13/14 Z1

1. $V_{DD} = 12V$

$R_g = 500\Omega$

$R_s = 500\Omega$

$R_1 = 300k\Omega$

$R_2 = 180k\Omega$

$R_D = 2k\Omega$

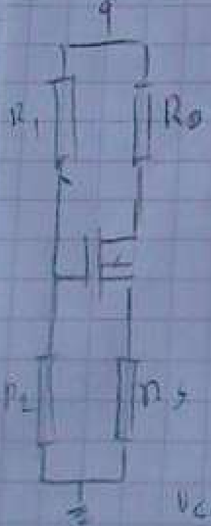
$R_g = 4.7k\Omega$

$k = 2.25 mA/V^2$

$V_{TN} = 0.3V$

$\lambda = 0.0045 V^{-1}$

[illegible]



$R_G = R_1 || R_2$

$V_{GG} = \frac{R_2}{R_1+R_2} V_{DD} = 4.5V$

$I_{DQ} = \frac{k}{2}(V_{GSQ} - V_{GSO})^2 = \frac{V_{GG} - V_{GSQ}}{R_S}$

$V_{GSQ}^2 - 2\left(\frac{1}{kR_S} - V_{GSO}\right)V_{GSQ} + V_{GSO}^2 - \frac{2V_{GG}}{kR_S} = 0$

$V_{GSQ} = 2.11V$ $I_{DQ} = 2.92 mA$

$V_{DD} = I_{DQ}R_D + V_{DSQ} + I_{DQ}R_S \Rightarrow V_{DSQ} = V_{DD} - I_{DQ}(R_D + R_S) =$

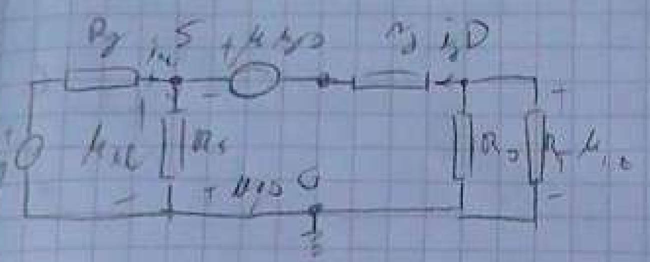
$V_{DSQ} \geq V_{GSQ} - V_{GSO}$ ✓ [illegible]

$I_{DQ} = \frac{k}{2}(V_{GSQ} - V_{GSO})^2(1 + \lambda V_{DSQ})$! !

$g_m = \frac{\partial I_{DQ}}{\partial V_{GSQ}} = k(V_{GSQ} - V_{GSO})(1 + \lambda V_{DSQ}) = 3.68 mA/V$

$g_d = \frac{\partial I_{DQ}}{\partial V_{DSQ}} = \lambda I_{DQ} =$

$r_d = \frac{1}{g_d} = 76 k\Omega$



$\mu = g_m r_d = 280$

$i_{rs} = \frac{u_{ul}}{R_s}$

$$R_{ul} = \frac{1}{\frac{1}{R_s} + \frac{(1+\mu)}{r_d + R_D \| R_T}} = 206\ \Omega$$

$$u_{ul} = \frac{R_{ul}}{R_g + R_{ul}} u_g \Rightarrow \frac{u_{ul}}{u_g} = \frac{R_{ul}}{R_g + R_{ul}}$$

$$A_{vg} = \frac{u_{iz}}{u_g} = \frac{u_{iz}}{u_{ul}} \cdot \frac{u_{ul}}{u_g} = A_v \frac{R_{ul}}{R_g + R_{ul}}$$

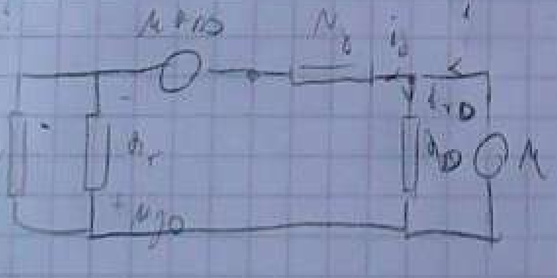
$u_{iz} = -i_d R_D \| R_T \qquad i_d R_D \| R_T + i_d r_d = -(1+\mu) u_{gs} \Rightarrow i_d = \frac{(1+\mu) u_{gs}}{r_d + R_D \| R_T}$

