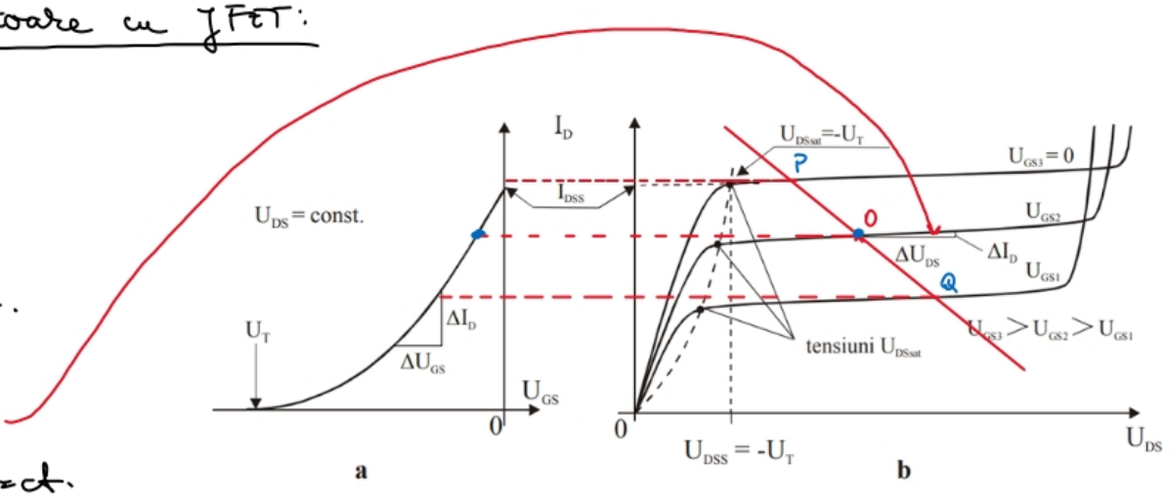
Seminar 5

Amplificatoare cu JFET:

Param. AC:

$$g_m = \left(\frac{\Delta I_D}{\Delta U_{GS}}\right)_{U_{DS}=ct.}$$

$$r_d = \left(\frac{\Delta U_{DS}}{\Delta I_D}\right)_{U_{GS}=ct.}$$

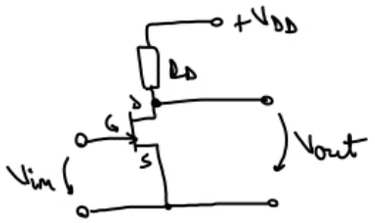


În datasheet: $|Y_{fs}| = g_m$

$$|Y_{os}| = \frac{1}{r_d}$$

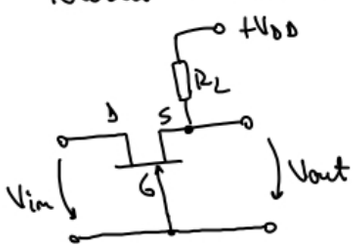
Conexiuni ale JFET:

1. Sursă comună:

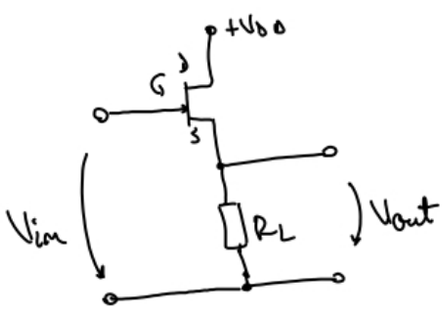


Își inversează faza: $\Delta\varphi = 180°$

2. Poartă comună:



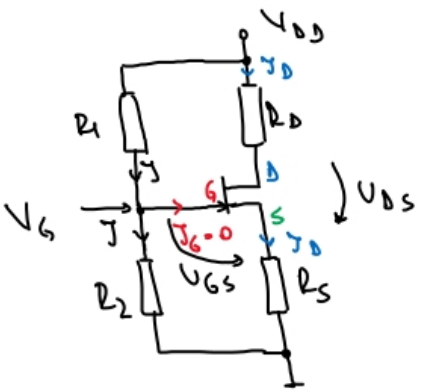
3. Drenă comună; „buffer"; „voltage follower"



$V_{out} = V_{in}$

Polarizarea JFET:

:) cu divizor de tensiune în poartă



Considerente practice

$R_1, R_2 \rightarrow M\Omega$

$R_D, R_S \rightarrow k\Omega$

$V_{DD} = I(R_1 + R_2)$

$V_{DD} = I_D R_D + I_D R_S + V_{DS}$

$I R_2 = V_{GS} + I_D R_S$

P1. Pentru circuitul de mai sus găsiți valorile rezistențelor astfel încât $I_D = 2\,mA$.

