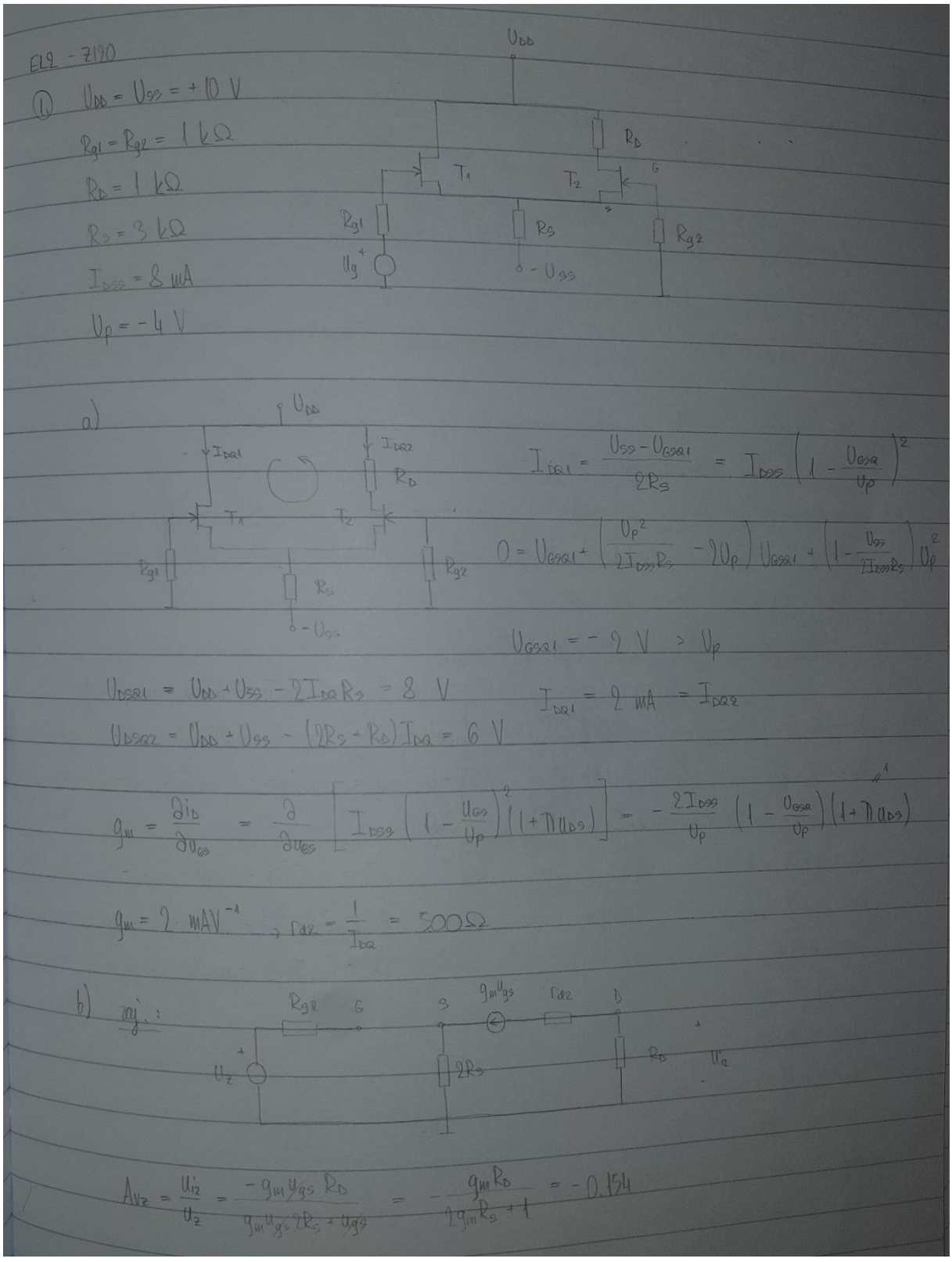
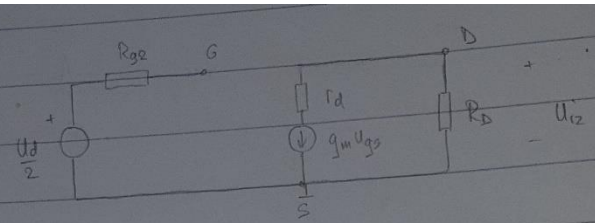
Elektronika 2 (FER-3) – Završni ispit 2019./2020.

