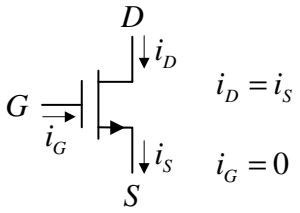
Režimi rada MOS tranzistora

- NMOS tranzistor



$i_D = i_S$

$i_G = 0$

- Zasićenje:

$v_{GS} > V_{TN}$ i $v_{GD} < V_{TN}$

$$i_D = \frac{B}{2}(v_{GS} - V_{TN})^2 = \frac{\mu_n C_{ox} W}{2L}(v_{GS} - V_{TN})^2; \qquad B = \frac{\mu_n C_{ox} W}{L}$$

- Triodna oblast:

$v_{GS} > V_{TN}$ i $v_{GD} > V_{TN}$

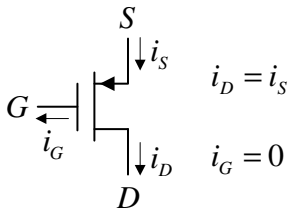
$$i_D = B\left[(v_{GS} - V_{TN})v_{DS} - \frac{v_{DS}^2}{2}\right] = \frac{\mu_n C_{ox} W}{L}\left[(v_{GS} - V_{TN})v_{DS} - \frac{v_{DS}^2}{2}\right];\ B = \frac{\mu_n C_{ox} W}{L}$$

- Zakočenje (OFF):

$v_{GS} < V_{TN}$

$i_D = 0$

- PMOS tranzistor



$i_D = i_S$

$i_G = 0$

  - Zasićenje:

$v_{SG} > |V_{TP}|$ i $v_{DG} < |V_{TP}|$

$$i_D = \frac{B}{2}\left(v_{SG} - |V_{TP}|\right)^2 = \frac{\mu_p C_{ox} W}{2L}\left(v_{SG} - |V_{TP}|\right)^2; \qquad B = \frac{\mu_p C_{ox} W}{L}$$

  - Triodna oblast:

$v_{SG} > |V_{TP}|$ i $v_{DG} > |V_{TP}|$

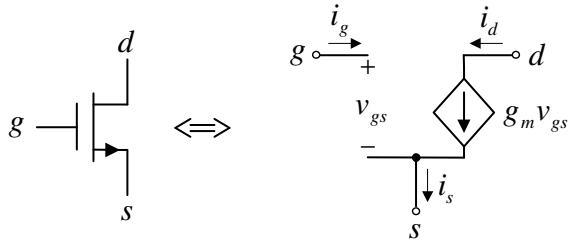
$$i_D = B\left[\left(v_{SG} - |V_{TP}|\right)v_{SD} - \frac{v_{SD}^2}{2}\right] = \frac{\mu_p C_{ox} W}{L}\left[\left(v_{SG} - |V_{TP}|\right)v_{SD} - \frac{v_{SD}^2}{2}\right];\ B = \frac{\mu_p C_{ox} W}{L}$$

  - Zakočenje (OFF):

$v_{SG} < |V_{TP}|$

$i_D = 0$

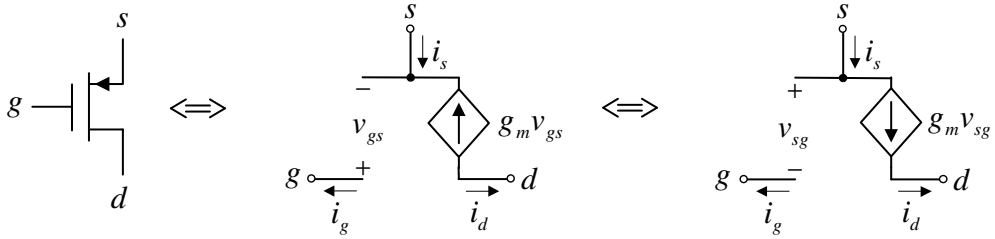
- Model NMOS tranzistora za mali signal:



$g_m = \sqrt{2BI_D}$

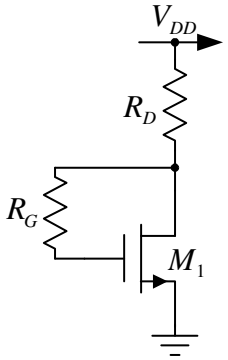
$i_d = i_s = g_m v_{gs}$; $\qquad i_g = 0$

- Model PMOS tranzistora za mali signal:

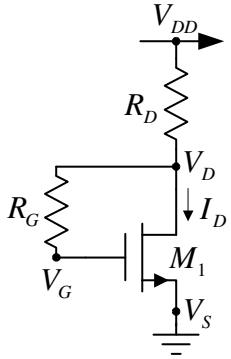


$g_m = \sqrt{2BI_D}$; $\qquad i_d = i_s = g_m v_{sg}$; $\qquad i_g = 0$

89. Parametri tranzistora u kolu sa slike su: $V_{TN} = V_T = 3\text{V}$ i $B = \dfrac{\mu_n C_{ox} W}{L} = 0{,}48\text{mA/V}^2$, dok je $V_{DD} = 12\text{V}$, $R_D = 2\text{k}\Omega$ i $R_G = 10\text{M}\Omega$. Izračunati napone V_{GS} i V_{DS}.



