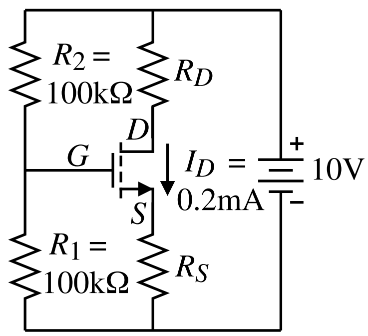
QUIZ NO. 1 - SOLUTION

(Average score = 7.9/10 of those taking this quiz)

The NMOS transistor shown has the parameters of K_n = 1mA/V^2, V_{TN} = 1V and λ_N = 0V^{-1}. In saturation, the large signal model is $i_D = 0.5K_n(v_{GS}-V_T)^2$.



S04Q01P1

a.) Assume the NMOS transistor is saturated and find the value of R_S that gives a drain current of 0.2mA.

b.) What value of R_D will cause the MOSFET to go from the saturation to the active region when I_D = 0.2mA?

Solution

a.) Let us solve for the value of V_{GS} that gives I_D = 0.2mA when the MOSFET is saturated.

$$I_D = 0.5K_n(V_{GS} - V_{TN})^2 = 0.5(V_{GS} - 1)^2 = 0.2$$

$$0.4 = V_{GS}{}^2 - 2V_{GS} + 1 \quad \rightarrow \quad V_{GS}{}^2 - 2V_{GS} + 0.6 = 0$$

$$\therefore \quad V_{GS} = 1 \pm 0.5\sqrt{4\text{-}0.6(4)} = 1 \pm 0.5\sqrt{1.6} = 1 \pm 0.632\text{V} \quad \rightarrow \quad V_{GS} = 1.632\text{V} \ (2)$$

Since we know that V_G = 5V (1), then V_S = 5 – 1.632 = 3.367V

Therefore, $$R_S = \frac{V_S}{I_D} = \frac{3.367}{0.2\text{mA}} = \underline{\underline{16.84\text{k}\Omega}} \ (3)$$

b.) To find the value of *RD* that will cause the MOSFET to leave the saturation region and enter the active region, we will use the following relationship that gives the conditions at the boundary of the two regions.

$$V_{DS} = V_{GS} - V_{TN} \quad (1)$$

This relationship can be rewritten as,

$$V_D - V_S = V_G - V_S - V_{TN} \quad \rightarrow \quad V_D = V_G - V_{TN} = V_G - 1 \quad (1)$$

Therefore, V_D = 5-1 = 4V is when the MOSFET will be at the boundary of the two regions. Thus, the voltage drop across R_D is 6V and the current through it is 0.2mA. From Ohm's law, we get,

$$R_D = \frac{(10\text{-}V_D)}{I_D} = \frac{6\text{V}}{0.2\text{mA}} = \underline{\underline{30\text{k}\Omega}} \quad (2)$$