(1) $N_D = 10^{14}\ cm^{-3}$ $w_p << L_p$ $S = 0,5\ mm^2$

$N_A = 8\cdot10^{15}\ cm^{-3}$ $w_n = 3\mu m << L_p$

a) $n_i(Si) = 1,45\cdot10^{10}\ cm^{-3}$ $\boxed{U_D = 0,5V}$

$n_{op} = \frac{n_i^2}{N_A} = 26,28\cdot10^{3}\ cm^{-3}$

$p_{on} = \frac{n_i^2}{N_D} = 21,03\cdot10^{5}\ cm^{-3}$

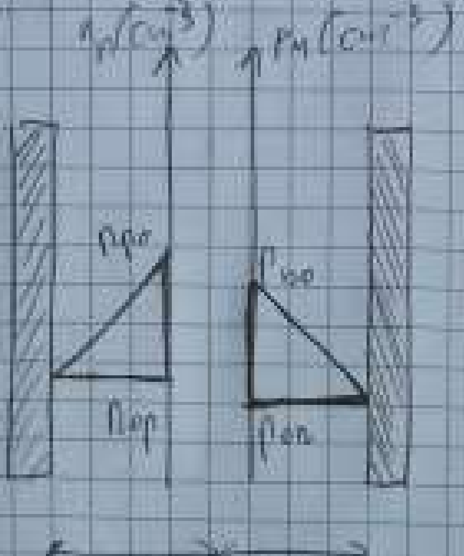
$n_{po} = n_{op}\exp\left(\frac{U}{U_T}\right) = 6,55\cdot10^{12}\ cm^{-3}$

$p_{no} = p_{on}\exp\left(\frac{U}{U_T}\right) = 5,24\cdot10^{12}\ cm^{-3}$

$w_n = 3\mu m$

$w_p = \frac{2Q_n}{qS(n_{op}-n_{po})}$ $S = \sqrt{0,5}\ mm = \sqrt{0,5}\cdot10^{-3}\ m = \sqrt{0,5}\cdot10^{-1}\ cm$
$= 0,5\cdot10^{-2}\ cm^2$

$w_p = 2,973\cdot10^{-4}\ cm = 3\mu m$



b)
$$I = I_s\left[\exp\left(\frac{U}{mU_T}\right) - 1\right]$$

$$I_s = qS\left(D_n \frac{n_{0p}}{W_n} + D_p \frac{p_{0n}}{W_p}\right)$$

$D_n = U_T \mu_n = 28,45$

$D_p = U_T \mu_p = 5,17$

$$I_s = 1,602 \cdot 10^{-19} \cdot 0,5 \cdot 10^{-4}\,cm^2 \left(28,45 \cdot \frac{25,23 \cdot 10^{2}}{3 \cdot 10^{-4}} + 5,17 \cdot \frac{25,23 \cdot 10^{2}}{3 \cdot 10^{-4}}\right)$$

$I_s = 2,28\,pA$

$I = 0,56\,mA$

$$t_n = \frac{W_p^2}{2D_n} = 1,58\,ns$$

$$t_p = \frac{W_n^2}{2D_p} = 8,7\,ns$$

$$r_d(0,5V) = \frac{U_T}{I_s + I} = 46,2\,\Omega$$

$r_d(-25V) = \infty$

① $I_{D2} = 4 I_{D1}$

a) Kako U_{GS} raste, I_D raste → n-tip

b) $I_{D1} = \frac{K}{2}(U_{GS1} - U_{GS0})^2$

$I_{D2} = \frac{K}{2}(U_{GS2} - U_{GS0})^2$

$4 \frac{K}{2}(U_{GS1} - U_{GS0})^2 = \frac{K}{2}(U_{GS2} - U_{GS0})^2 \;/\; U_{GS0} = x$

