ $\quad U_{gs}^2\left(\frac{8-3}{9}\right) + U_{gs}\left(\frac{1}{750} + \frac{16-9}{3}\right) + 8-3 = 0$

$U_{gs}^2(1) + U_{gs}(7{,}5) + 9 = 0$ $\quad U_{gs1,2} = \frac{-7{,}5 \pm 4{,}5}{2} = -6$ $= -1{,}5V$

$U_{gs} = -1{,}5V$ $\quad I_D = 0{,}2mA$

$g_m = \frac{2I_{DSS}}{U_P}\left(1 - \frac{U_{gs}}{U_P}\right) = 2{,}66mA/V$



$A_{vg} = \frac{U_{iz}}{U_g} = \frac{U_{iz}}{U_{gs}} \cdot \frac{U_{gs}}{U_{ul}} \cdot \frac{U_{ul}}{U_g}$ $\quad U_{ul} = -U_{gs}$

$\frac{U_{iz}}{U_{gs}} = -g_m R_D \| R_T = -9{,}575$

$R_{UL} = R_S \| \frac{1}{g_m} = 250{,}4\Omega$ $\quad \frac{U_{gs}}{U_{ul}} = -1$ $\quad \frac{U_{ul}}{U_g} = \frac{R_{UL}}{R_g + R_{UL}} = 0{,}333$

$A_{vg} = 3{,}328$

$\tau_{UL} = C_{gs}\left[(R_g \| R_S) \| \frac{1}{g_m}\right] = 500{,}55ps$ $\quad \omega = 1{,}997 \cdot 10^9 rad/s$ $\quad f = 317{,}96 MHz$

$\tau_{iz} = C_{gd}[R_D \| R_T] = 7{,}5ns$ $\quad \omega = 133{,}3 \cdot 10^6 rad/s$ $\quad f = 21{,}22 MHz$

$f_g = 21{,}22 MHz$