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 $r_{ds}$:

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

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

$R_{in} = ?$

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

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

$R_{out} = ?$

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

Voltage gain = ?

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