<u>Rešenje:</u>



Pretpostavka M_1 u zasićenju:

$$\left.\begin{aligned} I_D &= \frac{B}{2}(V_{GS} - V_T)^2 \\ V_{GS} &= V_G = V_D = V_{DD} - R_D I_D \end{aligned}\right\} \Rightarrow \quad I_D = \frac{B}{2}(V_{DD} - R_D I_D - V_T)^2$$

$$I_D = 0{,}00024 \cdot (9 - 2000 I_D)^2$$

$960I_D^2 - 9{,}64I_D + 0{,}01944 = 0$

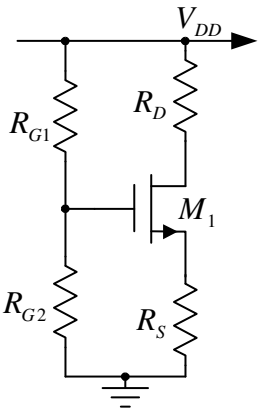
$I_D' = 7{,}25\text{mA} \;\Rightarrow\; V_{GS}' = V_{DD} - R_D I_D' = -2{,}5\text{V} < V_T \;\Rightarrow$ odbacuje se jer je M_1 po postavljenoj pretpostavci u zasićenju

$I_D'' = 2{,}79\text{mA} \;\Rightarrow\; V_{GS}'' = V_{DD} - R_D I_D'' = 6{,}42\text{V} > V_T \;\Rightarrow$ prihvata se jer je u skladu sa postavljenom pretpostavkom da je M_1 u zasićenju

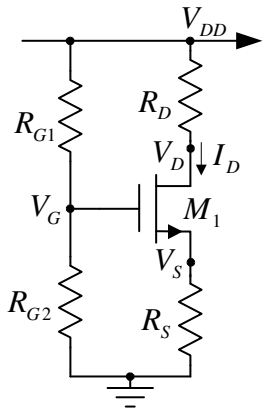
Dakle: $I_D = 2{,}79\text{mA}$, $V_{GS} = 6{,}42\text{V} > V_T$, $V_{GD} = 0 < V_T$, što znači da je M_1 zaista u zasićenju, tj. pretpostavka je tačna.

$\boxed{V_{GS} = V_{DS} = 6{,}42\text{V}}$

90. Parametri tranzistora u kolu sa slike su: $V_{TN} = V_T = 1\text{V}$ i $B = \dfrac{\mu_n C_{ox} W}{L} = 1\text{mA/V}^2$, dok je $V_{DD} = 10\text{V}$, $R_{G1} = R_{G2} = 10\text{M}\Omega$ i $R_D = R_S = 6\text{k}\Omega$. Izračunati struju I_D, kao i napone V_G, V_D i V_S.



Rešenje:



Pretpostavka M_1 u zasićenju:

$$\left.\begin{aligned} I_D &= \frac{B}{2}(V_{GS} - V_T)^2 \\ V_{GS} &= V_G - V_S = \frac{R_{G2}}{R_{G1} + R_{G2}} V_{DD} - R_S I_D = \frac{V_{DD}}{2} - R_S I_D \end{aligned}\right\} \Rightarrow$$

$$I_D = \frac{B}{2}\left(\frac{V_{DD}}{2} - R_S I_D - V_T\right)^2 \;\Rightarrow\; I_D = 0{,}0005 \cdot (4 - 6000 I_D)^2$$

$18000I_D^2 - 25I_D + 0{,}008 = 0$

$I_D' = 0{,}889\text{mA} \quad \Rightarrow \quad V_{GS}' = \dfrac{V_{DD}}{2} - R_S I_D' = -0{,}334\text{V} < V_T \quad \Rightarrow$ odbacuje se jer je M_1 po postavljenoj pretpostavci u zasićenju

$I_D'' = 0{,}5\text{mA} \quad \Rightarrow \quad V_{GS}'' = \dfrac{V_{DD}}{2} - R_S I_D'' = 2\text{V} > V_T \quad \Rightarrow$ prihvata se jer je u skladu sa postavljenom pretpostavkom da je M_1 u zasićenju

Dakle: $I_D = 0{,}5\text{mA}$, $V_{GS} = 2\text{V} > V_T$, $V_{GD} = V_G - V_D = \dfrac{R_{G2}}{R_{G1} + R_{G2}} V_{DD} - \left(V_{DD} - R_D I_D\right) = -2\text{V} < V_T$, što znači da je M_1 zaista u zasićenju, tj. pretpostavka je tačna.

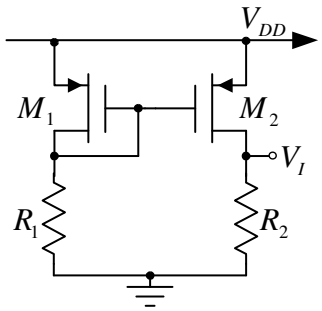
$\boxed{I_D = 0{,}5\text{mA}}$

$V_G = \dfrac{R_{G2}}{R_{G1} + R_{G2}} V_{DD} = \dfrac{V_{DD}}{2} \quad \Rightarrow \quad \boxed{V_G = 5\text{V}}$

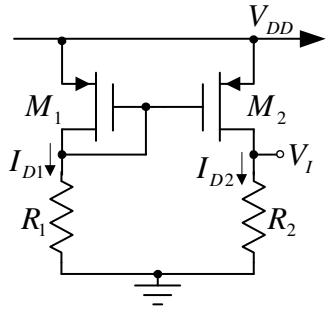
$V_D = V_{DD} - R_D I_D \quad \Rightarrow \quad \boxed{V_D = 7\text{V}}$

$V_S = R_S I_D \quad \Rightarrow \quad \boxed{V_S = 3\text{V}}$

91. Parametri tranzistora u kolu sa slike su: $V_{TP} = -V_T = -1\text{V}$, $B_1 = \dfrac{\mu_p C_{ox} W_1}{L_1} = 2\text{mA/V}^2$ i $B_2 = \dfrac{\mu_p C_{ox} W_2}{L_2} = 4\text{mA/V}^2$, dok je $V_{DD} = 12\text{V}$, $R_1 = 10\text{k}\Omega$ i $R_2 = 4\text{k}\Omega$. Izračunati struju drejna tranzistora M_1, kao i napon V_I.



