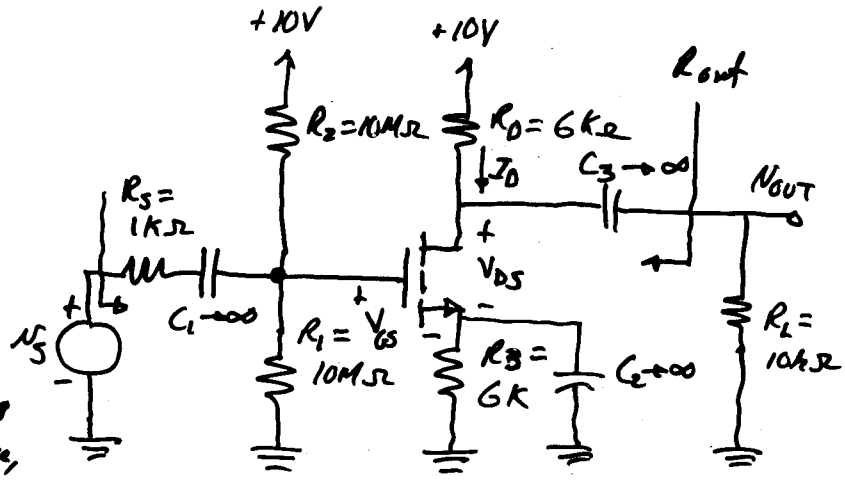
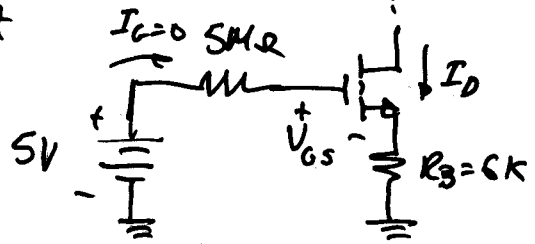
My Wednesday Office Hour has changed from 2-3pm to 3-4pm

## NMOS Example

If $k_n = 0.5\,mA/V^2$, $V_{TN} = 1V$ and $\lambda = 0.01\,V^{-1}$, find the small signal voltage gain, $\frac{V_{out}}{V_s}$, input resistance, $R_{in}$, and output resistance, $R_{out}$.




1.) Q point




$5 = V_{GS} + I_D R_3$

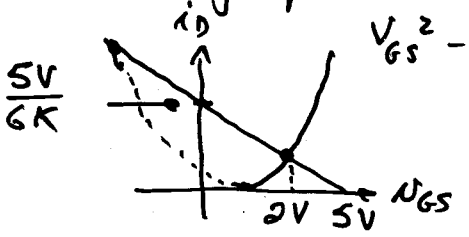
Assume saturation

$I_D = k_n (V_{GS} - V_{TN})^2 \cdots$

Resulting quadratic is:

$V_{GS}^2 - \frac{5}{3} V_{GS} - \frac{2}{3} = 0 \quad \frac{10}{6}$

$\frac{5}{6} \pm 1.1667 = 2V$




$I_D = 0.5\frac{mA}{V^2}(2-1)^2 = 0.5mA$

$V_{DS} = 10 - I_D R_D - I_D R_S = 10 - \frac{1}{2}(12) = 4V$

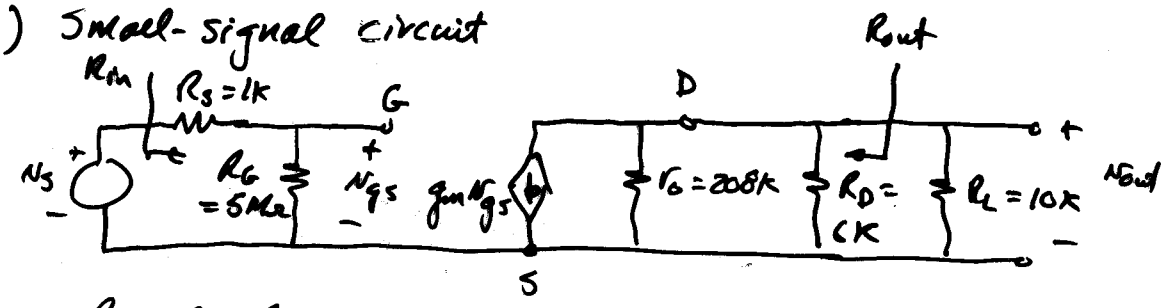
Is $4V \geq 2-1$ Yes

2.) SS model parameters

$g_m = \sqrt{2 k_n I_D (1 + \lambda V_{DS})} = 0.721mS$

$r_{ds} = \frac{V_{DS} + \frac{1}{\lambda}}{I_D} = \frac{4V + 100V}{0.5mA} = \frac{104}{0.5} K = 208k\Omega$

3.) Small-signal circuit



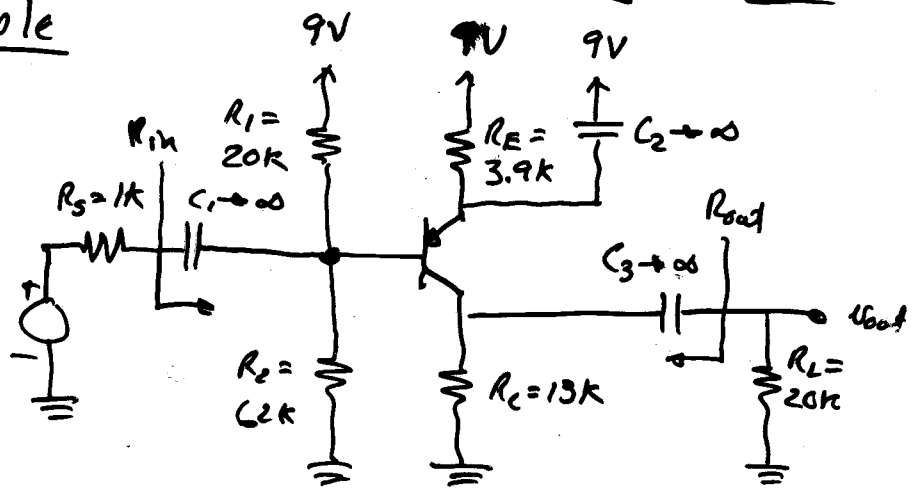

$R_{in} = R_S + R_G = \underline{5.001 M\Omega}$ $\quad R_{out} = 208K \| 16K \simeq \underline{6K}$ $(5.83k\Omega)$

$$\frac{v_{out}}{v_S} = \left(\frac{v_{out}}{v_{gs}}\right)\left(\frac{v_{gs}}{v_S}\right) = \left[-g_m\left(r_o \| R_D \| R_L\right)\right]\left[\frac{R_G}{R_S + R_G}\right]$$

$$= -(0.721 \times 10^{-3})\left[208K \| 16K \| 10K\right]\left[\frac{5M}{5.001M}\right] = \underline{-2.13\ V/V}$$

PNP Example

If $\beta_o = 135$ and $V_A = 100\ V$, find $\frac{v_{out}}{v_S}$, $R_{in}$ & $R_{out}$.




1.) Q point