Pripremio: Skiv



dif.:



$$A_{vd} = \frac{U_{i2}}{U_d} = \frac{1}{2} \cdot \frac{U_{i2}}{\frac{U_d}{2}} = \frac{-g_m U_{gs} R_D}{U_{gs}} \cdot \frac{1}{2} = \frac{-1}{2} g_m R_D = -1$$

$$S = \left| \frac{A_{vd}}{A_{v2}} \right| = 6.9$$

c) $U_{i2} = A_{vd} U_d + A_{v2} U_2 =$

$U_2 = \frac{U_{g1} + U_{g2}}{2} = 75$

$U_d = U_{g2} - U_{g1} = -150$

$U_{i2} = 150 - 0.154 \cdot 75 = 138$ circuit

② $U_{cc} = 15$ V

$R_G = 100$ kΩ

$R_D = 1$ kΩ

$R_E = 4$ kΩ

$R_T = 1$ kΩ

$C_G = 200$ μF

$C_E = 2$ μF

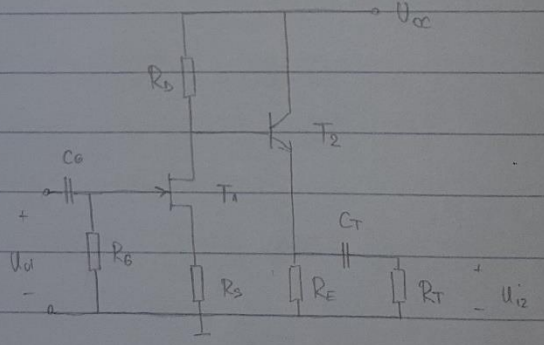
$I_{DSS} = 32$ mA

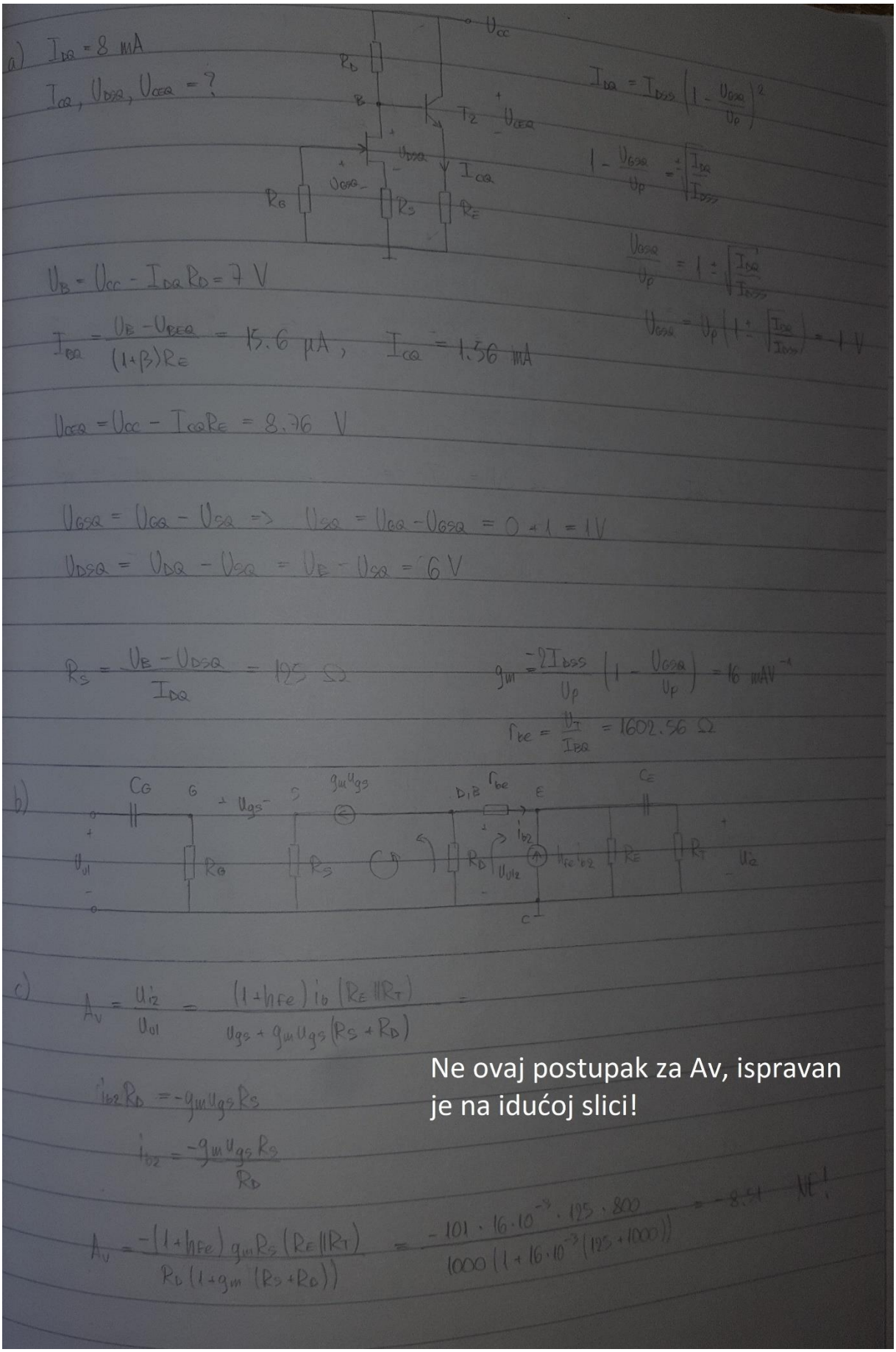
$U_p = -2$ V

$\beta \approx h_{fe} = 100$

$U_\gamma = 0.7$ V

$U_T = 25$ mV




a) $I_{DQ} = 8$ mA
$I_{CQ}, U_{DSQ}, U_{CEQ} = ?$
U_{CC}
R_D
B
T_2
U_{CEQ}
U_{DSQ}
I_{CQ}
U_{GSQ}
R_G
R_S
R_E
$I_{DQ} = I_{DSS}\left(1 - \frac{U_{GSQ}}{U_P}\right)^2$
$1 - \frac{U_{GSQ}}{U_P} = \pm\sqrt{\frac{I_{DQ}}{I_{DSS}}}$
$\frac{U_{GSQ}}{U_P} = 1 \pm \sqrt{\frac{I_{DQ}}{I_{DSS}}}$
$U_{GSQ} = U_P\left(1 \pm \sqrt{\frac{I_{DQ}}{I_{DSS}}}\right) = -1$ V
