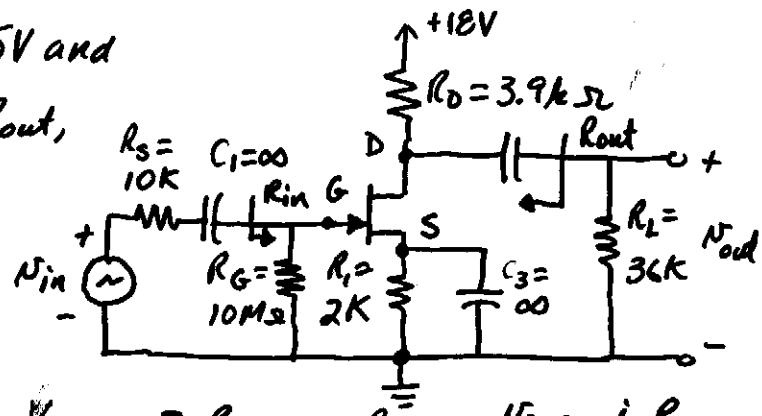
Example 4 - JFET Common Source Amplifier

If $I_{DSS} = 5mA$, $V_p = -5V$ and $\lambda = \frac{1}{50V}$, find R_{in}, R_{out}, and $\frac{v_{out}}{v_{in}}$.



a.) Find the Q-point.

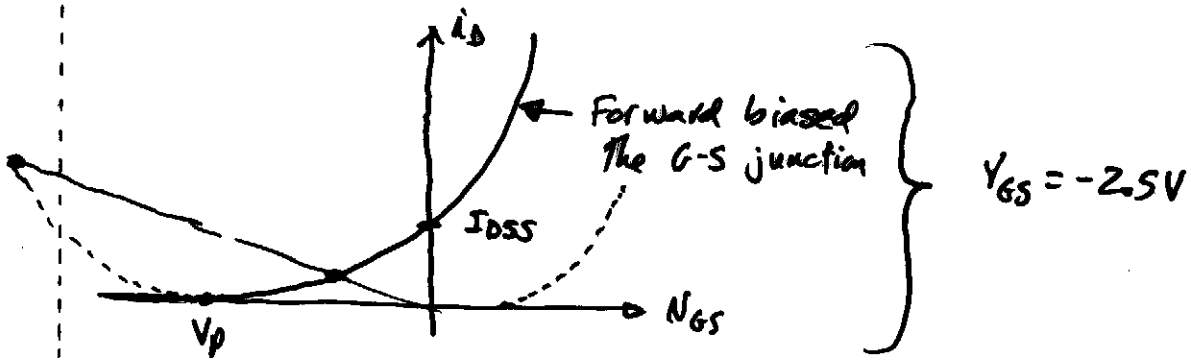
$$0 = V_{GS} + I_S R_1 \rightarrow V_{GS} = -I_S R_1 = -I_D R_1 \rightarrow v_{GS} = -i_D R_1$$

$$0 = I_G R_G + V_S + I_D R_1 \quad (I_G = 0)$$

$$i_D \cong I_{DSS}\left(1 - \frac{v_{GS}}{V_p}\right)^2$$

$$v_{GS} = -R_1\left[I_{DSS}\left(1 - \frac{v_{GS}}{V_p}\right)^2\right] \rightarrow v_{GS}^2 + 12.5 v_{GS} + 25 = 0$$

$$V_{GS} = -6.25 \pm 3.75$$



How do you relate a JFET to a MOSFET-

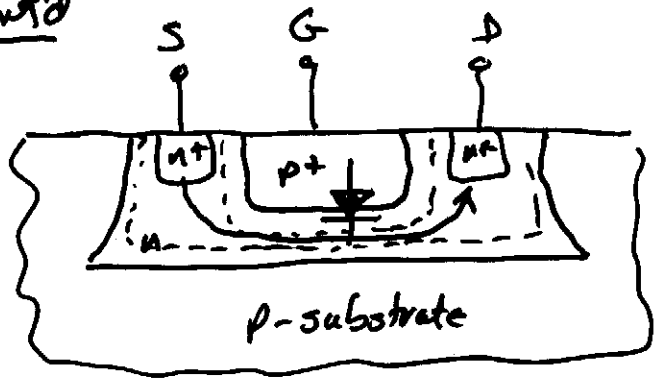
$$i_D = \frac{I_{DSS}}{V_p^2}\left(V_p - v_{GS}\right)^2 = \frac{I_{DSS}}{V_p^2}\left(v_{GS} - V_p\right)^2$$

$$i_{D\,MOSFET} = \frac{K'W}{2L}\left(v_{GS} - V_T\right)^2$$

$$\therefore \quad \frac{I_{DS}}{V_p^2} = \frac{K'W}{2L} \quad \text{and} \quad V_p = V_T$$

