

① $N_D = 3 \cdot 10^{13}$ $\mu_n = 650 \text{ cm}^2/\text{Vs}$
 $N_A = 6 \cdot 10^{15}$ $\mu_p = 370 \text{ cm}^2/\text{Vs}$
 $S = 10^{-2} \text{ cm}^2$ $\tau_n = 0.5 \text{ ns}$
 $T = 300 \text{ K}$ $\tau_p = 1 \text{ ns}$

Rekmanac 18.9.13.

$$\begin{cases} L_p \ll w_n \\ L_n \ll w_p \end{cases}$$

izračunati

a) struja zasićenja $I_0 = q \cdot S \left(D_n \frac{n_{0p}}{L_n} + D_p \frac{p_{0n}}{L_p} \right)$

$$D_n = U_T \mu_n = 16.81 \text{ cm}^2/\text{s}$$

$$D_p = U_T \mu_p = 9.57 \text{ cm}^2/\text{s}$$

$$L_n = \sqrt{D_n \cdot \tau_n} = 2.899 \cdot 10^{-3} \text{ cm}$$

$$L_p = \sqrt{D_p \cdot \tau_p} = 3.09 \cdot 10^{-3} \text{ cm}$$

$$n_{0p} = \frac{n_i^2}{N_A} = 34560 \text{ cm}^{-3}$$

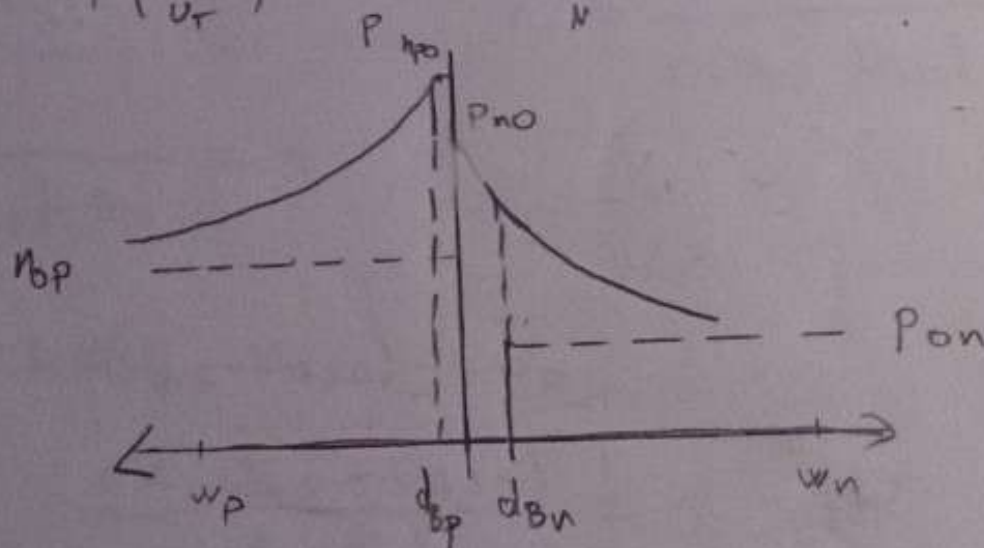
$$p_{0n} = \frac{n_i^2}{N_D} = 691.2 \text{ cm}^{-3}$$

$$I_0 = 324 \cdot 10^{-15} \text{ A} = 324 \text{ fA}$$

b) obje strane široke $U_D = 0.5 \text{ V}$

$$n_{p0} = n_{0p} \exp\left(\frac{U}{U_T}\right) = 8.61 \cdot 10^{12} \text{ cm}^{-3}$$

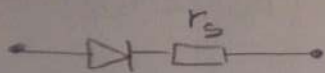
$$p_{n0} = p_{0n} \exp\left(\frac{U}{U_T}\right) = 1.72 \cdot 10^{11} \text{ cm}^{-3}$$



$$r_s = 8 \Omega$$

$$I_s = 324 \cdot 10^{-15} \text{ A}$$

$$i_d = 1 [\text{mA}] + 0,2 \sin(\omega t) [\text{mA}]$$



$$I_D = 1 \text{ mA}$$

$$U = U_D + I_D \cdot R_s = U_T \ln\left(\frac{I_D}{I_s} + 1\right) + I_D \cdot r_s = 0,573 \text{ V}$$

