QUIZ NO. 7 - SOLUTION

(Average Score = 6.8/10 for only those students taking the quiz)

If \( k_n = 1 \text{mA}/V^2 \), \( V_{TN} = 1V \), \( I_{DS} = 0.5 \text{mA} \) and \( \lambda = 0V^{-1} \), find the numerical values of the following small signal functions: \( v_{o2}/v_{in} \), \( v_{o1}/v_{in} \), \( R_{o1} \) and \( R_{o2} \).

**Solution**

Small signal model:

\[
g_m = \sqrt{2k_n I_{DS}} = \sqrt{2 \cdot 1 \cdot 1} = 1 \text{mS}
\]

\[
\frac{v_{o2}}{v_{in}} = \frac{v_{o2}}{v_{gs}} \left( \frac{v_{gs}}{v_{in}} \right) = (-g_m R_D) \left( \frac{1}{1+g_m R_S} \right) = \frac{-g_m R_D}{1+g_m R_S} = \frac{-10}{11} = -0.909 \text{ V/V}
\]

\[
\frac{v_{o1}}{v_{in}} = \frac{v_{o1}}{v_{gs}} \left( \frac{v_{gs}}{v_{in}} \right) = (g_m R_S) \left( \frac{1}{1+g_m R_S} \right) = \frac{g_m R_S}{1+g_m R_S} = \frac{10}{11} = +0.909 \text{ V/V}
\]

(This circuit happens to be a phase splitter because it creates a ± version of the input multiplied times 0.909 in this case.)

\[ R_{o2} = R_D = 10k\Omega \]

\( R_{o1} \) probably requires the use of a small signal model to make sure to avoid mistakes.

We see that,

\[
i_t = \frac{v_s}{R_S} + g_m v_s = v_s \left( \frac{1}{R_S} + g_m \right) = v_t \left( \frac{1}{R_S} + g_m \right)
\]

\[
\therefore R_{o1} = \frac{v_t}{i_t} = \frac{R_S}{1+g_m R_S} = \frac{10k\Omega}{11} = 0.909k\Omega
\]