ZAVRŠNI 2011/2012.

ZADATAK 1

by ~ Milan ~

a) STATIKA

$R_B = R_1 \| R_2 = 142.86\ k\Omega$ $\quad U_{BB} = U_{CC} \cdot \frac{R_2}{R_1 + R_2} = \boxed{4.29\ V}$

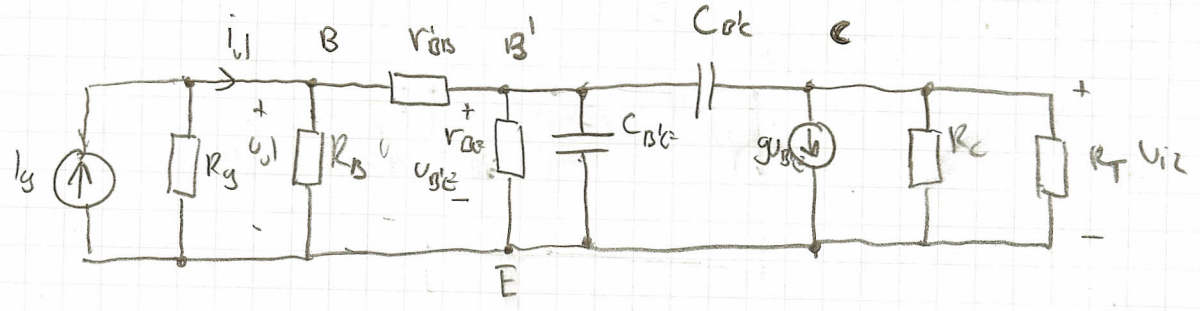
$U_{BB} = I_B \cdot R_B + U_{BE} + (1+\beta) I_B R_E$

$I_B = \frac{U_{BB} - U_{BE}}{R_B + (1+\beta) R_E} = \boxed{18.57\ \mu A}$ $\quad \boxed{I_C = 1.86\ mA}$

$U_{CE} = U_{CC} - I_C R_C - (I_C + I_B) R_E = \boxed{6.62\ V}$ $\quad \boxed{U_{CE} > U_{BE}}$

$r_{B'E} = \frac{U_T}{I_B} = \boxed{1346.25\ \Omega}$ $\quad g = \frac{h_{fe}}{r_{B'E}} = \boxed{74.3\ mA/V}$

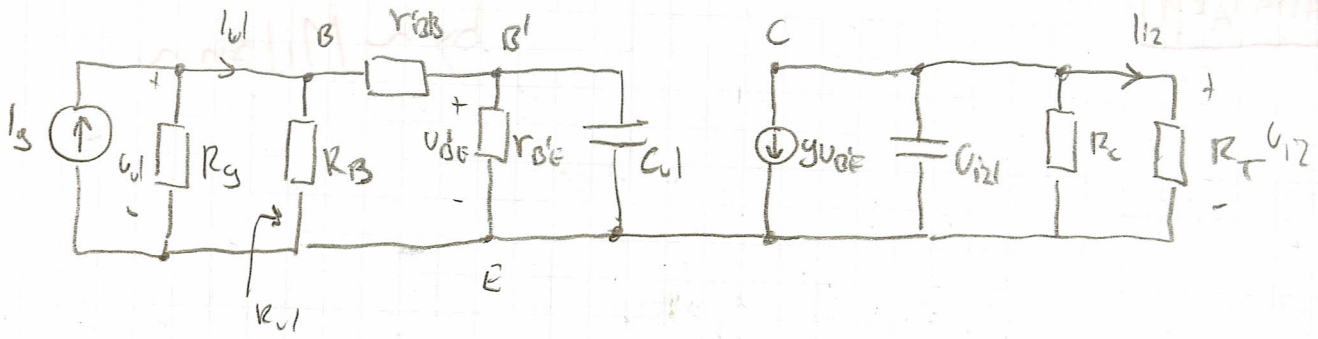
b) DINAMIKA



$K = \frac{U_{iz}}{U_{ul}} = \frac{-g U_{B'E} R_C \| R_T}{U_{B'E}} = -g R_C \| R_T = \boxed{-59.44}$