↳ istosmjerna komponenta napona

$$r_d \approx \frac{U_T}{I_d} = 25,86 \Omega$$

$$u_d = i_d (r_d + r_s) = 0,2 \text{ mA} (r_d + r_s) = 6,772 \text{ mV}$$

$$u_d = 0,573 [\text{V}] + 6,772 \sin(\omega t) [\text{mV}]$$

② $g_{mB} = 2 \text{ mA/V}$
 $U_{GSB} = 4 \text{ V}$
 $U_{DSB} = 15 \text{ V}$
 $I_{DB} = 5 \text{ mA}$

a) $K = ?$

$$g_{mB} = \frac{dI_D}{dU_{GS}} = K (U_{GSB} - U_{GS0}) \Rightarrow K = \frac{g_{mB}}{(U_{GSB} - U_{GS0})}$$

$$5 \cdot 10^{-3} = \frac{K}{2} (U_{GSB} - U_{GS0})^2$$

$$\frac{10^{-2}}{(U_{GSB} - U_{GS0})^2} = \frac{2 \cdot 10^{-3}}{(U_{GSB} - U_{GS0})}$$

$$U_{GSB} - U_{GS0} = 5$$

$$b) \Rightarrow U_{GS0} = -1 \text{ V}$$

$$K = 4 \cdot 10^{-4} \text{ A/V}$$

c) $M = 4 = g_m \cdot r_d$

$$U_{GSA} = 4 \text{ V}$$

$$U_{DSA} = ?$$

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

$$g_m = \frac{dI_D}{dU_{GS}} = K U_{DS}$$

$$r_d = \frac{1}{K (U_{GS} - U_{GS0}) - U_{DS}}$$

$$\frac{K U_{DS}}{K (U_{GS} - U_{GS0}) - U_{DS}} = 4$$

$$K U_{DS} = 4 K (U_{GS} - U_{GS0}) - 4 U_{DS}$$

$$U_{DS} = \frac{4 K (U_{GS} - U_{GS0})}{4 + K} = 2 \text{ mV}$$

d) $g_m = 8 \cdot 10^{-7} \text{ A/V}$

$$r_d = 2500 \text{ } \Omega$$

$$\begin{aligned}
 \textcircled{3} \quad U_{DD} &= 15 \text{ V} & R_S &= 8 \text{ k}\Omega & U_{GS0} &= 1 \text{ V} \\
 R_1 &= 1 \text{ M}\Omega & R_T &= 12 \text{ k}\Omega & \lambda &= 9005 \text{ V}^{-1} \\
 R_2 &= 2,5 \text{ M}\Omega & K &= 1 \text{ mA/V}^2
 \end{aligned}$$

a) I_{DQ}, U_{DSQ}, U_{GSQ}

$$U_{GG} = U_{DD} \cdot \frac{R_2}{R_1 + R_2} = 10,71 \text{ V}$$

$$R_G = 714,29 \text{ k}\Omega$$

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$$U_{GG} = I_{DQ} R_S + U_{GSQ} \Rightarrow I_{DQ} = \frac{U_{GG} - U_{GSQ}}{R_S}$$

$$\frac{U_{GG} - U_{GSQ}}{R_S} = \frac{K}{2} (U_{GSQ} - U_{GS0})^2$$

$$\frac{2U_{GG} - 2U_{GSQ}}{R_S K} = U_{GSQ}^2 - 2U_{GSQ}U_{GS0} + U_{GS0}^2$$

$$U_{GSQ}^2 + U_{GSQ} \left(-2U_{GS0} + \frac{2}{R_S K} \right) + U_{GS0}^2 - \frac{2U_{GG}}{R_S K} = 0$$

