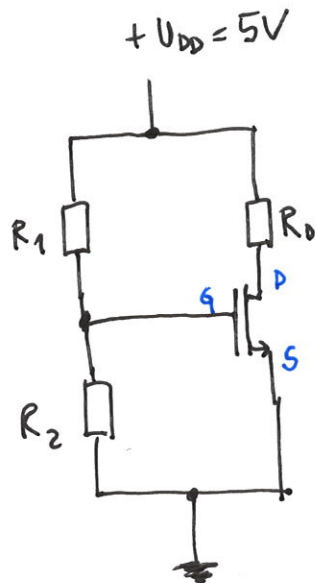


Fig. 3/25



$$R_1 = 30 \text{ k}\Omega$$

$$R_2 = 20 \text{ k}\Omega$$

$$R_D = 20 \text{ k}\Omega$$

$$U_{DD} = 5V$$

$$U_{TN} = 1V$$

$$K_U = 0.1 \frac{\text{mA}}{\text{V}^2}$$

$$I_a = 0A$$

$$U_G = \frac{R_2}{R_1 + R_2} \cdot U_{DD} = \frac{20 \text{ k}\Omega}{20 \text{ k}\Omega + 30 \text{ k}\Omega} \cdot 5V = \underline{2V} = U_{GS}$$

$$I_D = K_U \cdot (U_{GS} - U_{TN})^2 = 0.1 \frac{\text{mA}}{\text{V}^2} \cdot (2V - 1V)^2$$

$$= 0.1 \frac{\text{mA}}{\text{V}^2} \cdot 1V^2 = \underline{0.1 \text{ mA}}$$

$$I_D = 0.1 \text{ mA}$$

$$U_{DS} = U_{DD} - I_D \cdot R_D = 5V - 0.1 \text{ mA} \cdot 20 \text{ k}\Omega$$

$$= 5V - 2V = \underline{3V}$$

$$U_{DS} = 3V$$

NASILČENJE ?

$$U_{DS} > U_{GS} - U_{TN}$$

$$3V > 2V - 1V$$

$$3V > 1V \quad \checkmark$$

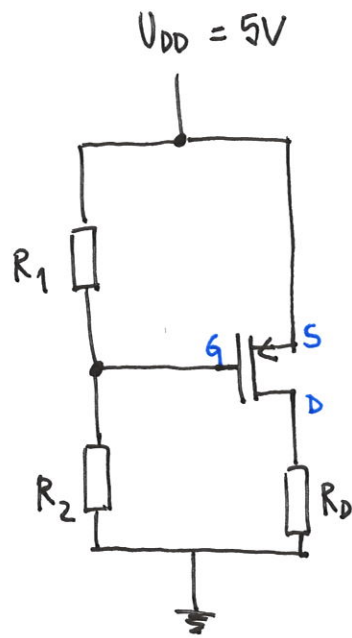
PORABA MOČI

$$P_T = I_D \cdot U_{DS}$$

$$= 0.1 \text{ mA} \cdot 3V$$

$$P_T = \underline{0.3 \text{ mW}}$$

$$\text{D.T. } (I_{DQ}, U_{DSQ}) = (0.1 \text{ mA}, 3V)$$



$$R_1 = 50 \text{ k}\Omega$$

$$R_2 = 50 \text{ k}\Omega$$

$$R_D = 7.5 \text{ k}\Omega$$

$$V_{DD} = 5 \text{ V}$$

$$V_{TP} = -0.8 \text{ V}$$

$$K_P = 0.2 \frac{\text{mA}}{\text{V}^2}$$

$$V_G = \frac{R_2}{R_1 + R_2} \cdot V_{DD} = \frac{50 \text{ k}\Omega}{50 \text{ k}\Omega + 50 \text{ k}\Omega} \cdot 5 \text{ V} = 2.5 \text{ V}$$

$$V_{SG} = V_{DD} - V_G = 5 \text{ V} - 2.5 \text{ V} = 2.5 \text{ V}$$

NAHČENJE:

$$I_D = K_P \cdot (V_{SG} + V_{TP})^2 = 0.2 \frac{\text{mA}}{\text{V}^2} \cdot (2.5 \text{ V} - 0.8 \text{ V})^2 = 0.578 \text{ mA}$$

