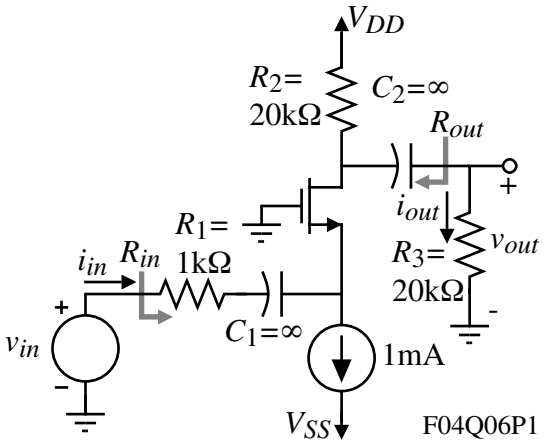
QUIZ NO. 6 - SOLUTION

(Average score = 7.6/10 of those taking the quiz.)

A NMOS transistor 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 an algebraic expression for the small signal input resistance, R_{in}, the output resistance, R_{out} , the voltage gain, v_{out}/v_{in}, and the current gain, i_{out}/i_{in}. (c.) Numerically evaluate the small signal input resistance, R_{in}, the output resistances R_{out} , the voltage gain, v_{out}/v_{in}, and the current gain, i_{out}/i_{in}.

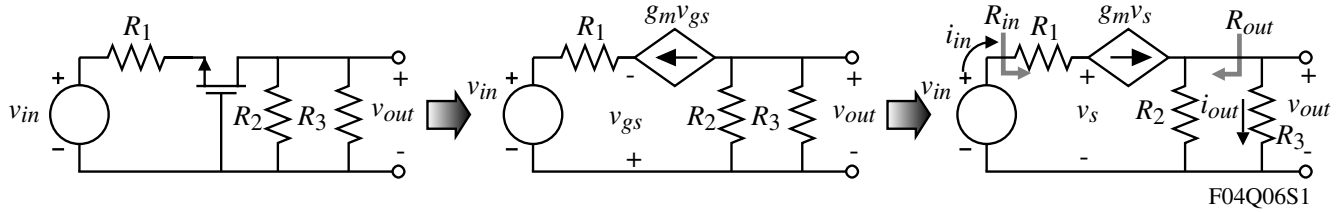


Solution

$$g_m = \sqrt{2K_N I_D} = \sqrt{2 \cdot 1 \cdot 1} = 1.414\text{mS}$$

$$r_o = \infty$$

Small-signal model:



$$R_{out} = R_2 = \underline{20\text{k}\Omega}$$

$$R_{in} = ? \quad v_t = i_t R_1 + v_s \quad \text{and } i_t = g_m v_s \quad \rightarrow \quad v_t = i_t \left(R_1 + \frac{1}{g_m} \right)$$

$$\therefore \qquad R_{in} = R_1 + \frac{1}{g_m} = \frac{1+g_m R_1}{g_m} = 1\text{K} + 0.707\text{K} = \underline{1.707\text{k}\Omega}$$

$$\frac{v_{out}}{v_{in}} = \left(\frac{v_{out}}{v_s}\right)\left(\frac{v_s}{v_{in}}\right) = [g_m \cdot (R_2 \| R_3)] \left(\frac{\frac{1}{g_m}}{R_1 + \frac{1}{g_m}} \right) = \frac{g_m \cdot (R_2 \| R_3)}{1 + g_m R_1} = \frac{1.414 \cdot 10}{1 + 1.414} = \underline{\pm 5.858\ \text{V/V}}$$

$$\frac{i_{out}}{i_{in}} = \left(\frac{v_{out}}{R_3}\right)\left(\frac{R_{in}}{v_{in}}\right) = \left(\frac{v_{out}}{v_{in}}\right)\left(\frac{R_{in}}{R_3}\right) = \left(\frac{g_m \cdot (R_2 \| R_3)}{1 + g_m R_1}\right)\left(\frac{1+g_m R_1}{g_m R_3}\right) = \frac{R_2 \| R_3}{R_3} = \frac{R_2}{R_2 + R_3} = \underline{0.5\ \text{A/A}}$$