$$U_{GSQ}^2 - 0,5 U_{GSQ} - 1,6775 = 0$$

$$\boxed{U_{GSQ} = 1,11 \text{ V}}$$

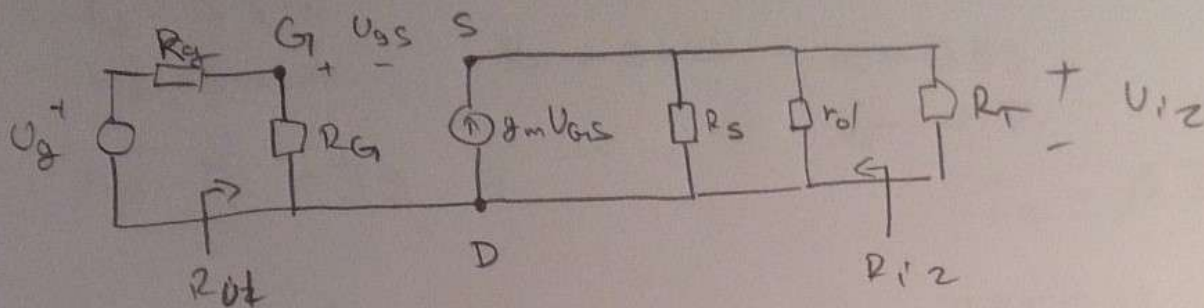
$$I_{DQ} = \frac{K}{2} (U_{GSQ} - U_{GS0})^2 = \boxed{6,05 \mu\text{A}}$$

$$U_{DD} = I_{DQ} R_S + U_{DSQ}$$

$$\boxed{U_{DSQ} = 14,95 \text{ V}}$$

3. b) najodnjesna shema

SZD



$$A_v = \frac{U_{iz}}{U_{ul}} = \frac{g_m U_{GS} \cdot r_{ol} \parallel R_S \parallel R_T}{U_{GS} (1 + r_{ol} \parallel R_S \parallel R_T)}$$

$$= \frac{g_m r_{ol} \parallel R_S \parallel R_T}{1 + r_{ol} \parallel R_S \parallel R_T}$$

$$= 0.362$$

$$U_{GD} = \frac{U_g}{R_g + R_G} \cdot R_G$$

$$U_{SD} = g_m U_{GS} (R_S \parallel r_{ol} \parallel R_T)$$

$$r_{ol} = 33 \text{ M}\Omega = 1. I_{DQ}$$

$$r_{ol} \parallel R_S \parallel R_T = 4799.3 \Omega$$

$$g_m = 0.118 \cdot 10^{-3}$$

$$c) G_m = \frac{I_{iz}}{U_{ul}} = \frac{g_m U_{GS} \frac{R_S}{R_S + R_T}}{U_{GS} (1 + g_m r_{ol} \parallel R_S \parallel R_T)}$$

$$= 3.01 \cdot 10^{-5} \quad \text{— SUMNJI VO}$$

$$d) R_{ul} = R_G = 714.29 \text{ k}\Omega$$

$$R_{iz} = R_S \parallel r_{ol} = 7998.06 \approx R_S$$

④ $U_{CC} = 12V$ $R_C = 2k\Omega$ $R_g = 100\Omega$
 $R_1 = 15k\Omega$ $R_E = 1k\Omega$ $U_T = 25mV$
 $R_2 = 5k\Omega$ $R_T = 2k\Omega$ $\alpha = 0.99$
 $U_{BE} = 0.7V$
 $\beta = \frac{\alpha}{1-\alpha} = 99$ $I_C = \beta I_B$

$U_{BB} = U_{CC} \cdot \frac{R_2}{R_1 + R_2} = 3V$ $R_B = 3750\Omega$

JUK

$U_{BB} = I_B R_B + (I_B + I_C) R_E + U_{BEQ}$

$U_{BB} - U_{BEQ} = I_B [R_B + (1 + \beta) R_E]$

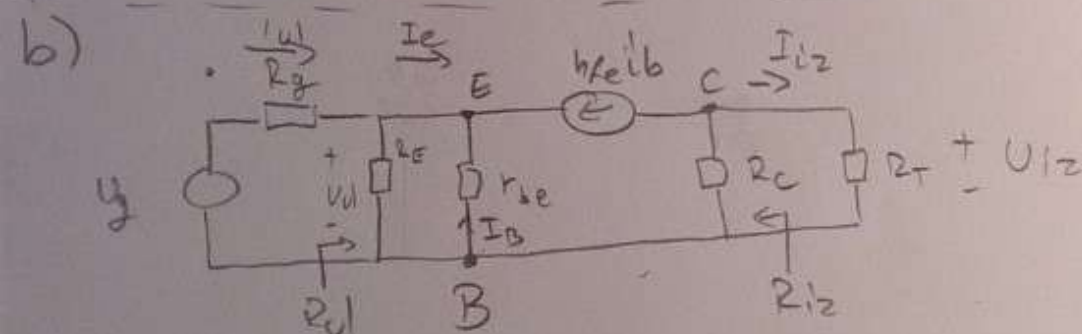
$I_{BQ} = 2.22 \cdot 10^{-5} A$

$I_{CQ} = \beta I_B = 2.195 \cdot 10^{-3} A$

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$U_{CC} = I_{CQ} R_C + (I_{CQ} + I_{BQ}) R_E + U_{CEQ}$

