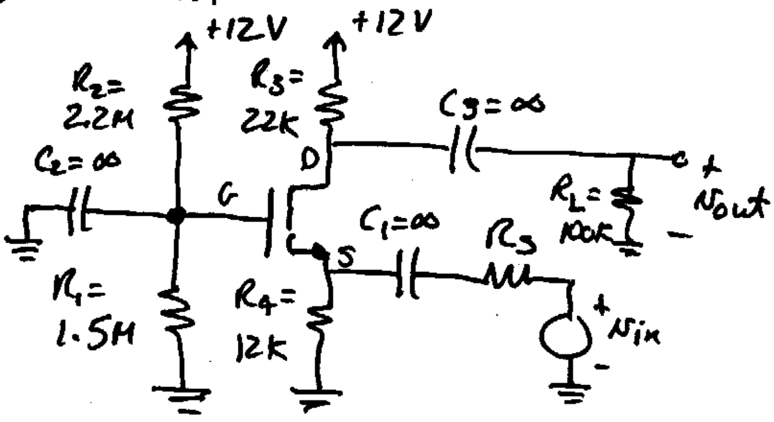
Common-Gate FET Amplifier

1.) Circuit



$K_n = 500\mu A/V^2$

$V_{TN} = 1V$

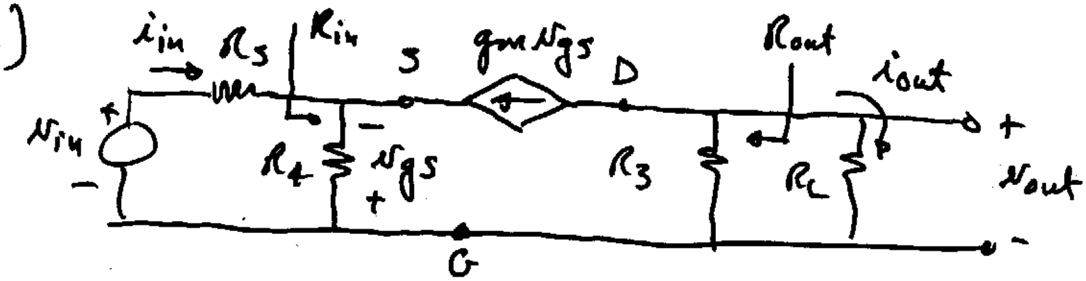
$\lambda = 0$

$I_{DS} = 241\mu A$

$g_m(BJT) = \frac{I_C}{V_t}$

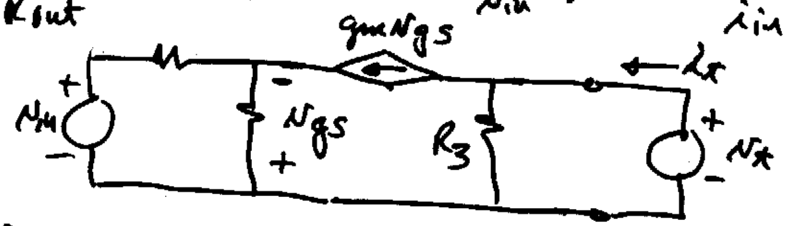
2.) Calculate $g_m = \sqrt{2K_n \cdot I_{DS}} = 509\mu S$ $\quad g_m(FET) = \sqrt{2 \cdot K_n I_{DS}}$

3.)



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

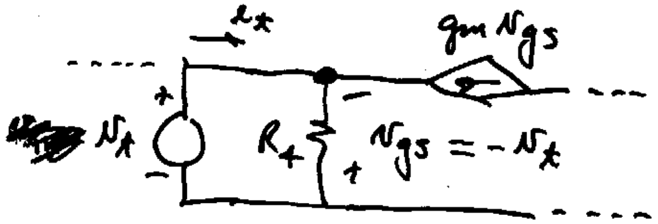
a.) R_{out}



$R_{out} = \left.\frac{v_t}{i_t}\right| = R_3 = \underline{\underline{22k}}$

$v_{in} = 0 \Rightarrow v_{gs} = 0$

b.) R_{in}

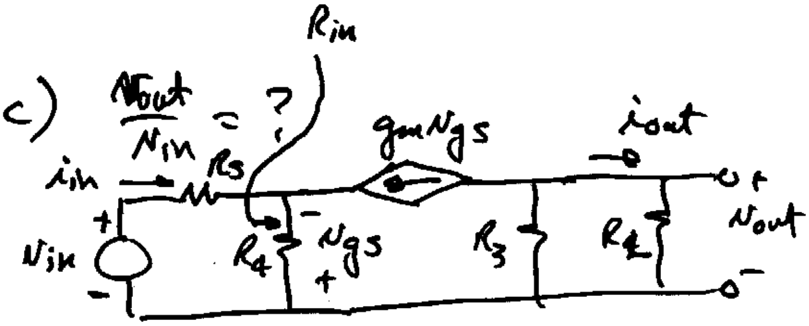


$i_t + \frac{v_{gs}}{R_4} + g_m v_{gs} = 0$

$i_t = \frac{v_t}{R_4} + g_m v_t$

$$R_{in} = \frac{v_t}{i_t} = \frac{1}{\frac{1}{R_4} + g_m} = \frac{1}{g_m} \| R_4 \approx \frac{1}{g_m} = \underline{\underline{1.96k\Omega}}$$

