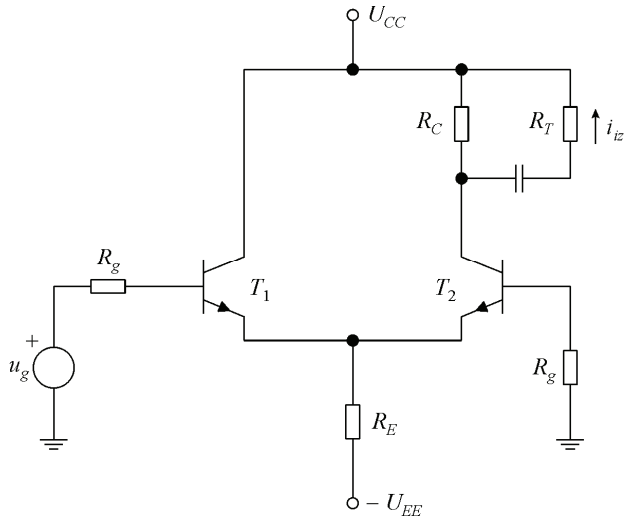
Međuispit iz "Elektronike 2" - rješenja

1. zadatak

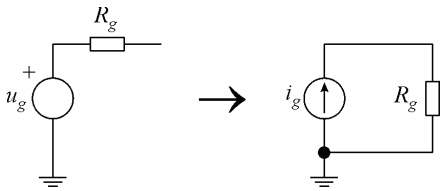


$$I_{BQ1} = I_{BQ2} = \frac{U_{EE} - U_{BEQ1}}{R_g + 2(1+\beta)R_E} = 11{,}2\ \mu\text{A}\,, \quad I_{CQ1} = I_{CQ2} = \beta I_{BQ1} = 1{,}12\ \text{mA}\,,$$

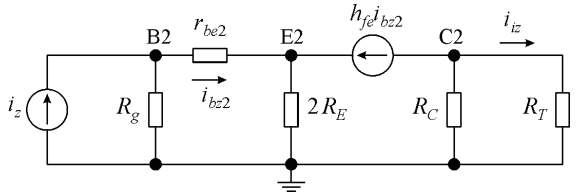
$$U_{CEQ1} \approx U_{CC} + U_{EE} - 2R_E I_{CQ1} = 12{,}8\ \text{V}\,,$$

$$U_{CEQ2} \approx U_{CC} + U_{EE} - (R_C + 2R_E) I_{CQ1} = 11{,}7\ \text{V}\,,$$

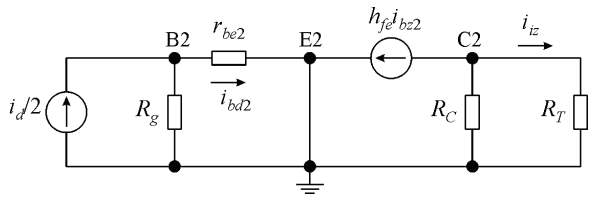
$$r_{be1} = r_{be1} = \frac{U_T}{I_{BQ1}} = 2{,}23\ \text{k}\Omega\,.$$



$$I_{gm} = \frac{U_{gm}}{R_g} = 100\ \mu\text{A}\,.$$



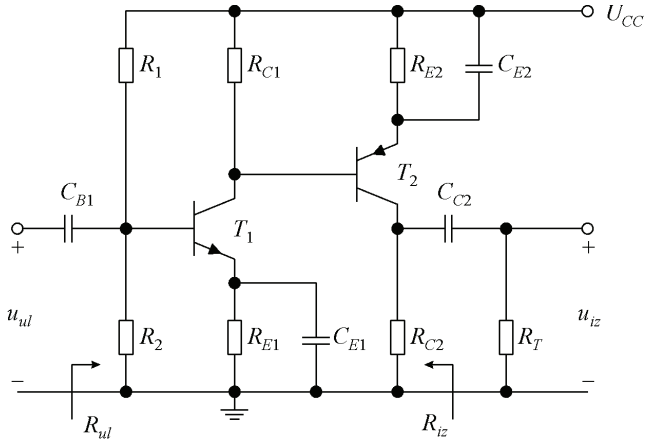
$$A_{Iz} = \frac{i_{iz}}{i_z} = -h_{fe} \frac{R_C}{R_C + R_T} \frac{R_g}{R_g + r_{be2} + 2(1+h_{fe})R_E} = -0{,}041\,.$$



$$A_{Id} = \frac{i_{iz}}{i_d} = \frac{1}{2}\frac{i_{iz}}{i_d/2} = -\frac{h_{fe}}{2}\frac{R_C}{R_C + R_T}\frac{R_g}{R_g + r_{be2}} = -7{,}63\,,$$

$$I_{izm} = A_{Iz}\, I_{zm} + A_{Id}\, I_{dm} = 761\ \mu\text{A}, \quad i_{iz} = 761\sin\omega t\ \mu\text{A}\,.$$