$V_G = 5V$

$V_{DD} = 20V$

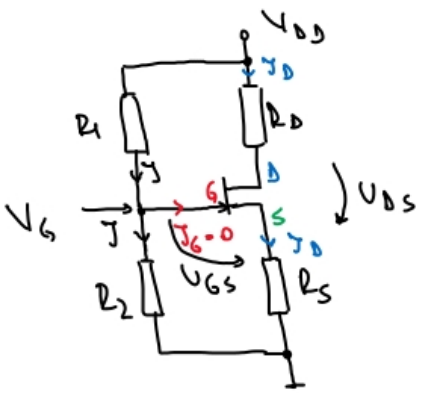
$I_{DSS} = 4mA$

$V_T = -2V$

$R_D = 2.2k\Omega$

$R_1, R_2, R_S = ?$

Determinați regiunul în care se află tranzistorul



$V_G = 5V$

$V_{DD} = 20V$

$V_{DD} = I(R_1 + R_2)$

$V_G = I R_2$

$$\frac{V_G}{V_{DD}} = \frac{I R_2}{I(R_1 + R_2)}$$

$V_G(R_1 + R_2) = V_{DD} R_2$

$V_G R_1 + V_G R_2 = V_{DD} R_2$

$V_G R_1 = (V_{DD} - V_G) R_2$

$$\frac{R_1}{R_2} = \frac{V_{DD} - V_G}{V_G} = \frac{20-5}{5} = \frac{15}{5} = 3$$

$R_1 = 3R_2$

Alegem $R_2 = 1M\Omega \Rightarrow R_1 = 3M\Omega$

$$I_D = I_{DSS}\left(1-\frac{V_{GS}}{V_T}\right)^2$$

$$2\,mA = 4\,mA\left(1-\frac{V_{GS}}{-2}\right)^2$$

$$\frac{1}{2} = \left(1+\frac{V_{GS}}{2}\right)^2$$

$$\frac{1}{\sqrt{2}} = 1+\frac{V_{GS}}{2} \Leftrightarrow \frac{1}{\sqrt{2}} = \frac{2+V_{GS}}{2}$$

$$\frac{2}{\sqrt{2}} = 2+V_{GS} \Rightarrow$$

$$\Rightarrow V_{GS} = \frac{2}{\sqrt{2}} - 2 = -0.5857$$

$$V_{GS} \cong -0.59V$$

$$V_G = V_{GS} + I_D R_S$$

$$5V = -0.59V + I_D R_S \Rightarrow I_D R_S = 5.59V$$

$$R_S = \frac{5.59V}{2\,mA} = 2.795\,k\Omega$$

$$R_S \cong 2.8\,k\Omega$$

$$\left.\begin{array}{l} V_{DSsat} = V_{GS} - V_T \\ V_{GS} = -0.58V \\ V_T = -2V \end{array}\right\} \Rightarrow V_{DSsat} = -0.58 - (-2) = 1.42V$$

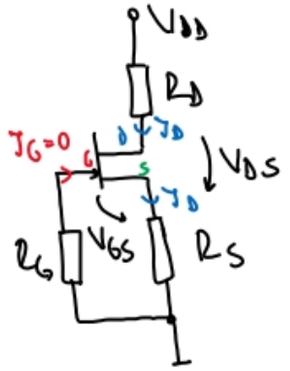
$$V_{DD} = I_D R_D + V_{DS} + I_D R_S \Rightarrow$$

$$\Rightarrow V_{DS} = V_{DD} - I_D(R_D+R_S) = 20V - 2\,mA \cdot 5\,k\Omega = 10V$$

$$\left.\begin{array}{l} V_{DS} = 10V \\ V_{DSsat} = 1.42V \end{array}\right\} \Rightarrow V_{DS} > V_{DSsat} \Rightarrow$$

$\Rightarrow$ tranzistorul este în zona activă (de saturație)

·) polarizarea JFET cu poarta conectată la masă:



$$V_{DD} = I_D(R_D + R_S) + V_{DS}$$

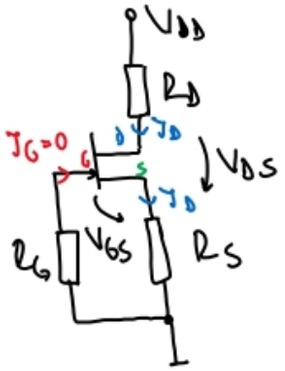
$$I_G \cancel{R_G}^{\,0} = V_{GS} + I_D R_S$$

$$V_{GS} = -I_D R_S$$

(P2) Pentru schema de mai sus determinați R_D astfel încât tranzistorul să lucreze în regim de saturație.