$U_B = U_{CC} - I_{DQ}R_D = 7$ V
$I_{DQ} = \frac{U_B - U_{BEQ}}{(1+\beta)R_E} = 15.6\ \mu A$, $I_{CQ} = 1.56$ mA
$U_{CEQ} = U_{CC} - I_{CQ}R_E = 8.76$ V
$U_{GSQ} = U_{GQ} - U_{SQ} \Rightarrow U_{SQ} = U_{GQ} - U_{GSQ} = 0 + 1 = 1$ V
$U_{DSQ} = U_{DQ} - U_{SQ} = U_E - U_{SQ} = 6$ V
$R_S = \frac{U_E - U_{DSQ}}{I_{DQ}} = 125\ \Omega$
$g_m = \frac{-2I_{DSS}}{U_P}\left(1 - \frac{U_{GSQ}}{U_P}\right) = 16$ mAV^{-1}
$r_{be} = \frac{U_T}{I_{BQ}} = 1602.56\ \Omega$
b)
C_G
G
u_{gs}
S
$g_m u_{gs}$
D, B
r_{be}
E
C_E
U_{ul}
R_G
R_S
R_D
i_{b2}
U_{ul2}
$h_{fe} i_{b2}$
R_E
R_T
U_{iz}
C
c)
$A_v = \frac{U_{iz}}{U_{ul}} = \frac{(1+h_{fe}) i_b (R_E \| R_T)}{u_{gs} + g_m u_{gs}(R_S + R_D)} =$
$i_{b2} R_D = -g_m u_{gs} R_S$
$i_{b2} = \frac{-g_m u_{gs} R_S}{R_D}$
$A_v = \frac{-(1+h_{fe}) g_m R_S (R_E \| R_T)}{R_D (1 + g_m (R_S + R_D))} = \frac{-101 \cdot 16 \cdot 10^{-3} \cdot 125 \cdot 800}{1000 (1 + 16 \cdot 10^{-3} (125 + 1000))} = -8.41$ NE!
Ne ovaj postupak za Av, ispravan je na idućoj slici!