$C_{ul} = C_{B'E} + (1-K) C_{B'C} = \boxed{115.66\ pF}$

$C_{HZ} = \frac{(K-1)}{K} C_{B'C} = \boxed{1.53\ pF}$



$$A_{Ig} = \frac{I_{i2}}{I_g} \quad \frac{I_{i2}}{U_{B'E}} \cdot \frac{U_{B'E}}{I_{u1}} \cdot \frac{I_{u1}}{I_g}$$

$$\frac{I_{i2}}{U_{B'E}} = \frac{-gU_{B'E} \cdot \frac{R_c}{R_c+R_T}}{U_{B'E}} = -g\frac{R_c}{R_c+R_T} = -0.506$$

$$R_{u1} = R_B \| (r'_{BB} + r_{B'E})$$

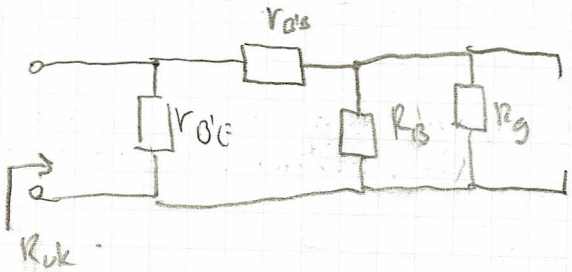
$$R_{u1} = 1370\,\Omega$$

$$\frac{U_{B'E}}{I_{u1}} = \frac{I_{u1} \cdot \frac{R_B}{R_B + (r'_{BB} + r_{B'E})} \cdot r_{B'E}}{I_{u1}} = 1333.2$$

$$\frac{I_{u1}}{I_g} = \frac{I_g \cdot \frac{R_g}{R_g + R_{u1}}}{I_g} = 0.88$$

$$A_{Ig} = -70.4$$

$f_g = ?$ Sa stezaljke prvog kondenzatora

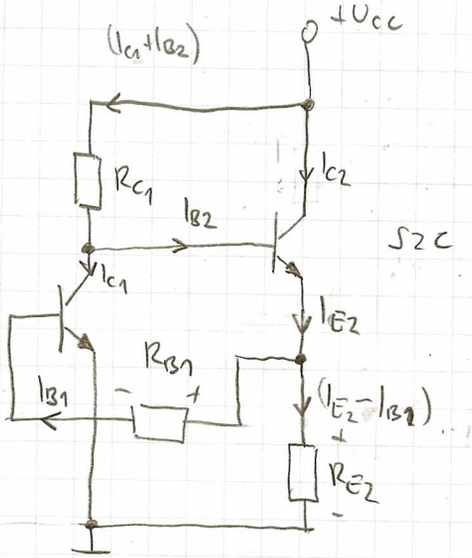


$$R_{uk} = (R_g \| R_B + r_{B'E}) \| r_{B'E} = 939.5 \| 1346.25 = 1177.5\,\Omega$$

$$\tau = C_{u1} R_{uk} = 136.2\,ns \qquad 2\pi f_g = \frac{1}{\tau} \qquad f_g = \frac{1}{\tau 2\pi} = 1.1686\,MHz$$

ZADATAK 2

STATIKA



$$U_{CC} = (I_{C1}+I_{B2})R_{C1} + U_{BE2} + (I_{E2}-I_{B1})R_{E2}$$

$$U_{CC} = \beta I_{B1} R_C + I_{B2} R_C + U_{BE2} + I_{B2}(\beta+1) R_{E2} - I_{B1} R_{E2}$$

$$U_{BE1} = -I_{B1} \cdot R_{B1} + (I_{E2} - I_{B1}) R_{E2} = -I_{B1} R_{B1} + R_E(\beta+1) I_{B2} - I_{B1} R_{E2}$$

$$\Downarrow$$

Može se zanemarit

$$U_{CC} = \beta I_{B1} R_C + I_{B2} R_C + U_{BE2} + U_{BE1} + I_{B1} R_{B1}$$

$$U_{CC} \approx \beta I_{B1} R_C + U_{BE2} + U_{BE1} + I_{B1} R_{B1}$$

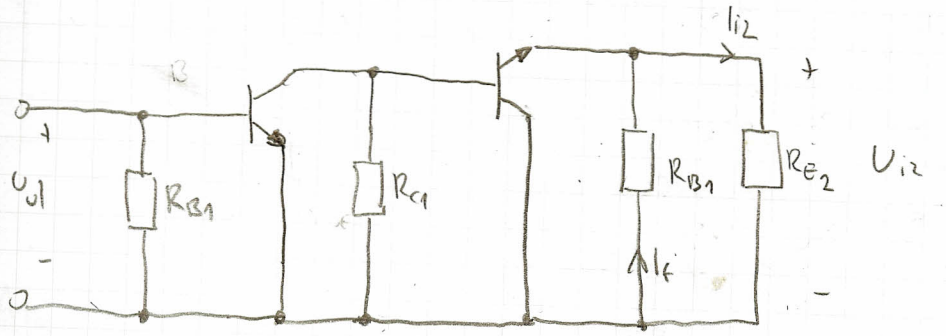
$$I_{B1} = \frac{U_{CC} - U_{BE2} - U_{BE1}}{\beta R_C + R_{B1}} = 28.33\,\mu A \qquad I_{C1} = 2.833\,mA$$

