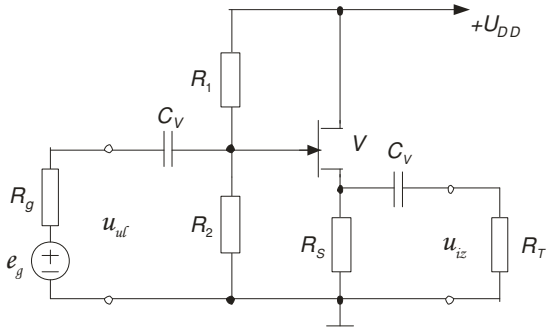
13.12.2006., Zagreb

7. domaća zadaća iz Analognih sklopova i Elektroničkih sklopova

1. Na pojačalo sa slike spojen je naponski izvor e_g = sinωt, V. Izračunajte izlazni napon pojačala u_{iz}. Poznato je: U_{DD} = 12 V, R_1 = 1 MΩ, R_2 = 390 kΩ, R_S = 1,5 kΩ, U_P = 5 V, I_{DSS} = 8 mA, μ = 90, R_g = 200 kΩ, R_T = 1 kΩ.



Rješenje:

$$U_{GG} = U_{GSQ} + R_S \cdot I_{DQ} \qquad (1) \qquad\qquad U_{GG} = \frac{R_2}{R_1 + R_2} \cdot U_{DD} = 3{,}367 \text{ V}$$

$$I_{DQ} = I_{DSS} \cdot \left(1 + \frac{U_{GSQ}}{U_P}\right)^2 \qquad (2) \qquad\qquad (1) \rightarrow (2)$$

$$I_{DQ} = \frac{U_{GG} - U_{GSQ}}{R_S} = \frac{I_{DSS} \cdot U_{GSQ}{}^2}{U_P{}^2} + \frac{2U_{GSQ} \cdot I_{DSS}}{U_P} + I_{DSS}$$

$$U_{GSQ}{}^2 + U_{GSQ} \cdot \left(2U_P + \frac{U_P{}^2}{R_S \cdot I_{DSS}}\right) + U_P{}^2 - \frac{U_{GG} \cdot U_P{}^2}{R_S \cdot I_{DSS}} = 0$$

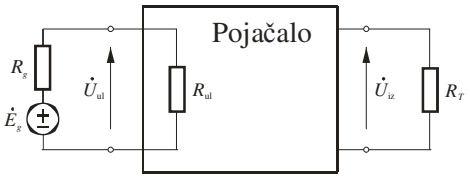
$$U_{GSQ}{}^2 + 12{,}08\dot{3}U_{GSQ} + 17{,}986 = 0 \qquad\qquad U_{GSQ1} = -1{,}739 \text{ V}, \quad U_{GSQ2} = -10{,}34 \text{ V}$$

$$U_{GSQ} = -1{,}739 \text{ V}$$

Drugo se rješenje $U_{GSQ2} = -10{,}34$ V odbacuje. To bi značilo da FET ne vodi. Uvrštenjem $I_{DQ} = 0$ u izraz (1) ne dobije se da je $U_{GSQ2} = -10{,}34$ V što je u suprotnosti s polaznom pretpostavkom.

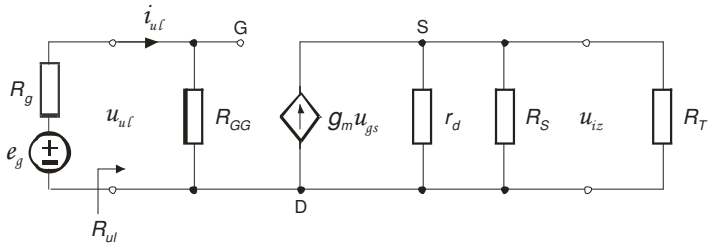
$$I_{DQ} = 3{,}404 \text{ mA} \qquad\qquad U_{DSQ} = U_{DD} - R_S \cdot I_{DQ} = 6{,}894 \text{ V}$$

$$g_m = \left.\frac{\partial I_D}{\partial U_{GS}}\right|_{U_{GS}=U_{GSQ}} = \frac{2I_{DSS}}{U_P} \cdot \left(1 + \frac{U_{GSQ}}{U_P}\right) = 2{,}087 \frac{\text{mA}}{\text{V}} \qquad\qquad r_d = \frac{\mu}{g_m} = 43{,}12 \text{ kΩ}$$



$$\dot{U}_{\text{iz}} = A_V \cdot \dot{U}_{\text{ul}}$$

$$\dot{U}_{\text{ul}} = \frac{R_{\text{ul}}}{R_{\text{ul}} + R_g} \cdot \dot{E}_g$$



$$R_{GG} = R_1 \| R_2 = 280{,}6\ \text{k}\Omega$$

$$R_{\text{ul}} = \frac{\dot{U}_{\text{ul}}}{\dot{I}_{\text{ul}}} = R_{GG} = 280{,}6\ \text{k}\Omega$$

$$A_V = \frac{\dot{U}_{\text{iz}}}{\dot{U}_{\text{ul}}} = \ldots = \frac{u_{\text{iz}}}{u_{\text{ul}}} = \frac{g_m \cdot u_{gs} \cdot r_d \| R_S \| R_T}{u_{gs} + g_m \cdot u_{gs} \cdot r_d \| R_S \| R_T} = \frac{g_m \cdot r_d \| R_S \| R_T}{1 + g_m \cdot r_d \| R_S \| R_T} = 0{,}5526$$

$$r_d \| R_S \| R_T = 591{,}8\ \Omega$$

$$\dot{U}_{\text{ul}} = \frac{R_{\text{ul}}}{R_{\text{ul}} + R_g} \cdot \dot{E}_g = 0{,}5838 \cdot \dot{E}_g$$

$$u_{\text{ul}} = 583{,}8 \sin \omega t,\ \text{mV}$$

$$\boxed{u_{\text{iz}} = 322{,}6 \sin \omega t,\ \text{mV}}.$$