2. zadatak



$$U_{BB1} = \frac{R_2}{R_1 + R_2}U_{CC} = 2{,}4\ \text{V}\,, \quad R_{B1} = R_1 \,\|\, R_2 = 20\ \text{k}\Omega\,,$$

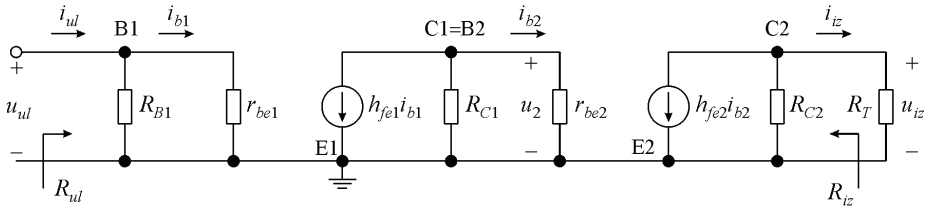
$$I_{BQ1} = \frac{U_{BB1} - U_{BEQ1}}{R_{B1} + (1+\beta)R_{E1}} = 14\ \mu\text{A}\,, \quad I_{CQ1} = \beta\, I_{BQ1} = 1{,}4\ \text{mA}\,,$$

$$(I_{CQ1} + I_{BQ2})R_{C1} = -(1+\beta)I_{BQ2}\,R_{E2} - U_{BEQ2}\,,$$

$$I_{BQ2} = -\frac{I_{CQ1}R_{C1} + U_{BEQ2}}{R_{C1} + (1+\beta)R_{E2}} = -19\ \mu\text{A}\,, \quad I_{CQ2} = \beta\, I_{BQ2} = -1{,}9\ \text{mA}\,,$$

$$U_{CEQ1} \approx U_{CC} - (R_{C1} + R_{E1})I_{CQ1} = 5\ \text{V}\,, \quad U_{CEQ2} \approx -U_{CC} - (R_{E2} + R_{C2})I_{CQ2} = -3{,}5\ \text{V}\,,$$

$$r_{be1} = \frac{U_T}{I_{BQ1}} = 1{,}78\ \text{k}\Omega\,, \quad r_{be2} = \frac{U_T}{-I_{BQ2}} = 1{,}32\ \text{k}\Omega\,.$$



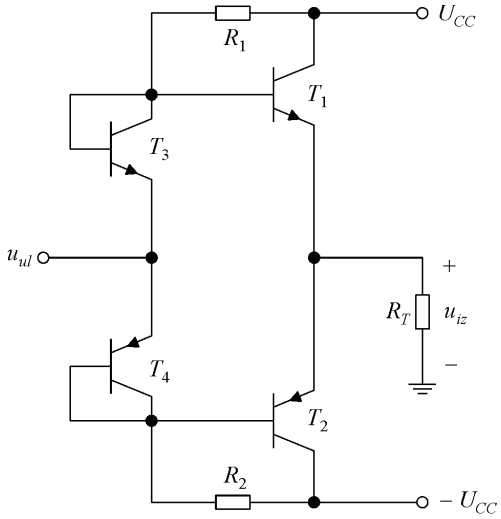
$$A_{V2} = \frac{u_{iz}}{u_2} = -\,h_{fe}\frac{R_{C2}\,\|\,R_T}{r_{be2}} = -\,75{,}8\,, \quad A_{V1} = \frac{u_2}{u_{ul}} = -\,h_{fe}\frac{R_{C1}\,\|\,r_{be2}}{r_{be1}} = -\,55{,}8\,,$$

$$A_V = \frac{u_{iz}}{u_{ul}} = A_{V2}\,A_{V1} = 4230\,,$$

$$R_{ul} = \frac{u_{ul}}{i_{ul}} = R_{B1}\,\|\,r_{be1} = 1{,}63\ \text{k}\Omega\,, \quad A_I = \frac{i_{iz}}{i_{ul}} = \frac{u_{iz}\,/\,R_T}{u_{ul}\,/\,R_{ul}} = A_V\,\frac{R_{ul}}{R_T} = -\,3450\,,$$

$$R_{iz} = R_{C2} = 2\ \text{k}\Omega\,.$$

3. zadatak



$$\text{Bez signala} \quad \rightarrow \quad P_{T1}\big|_{I_{cm}=0} = P_{T1,\min} = U_{CC}\,I_{CQ1} \quad \rightarrow \quad I_{CQ1} = \frac{P_{T1,\min}}{U_{CC}} = 23\ \text{mA}\,,$$

$$\text{Uz signal} \quad \rightarrow \quad P_{T1} = U_{CC}I_{CQ1} + U_{CC}\,\frac{I_{cm}}{\pi} - R_T\,\frac{I_{cm}^2}{4}\,,$$

$$\frac{\partial P_{T1}}{\partial I_{cm}} = \frac{U_{CC}}{\pi} - R_T\,\frac{I_{cm}}{2} \equiv 0 \quad \rightarrow \quad I_{cm|P_{T1\max}} = \frac{2}{\pi}\,\frac{U_{CC}}{R_T}\,,$$