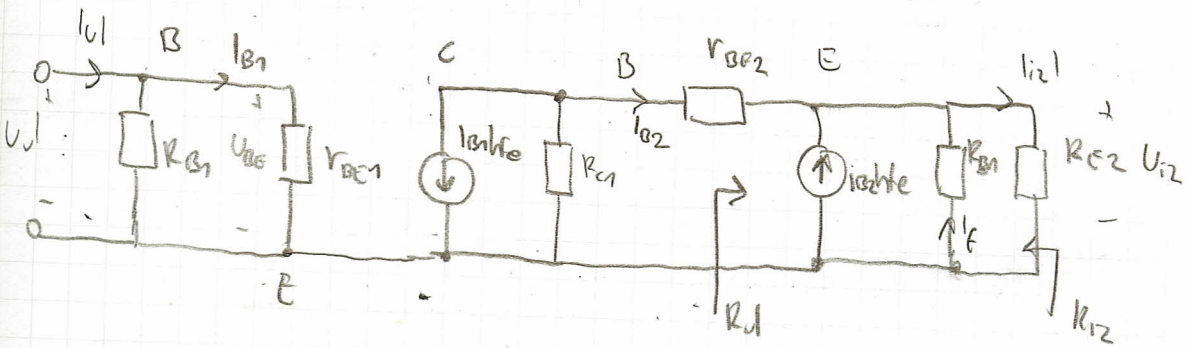
$$I_{B2} = \frac{U_{BE1} + I_{B1} R_{B1} + I_{B1} R_{E2}}{R_E(\beta+1)} = 14.97\,\mu A \qquad I_{C2} = 1.5\,mA$$

$$r_{BE1} = \frac{U_T}{I_{B1}} = 882\,\Omega \qquad r_{BE2} = 1670\,\Omega$$

Naponsko - paralelna povratna veza

Za idealni krug $U_{i2}=0V$, za izlazni $U_{ul}=0V$





$$R_M = \frac{U_{i2}}{I_{ul}} = \frac{U_{i2}}{I_{B2}} \cdot \frac{I_{B2}}{I_{B1}} \cdot \frac{I_{B1}}{I_{ul}}$$

$$R_{ul2} = \frac{U}{I_{B2}} = \frac{I_{B2} r_{BE2} + I_B(h_{fe}+1) R_{B1} \| R_{E2}}{I_{B2}}$$

$$\frac{U_{i2}}{I_{B2}} = \frac{I_{B2}(h_{fe}+1) R_{B1} \| R_{E2}}{I_{B2}} = 197073$$

$$R_{ul2} = r_{BE2} + (h_{fe}+1) R_{B1} \| R_{E2}$$

$$\frac{I_{B2}}{I_{B1}} = \frac{-I_{B1} h_{fe} \cdot \frac{R_{C1}}{R_{ul2} + R_{C1}}}{I_{B1}} = -1.973$$

$$R_{ul2} = 19874\,k\Omega$$

$$\frac{I_{B1}}{I_{ul}} = \frac{I_{ul} \frac{R_{B1}}{R_{B1}+r_{BE1}}}{I_{ul}} = 0.989$$

$$\boxed{R_M = -384584} \quad \text{- pojačanje A grane}$$

$$\beta = \frac{I_f}{U_{i2}} = -\frac{i_f}{i_f \cdot R_{B1}} = \boxed{-\frac{1}{80000}}$$

