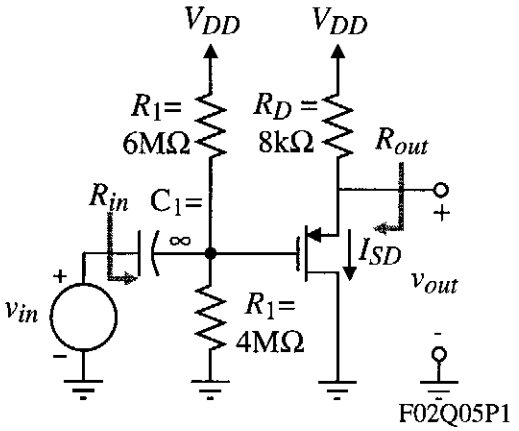
# QUIZ NO. 5 - SOLUTION

(Average Score = 6.2/10 of those who took the quiz)

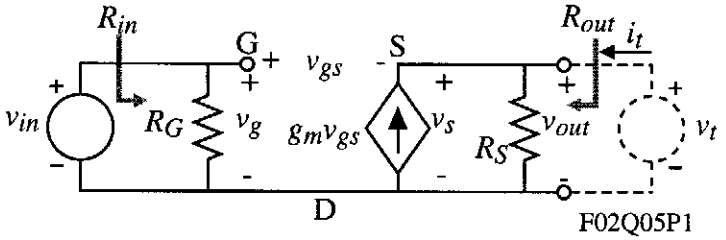
A PMOS common-drain amplifier is shown. Assume the parameters of the transistor are $k_F$ = 0.5mA/V$^2$, $V_{TP}$ = -1V, and $\lambda = 0$. (a.) If $I_{SD}$ = 0.5mA, find the small signal model parameter values for $g_m$ and $r_o$. (b.) Find an algebraic expression for the small signal input resistance, $R_{in}$, 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*

(a.) $g_m = \sqrt{2I_{SD}k_P} = \sqrt{2 \cdot 0.5 \cdot 0.5}$ mS = <u>0.707mS</u> and $r_o = \infty$

(b.) First we need a small signal model.




Obviously, $\boxed{R_{in} = R_G = R_1 \| R_2}$ . For $R_{out}$ we apply the voltage source, $v_t$, and set $v_{in}$ = 0 and solve for $v_t/i_t$ which equivalent to $R_{out}$.

$$\therefore\ i_t = G_S v_t - g_m v_{gs} = G_S v_t - g_m(v_g - v_s) = G_S v_t - g_m(0 - v_s)$$

$$= G_S v_t + g_m v_s = G_S v_t + g_m v_t = (G_S + g_m) v_t$$

$$\therefore\quad R_{out} = \frac{v_t}{i_t} = \frac{1}{G_S + g_m} = \frac{R_S}{1 + g_m R_S} \quad \rightarrow \quad \boxed{R_{out} = \frac{R_S}{1 + g_m R_S}}$$

The output voltage can be expressed as,

$$v_{out} = g_m R_S v_{gs} = g_m R_S (v_g - v_s) = g_m R_S (v_{in} - v_{out})$$

$$\therefore\quad v_{out}(1 + g_m R_S) = g_m R_S v_{in} \quad \rightarrow \quad \boxed{\frac{v_{out}}{v_{in}} = \frac{g_m R_S}{1 + g_m R_S}}$$

(c.) $R_{in} = R_G = R_1 \| R_2 =$ <u>2.4MΩ</u>, $R_{out} = \frac{8\text{k}\Omega}{1 + 0.707 \cdot 8} =$ <u>1.2kΩ</u> and $\frac{v_{out}}{v_{in}} = \frac{0.707 \cdot 8}{1 + 0.707 \cdot 8} =$ <u>0.85V/V</u>