d) $\tau_G = R_G C_G = 0{,}02$

$\omega_G = \frac{1}{\tau_G} = 50 \text{ rads}^{-1}$

$f_G = 7{,}96 \text{ Hz}$

$$A_V = \frac{u_{i2}}{u_{01}} = \frac{u_{i2}}{u_{oi2}} \cdot \frac{u_{oi2}}{u_{01}} = \frac{(1+h_{fe})\cancel{i_{b2}}(R_E \| R_T)}{(1+h_{fe})\cancel{i_{b2}}(R_E \| R_T) + \cancel{i_{b2}} r_{be}} \cdot \frac{-g_m \cancel{u_{gs}} R_D}{u_{gs} + g_m \cancel{u_{gs}} R_S}$$

$$= \frac{(1+h_{fe})(R_E \| R_T)}{(1+h_{fe})(R_E \| R_T) + r_{be}} \cdot \frac{-g_m R_D}{1 + g_m R_S} = -5{,}22 \quad \text{DA!}$$

③ $U_{CC} = 12 \text{ V}$

$R_g = 5 \text{ k}\Omega$

$C_B = 2 \mu\text{F}$

$R_1 = 40 \text{ k}\Omega$

$R_2 = 10 \text{ k}\Omega$

$R_C = 2 \text{ k}\Omega$

$R_E = 500 \Omega$

$C_E = 50 \mu\text{F}$

$C_C = 2 \mu\text{F}$

$R_T = 500 \Omega$

$\beta \approx h_{fe} = 100$

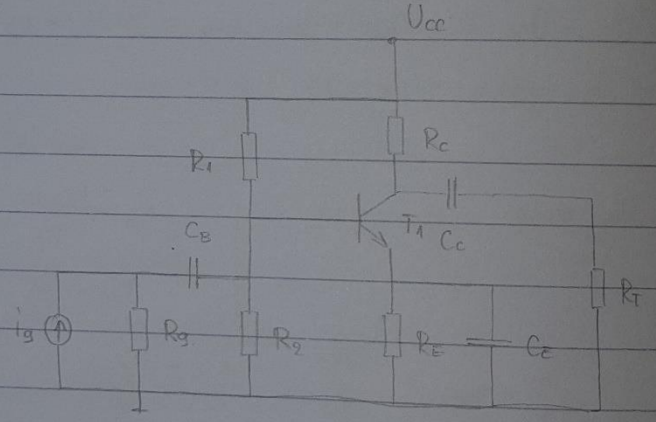
$U_\gamma = 0{,}7 \text{ V}$

$r_{bb'} = 50 \Omega$

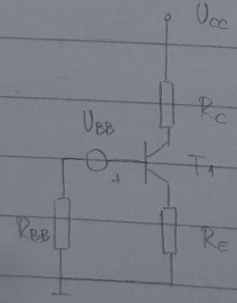
$C_{b'e} = 25 \text{ pF}$

$C_{b'c} = 2 \text{ pF}$

$U_T = 25 \text{ mV}$



a)