$u_{ul} = -u_{gs}$

$$u_{iz} = -\frac{(1+\mu) u_{gs}}{r_d + R_D \| R_T} \cdot R_D \| R_T$$

$$\underline{A_v} = \frac{(1+\mu) R_D \| R_T}{r_d + R_D \| R_T} = \underline{5.08} \qquad \underline{A_{vg}} = \frac{(1+\mu) R_D \| R_T}{r_d + R_D \| R_T} \cdot \frac{R_{ul}}{R_g + R_{ul}} = \underline{1.48}$$

R_{iz}:



$R_{iD} = \frac{u}{R_D}$

$u = i_d r_d - (1+\mu) u_{gs} \qquad u_{gs} = -i_d R_S \| R_g$

$u = i_d r_d + (1+\mu) R_S \| R_g \Rightarrow i_d = \frac{u}{r_d + (1+\mu) R_S \| R_g}$

$$\underline{R_{iz}} = \frac{u}{i} = \frac{u}{\frac{u}{R_D} + \frac{u}{r_d + (1+\mu) R_S \| R_g}} = \frac{1}{\frac{1}{R_D} + \frac{1}{r_d + (1+\mu) R_S \| R_g}} = \underline{1{,}98\ k\Omega}$$

2. $N_{DE} = 8 \cdot 10^{?}\ cm$

$N_{AB} = 3 \cdot 10^{10}\ cm^{-3}$

$\mu_p = 300\ cm^2/Vs$

$\mu_n = 550\ cm^2/Vs$

$w_B = 1\mu m = 10^{-4}\ cm$

$w_E = 2\mu m = 2 \cdot 10^{-4}\ cm$

$\tau_n = 0.1\ \mu s$

$S = 0.2\ mm^2 = 2 \cdot 10^{-3}\ cm^2$

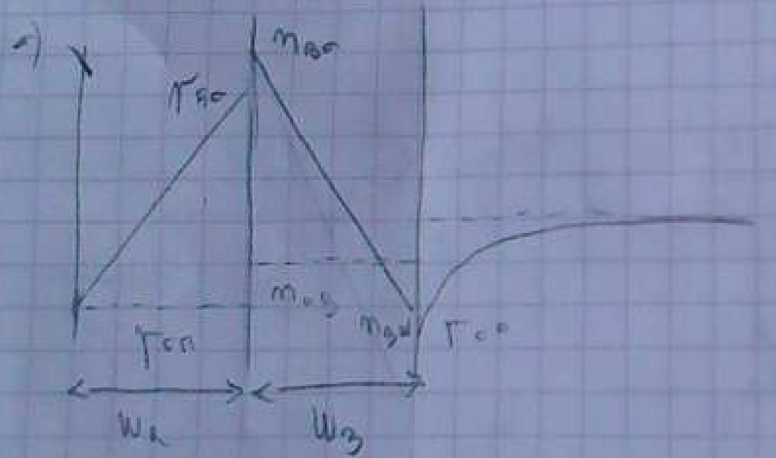
$V_{BE} = 0.6\ V$

$V_{CB} = 3\ V$

$T = 300\ K$

$I_{CBO} = 1\ nA$

a)



$U_T = \frac{3}{116}$ ✓

$p_{cn} = \frac{n_i^2}{N_{DE}} = 2.63 \cdot 10^{2}\ cm^{-3}$

$p_{E0} = p_{cn} \exp\left(\frac{V_{BE}}{U_T}\right) = 3.13 \cdot 10^{12}\ cm^{-3}$

$n_{0B} = \frac{n_i^2}{N_{AB}} = 7 \cdot 10^{3}\ cm^{-3}$

$n_{B0} = n_{0B} \exp\left(\frac{V_{BE}}{U_T}\right) = 8.33 \cdot 10^{13}\ cm^{-3}$