Rešenje:



Pretpostavka M_1 i M_2 u zasićenju:

$$\left.\begin{aligned} I_{D1} &= \frac{B_1}{2}\left(V_{SG1}-\left|V_{TP}\right|\right)^2 \\ V_{DD}-V_{SG1}-R_1 I_{D1} &= 0 \end{aligned}\right\} \Rightarrow \quad V_{DD}-V_{SG1}-R_1\frac{B_1}{2}\left(V_{SG1}-\left|V_{TP}\right|\right)^2=0$$

$$12-V_{SG1}-10\left(V_{SG1}-1\right)^2=0$$

$$10V_{SG1}^2-19V_{SG1}-2=0$$

$V'_{SG1}=-0{,}1\text{V}<\left|V_{TP}\right| \quad \Rightarrow$ odbacuje se jer je M_1 po postavljenoj pretpostavci u zasićenju

$V''_{SG1}=2\text{V}>\left|V_{TP}\right| \quad \Rightarrow$ prihvata se jer je u skladu sa postavljenom pretpostavkom da je M_1 u zasićenju

$$V_{DD}-V_{SG1}-R_1 I_{D1}=0 \quad \Rightarrow \quad I_{D1}=\frac{V_{DD}-V_{SG1}}{R_1}=1\text{mA}$$

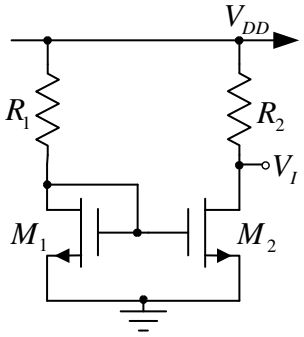
$$\left.\begin{aligned} I_{D1} &= \frac{B_1}{2}\left(V_{SG1}-\left|V_{TP}\right|\right)^2 \\ I_{D2} &= \frac{B_2}{2}\left(V_{SG2}-\left|V_{TP}\right|\right)^2 \\ V_{SG1} &= V_{SG2} \end{aligned}\right\} \Rightarrow \quad \frac{I_{D1}}{I_{D2}}=\frac{B_1}{B_2}=\frac{1}{2} \quad \Rightarrow \quad I_{D2}=2I_{D1}=2\text{mA}$$

Dakle: $V_{SG1}=2\text{V}>\left|V_{TP}\right|$, $V_{DG1}=0<\left|V_{TP}\right|$, što znači da je M_1 zaista u zasićenju; $V_{SG2}=V_{SG1}=2\text{V}>\left|V_{TP}\right|$, $V_{DG2}=V_{D2}-V_{G2}=R_2 I_{D2}-\left(V_{DD}-V_{SG2}\right)=-2\text{V}<\left|V_{TP}\right|$, što znači da je M_2 zaista u zasićenju.

$\boxed{I_{D1}=1\text{mA}}$

$V_I=R_2 I_{D2} \quad \Rightarrow \quad \boxed{V_I=8\text{V}}$

92. (Zadatak za vežbu) Parametri tranzistora u kolu sa slike su:
$V_{TN} = V_T = 1\text{V}$, $B_1 = \dfrac{\mu_n C_{ox} W_1}{L_1} = 2\text{mA/V}^2$ i $B_2 = \dfrac{\mu_n C_{ox} W_2}{L_2} = 4\text{mA/V}^2$,
dok je $V_{DD} = 12\text{V}$, $R_1 = 10\text{k}\Omega$ i $R_2 = 4\text{k}\Omega$. Izračunati struju drejna tranzistora M_1, kao i napon V_I.



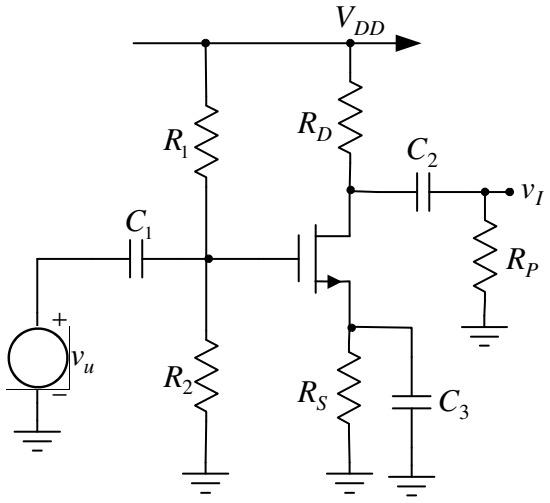
Rešenje:

$\boxed{I_{D1} = 1\text{mA}}$ $\boxed{V_I = 4\text{V}}$

93. Za pojačavač sa slike je poznato: $V_{DD} = 12\text{V}$, $V_{TN} = V_T = 1\text{V}$, $B = \dfrac{\mu_n C_{ox} W}{L} = 0{,}5\text{mA/V}^2$, $C_1 \to \infty$, $C_2 \to \infty$, $C_3 \to \infty$, $R_1 = 20\,\text{k}\Omega$, $R_2 = 10\,\text{k}\Omega$, $R_D = 4\,\text{k}\Omega$, $R_S = 1\,\text{k}\Omega$ i $R_P = 4\,\text{k}\Omega$.

a) Izračunati jednosmernu struju drejna (I_D) i jednosmerne napone tranzistora (V_G, V_S i V_D).

b) Izračunati naponsko pojačanje pojačavača $a_v = \dfrac{v_i}{v_u}$, ulaznu otpornost koju vidi generator naizmeničnog signala v_u i izlaznu otpornost koju vidi potrošač R_P.