$4(3 - x)^2 = (4 - x)^2$

$4(9 - 6x + x^2) = 16 - 8x + x^2$

$4x^2 - x^2 - 24x + 8x + 36 - 16 = 0$

$x_1 = 3{,}33\,V$

$x_2 = 2\,V$ $U_{GS0} > 0$ → obogaćeni tip

n-tip → $U_{GS} > U_{GS0}$

$I_{DC} = K\left[(4-2) \cdot 1 - \frac{1^2}{2}\right]$

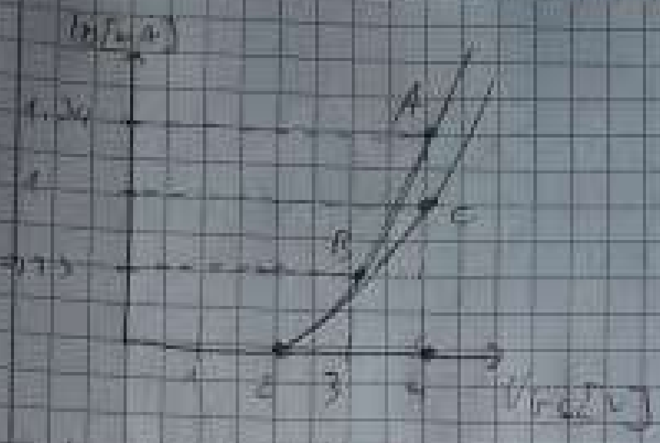
$K = \frac{I_{DC}}{\frac{2}{2}} = 0{,}67\,mA$

c) $I_{D1} = 1{,}34\,mA$

d) $g_{m1} = \frac{dI_D}{dU_{GS}} = K(U_{GS} - U_{GS0}) = 1{,}74\,mA/V$

$g_{m3} = \frac{dI_D}{dU_{GS}} = 0{,}67\,\frac{mA}{V}$

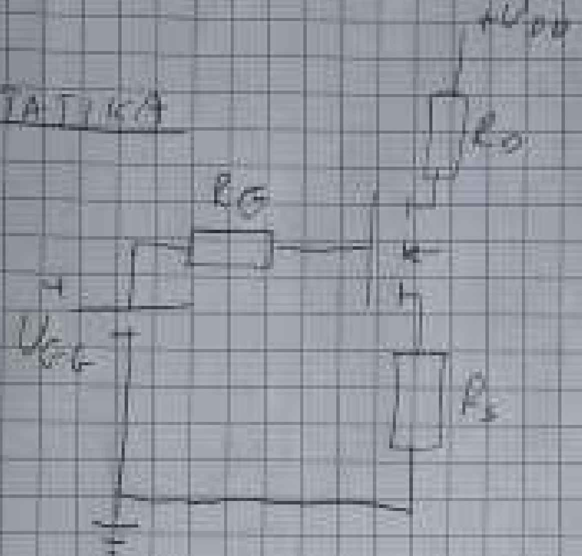
c)



$I_{D0} = 0{,}25\,mA$

(3)