4c) $\frac{v_{out}}{v_{in}} = ?$



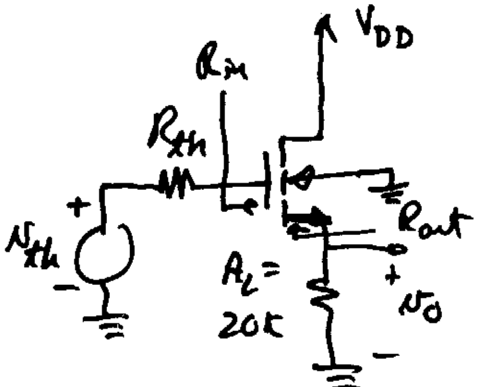
$$\frac{v_{out}}{v_{in}} = \left(\frac{v_{out}}{v_{gs}}\right)\left(\frac{v_{gs}}{v_{in}}\right) = \left(-g_m R_3 \| R_L\right)\left(-\frac{R_{in}}{R_s + R_{in}}\right)$$

$$= (-0.509 \times 18)\left(-\frac{1.96k}{3.96k}\right) = +4.54 \text{ V/V}$$

4d) $$\frac{i_{out}}{i_{in}} = \left(\frac{i_{out}}{v_{gs}}\right)\left(\frac{v_{gs}}{v_{in}}\right)\left(\frac{v_{in}}{i_{in}}\right) = \left(-g_m \frac{R_3}{R_3 + R_L}\right)\left(-\frac{R_{in}}{R_s + R_{in}}\right)\left(R_s + R_{in}\right)$$

$$\frac{i_{out}}{i_{in}} = (-0.509 \times 10^{-3} \times 18)\left(-\frac{1.96k}{3.96k}\right) 3.96k \cong 18 \text{ A/A}$$

Source Follower with $V_{BS} \neq 0$



Find $\frac{v_{out}}{v_{th}}$, R_{in} & R_{out}

$K_n = 500 \frac{\mu A}{V^2}$, $V_{TN} = 1$, $\lambda = 0$,

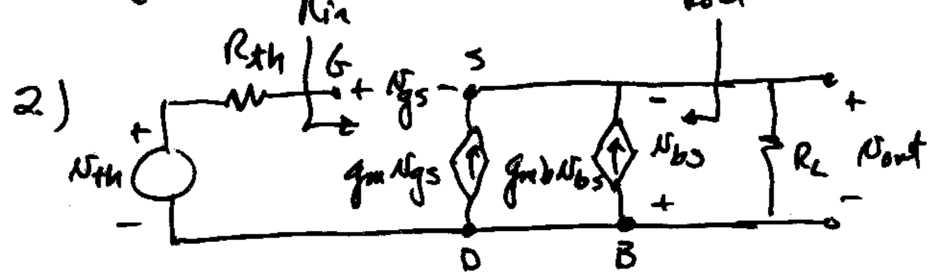
$\gamma_N = 0.75 V^{+1/2}$ and $2\phi_F = 0.6V$

$I_{DS} = 241 \mu A$ & $V_o(DC) \cong 5V$.

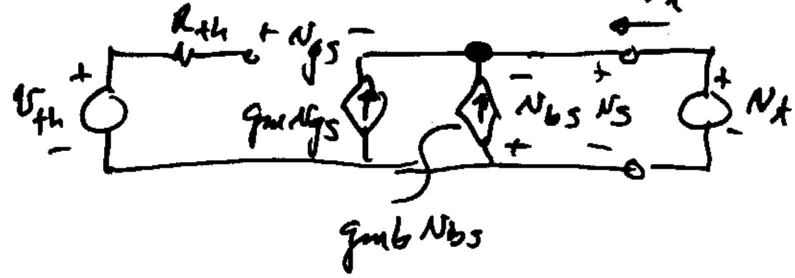
1.) $g_m = 509 \mu S$, $g_{mb} = \frac{\gamma g_m}{2\sqrt{V_{SB} + 2\phi_F}} = \frac{0.75(509 \mu S)}{2\sqrt{5 + 0.6}} = 77.8 \mu S$

$r_o = \infty$

2)



3) $R_{in} = \infty$



$i_x + g_m v_{gs} + g_{mb} v_{bs} = 0$

$i_x + g_m(v_g - v_s) - g_{mb} v_x = 0$

$i_x - g_m v_x - g_{mb} v_x = 0$

$i_x = v_x(g_m + g_{mb}) \rightarrow R_{out} = \frac{v_x}{i_x} = \frac{1}{g_m + g_{mb}} = \frac{10^6}{501 + 77.8} \cong 1.76k$

(Note that g_m includes lambda $\neq 0$)
Should use $g_m = 491 \mu S$

$$\frac{v_{out}}{v_{in}} = \frac{g_m R_L}{1 + g_m R_L + g_{mb} R_L} = \frac{(0.491)(20)}{1 + 0.491 \cdot 20 + 77.8 \cdot 20} = 0.793 \text{ V/V}$$