$R_{BB} = R_1 \| R_2 = 8 \text{ k}\Omega$

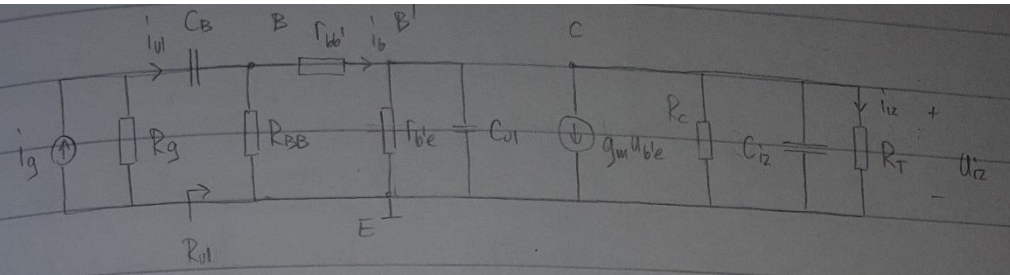
$U_{BB} = U_{CC} \frac{R_2}{R_1 + R_2} = 2{,}4 \text{ V}$

$I_{BQ} = \frac{U_{BB} - U_{BEQ}}{(1+\beta)R_E + R_{BB}} = 25{,}06 \mu\text{A}$

$I_{CQ} = 2{,}9 \text{ mA}$

$U_{CEQ} = U_{CC} - I_{CQ}(R_C + R_E) = 4{,}75 \text{ V}$

b)



c) $A_{Ig} = \frac{i_{iz}}{i_g} = g_m = \frac{I_{CQ}}{U_T} = 116\ mAV^{-1}$ $\quad r_{b'e} = \frac{U_T}{I_{BQ}} = 860.3\ \Omega$

$= \frac{g_m u_{b'e} \cdot \frac{R_c}{R_T + R_c}}{i_g}$ $\quad R_{ul} = R_{BB} \parallel (r_{bb'} + r_{b'e}) = 817.3\ \Omega$

$u_{b'e} = r_{b'e} \left(i_g \cdot \frac{R_g}{R_g + R_{ul}} \cdot \frac{R_{BB}}{R_{BB} + r_{bb'} + r_{b'e}} \right)$

$A_{Ig} = -g_m r_{b'e} \frac{R_g}{R_g + R_{ul}} \cdot \frac{R_{BB}}{R_{BB} + r_{bb'} + r_{b'e}} \cdot \frac{R_c}{R_T + R_c} = -61.6$

d) $K = \frac{u_{iz}}{u_{b'e}} = \frac{-g_m u_{b'e} (R_T \parallel R_c)}{u_{b'e}} = -g_m (R_T \parallel R_c) = 4.46$

$C_{ul} = C_{b'e} + C_{b'c} (1 - K) = 0.119\ nF$

$C_{iz} = C_{b'c} \frac{K - 1}{K} = 2.04\ pF$

$T_{ul} = C_{ul} \cdot \left[r_{b'e} \parallel \left(r_{bb} + R_{BB} \parallel R_g \right) \right] = 80.29\ ns$