$$P_{T1,\max} = U_{CC}\,I_{CQ1} + \frac{U_{CC}^2}{\pi^2\,R_T} = P_{T1,\min} + \frac{U_{CC}^2}{\pi^2\,R_T} \quad \rightarrow \quad R_T = \frac{U_{CC}^2}{\pi^2\left(P_{T1,\max} - P_{T1,\min}\right)} = 8\ \Omega\,,$$

$$I_{RQ1} = \frac{U_{CC} - U_{BEQ1}}{R_1} = I_{BQ3} + I_{CQ3} + I_{BQ1} = \frac{2+\beta}{\beta} I_{CQ1},$$

$$R_1 = R_2 = \frac{U_{CC} - U_\gamma}{(2+\beta) I_{CQ1}} \beta = 390\ \Omega,$$

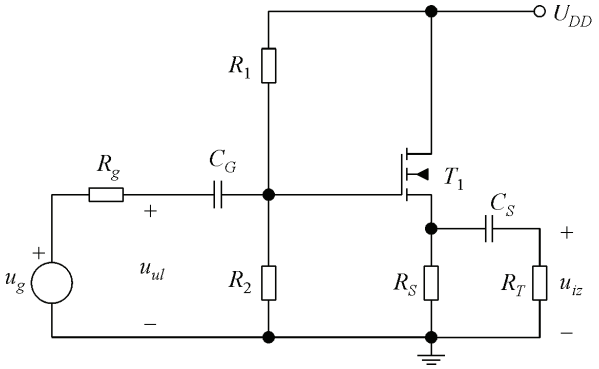
$$P_{T3} = U_{CEQ3} I_{CQ3} = U_{BEQ3} I_{CQ3} = 16\ \text{mW},$$

$$U_{CC} = R_1 I_{B\max} + u_{BE} + (1+\beta) R_T I_{B\max},$$

$$U_{izm\max} = (1+\beta) R_T I_{B\max} = (U_{CC} - U_\gamma) \frac{(1+\beta) R_T}{R_1 + (1+\beta) R_T} = 5{,}8\ \text{V},$$

$$P_{RT\max} = \frac{U_{izm\max}^2}{2 R_T} = \frac{5{,}8^2}{2 \cdot 8} = 2{,}1\ \text{W}.$$

4. zadatak



$$U_{GG} = \frac{R_2}{R_1 + R_2} U_{DD} = 8\ \text{V}, \quad R_G = R_1 \| R_2 = 2\ \text{M}\Omega,$$

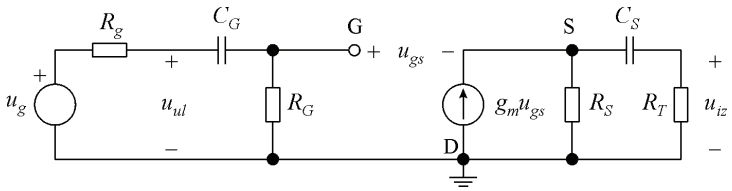
$$U_{GG} = U_{GSQ} + R_S I_{DQ} = U_{GSQ} + R_S \frac{K}{2} (U_{GSQ} - U_{GS0})^2,$$

$$U_{GSQ}^2 + \left(\frac{2}{R_S K} - 2U_{GS0} \right) U_{GSQ} + U_{GS0}^2 - \frac{2U_{GG}}{R_S K} = 0 \quad \rightarrow \quad U_{GSQ}^2 - 1{,}2 \cdot U_{GSQ} + 5{,}4 = 0,$$

$$U_{GSQ} = 0{,}6 + 2{,}4 = 3\ \text{V},$$

$$I_{DQ} = \frac{U_{GG} - U_{GSQ}}{R_S} = 5\ \text{mA}, \quad U_{DSQ} = U_{DD} - R_S I_{DQ} = 7\ \text{V},$$

$$g_m = K (U_{GSQ} - U_{GS0}) = 5\ \text{mA/V}.$$



$$\frac{U_{iz}}{U_{gs}} = g_m \left(R_S \,\|\, R_T \right), \quad U_{gs} = U_{ul} - U_{iz} \,,$$

$$A_{Vg0} = \frac{U_{iz}}{U_g} = \frac{U_{iz}}{U_{gs}} \frac{U_{gs}}{U_{ul}} \frac{U_{ul}}{U_g} = \frac{g_m \left(R_S \,\|\, R_T \right)}{1 + g_m \left(R_S \,\|\, R_T \right)} \frac{R_G}{R_g + R_G} = 0,714 \,,$$

$$\tau_G = \left(R_g + R_G \right) C_G = 40 \text{ ms} \,, \quad \omega_G = \frac{1}{\tau_G} = 25 \text{ rad/s} \,,$$

$$\tau_S = \left(R_S \,\| \frac{1}{g_m} + R_T \right) C_S = 5,8 \text{ ms} \,, \quad \omega_S = \frac{1}{\tau_S} = 172 \text{ rad/s} \,,$$

$$\omega_d = \omega_S = 172 \text{ rad/s} \,, \quad f_d = \frac{\omega_d}{2\pi} = 27,4 \text{ Hz} \,.$$