$U_{CEQ} = 9.83V$



$r_{be} = \frac{U_T}{I_{BQ}} = 113.64\Omega$

$h_{fe} = 99$

$R_{ul}' = \frac{r_{be}}{1 + h_{fe}}$

$= 1.1364\Omega$

c) $A_I = \frac{i_{i2}}{i_{o1}} = A_V \frac{R_E \parallel R_{ul}'}{R_T} = 0.33$

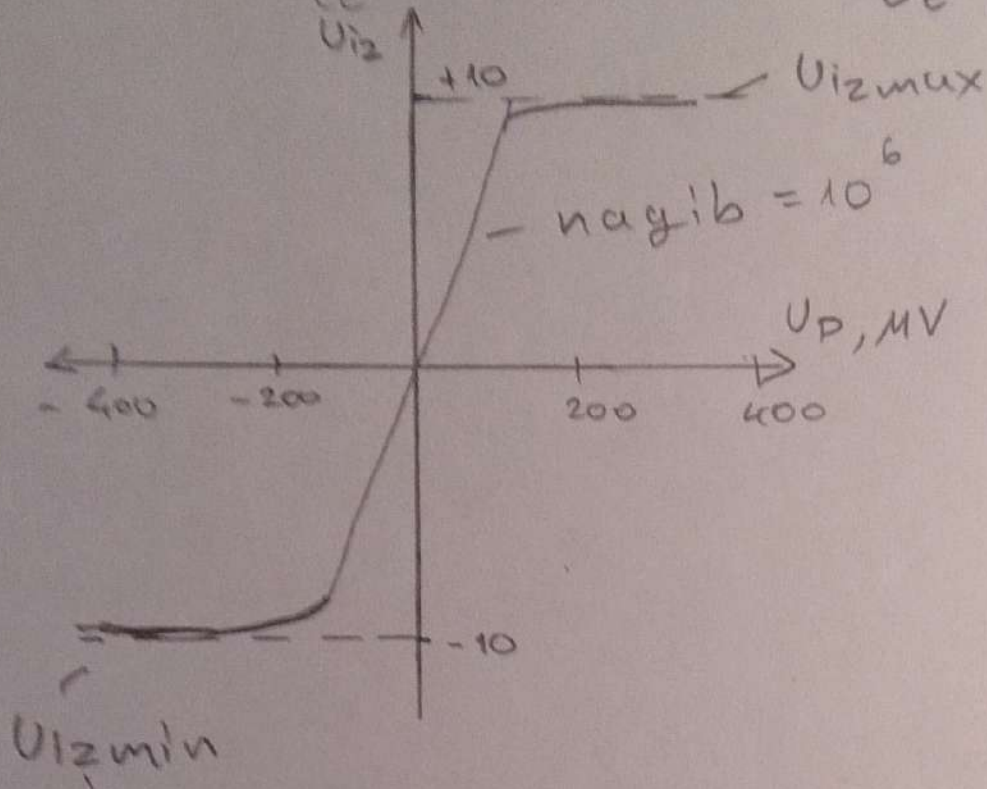
$A_V = h_{fe} \frac{R_C \parallel R_T}{r_{be}} = 580.78$

d) $R_{ul} = \frac{u_{o1}}{i_{o1}} = \frac{1}{\frac{1}{R_E} + \frac{1}{r_{be}(1 + h_{fe})}} = 1.135\Omega$

$R_{i2} = R_C = 2k\Omega$

5 a) $A_{VOP} = 10^6$

$U_{CC} = +10\text{ V}$ $U_{EE} = -10\text{ V}$



max hod
 $\pm 10\text{ V}$

b) $U_{CC} = 3\text{ V}$

JEBIGA, NE ZNAM