$$V_{SD} = V_{DD} - I_D \cdot R_D = 5 \text{ V} - 0.578 \text{ mA} \cdot 7.5 \text{ k}\Omega = 0.665 \text{ V}$$

$$V_{SD} > V_{SG} + V_{TP}$$

$$0.665 \text{ V} > 2.5 \text{ V} - 0.8 \text{ V}$$

$$0.665 \text{ V} > 1.7 \text{ V} //$$

LINEARNO PODROČJE

$$I_D = K_P \left[ 2(V_{SG} + V_{TP})V_{SD} - V_{SD}^2 \right]$$

$$V_{SD} = V_{DD} - I_D R_D$$

$$I_D = K_P \left[ 2(V_{SG} + V_{TP})(V_{DD} - I_D R_D) - (V_{DD} - I_D R_D)^2 \right]$$



↓  
Kvadraticke rovnice

$$I_D = \underline{0.515 \text{ mA}}$$

$$U_{SD} = U_{DD} - I_D \cdot R_D = \underline{1.14 \text{ V}}$$

$$U_{SD} < U_{SG} + U_{Tp}$$

$$1.14 \text{ V} < 2.5 \text{ V} - 0.8 \text{ V}$$

$$1.14 \text{ V} < 1.7 \text{ V} \quad \checkmark$$

$$\text{D.T. } (I_D, U_{SD}) = (0.515 \text{ mA}, 1.14 \text{ V})$$

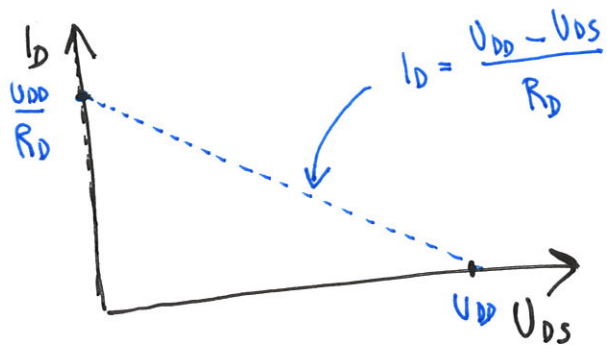
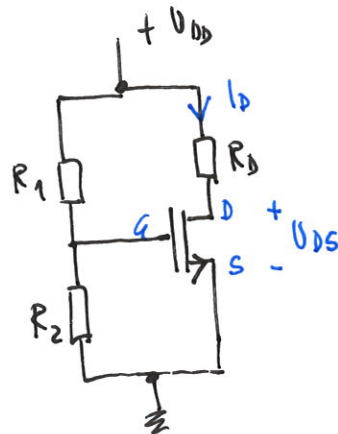
DELOVNA PŘEMICA  
(LOAD LINE)

$$U_{DD} = I_D \cdot R_D + U_{DS}$$

$$I_D = \frac{U_{DD} - U_{DS}}{R_D}$$

$$I_D = 0 \text{ A} \Rightarrow U_{DS} = U_{DD}$$

$$U_{DS} = 0 \text{ V} \Rightarrow I_D = \frac{U_{DD}}{R_D}$$



$$U_{DS} = U_{as}$$

NASÄŤENIE:

$$U_{DS} > U_{as} - U_{TN}$$

$$0 > -U_{TN} \quad (U_{TN} > 0)$$

TRANZISTOR JE VEDNO V NASÄŤENÍ

$$I_D = K_N \cdot (U_{as} - U_{TN})^2$$

$$I_D = K_N \cdot (U_{DS} - U_{TN})^2$$

PODROČIE II

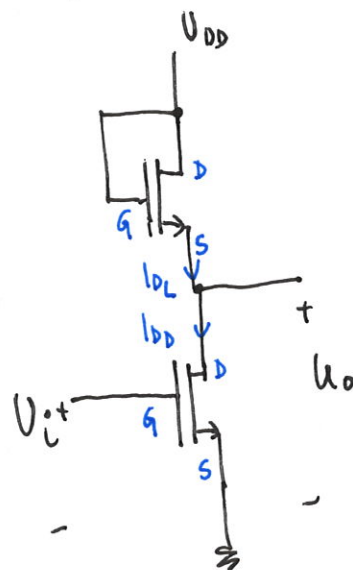
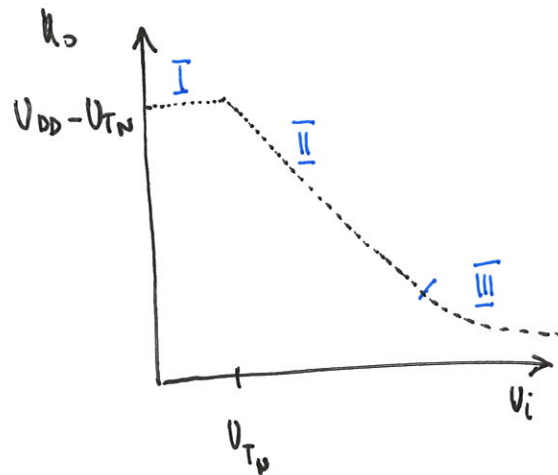
$M_D, M_L$  NASÄŤENIE

$$I_{D_D} = I_{D_L}$$

$$K_{N_D} (U_{as_D} - U_{TN})^2 = K_{N_L} (U_{as_L} - U_{TN})^2$$

$$\sqrt{\frac{K_{N_D}}{K_{N_L}}} (U_i - U_{TN}) = U_{DD} - U_o - U_{TN}$$

$$U_o = U_{DD} - U_{TN} - \sqrt{\frac{K_{N_D}}{K_{N_L}}} (U_i - U_{TN})$$

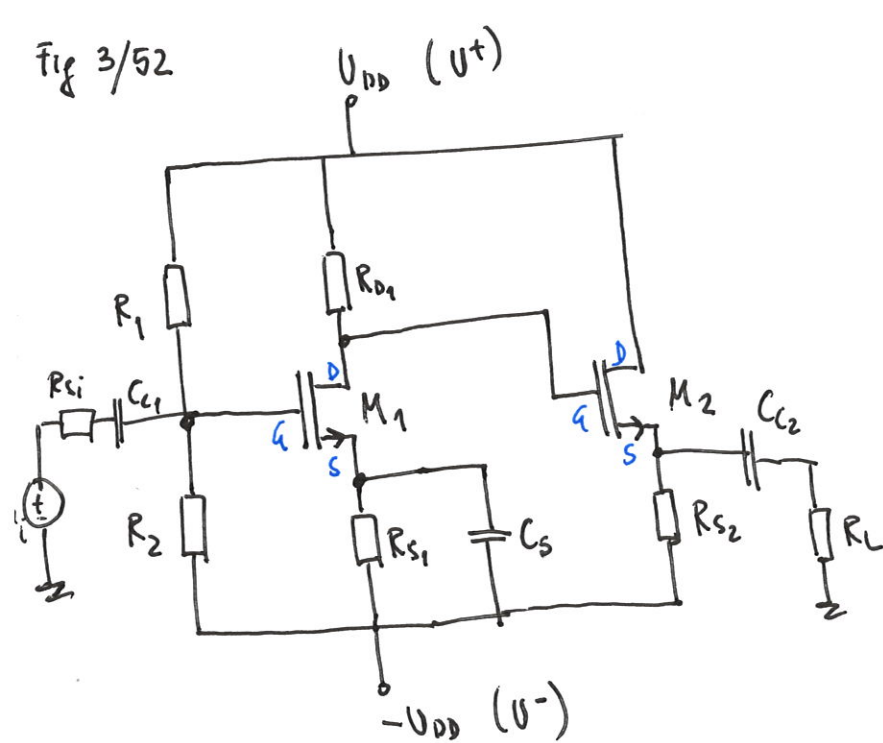


$$I_{D_L} = K_{N_L} \cdot (U_{as_L} - U_{TN})^2$$

$$I_{D_L} = K_{N_L} \cdot (U_{DS_L} - U_{TN})^2 = K_{N_L} \cdot (U_{DD} - U_o - U_{TN})^2$$

$$I_{D_L} = 0 \Rightarrow$$

$$U_o = U_{DD} - U_{TN}$$



$$K_{M1} = 0,5 \frac{\mu\text{A}}{\text{V}^2}$$

$$K_{M2} = 0,2 \frac{\mu\text{A}}{\text{V}^2}$$

$$U_{TP1} = U_{TP2} = 1,2\text{V}$$

$$\lambda_1 = \lambda_2 = 0$$

$$U_{DD} = 5\text{V}$$

ŽELIMO:

$$I_{D1} = 0,2 \text{ mA}$$

$$I_{D2} = 0,5 \text{ mA}$$

$$U_{DS1} = U_{DS2} = 6\text{V}$$

$$R_i = 100 \text{ k}\Omega$$

$$U_{DS2} = U^+ - U^- - U_{RS2}$$

$$U_{DS2} = U^+ - U^- - I_{D2} \cdot R_{S2}$$

$$6\text{V} = 5\text{V} - (-5\text{V}) - 0,5 \text{ mA} \cdot R_{S2}$$

$$\Rightarrow R_{S2} = \underline{8 \text{ k}\Omega}$$

PREDPOSTAVIMO  $M_2$  U NASIĆENJU:

$$I_{D2} = K_{M2} \cdot (U_{GS2} - U_{TM2})^2$$

$$0,5 \text{ mA} = 0,2 \frac{\mu\text{A}}{\text{V}^2} \cdot (U_{GS2} - 1,2\text{V})^2 \Rightarrow U_{GS2} = 2,78\text{V}$$

$$U_{DS2} = 6\text{V} \Rightarrow U_{S2} = 5\text{V} - 6\text{V} = -1\text{V} \Rightarrow U_{G2} = U_{S2} + U_{GS2}$$

$$U_{G2} = -1\text{V} + 2,78\text{V} = 1,78\text{V}$$

$$U_{G2} = 1,78\text{V} = U_{D1}$$

$$U_{D1} = U^+ - I_{D1} \cdot R_{D1} = 5\text{V} - 0,2 \text{ mA} \cdot R_{D1} = 1,78\text{V} \Rightarrow R_{D1} = \underline{16,1 \text{ k}\Omega}$$

$$U_{DS1} = 6\text{V} \quad U_{S1} = U_{D1} - U_{DS1} = 1,78\text{V} - 6\text{V} = -4,22\text{V}$$

$$U_{S1} = I_{D1} \cdot R_{S1} + U^- = -4,22\text{V} = 0,2 \text{ mA} \cdot R_{S1} + (-5\text{V}) \Rightarrow R_{S1} = \underline{3,9 \text{ k}\Omega}$$

$$I_{D1} = K_{M1} \cdot (U_{GS1} - U_{T_{M1}})^2$$

$$0.2 \text{ mA} = 0.5 \frac{\text{mA}}{\text{V}^2} \cdot (U_{GS1} - 1.2\text{V})^2 \Rightarrow U_{GS1} = 1.83\text{V}$$

$$U_{GS1} = \underbrace{\frac{R_2}{R_1 + R_2} \cdot (U^+ - U^-) + U^-}_{U_{G1}} - \underbrace{(U^- + I_{D1} \cdot R_{S1})}_{U_{S1}}$$

$$U_{GS1} = 1.83\text{V} = \frac{R_2}{R_1 + R_2} \cdot (U^+ - U^-) - I_{D1} \cdot R_{S1}$$

$$1.83\text{V} = \frac{\underbrace{R_1 \cdot R_2}_{R_i}}{R_1 \cdot (R_1 + R_2)} \cdot (U^+ - U^-) - I_{D1} \cdot R_{S1}$$