$R_G = 1\,M\Omega$
$R_S = 250\,\Omega$

$I_{DSS} = 9\,mA$
$V_T = -3V$
$V_{DD} = 16V$



$$V_{GS} = -I_D R_S = -250 \cdot I_D$$

$$I_D = I_{DSS}\left(1 - \frac{V_{GS}}{V_T}\right)^2$$

$$I_D = 9\times10^{-3}\left(1 - \frac{-250 I_D}{-3}\right)^2$$

$$I_D = 9\times10^{-3}\left(1 - 83.33 I_D\right)^2$$

$$I_D = 9\times10^{-3}\left(1 - 166.67 I_D + 6943.89 I_D^2\right)$$

$$I_D = 9\times10^{-3} - 1.503 I_D + 62.495 I_D^2$$

$$62.495 I_D^2 - 2.503 I_D + 9\times10^{-3} = 0$$

$$I_D^2 - 0.04 I_D + 0.144\times10^{-3} = 0$$

$$\Delta = 0.04 \times 0.04 - 4 \times 0.144\times10^{-3} = 10.24\times10^{-4}$$

$$I_D = \frac{0.04 \pm \sqrt{10.24\times10^{-4}}}{2} = 0.02 \pm \frac{1}{2}\sqrt{1024}\times10^{-2} =$$

$$= 0.02 \pm 0.016\,A = 20 \pm 16\,mA$$

·) Presupunem ~~$I_D = 36\,mA$~~ $(I_{DSS} = 9\,mA)$

$I_D \gg I_{DSS} \Rightarrow ???$

$V_{GS} = -9V << V_T \Rightarrow I_D = 0$ dar $I_D = 36\,mA \Rightarrow ???$

·) Presupunem $I_D = 4\,mA$

$V_{GS} = -250 \times 4 \times 10^{-3} = -1V$

$$I_D = I_{DSS}\left(1 - \frac{V_{GS}}{V_T}\right)^2 \Rightarrow \frac{I_D}{I_{DSS}} = \left(1 - \frac{V_{GS}}{V_T}\right)^2$$

$$\frac{4}{9} = \left(1 - \frac{V_{GS}}{V_T}\right)^2 \Rightarrow \frac{2}{3} = 1 - \frac{V_{GS}}{-3}$$

