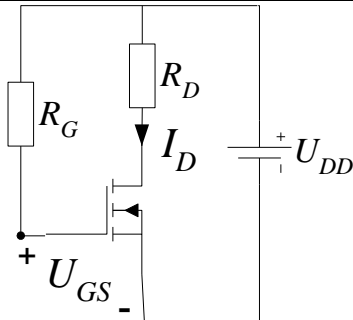


Komunikacijska elektronika

Delovna točka in napajalna vezja MOS tranzistorjev

1.

Za ojačevalnik z n kanalnim MOS tranzistorjem z induciranim kanalom izračunajte U_{GS} in R_D tako, da bo $I_D = 2\text{mA}$. Pragovna napetost $U_T = 3\text{V}$, $U_{DD} = 20\text{V}$.



$$U_{GS} = U_T \pm \sqrt{\frac{I_D}{k}} = 7,47\text{V}$$

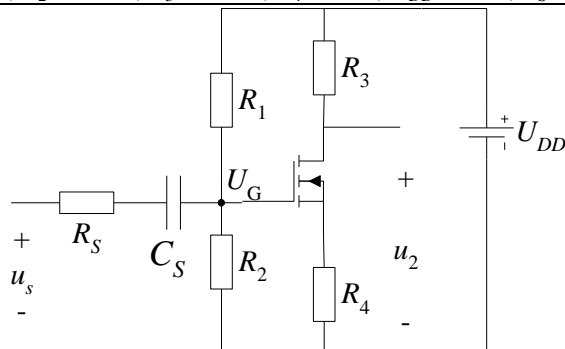
$$k = 0,1\text{mA/V}^2$$

$$U_{DS} \geq U_{GS} - U_T = 4,47\text{V}$$

$$R_{D\text{max}} = \frac{U_{DD} - U_{DS}}{I_D} = 7,76\text{k}\Omega$$

2.

Za vezje izračunajte delovno točko. Preverite ali je tranzistor v nasičenju. $U_T = 1\text{V}$, $\mu_n C_{OX} = 20 \mu\text{A/V}^2$, $W = 10 \mu\text{m}$, $L = 1 \mu\text{m}$. $R_1 = 30\text{k}\Omega$, $R_2 = 20\text{k}\Omega$, $R_3 = 10\text{k}\Omega$, $R_4 = 2\text{k}\Omega$, $U_{DD} = 10\text{V}$, $R_S = 4\text{k}\Omega$, $C_S = 1\mu\text{F}$.



$$U_G = U_{DD} \frac{R_2}{R_1 + R_2} = 4\text{V}$$

$$U_{GS} = U_G - I_D R_4; \quad I_D = k(U_{GS} - U_T)^2$$

rešimo kvadratno enačbo za U_{GS} :

$$0,2U_{GS}^2 + 0,6U_{GS} - 3,8 = 0$$

$$U_{GS} = 3,1V; \quad I_D = 0,44mA$$

$$U_{DS} = U_{DD} - I_D(R_3 + R_4) = 4,7V$$

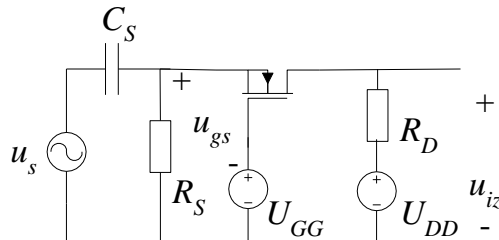
v področju nasičenja?: DA

$$U_{DS} \lessdot U_{GS} - U_T$$

$$4,7V > 3,1V - 1V$$

3.

Določite R_S in R_D tako, da bo delovna točka vezja na sliki $I_D = 5mA$, $U_{DS} = 10V$. Tranzistor deluje v področju nasičenja. $U_{DD} = 20V$, $U_{GG} = 10V$, $U_T = -2V$, $k = 0,5mA/V^2$.



$$U_{GS} = \sqrt{\frac{I_D}{k}} + U_T = 1,16V$$

$$U_{GS} = U_{GG} - I_D R_S$$

$$R_S = \frac{U_{GS} - U_{GG}}{I_D} = 1,77k\Omega$$

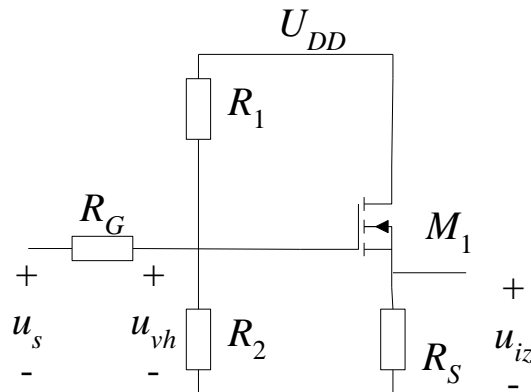
$$U_{DS} = U_{DD} - I_D R_D - I_D R_S$$

$$R_D = \frac{U_{DS} - U_{DD} - I_D R_S}{I_D} = 232\Omega$$

Malosignalna analiza vezij z MOS tranzistorjem

4.