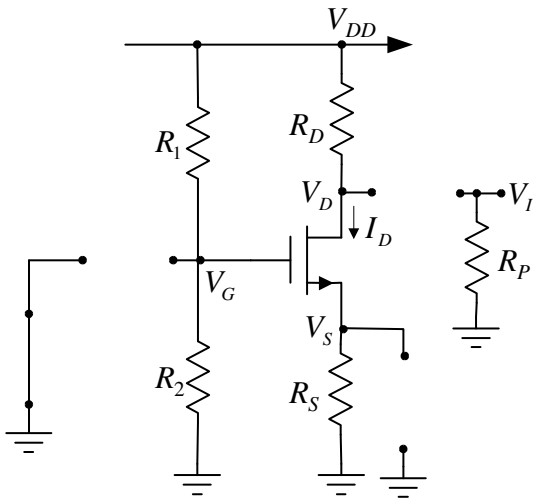


Rešenje:

a) DC analiza:

Formiranje šeme za DC analizu:

- ukidanje svih naizmeničnih generatora;
- zamena kondenzatora otvorenim vezama.



Tranzistor je u zasićenju (preduslov da bi pojačavač ispravno radio)!

$$\left.\begin{aligned} I_D &= \frac{B}{2}(V_{GS}-V_T)^2 \\ V_{GS} &= V_G - V_S = \frac{R_2}{R_1+R_2}V_{DD} - R_S I_D = \frac{V_{DD}}{3} - R_S I_D \end{aligned}\right\} \Rightarrow$$

$$I_D = \frac{B}{2}\left(\frac{V_{DD}}{3} - R_S I_D - V_T\right)^2 \quad \Rightarrow \quad I_D = 0{,}00025\cdot(3-1000 I_D)^2$$

$$10^6 \cdot I_D^2 - 10^4 \cdot I_D + 9 = 0$$

$I_D' = 9\text{mA} \quad \Rightarrow \quad V_{GS}' = \frac{V_{DD}}{3} - R_S I_D' = -5\text{V} < V_T \quad \Rightarrow$ odbacuje se jer M_1 mora biti u zasićenju

$I_D'' = 1\text{mA} \quad \Rightarrow \quad V_{GS}'' = \frac{V_{DD}}{3} - R_S I_D'' = 3\text{V} > V_T \quad \Rightarrow$ prihvata se jer je u skladu sa činjenicom da M_1 mora biti u zasićenju

$\boxed{I_D = 1\text{mA}}$

$$V_G = \frac{R_2}{R_1 + R_2} V_{DD} = \frac{V_{DD}}{3} \quad \Rightarrow \quad \boxed{V_G = 4\text{V}}$$

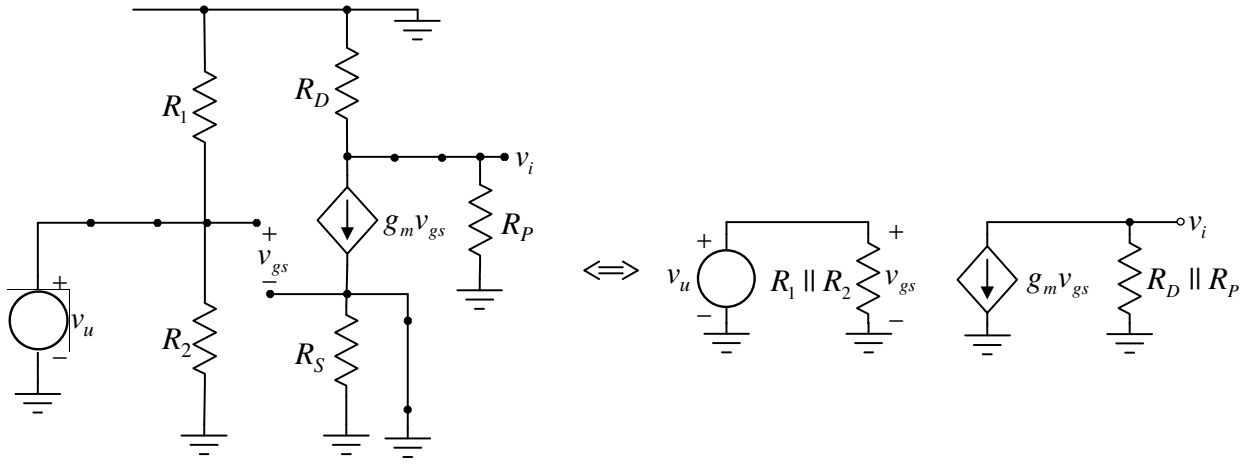
$$V_D = V_{DD} - R_D I_D \quad \Rightarrow \quad \boxed{V_D = 8\text{V}}$$

$$V_S = R_S I_D \quad \Rightarrow \quad \boxed{V_S = 1\text{V}}$$

b) AC analiza:

Formiranje šeme za AC analizu:

- ukidanje svih jednosmernih generatora;
- zamena kondenzatora $C \to \infty$ kratkim spojevima;
- zamena tranzistora modelom za mali signal.