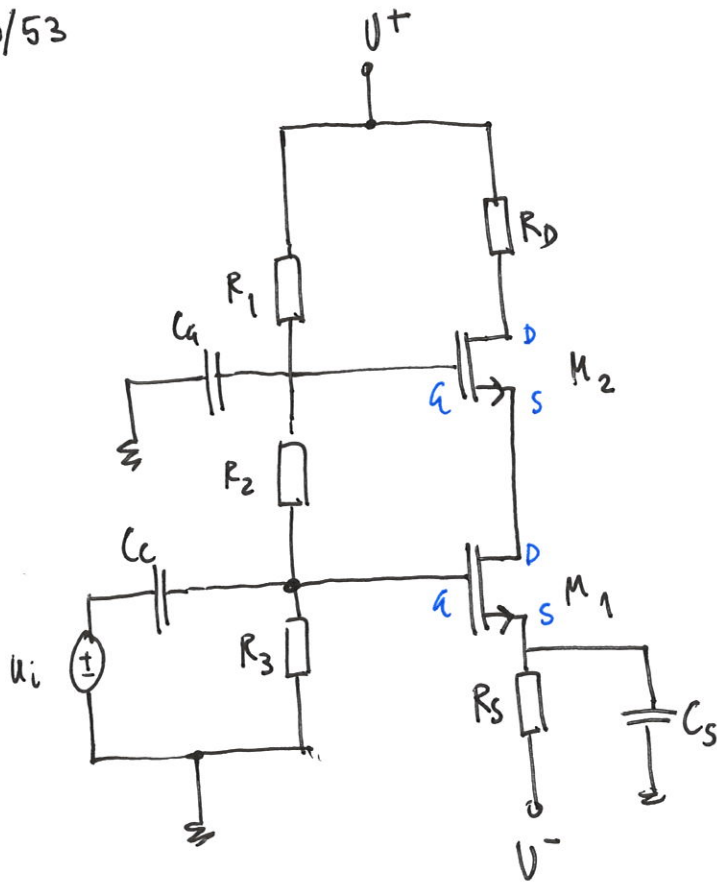
$$1.83\text{V} = \frac{R_i}{R_1} \cdot (U^+ - U^-) - I_{D1} \cdot R_{S1}$$

$$1.83\text{V} = \frac{100\text{k}\Omega}{R_1} \cdot (5\text{V} - (-5\text{V})) - 0.2 \text{ mA} \cdot 3.9\text{k}\Omega$$

$$\Rightarrow R_1 = \underline{383\text{k}\Omega}$$

$$R_i = \frac{R_1 \cdot R_2}{R_1 + R_2} = 100\text{k}\Omega \Rightarrow R_2 = \underline{135\text{k}\Omega}$$

Fig 3/53



$$U^+ = 5V \quad U^- = -5V$$

$$U_{TN1} = U_{TN2} = 1.2V$$

$$K_{N1} = K_{N2} = 0.8 \frac{\text{mA}}{\text{V}^2}$$

$$\lambda_1 = \lambda_2 = 0$$

$$R_1 + R_2 + R_3 = 300 \text{ k}\Omega$$

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

ŽELIMO:

$$I_D = 0.4 \text{ mA} \Rightarrow (I_{D1} = I_{D2} = 0.4 \text{ mA})$$

$$U_{DS} = 2.5V$$

$$U_{S1} = U^- + I_D \cdot R_s$$

$$U_{S1} = -5V + 0.4 \text{ mA} \cdot 10 \text{ k}\Omega = -1V$$

$$I_D = K_N \cdot (U_{GS} - U_{TN})^2$$

$$0.4 \text{ mA} = 0.8 \frac{\text{mA}}{\text{V}^2} \cdot (U_{GS} - 1.2V)^2 \Rightarrow U_{GS} = 1.907V$$

$$U_{G1} = \frac{R_3}{R_1 + R_2 + R_3} \cdot U^+ = U_{S1} + U_{GS1}$$

$$\frac{R_3}{300 \text{ k}\Omega} \cdot 5V = -1V + 1.907V \Rightarrow R_3 = \underline{54.4 \text{ k}\Omega}$$

$$U_{G2} = \frac{R_2 + R_3}{R_1 + R_2 + R_3} \cdot U^+ = U_{S2} + U_{GS2} = 1.5V + 1.907V \Rightarrow R_2 = \underline{150 \text{ k}\Omega}$$

$$R_1 + R_2 + R_3 = 300 \text{ k}\Omega \Rightarrow R_1 = \underline{95.6 \text{ k}\Omega}$$

$$U_{D2} = U_{S2} + U_{DS2}$$

$$U_{D2} = 1.5V + 2.5V = 4V$$

$$I_D \cdot R_D = U^+ - U_{D2}$$

$$0.4mA \cdot R_D = 5V - 4V = 1V \Rightarrow R_D = \frac{1V}{0.4mA} = \underline{2.5k\Omega}$$

NAPŮČENJE ?

$$U_{DS} > U_{GS} - U_T$$

$$2.5V > 1.907V - 1.2V$$