$n_{Bd} = n_{0B} \exp\left(\frac{-V_{CB}}{U_T}\right) \approx 0$

$p_{c0} = p_{c0} \exp\left(\frac{-V_{CB}}{U_T}\right) \approx 0$

b) $\tau_n = \tau_{cn} + (\tau_{bo} - \tau_{cn}) \frac{x_E}{w_n}$

$I_{\tau n} = q S D_{\tau n} \frac{\tau_{no} - \tau_{cn}}{w_n} \approx q S V_T / \tau \frac{\tau_{no}}{w_n} = 39 \mu A$

$n_B = n_{Bo} + (n_{BW} - n_{Bo}) \frac{w_B - x_D}{w_B}$

$I_n = q S D_{nB} \frac{n_{Bo} - n_{BW}}{w_B} \approx q S V_T / r_n \frac{n_{Bo}}{w_B} = 3.792 \, mA$

$Q_B = q S \frac{n_{Bo} w_B}{2} = \tau_n I_n$

$I_n = \frac{Q_B}{\tau_n} = 13 \mu A$

$I_{nE} = I_{nE} - I_n = 3.779 \, mA$

$I_R = -I_{nR} - I_{\tau n} = -3.831 \, mA$

$I_B = I_{\tau n} + I_n - I_{CBo} = 52 \mu A$

$I_C = I_{nE} + I_{CBo} = 3.779 \, mA$

c) $\alpha = \frac{I_C}{-I_R} = 0.9864$

$\beta = \frac{\alpha}{1 - \alpha} = 73$

$\gamma = \frac{I_{nE}}{I_{nR} + I_{\tau n}} = 0.9898$

$\beta^* = 1 - \frac{1}{2} \left(\frac{w_B}{L_B} \right)^2$

$R_g = 500\,\Omega$

$R_1 = 50\,k\Omega$

$R_2 = 20\,k\Omega$

$R_C = 2\,k\Omega$

$R_B = 1\,k\Omega$

$R_T = 1\,k\Omega$

$\mu_g = 1.5\,mV$

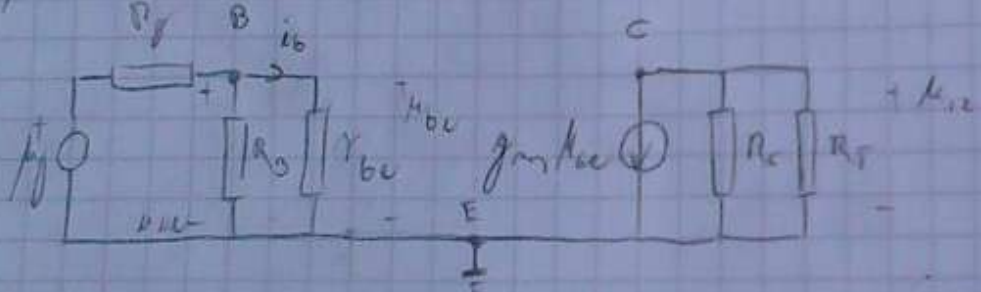
$\mu_{1L} = 1\,mV$

$\mu_2 = 50\,mV = \mu_{1R}$

$\mu_T = 25\,mV$

$$A_{\mu L} = \frac{\mu_{1L}}{\mu_g - \mu_{1L}} R_g$$

a)



$$A_T = \frac{\mu_{12}}{\mu_{1L}} = \frac{-g_m \mu_{be} R_C \| R_T}{\mu_{be}} = -g_m R_C \| R_T = -\frac{\frac{1}{r_{be}} R_C \| R_T}{r_{be}}$$

$$R_{\mu L} = \frac{\mu_{1L}}{i_{1L}} = R_B \| r_{be}$$

b)

$$\frac{\mu_{1L}}{\mu_g} = \frac{R_{\mu L}}{R_{\mu L} + R_g} \rightarrow R_{\mu L} = \frac{R_g}{\frac{\mu_g}{\mu_{1L}} - 1} = 1\,k\Omega$$