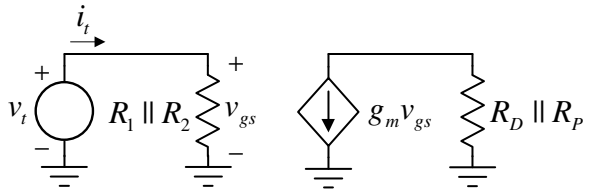
$$g_m = \sqrt{2BI_D} = 1\text{mS}$$

$$\left.\begin{aligned} v_i &= -g_m v_{gs} \left(R_D \parallel R_P\right) \\ v_{gs} &= v_u \end{aligned}\right\} \quad \Rightarrow \quad v_i = -g_m v_u \left(R_D \parallel R_P\right) \quad \Rightarrow \quad a_v = \frac{v_i}{v_u} = -g_m \left(R_D \parallel R_P\right) \quad \Rightarrow$$

$$\boxed{a_v = -2}$$

Šema za računanje ulazne otpornosti:

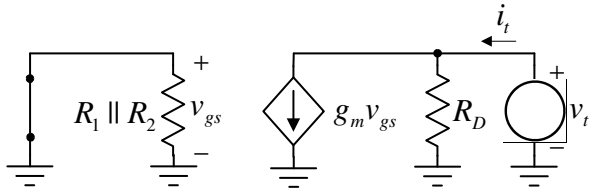
- povezivanje naponskog test generatora v_t između ulazne tačke i mase i označavanje struje i_t;
- ukidanje svih nezavisnih generatora u ostatku kola;
- $R_{ul} = \frac{v_t}{i_t}$;



$$v_t = (R_1 \parallel R_2) i_t \quad \Rightarrow \quad R_{ul} = \frac{v_t}{i_t} = R_1 \parallel R_2 \quad \Rightarrow \quad \boxed{R_{ul} = 6{,}67\text{k}\Omega}$$

Šema za računanje izlazne otpornosti:

- povezivanje naponskog test generatora v_t između izlazne tačke i mase i označavanje struje i_t;
- ukidanje svih nezavisnih generatora u ostatku kola;
- $R_{izl} = \frac{v_t}{i_t}$;

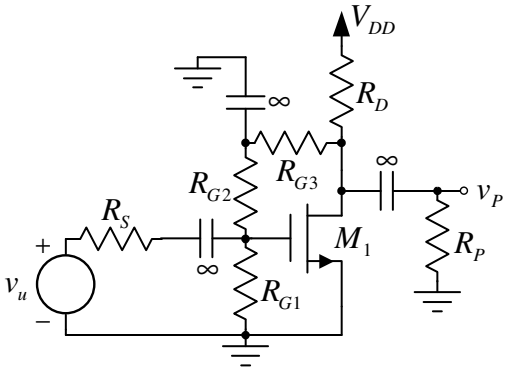


$$v_{gs} = 0 \quad \Rightarrow \quad g_m v_{gs} = 0 \quad \Rightarrow \quad v_t = R_D i_t \quad \Rightarrow \quad R_{izl} = \frac{v_t}{i_t} = R_D \quad \Rightarrow \quad \boxed{R_{izl} = 4\text{k}\Omega}$$

94. Za pojačavač sa slike je poznato: $V_{DD}=10\text{V}$, $V_{TN}=V_T=1\text{V}$, $B=\dfrac{\mu_n C_{ox} W}{L}=0{,}5\text{mA/V}^2$, $R_{G1}=2\text{M}\Omega$, $R_{G2}=2\text{M}\Omega$, $R_{G3}=1\text{M}\Omega$, $R_D=20\text{k}\Omega$, $R_S=10\text{k}\Omega$ i $R_P=100\text{k}\Omega$.

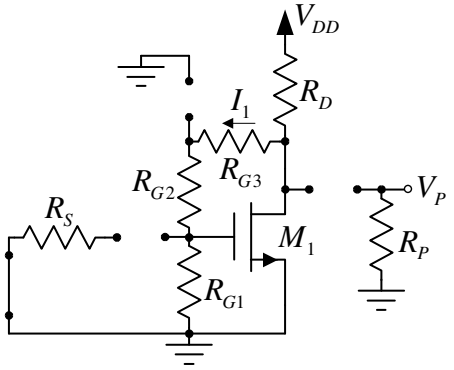
a) Izračunati jednosmernu struju drejna I_D i jednosmerne napone V_{GS} i V_{DS}.

b) Izračunati naponsko pojačanje pojačavača $a_v=\dfrac{v_p}{v_u}$, ulaznu otpornost koju vidi generator naizmeničnog signala v_u i izlaznu otpornost koju vidi potrošač R_P.



Rešenje:

a) DC analiza:



Tranzistor je u zasićenju (preduslov da bi pojačavač ispravno radio).

$$\left.\begin{aligned} V_{DS} &= V_{DD}-R_D\left(I_D+I_1\right)\\ I_1 &= \frac{V_{DS}}{R_{G3}+R_{G2}+R_{G1}}=\frac{V_{DS}}{5\cdot 10^6}\\ I_D &= \frac{B}{2}\left(V_{GS}-V_T\right)^2\\ V_{GS} &= \frac{R_{G1}}{R_{G3}+R_{G2}+R_{G1}}\cdot V_{DS}=0{,}4V_{DS}\end{aligned}\right\} \Rightarrow \quad V_{DS}=10-2\cdot 10^4\cdot\left(2{,}5\cdot 10^{-4}\cdot\left(0{,}4V_{DS}-1\right)^2+\frac{V_{DS}}{5\cdot 10^6}\right)$$

