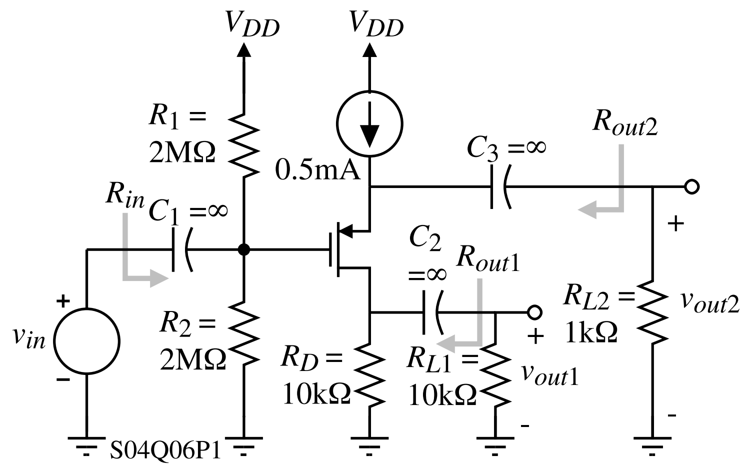
QUIZ NO. 6 - SOLUTION

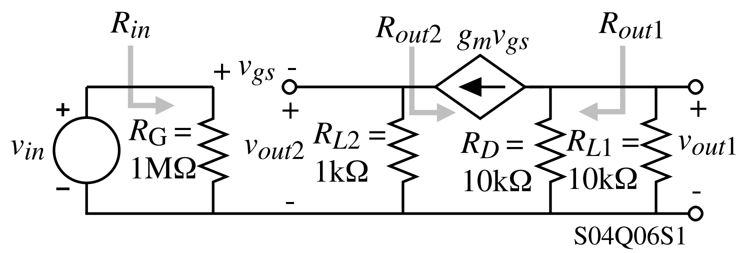
(Average Score = 6.4/10 of those students taking the quiz)

A PMOS transistor amplifier *with two outputs* is shown. Assume the parameters of the transistor are K_P = 1mA/V^2, V_{TP}= -1V, and λ = 0. (a.) Find an algebraic expression for the small signal input resistance, R_{in}, the output resistances, R_{out1} and R_{out2}, the voltage gains, v_{out1}/v_{in}, and, v_{out2}/v_{in}. (c.) Numerically evaluate the small signal input resistance, R_{in}, the output resistances, R_{out1} and R_{out2}, the voltage gains, v_{out1}/v_{in}, and, v_{out2}/v_{in}.



Solution

a.) Small-signal model:



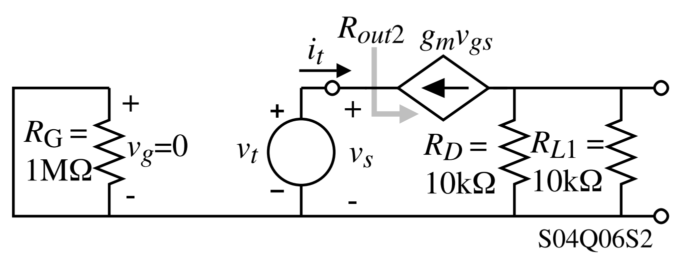
We can write by inspection,

$$\boxed{R_{in} = R_G}$$

and

$$\boxed{R_{out1} = R_D}$$

The value of R_{out2} is equal to $1/g_m$ but will be proven as follows using the small-signal model shown,



$$R_{out2} = \frac{v_t}{i_t}$$

Now, $i_t = -g_m v_{gs} = -g_m(v_g - v_s) = -g_m(0 - v_t) = g_m v_t \;\rightarrow R_{out2} = \frac{v_t}{i_t} = \frac{1}{g_m} \quad \rightarrow \boxed{R_{out1} = \frac{1}{g_m}}$

$$\frac{v_{out1}}{v_{in}} = \left(\frac{v_{out1}}{v_{gs}}\right)\left(\frac{v_{gs}}{v_{in}}\right) = [-g_m(R_D||R_{L1})]\left(\frac{1}{1+g_m R_{L2}}\right) = \frac{-g_m(R_D||R_{L1})}{1+g_m R_{L2}} \rightarrow \boxed{\frac{v_{out1}}{v_{in}} = \frac{-g_m(R_D||R_{L1})}{1+g_m R_{L2}}}$$

$$\frac{v_{out2}}{v_{in}} = \left(\frac{v_{out2}}{v_{gs}}\right)\left(\frac{v_{gs}}{v_{in}}\right) = (g_m R_{L2})\left(\frac{1}{1+g_m R_{L2}}\right) = \frac{g_m R_{L2}}{1+g_m R_{L2}} \rightarrow \boxed{\frac{v_{out2}}{v_{in}} = \frac{g_m R_{L2}}{1+g_m R_{L2}}}$$

b.) R_{in} = <u>1MΩ</u>, R_{out1} = <u>10kΩ,</u> $R_{out2} = \frac{1}{g_m} = \frac{1}{\sqrt{2K_P I_D}} = \frac{10^3}{\sqrt{2\cdot 1\cdot 0.5}} =$ <u>1kΩ</u>,

$$\frac{v_{out1}}{v_{in}} = \frac{1\text{mS}(10\text{k}\Omega||10\text{k}\Omega)}{1+1\cdot 1} = \underline{\underline{-2.5\text{ V/V}}} \quad \text{and} \quad \frac{v_{out2}}{v_{in}} = \frac{1\text{mS}(1\text{k}\Omega)}{1+1\cdot 1} = \underline{\underline{+0.5\text{ V/V}}}$$