$$R_{Mf} = \frac{R_M}{1+\beta R_M} = \boxed{-66224}$$

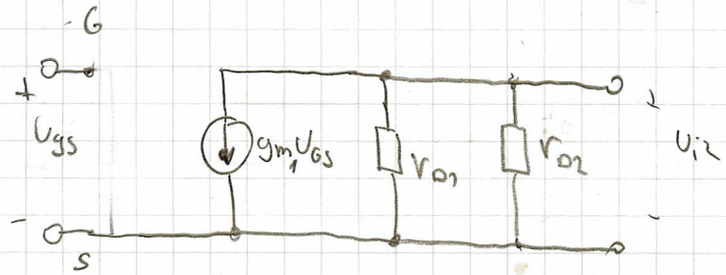
$$R_{i1} = R_{B1} \parallel r_{BE1} = 872\,\Omega$$

$$R_{i1f} = \frac{R_{i1}}{(1+\beta R_M)} = \boxed{150.15\,\Omega}$$

$$A_{vf} = \frac{U_{i2}}{U_{i1}} = \frac{U_{i2}}{i_{i1}} \cdot \frac{i_{i1}}{U_{i1}} = R_{Mf} \cdot \frac{1}{R_{if}} = \boxed{-441.}$$

$$A_{if} = \frac{i_{i2}}{i_{i1}} = \frac{\frac{U_{i2}}{R_{E2}}}{\frac{i_{i1}}{1}} = \frac{U_{i2}}{i_{i1}} \cdot \frac{1}{R_{E2}} = R_M \frac{1}{R_{E2}} = \boxed{-33.11}$$

ZADATAK 4



$$g_{m_1} = \sqrt{2K_n' (W_1/L_1) I_{REF}} \qquad I_{D1} = -I_{D2} = I_{OREF}$$

$$r_{O1} = \frac{1}{\lambda_n I_{REF}} \qquad r_{O2} = \frac{1}{-\lambda_p I_{REF}}$$

$$A_v = \frac{U_{i2}}{U_{ul}} = \frac{-g_{m_1} U_{gs} \cdot (r_{O1} \parallel r_{O2})}{U_{gs}} = -g_{m_1}(r_{O1} \parallel r_{O2})$$

$$A_v = -g_{m_1}(r_{O1} \parallel r_{O2}) = -\sqrt{2K_n' (W_1/L_1) I_{REF}} \left(\frac{1}{\lambda_n I_{REF} - \lambda_p I_{REF}} \right)$$

$$A_v = -\frac{\sqrt{2K_n' (W_1/L_1)}}{(\lambda_n - \lambda_p)} \cdot \frac{\sqrt{I_{REF}}}{I_{REF}} = -\frac{\sqrt{2K_n' (W_1/L_1)}}{(\lambda_n - \lambda_p)} \frac{1}{\sqrt{I_{REF}}} \quad / \,^2$$

$$A_v^2 = \frac{2K_n' (W_1/L_1)}{(\lambda_n - \lambda_p)^2} \cdot \frac{1}{I_{REF}} \Rightarrow I_{REF} = \frac{2K_n (W_1/L_1)}{(\lambda_n - \lambda_p)^2 A_v^2}$$

$$\boxed{I_{REF} = 12\ \mu A}$$

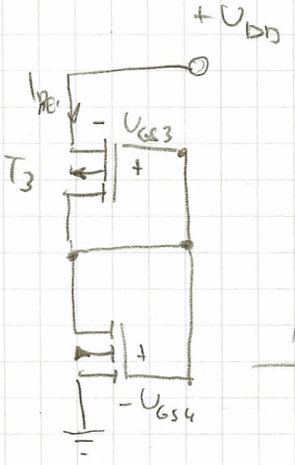
$I_{D3} = -I_{REF}$

$$I_{D3} = \frac{K_p'}{2} \frac{W_3}{L_3} \left(U_{GS3} - U_{GSop}\right)^2$$

$$U_{GS3} = \ominus \sqrt{\frac{2 I_{D3}}{K_p' (W_3/L_3)}} + U_{GSop} = -\sqrt{\frac{-2 I_{REF}}{K_p' (W_3/L_3)}} + U_{GSop}$$

Minus jer mora biti negativniji od U_{GSop}

$$\boxed{U_{GS3} = -0.9\ V}$$



$$U_{GS4} = U_{DD} + U_{GS3}$$

$$\boxed{U_{GS4} = 2.6\ V}$$

$I_{D4} = I_{REF}$

$$I_{D4} = \frac{k_n'}{2} \frac{W_4}{L_4} \left(U_{GS4} - U_{GSon}\right)^2$$

$$\frac{W_4}{L_4} = \frac{2 I_{REF}}{k_n' \left(U_{GS4} - U_{GSon}\right)^2} = \boxed{0.044}$$