$$0{,}8V_{DS}^2 - 2{,}996V_{DS} - 5 = 0$$

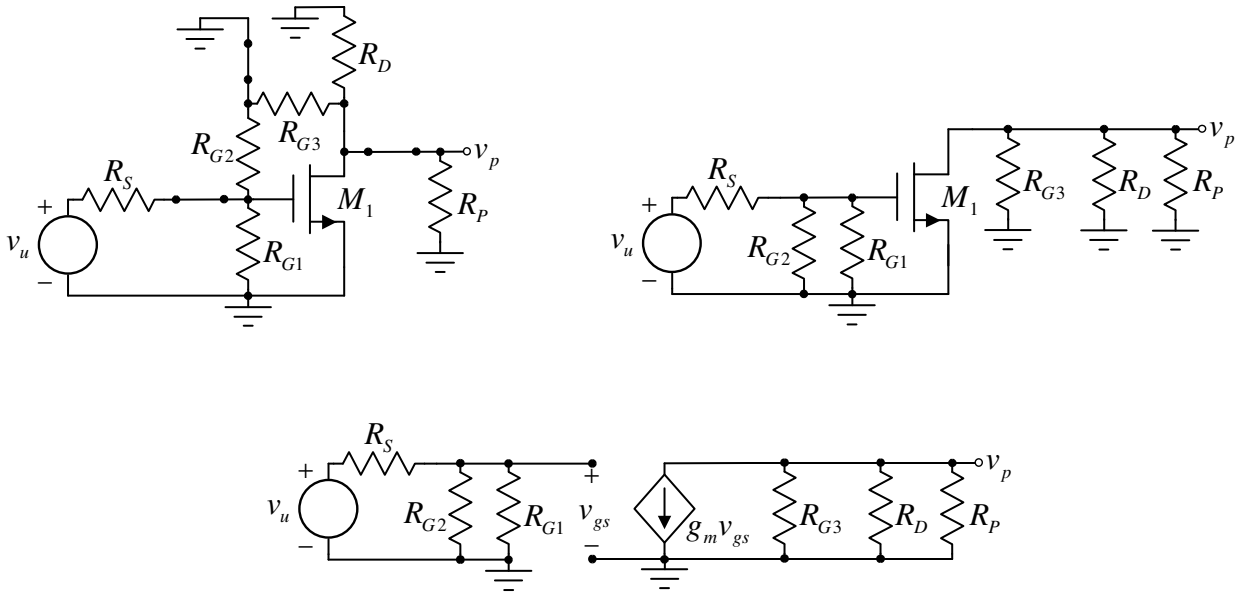
$V'_{DS} \approx 5\text{V} \quad \Rightarrow \quad V'_{GS} = 0{,}4V'_{DS} \approx 2\text{V} > V_T \quad \Rightarrow$ prihvata se jer je u skladu sa činjenicom da M_1 mora biti u zasićenju

$V''_{DS} \approx -1{,}25\text{V} \quad \Rightarrow \quad V''_{GS} = 0{,}4V''_{DS} \approx -0{,}5\text{V} < V_T \quad \Rightarrow$ odbacuje se jer M_1 mora biti u zasićenju

$\boxed{V_{DS} \approx 5\text{V}}$ $\qquad$ $\boxed{V_{GS} \approx 2\text{V}}$

$$I_D = \frac{B}{2}(V_{GS} - V_T)^2 \quad \Rightarrow \quad \boxed{I_D \approx 250\mu\text{A}}$$

b) AC analiza:

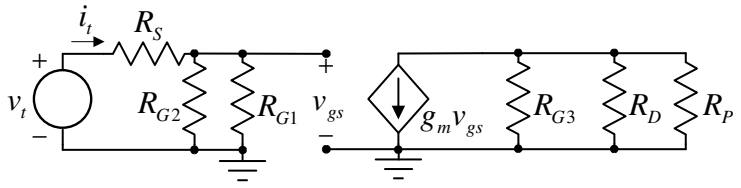


$$g_m = \sqrt{2BI_D} = 0{,}5\text{mS}$$

$$\left.\begin{aligned} v_p &= -g_m v_{gs}(R_D \parallel R_P \parallel R_{G3}) \\ v_{gs} &= \frac{R_{G1} \parallel R_{G2}}{R_S + R_{G1} \parallel R_{G2}} v_u \end{aligned}\right\} \quad \Rightarrow \quad v_p = -g_m \frac{R_{G1} \parallel R_{G2}}{R_S + R_{G1} \parallel R_{G2}}(R_D \parallel R_P \parallel R_{G3}) v_u \quad \Rightarrow$$

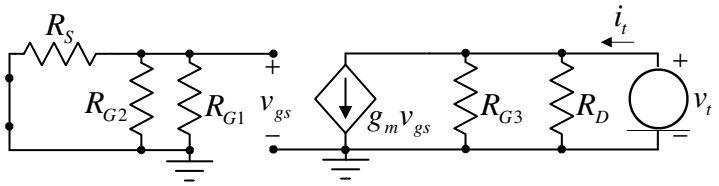
$$a_v = \frac{v_p}{v_u} = -g_m \frac{R_{G1} \parallel R_{G2}}{R_S + R_{G1} \parallel R_{G2}}(R_D \parallel R_P \parallel R_{G3}) \quad \Rightarrow \quad \boxed{a_v = -8{,}116}$$

Šema za računanje ulazne otpornosti:



$$v_t = (R_S + R_{G1} \parallel R_{G2}) i_t \quad \Rightarrow \quad R_{ul} = \frac{v_t}{i_t} = R_S + R_{G1} \parallel R_{G2} \quad \Rightarrow \quad \boxed{R_{ul} = 1{,}01\,\mathrm{M\Omega}}$$