You cannot forward bias the G-S junction for a JFET

JFET Cont'd



Back to Example –

$$I_D = 5mA\left(1 - \frac{-2.5}{-5}\right)^2 = 1.25mA \qquad V_{DS} = 18 - 1.25mA(5.9K)$$

$$V_{DS} = 10.6\,V$$

Saturation –

$$V_{DS} \geq V_{GS} - V_p = -2.5 - (-5) = 2.5$$

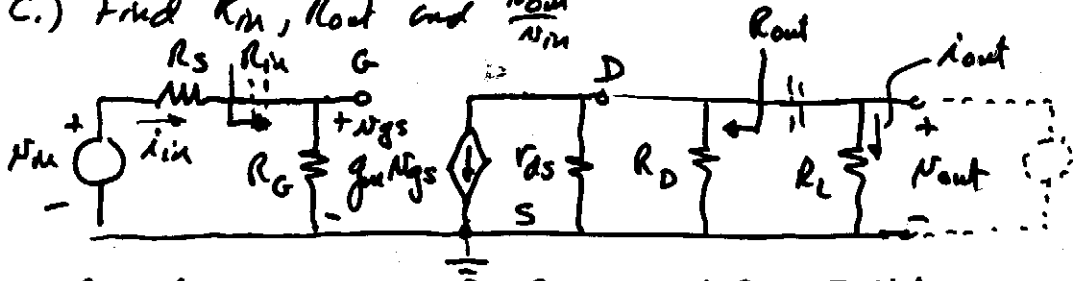
b.) Small parameter calculation

$$g_m = \frac{2}{|V_p|}\sqrt{I_{DSS} I_D (1+\lambda V_{DS})} = \frac{2}{5V}\sqrt{5mA \cdot 1.25mA\left(1+\frac{10.6}{50}\right)}$$

$$= 1.1mS$$

$$r_o = r_{ds} = \frac{\frac{1}{\lambda} + V_{DS}}{I_D} = \frac{50 + 10.6}{2.5mA} = 42.5k\Omega$$

c.) Find R_{in}, R_{out} and $\frac{v_{out}}{v_{in}}$



$$R_{in} = R_G = \underline{10M\Omega} \qquad R_{out} = r_{ds} \| R_D = \underline{3.61k\Omega}$$

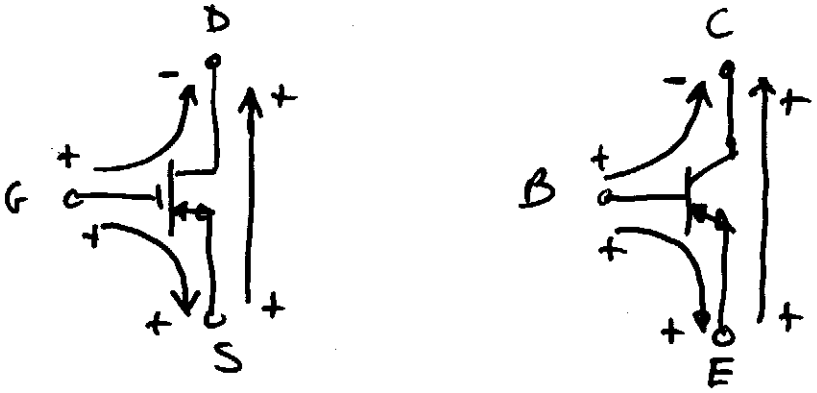
$$\frac{v_{out}}{v_{in}} = \left(\frac{v_{out}}{v_{gs}}\right)\left(\frac{v_{gs}}{v_{in}}\right) = \left(-g_m r_{ds} \| R_D \| R_L\right)\left(\frac{R_G}{R_S + R_G}\right)$$

$$= (-1.1 \cdot 3.28)\left(\frac{10}{10 + 0.01}\right) = \underline{-3.605\,V/V}$$

$$\frac{i_{out}}{i_{in}} = \frac{v_{out}/R_L}{v_{in}/(R_S + R_G)} = \frac{v_{out}}{v_{in}}\left(\frac{R_S + R_G}{R_L}\right)$$

Table 13.5

Signal Flow in Transistors



1.) You can't apply a signal to the D or C.

2.) You can't take an output from the B or G.

3.) Signals invert when going from B to C or G to D.

Inverting Amplifier with Un bypassed source resistor