$$\frac{2}{3} = 1 + \frac{V_{GS}}{3}$$

$$\frac{V_{GS}}{3} = -\frac{1}{3} \Rightarrow V_{GS} = -1V$$

$V_{DSsat} = V_{GS} - V_T = -1 - (-3) = 2V$

Pentru ca JFET activ (saturație) $V_{DS} > V_{DSsat}$ sau $V_{DS} > 2V$

$$V_{DD} = I_D(R_D + R_S) + V_{DS}$$

$$V_{DS} = V_{DD} - I_D(R_D + R_S) > 2$$

$$V_{DD} - I_D R_D - I_D R_S > 2$$

$$-I_D R_D > 2 + I_D R_S - V_{DD}$$

$$R_D < -\frac{2}{I_D} - R_S + \frac{V_{DD}}{I_D}$$

$$R_D < -\frac{2}{4} \times 10^3 - 250 + \frac{16}{4} \times 10^3$$

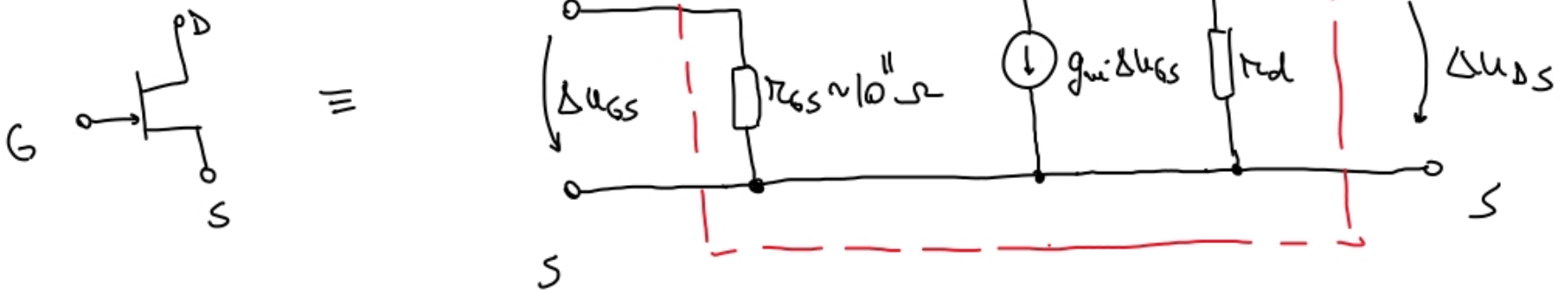
$$R_D < -500 - 250 + 1000$$

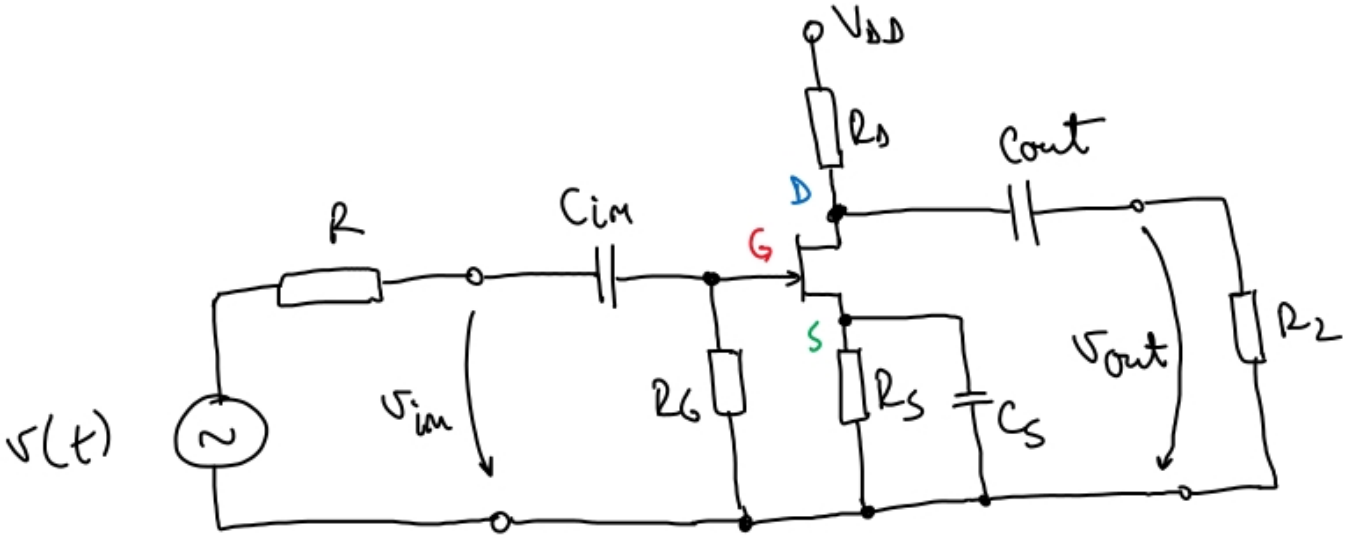
$$R_D < 3250\,\Omega$$

Pt. ca JFET să fie activ $\Rightarrow R_D < 3.25\,k\Omega$

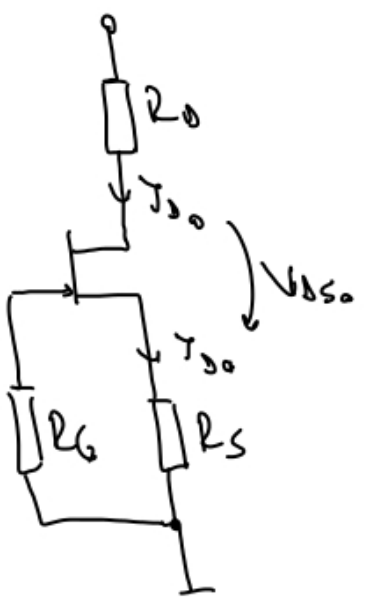
Amplificatorul cu JFET conexiune sursă comună