Šema za računanje otpornosti koju vidi potrošač:



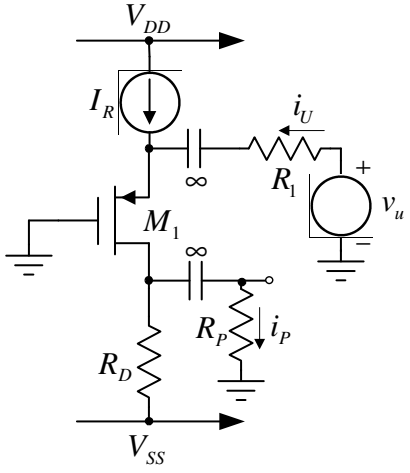
$$v_{gs} = 0 \quad \Rightarrow \quad g_m v_{gs} = 0 \quad \Rightarrow \quad v_t = (R_D \parallel R_{G3}) i_t \quad \Rightarrow \quad R_{izl} = \frac{v_t}{i_t} = R_D \parallel R_{G3} \quad \Rightarrow \quad \boxed{R_{izl} = 19{,}61\,\mathrm{k\Omega}}$$

95. U pojačavaču sa slike parametri tranzistora su: $V_{TP} = -V_T = -1\,\mathrm{V}$ i $B = 1\,\mathrm{mA/V^2}$, dok je $V_{DD} = -V_{SS} = 10\,\mathrm{V}$, $R_1 = 250\,\Omega$, $R_D = 2\,\mathrm{k\Omega}$, $R_P = 6\,\mathrm{k\Omega}$ i $I_R = 2\,\mathrm{mA}$.

a) Odrediti jednosmerne vrednosti napona na drejnu i sorsu, kao i jednosmernu struju drejna tranzistora.

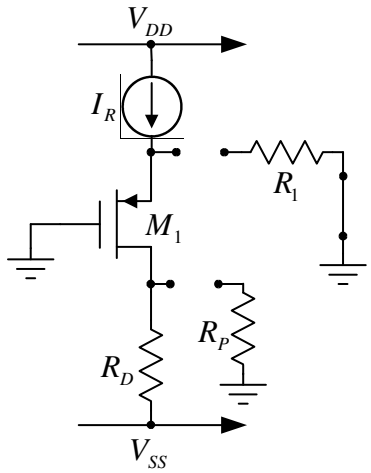
b) Odrediti strujno pojačanje pojačavača $a_i = i_p / i_u$.

c) Odrediti otpornosti koje vide ulazni generator i potrošač.



Rešenje:

a) DC analiza:



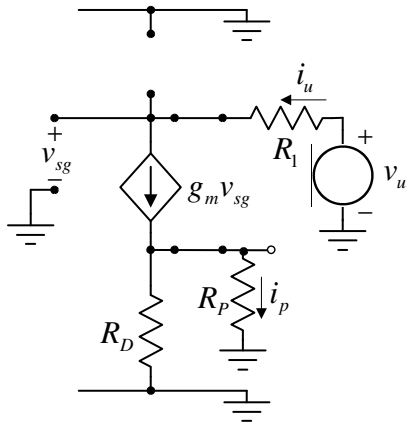
$$I_D = I_R \quad \Rightarrow \quad \boxed{I_D = 2\text{mA}}$$

$$V_D = V_{SS} + R_D I_D \quad \Rightarrow \quad \boxed{V_D = -6\text{V}}$$

$$V_{SG} = \sqrt{\frac{2I_D}{B}} + |V_{TP}| \quad \Rightarrow \quad V_{SG} = 3\text{V}$$

$$V_S = V_G + V_{SG} = 0 + V_{SG} \quad \Rightarrow \quad \boxed{V_S = 3\text{V}}$$

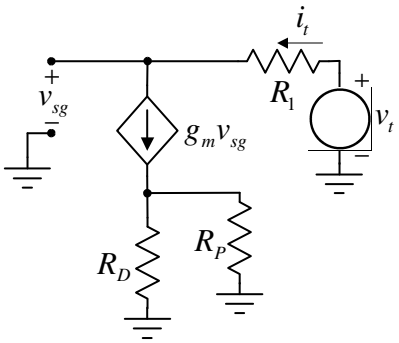
b) AC analiza:



$$g_m = \sqrt{2BI_D} = 2\text{mS}$$

$$i_p = \frac{R_D}{R_D + R_P} i_u \quad \Rightarrow \quad a_i = \frac{i_p}{i_u} = \frac{R_D}{R_D + R_P} \quad \Rightarrow \quad \boxed{a_i = 0{,}25}$$

c) Šema za računanje ulazne otpornosti:

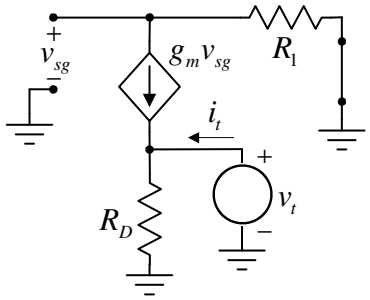


$$i_t = \frac{v_t - v_{sg}}{R_1} \quad \Rightarrow \quad v_{sg} = v_t - R_1 i_t$$

$$i_t = g_m v_{sg} = g_m (v_t - R_1 i_t) \quad \Rightarrow \quad v_t = \left(\frac{1}{g_m} + R_1 \right) i_t$$

$$R_{ul} = \frac{v_t}{i_t} = \frac{1}{g_m} + R_1 \quad \Rightarrow \quad \boxed{R_{ul} = 750\Omega}$$