$$r_{be} = \frac{R_B R_{\mu L}}{R_B - R_{\mu L}} = 1.08\,k\Omega$$

$$I_{BQ} = \frac{V_T}{r_{be}} = 23.1\,\mu A$$

$I_{CQ} = \beta I_{BQ}$

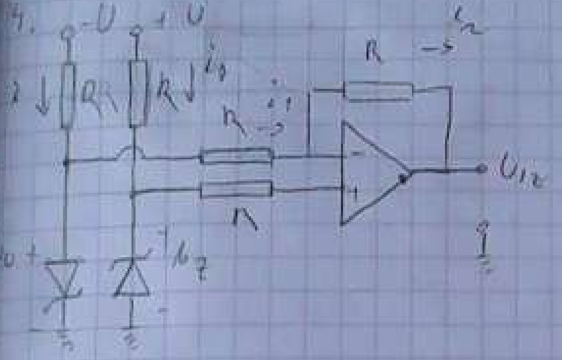
$A_v = \frac{u_{iz}}{u_{ul}} = -60$

$A_i = -A_v \frac{r_{ul}}{R_C \| R_T} \approx \beta = 81$

$I_{CQ} = 1.87$ mA

$U_{CEQ} \approx U_{CC} - I_{CQ}(R_C + R_E) = 6.39$ V

4.



$I_Z = \frac{U - U_Z}{R} = 5.8$ mA $\quad I_{Zmin} = 5.7$ mA

$I_Z > I_{Zmin}$ ✓ PROVJERENO

$u_{iz} = U_Z\left(1 + \frac{R_2}{R_1}\right) + U_0\left(-\frac{R_2}{R_1}\right) = 2U_Z - U_0 = 11.9$ V

$u_1 = u_+ = u_Z$

$\frac{u_0 - u_Z}{R} = \frac{u_Z - u_{iz}}{R} \Rightarrow u_{iz} = 2u_Z - u_0 = 11.9$ V

1. B) ZASTORNJEK | UVOD, STABILIZIRANJE

2. E) $\overline{AB(C+D+A)}$

3. $g_m = \frac{I_{CQ}}{U_T}$ $\quad$ SZB : $I_{12} = I_C > 0$, $I_{UL} = I_n < 0$ $\}$ npn

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

$I_{CQ} = 4.93$ mA, $I_{EQ} = -5$ mA $\} \; I_B = 30\,\mu A$

$r_{be} = \frac{U_T}{I_{BQ}} = 500\,\Omega$

E) $g_m = 198$ mA/V, $r_{be} = 500\,\Omega$

4. nagl otpor $R_{1,8}$

- R_{12} nagl
- $R=0$

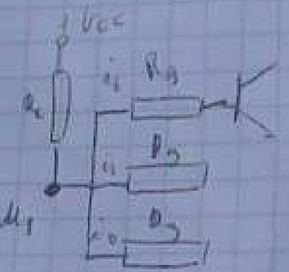
D

5. $u_{y1} = -4$ nm mA

$u_{y2} = 0$ n mA

6. T_1 u zasićenju zapornom

$i_{c1} = 0$



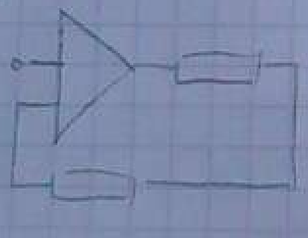
$V_{cc} = 3 i_b R_c + i_b R_B + U_{BE}$

$i_b = \frac{V_{cc} - U_{BE}}{3R_c + R_B} = 71.2\ \mu A$

$U_1 = V_{cc} - 3 i_b R_c = 4.36\ V$

7. $U_{i2} = \pm(2U_D + U_Z) = \pm 6.1\ V$

$U_D = 0.7\ V$



$U_{GP} = 3.55\ V$

$U_{GN} = 2.45\ V$ $\quad + \rightarrow -$

$U_H = 3\ V$