a) STATIKA



$R_G = R_1 \| R_2 = 666{,}66\,k\Omega$

$U_{GG} = U_{DD}\dfrac{R_2}{R_1+R_2} = 5V$

$U_{GG} = U_{GS} + I_D R_S$

$I_D = \dfrac{k}{2}(U_{GS} - U_{GS0})^2$

$\dfrac{k}{2} = B$

$U_{GS} = x$

$U_{GG} = x + I_D R_S$

$I_D = B(x-1)^2$

$U_{GG} = x + B(x-1)^2 R_S$

$U_{GG} = x + BR_S x^2 - 2BR_S x + BR_S$

$(BR_S)x^2 + x(1 - 2BR_S) + BR_S - U_{GG} = 0$

$x_1 = 1{,}84V$ $\quad U_{GS} > U_{GS0}$

$x_2 = -2{,}03V$

$I_D = \frac{K}{2}(1,8)^2 = 1,91\,mA$

$U_{DD} = U_{DS} + I_D(R_D + R_S)$

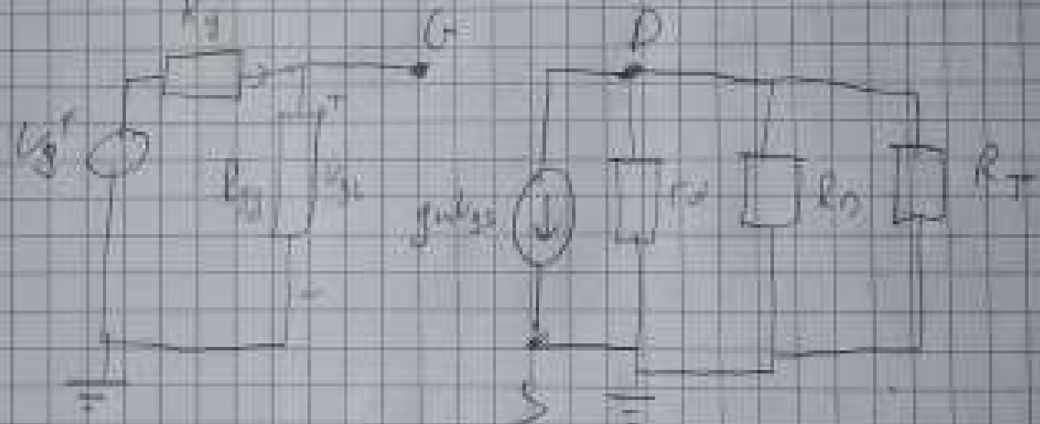
$U_{DS} = U_{DD} - I_D(R_D + R_S) = 10,206\,V$

$g_m = \frac{dI_D}{dU_{GS}} = K(U_{GS} - U_{GS0})(1 + \lambda U_{DS}) = 3,5\,mA/V$

$\frac{1}{r_d} = \frac{dI_D}{dU_{DS}} = \frac{K}{2}(U_{GS} - U_{GS0})^2 \lambda$

$r_d = 127,15\,k\Omega$

b)



