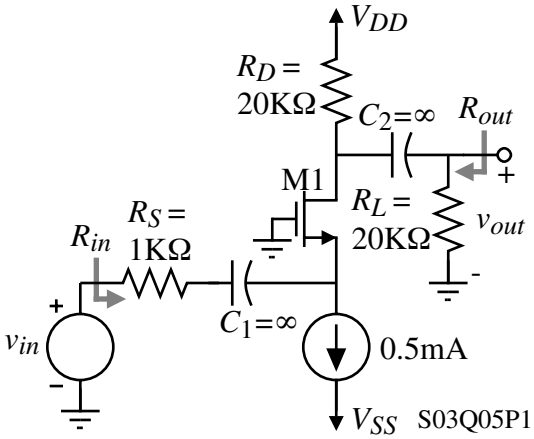
QUIZ NO. 5 - SOLUTION

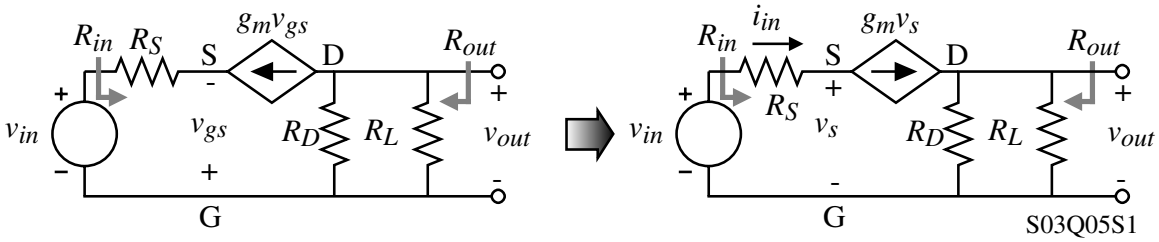
(Average score = xx/10 of those students taking the quiz.)

A NMOS common-gate 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_{in}. (c.) Numerically evaluate the small signal input resistance, R_{in}, the output resistance, R_{out}, and the voltage gain, v_{out}/v_{in}.



Solution

1.) Small-signal model:



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

3.) Find R_{in}, R_{out}, and v_{out}/v_{in}.

$R_{in} = ?$

$$v_{in} = g_m R_S v_s + v_s \qquad \text{and} \qquad i_{in} = g_m v_s$$

$$\therefore \qquad R_{in} = \frac{v_{in}}{i_{in}} = \frac{g_m R_S v_s + v_s}{g_m v_s} = R_S + \frac{1}{g_m} = 1\text{k}\Omega + 1\text{k}\Omega = \underline{\underline{2\text{k}\Omega}}$$

$R_{out} = ?$

$R_{out} = R_D \| R_L = \underline{\underline{10\text{k}\Omega}}$

Voltage gain = ?

$$\frac{v_{out}}{v_{in}} = \frac{v_{out}}{v_s}\frac{v_s}{v_{in}} = (g_m R_{out})\left(\frac{1}{1+g_m R_S}\right) = (10)\left(\frac{1}{1+1\cdot 1}\right) = \underline{\underline{+5\text{V/V}}}$$