Za vezje z MOS tranzistorjem z induciranim n kanalom določite Z_{uh} , Z_{iz} , in A_u . $R_1 = 750\text{k}\Omega$, $R_2 = 150\text{k}\Omega$, $R_S = 2,5\text{k}\Omega$, $R_G = 100\Omega$, $g_m = 4\text{mS}$.



$$Z_{vh}: Z_{vh} = \frac{u_{vh}}{i_{vh}} = R_{12} = 125\text{k}\Omega$$

$$i_{iz} = \frac{u_{iz}}{R_S} - g_m u_{gs} = \frac{u_{iz}}{R_S} - g_m u_{iz} \quad ; u_s = 0$$

$$Z_{iz}: Z_{iz} = \frac{u_{iz}}{i_{iz}} = \frac{R_S}{1 + g_m R_S} = 227\Omega$$

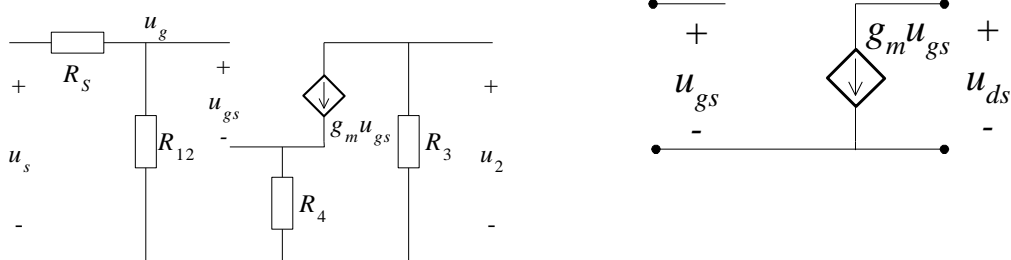
$$u_{iz} = g_m u_{gs} R_S$$

$$A_u: u_{gs} = u_{vh} - u_{iz}$$

$$A_u = \frac{u_{iz}}{u_{vh}} = \frac{g_m R_S}{1 + g_m R_S} = 0,909$$

5.

Za vezje iz naloge 2 izračunajte g_m , narišite nadomestno vezje za majhne signale ter izračunajte napetostno ojačanje.



$$g_m = 2k(U_{GS} - U_T) = 0,42\text{mA/V}$$

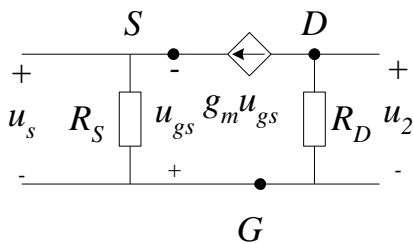
$$u_2 = -g_m u_{gs} R_3$$

$$u_{gs} = u_g - g_m u_{gs} R_4; \quad u_g = \frac{R_1 \parallel R_2}{R_1 \parallel R_2 + R_S}$$

$$A_u = \frac{-g_m R_3}{(1 + g_m R_4) R_1 \parallel R_2 + R_S} = -1,72$$

6.

Za vezje 3 narišite nadomestno vezavo za majhne signale ter izračunajte napetostno ojačanje A_u .



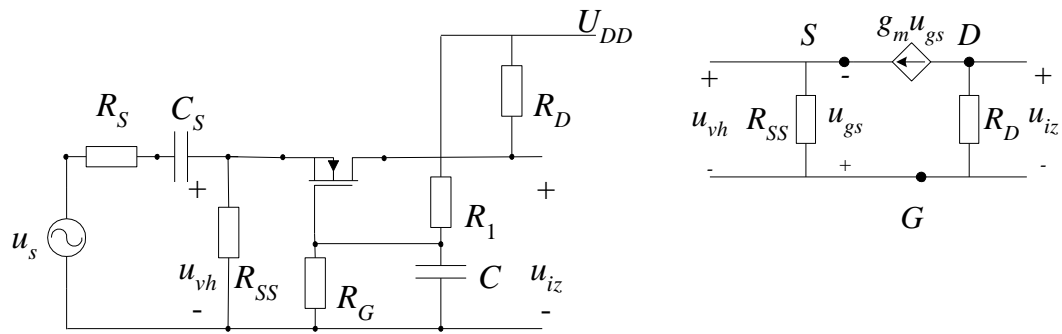
$$u_2 = -g_m u_{gs} R_D = g_m u_s R_D$$

$$g_m = 2k(U_{GS} - U_T) = 3,16\text{mS}$$

$$A_u = \frac{u_2}{u_s} = g_m R_D = 0,733$$

7.

Za vezje z MOS tranzistorjem z induciranim n kanalom narišite nadomestno vezje za majhne signale ter določite Z_{vh} , Z_{iz} , in A_u . $R_1 = 750\text{k}\Omega$, $R_D = 4\text{k}\Omega$, $R_{SS} = 2,5\text{k}\Omega$, $R_G = 150\text{k}\Omega$, $R_S = 100\Omega$, $g_m = 4\text{mS}$.



$$i_{vh} + g_m u_{gs} = u_{vh} / R_{SS}$$

$$Z_{vh}: Z_{vh} = \frac{u_{vh}}{i_{vh}} = \frac{R_{SS}}{1 + g_m R_{SS}} = 0,227\Omega$$

$$Z_{iz}: Z_{iz} = R_D = 4\text{k}$$

$$u_{iz} = g_m u_{gs} R_S$$

$$A_u: u_{gs} = u_{vh} - u_{iz}$$

$$A_u = \frac{u_{iz}}{u_{vh}} = \frac{-g_m u_{gs} R_D}{u_{vh}} = g_m R_D = 16$$