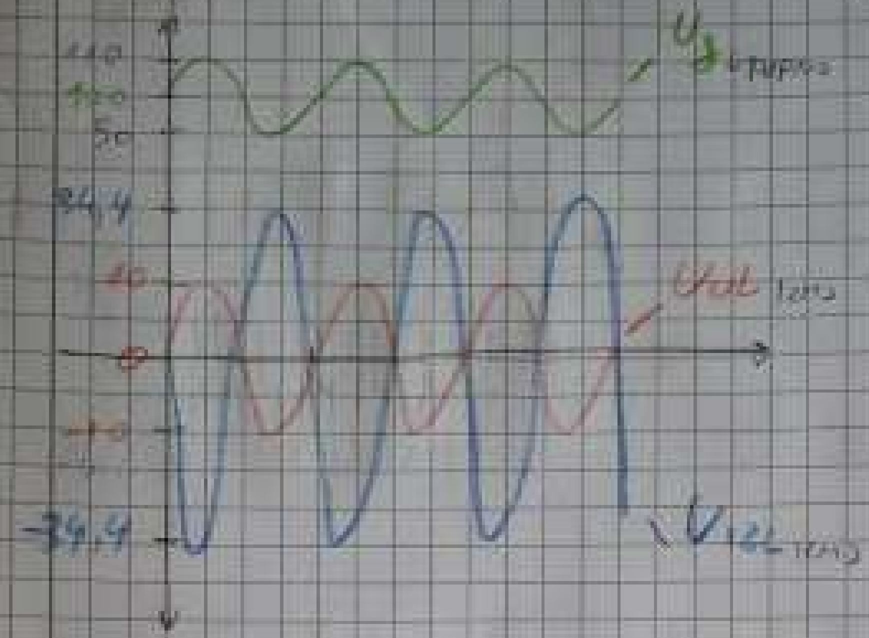
c) $u_{g,ulaz} = 10 \sin(\omega t)\,mV$

$i_{g,ulaz} = \frac{u_{g,ulaz}}{R_g + R_{g1}} = 0,005 \sin(\omega t)\,\mu A$

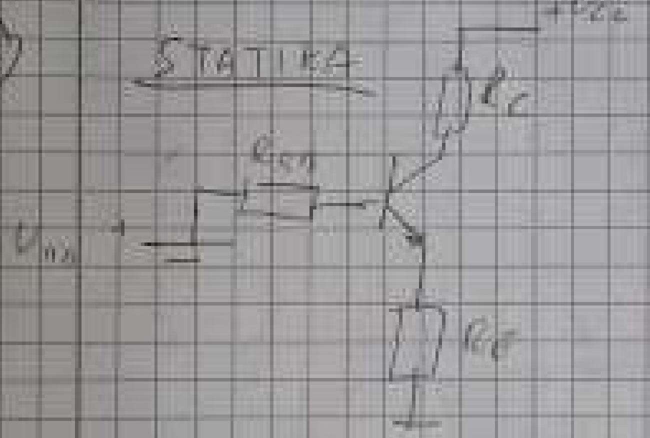
d) $u_{izl} = -g_m u_{gs}(r_d \| R_D \| R_T) = -g_m u_{gs} \cdot 132,75 = -34,4 \sin(\omega t)\,mV$

$i_{izl} = \frac{u_{izl}}{R_T} = 6,74 \sin(\omega t)\,\mu A$

c)



(4) STATIKA



$R_{BB} = 3,59 k\Omega$

$U_{BB} = 5,38 V$

$I_C = \beta I_B = 2,287 mA$

$I_E = I_B + I_C \quad 2,306 mA$

$I_E = I_B(1+\beta)$

$U_{BB} = I_B \cdot R_{BB} + U_{BE} + I_E R_E$

$U_{BB} = I_B R_{BB} + 0,7 + I_B(1+\beta)R_E$

$I_B(R_{BB} + (1+\beta)R_E) = U_{BB} - 0,7$

$I_B = 19,06 \mu A$

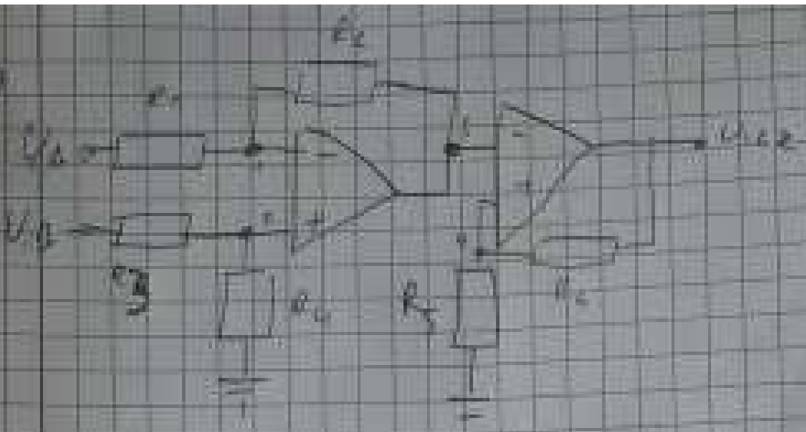
$U_{CC} = I_C R_C + U_{CE} + I_E R_E$

$U_{CE} = U_{CC} - I_C R_C - I_E R_E = 8,121 V$

$r_{be} = \frac{U_T}{I_B} = 1,35 k\Omega$

$g_m = \frac{h_{fe}}{r_{be}} = 87,5 \frac{mA}{V}$

5



a) $U_1\left(\frac{1}{R_1}+\frac{1}{R_2}\right)-U_3\left(\frac{1}{R_2}\right)=\frac{U_1}{R_1}$

$U_2\left(\frac{1}{R_3}+\frac{1}{R_4}\right)=\frac{U_B}{R_3}$ $U_1=U_2$ $U_3=U_{izh1}$

$\frac{U_1}{1200}=\frac{U_A}{1800}+\frac{U_3}{3600}$ / 3600

$3U_1-2U_A=U_3$

$\frac{U_2}{1800}=\frac{U_B}{2700}$ / $2700\,U_2=1800\,U_B$

$U_1=\frac{2}{3}U_B$

$3\cdot\frac{2}{3}U_B-2U_A=U_3$

$U_{iz1}=2(U_B-U_A)$

$U_{izh1}=3V$

b) $U_4\left(\frac{1}{R_5}+\frac{1}{R_6}\right)-U_{iz2}\left(\frac{1}{R_6}\right)=0$

