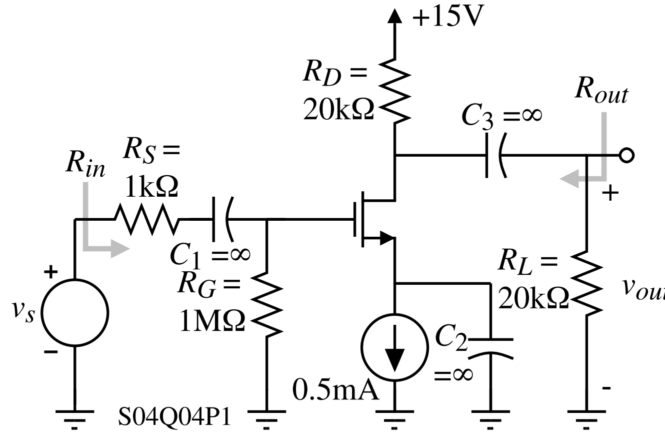
QUIZ NO. 4 - SOLUTION

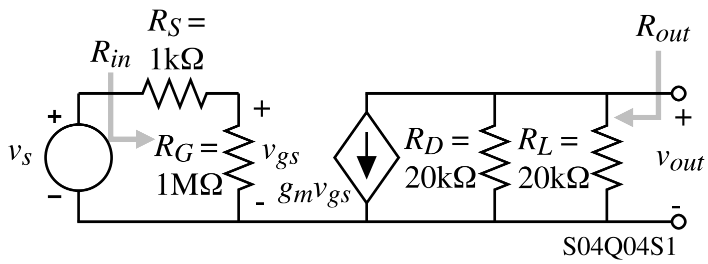
(Average score = 8.2/10 of those taking the quiz.)

A NMOS common-source inverting amplifier is shown. Assume the parameters of the transistor are $K_N = 1\text{mA/V}^2$, $V_{TN} = 1\text{V}$, and $\lambda = 0$. (a.) Find the small signal model parameter values for g_m and r_{ds}. (b.) Find an algebraic expression for the small signal input resistance, R_{in}, the output resistance, R_{out}, and the voltage gain, v_{out}/v_s. (c.) Numerically evaluate the small signal input resistance, R_{in}, the output resistance, R_{out}, and the voltage gain, v_{out}/v_{in}.



Solution

(a.) Small-signal model (Note the dc current source is replaced by an infinite):



Find g_m and r_{ds}: $g_m = \sqrt{2K_N I_D} = \sqrt{2\cdot 1\cdot 0.5} = \underline{1\text{mS}}$ and $r_{ds} = \underline{\underline{\infty}}$ (ignore V_{DS})

(b.) Find R_{in}, R_{out}, and v_{out}/v_s.

$$\boxed{R_{in} = R_S + R_G} \qquad \boxed{R_{out} = R_D || R_L}$$

$$\frac{v_{out}}{v_s} = \frac{v_{out}}{v_{gs}}\frac{v_{gs}}{v_s} = (-g_m R_{out})\left(\frac{R_G}{R_G + R_S}\right) = -g_m\left(\frac{R_D R_L}{R_D + R_L}\right)\left(\frac{R_G}{R_G + R_S}\right)$$

$$\boxed{\frac{v_{out}}{v_s} = -g_m\left(\frac{R_D R_L}{R_D + R_L}\right)\left(\frac{R_G}{R_G + R_S}\right)}$$

(c.) Evaluate R_{in}, R_{out}, and v_{out}/v_s..

$R_{in} = 1\text{k}\Omega + 1\text{M}\Omega \approx \underline{1\text{M}\Omega}$ $\qquad$ $R_{out} = R_D || R_L = \underline{10\text{k}\Omega}$

$$\frac{v_{out}}{v_s} = \frac{v_{out}}{v_{gs}}\frac{v_{gs}}{v_s} = -g_m\left(\frac{R_D R_L}{R_D + R_L}\right)\left(\frac{R_G}{R_G + R_S}\right) = (-1\text{mS})(10\text{k}\Omega)(1) = \underline{\underline{-10\text{V/V}}}$$