$T_{iz} = C_{iz} \cdot R_T \parallel R_c = 0.816\ ns$

$\omega_u = \frac{1}{T_{ul}} = 12.45 \cdot 10^6\ rads^{-1}$

$f_u = 1.98\ MHz$

④ $U_{CC} = 12\ V$

$R_{C1} = 3\ k\Omega$

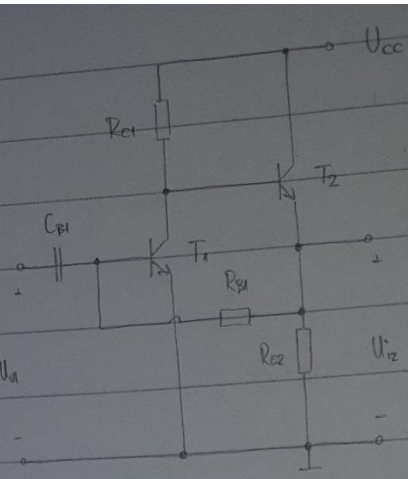
$R_{B1} = 100\ k\Omega$

$R_{E2} = 500\ \Omega$

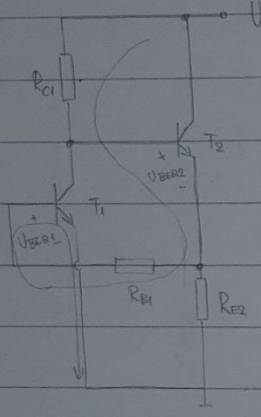
$\beta \approx h_{FE} = 100$

$U_\gamma = 0.7\ V$

$U_T = 25\ mV$



a)



$$U_{CC} = I_{CQ1} R_{C1} + U_{BEQ2} + I_{BQ1} R_B + U_{BEQ1}$$

$$U_{CC} = \beta I_{BQ1} R_{C1} + U_{BEQ2} + I_{BQ1} R_B + U_{BEQ1}$$

$$I_{BQ1} = \frac{U_{CC} - U_{BEQ1} - U_{BEQ2}}{\beta R_{C1} + R_B} = 26.5\ \mu A$$

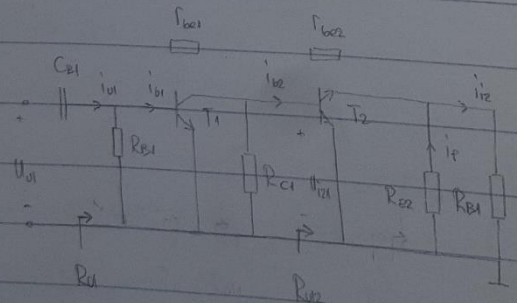
$$I_{CQ1} = 2.65\ mA$$

$$I_{BQ2} = \frac{U_{CC} - I_{CQ1} R_{C1} - U_{BEQ2}}{(1+\beta) R_{E2}} = 66.33\ \mu A$$

$$I_{CQ2} = 6.63\ mA$$

b) R_{B1} преден на u_{iz} – паралелна

R_{B1} преден на i_{iz} – паралелна



$$r_{be1} = \frac{U_T}{I_{BQ1}} = 943.4\ \Omega$$

$$r_{be2} = 376.9\ \Omega$$

c) $R_u = \frac{u_{iz}}{i_a} = \frac{u_{iz}}{i_a} = \frac{u_{iz}}{u_{iz1}} \cdot \frac{u_{iz1}}{u_{o1}} \cdot \frac{u_{o1}}{i_{o1}}$

$R_{u1} = R_{B1} \parallel r_{be1} = 934.6\ \Omega$

$R_{u11} = r_{be2} + (1+h_{fe})(R_{E2} \parallel R_{B1}) = 30\,625\ \Omega$

$R_u = (1+h_{fe}) \frac{R_{E2} \parallel R_{B1}}{R_{u11}} \cdot (-h_{fe}) \frac{R_{c11} \parallel R_{u11}}{r_{be1}} \cdot R_{u1} = -281\ V m A^{-1}$

d) $\beta = \frac{i_f}{u_{iz}} = \frac{-i_F}{i_f R_{B1}} = -\frac{1}{100}\ mAV^{-1}$

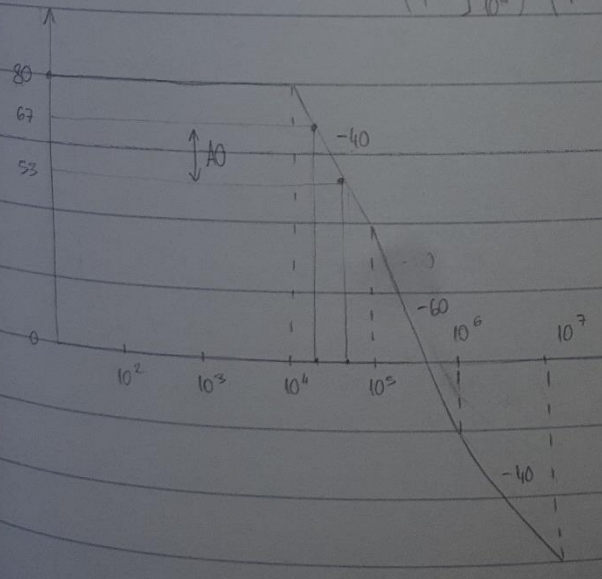
e) $A_{uF} = \frac{u_{iz}}{u_u} = \frac{R_{uF}}{R_{uf}}$