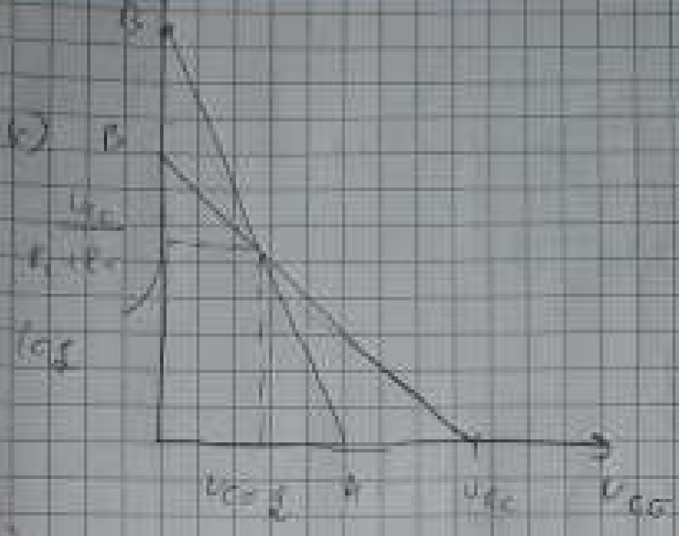
$U_4=U_3$

$\frac{U_{izh2}}{56000}=\frac{3}{28000}$ $U_{izh2}=6$

↳ ULAZ JE SPOJEN

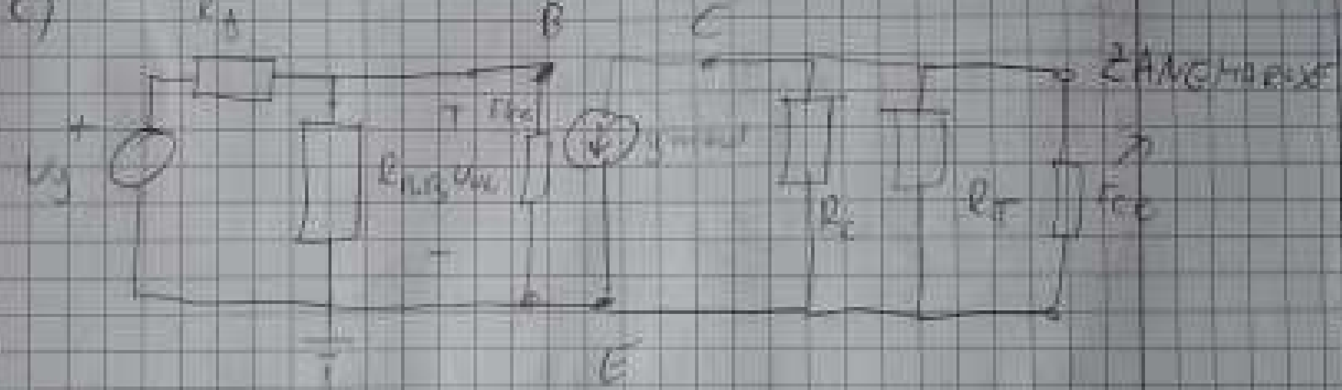
NA (−) ULAZ → $U_{izh2}=-6$

max = −5 = U_{izh2}



$i_{Cmax} = I_{CQ} + \frac{U_{CE}}{R_C \| R_T} = 1,15\, mA$

c)



$A_v = \frac{u_{iz}}{u_{ul}} = \frac{-g_m u_{be} \, R_C \| R_T}{u_{be}} = -g_m \, R_C \| R_T = -114,45$

$A_i = \frac{i_{iz}}{i_{ul}} = \frac{\frac{u_{iz}}{R_T}}{\frac{u_{ul}}{R_{B} \| r_{be}}} = \frac{587,07}{R_T} \cdot A_v = -43,64$

$R_{B} \| r_{be} = 587,07\, \Omega = r_{ul}$

$A_{vg} = \frac{u_{iz}}{u_g} = \frac{u_{iz}}{u_{ul}} \cdot \frac{u_{ul}}{u_g} = A_v \frac{R_{B} \| r_{be}}{R_{B} \| r_{be} + R_g} = -42,3$

$r_{iz} = R_C = 1\, k\Omega$