Šema za računanje otpornosti koju vidi potrošač:



$$\frac{v_{sg}}{R_1} = -g_m v_{sg} \quad \Rightarrow \quad v_{sg}\left(\frac{1}{R_1} + g_m\right) = 0 \quad \Rightarrow \quad v_{sg} = 0$$

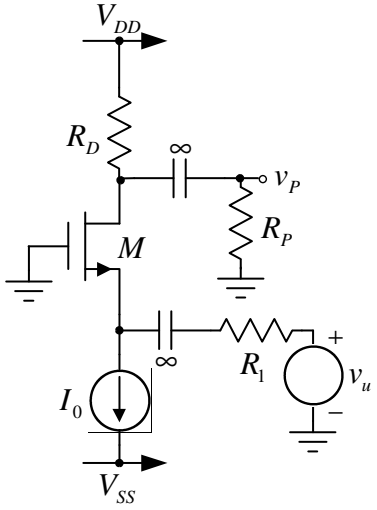
$$v_{sg} = 0 \quad \Rightarrow \quad g_m v_{sg} = 0 \quad \Rightarrow \quad v_t = R_D i_t \quad \Rightarrow \quad R_{izl} = \frac{v_t}{i_t} = R_D \quad \Rightarrow \quad \boxed{R_{izl} = 2\text{k}\Omega}$$

96. (Zadatak za vežbu) U pojačavaču sa slike parametri tranzistora su: $B = 1\,\text{mA/V}^2$ i $V_T = 1\,\text{V}$, dok je: $V_{DD} = -V_{SS} = 10\,\text{V}$, $R_1 = 250\Omega$, $R_D = 10\,\text{k}\Omega$, $R_P = 30\,\text{k}\Omega$ i $I_0 = 500\,\mu\text{A}$.

a) Odrediti jednosmerne vrednosti napona na sorsu i drejnu, kao i jednosmernu struju drejna.

b) Odrediti naponsko pojačanje pojačavača $a = v_p / v_u$.

c) Odrediti ulaznu otpornost i otpornost koju vidi potrošač R_P.



Rešenje:

a) $\boxed{I_D = 500\mu\text{A}}$ $\boxed{V_D = 5\text{V}}$ $\boxed{V_S = -2\text{V}}$

b) $a_v = \dfrac{v_p}{v_u} = \dfrac{g_m\left(R_D \parallel R_P\right)}{1 + g_m R_1} \Rightarrow \boxed{a_v = 6}$

c) $R_{ul} = R_1 + \dfrac{1}{g_m} \Rightarrow \boxed{R_{ul} = 1{,}25\text{k}\Omega}$

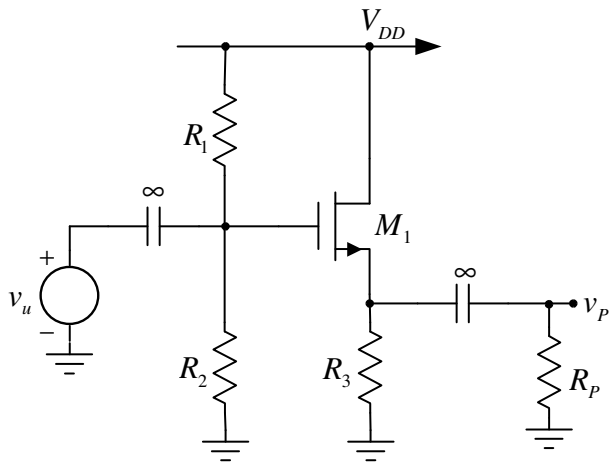
$R_{izl} = R_D \Rightarrow \boxed{R_{izl} = 10\text{k}\Omega}$

97. (Zadatak za vežbu) U pojačavaču sa slike, parametri tranzistora su: $V_T = 1\,\text{V}$, $B = \dfrac{\mu_n C_{ox} W}{L} = 1\dfrac{mA}{V^2}$, dok je: $V_{DD} = 5\,\text{V}$, $R_1 = 128\,\text{k}\Omega$, $R_3 = 10\,\text{k}\Omega$ i $R_P = 20\,\text{k}\Omega$. Odrediti:

a) Otpornost R_2 tako da jednosmerni napon na sorsu bude $V_S = \dfrac{V_{DD}}{2}$;

b) Naponsko pojačanje pojačavača $a_v = \dfrac{v_p}{v_u}$;

c) Ulaznu otpornost i otpornost koju vidi potrošač.



Rešenje:

a) $\boxed{R_2 = 680\text{k}\Omega}$

b) $a_v = \dfrac{v_p}{v_u} = \dfrac{g_m(R_3 \parallel R_P)}{1 + g_m(R_3 \parallel R_P)} \quad \Rightarrow \quad \boxed{a_v = 0{,}825}$

c) $R_{ul} = R_1 \parallel R_2 \quad \Rightarrow \quad \boxed{R_{ul} = 107{,}7\text{k}\Omega}$

$R_{izl} = R_3 \parallel \dfrac{1}{g_m} \quad \Rightarrow \quad \boxed{R_{izl} = 1{,}24\text{k}\Omega}$

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OSNOVI DIGITALNE ELEKTRONIKE (13S042ODE)

- Izborni predmet u na drugoj godini (u četvrtom semestru) Odseka za softversko inženjerstvo (6 kredita)
- Predavanja (2 časa nedeljno): dr Milan Ponjavić
- Računske vežbe (2 časa nedeljno): mr Goran Savić
- Detaljnije informacije i prezentacija predmeta na sajtu: http://tnt.etf.rs/~si2ode

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