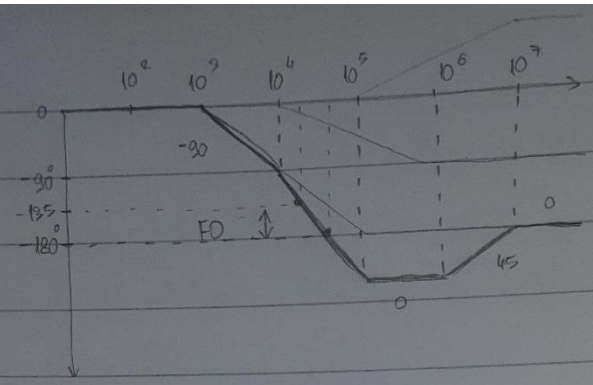
$R_{uF} = \frac{R_u}{1+\beta R_u} = -73.75\ V m A^{-1}, \quad R_{uf} = \frac{R_{u1}}{1+\beta R_{u1}} = 245.3$

$A_{VF} = \frac{-73\,750}{245.3} = -300.65$

5.

$T = A(j\omega)\beta(j\omega) = +10^4 \frac{1 + j\frac{\omega}{10^0}}{\left(1 + j\frac{\omega}{10^4}\right)^2 \left(1 + j\frac{\omega}{10^5}\right)}$





$A0 = 14\ dB$

$-67 = 20 \log \beta_0$

$\beta_0 = -0{,}45 \cdot 10^{-3}$

⑥ $f_{osc} = 1\ MHz$

$U_{ref} = 5\ V$

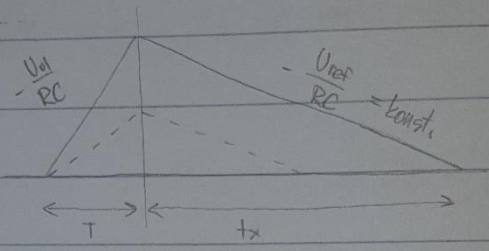
$N = 10^4$

$U_{ul} = 2{,}5\ V$

$U_{sm} = 20\ mV$

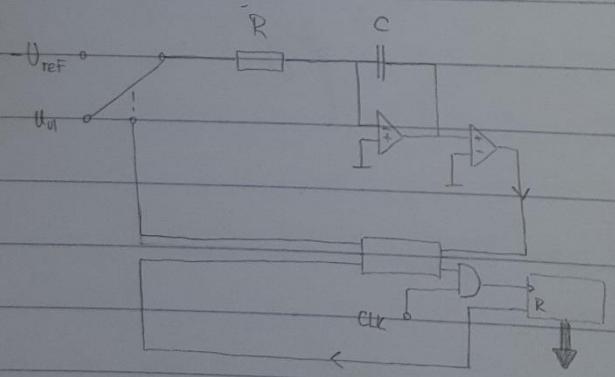
$f_{sm} = 50\ Hz$

a)



$$T\frac{U_{ul}}{RC} = \frac{U_{ref}}{RC} t_x$$

$$t_x = \frac{U_{ul}}{U_{ref}} T$$



b) $N_i = \frac{N}{U_{ref}} \cdot U_{ul} = 5000$

c) $N_i' = \frac{N}{U_{ref}} \left(U_{ul} + \frac{U_{sm}}{\sqrt{3}} \right) \approx \frac{10^4}{5} \cdot 2{,}51 = 5020$ (trokut)

d) $f_{min} = f_{sm} = 50\ Hz$

$f_{max} = \frac{f_{osc}}{N} = 100\ Hz$