Schema de semnal mic (AC) a JFET





) Schema echivalentă DC ⇒ PSF

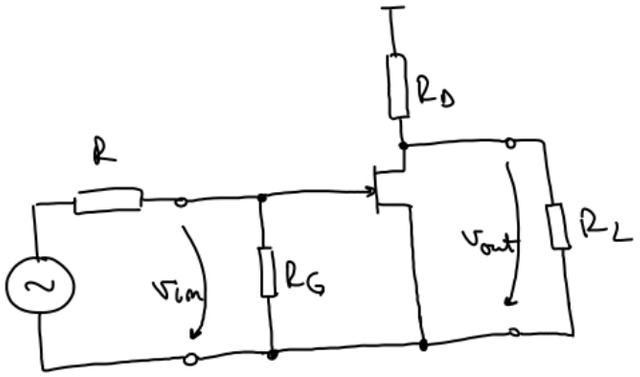


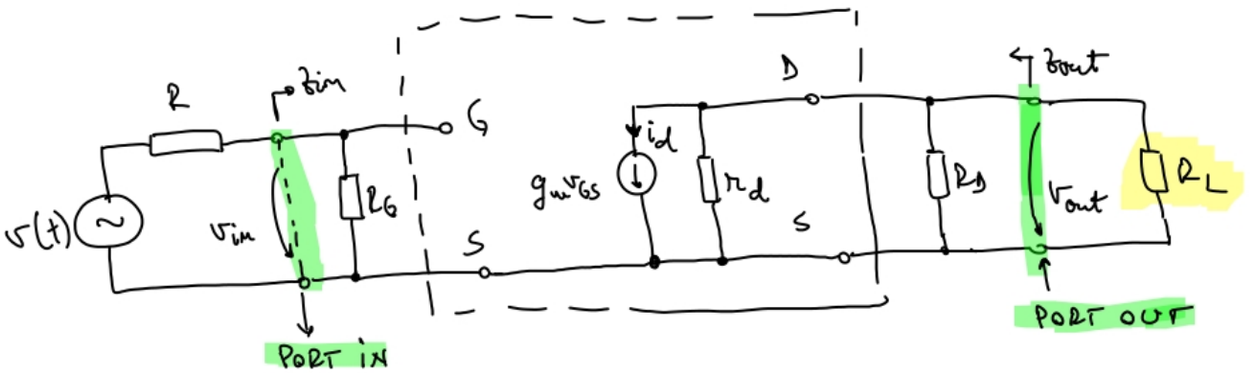
se cunosc

IDSS

VT

•) Schema echivalentă AC





$$z_{in} = R_G = \frac{v_{in}}{i_{in}}$$

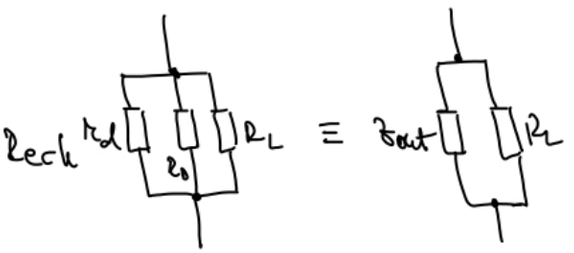
$$z_{out} = r_d \| R_D$$

$$z_{out} = \frac{1}{\frac{1}{r_d} + \frac{1}{R_D}} = \frac{r_d R_D}{r_d + R_D}$$

câștigul în tensiune:

$$A_v = \frac{v_{out}}{v_{in}} = \frac{-g_m v_{GS} \cdot R_{ech}}{v_{GS}}$$

$$A_v = -g_m R_{ech}$$



Câștigul efectiv în tensiune

$$A_{vs} = \frac{v_{out}}{v}$$

$$v_{in} = \frac{R_G}{R+R_G} \cdot v \Rightarrow v = \frac{v_{in}}{\frac{R_G}{R+R_G}}$$

$$A_{vs} = \frac{v_{out}}{\frac{v_{in}}{\frac{R_G}{R+R_G}}} = \frac{v_{out}}{v_{in}} \cdot \frac{R_G}{R+R_G} = -g_m \cdot R_{ech} \cdot \frac{R_G}{R+R_G}$$