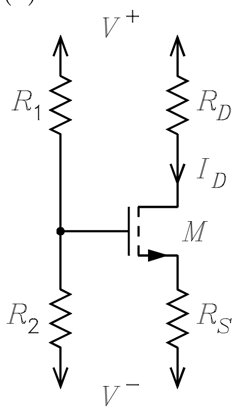
ECE 3040 Microelectronic Circuits Quiz 5

June 16, 2004

Professor Leach Name______________________________

Instructions. Print your name in the space above. The quiz is closed-book and closed-notes. The quiz consists of 2 problems. **Honor Code Statement:** *I have neither given nor received help on this quiz.* Initials ____________

1. The MOSFET has the parameters $K = 0.0005\,\mathrm{A/V}$ and $V_{TH} = 1.75\,\mathrm{V}$. It is given that $V^{+} = +18\,\mathrm{V}$, $V^{-} = -18\,\mathrm{V}$, $R_1 = 3\,\mathrm{M}\Omega$, $R_S = 2\,\mathrm{k}\Omega$, and $i_D = K\left(v_{GS} - V_{TH}\right)^2$.
(a) Solve for R_2 such that $I_D = 1.5\,\mathrm{mA}$.
(b) What is the maximum value that R_D can have for the MOSFET to remain in the saturation state?



Answers:

$$V_{GS} = \sqrt{\frac{I_D}{K}} + V_{TH} = 3.482\,\mathrm{V} \qquad V_G = V_{GS} + I_D R_S + V^{-} = -11.518\,\mathrm{V}$$

$$I_{R_2} = I_{R_1} = \frac{V^{+} - V_G}{R_1} = 9.839\,\mu\mathrm{A} \qquad R_2 = \frac{V_G - V^{-}}{I_{R_2}} = 658.8\,\mathrm{k}\Omega$$

$$\begin{aligned} V_{DS} &= \left(V^{+} - I_D R_D\right) - \left(V^{-} + I_D R_S\right) = 33 - I_D R_D \geq V_{GS} - V_{TH} = \sqrt{\frac{I_D}{K}} = 1.732\,\mathrm{V} \\ &\Rightarrow \quad R_D \leq \frac{33 - 1.732}{I_D} = 20.85\,\mathrm{k}\Omega \end{aligned}$$

2. The MOSFET drain current is given by the equation $i_D = K_0\left(1 + \lambda v_{DS}\right)\left(v_{GS} - V_{TH}\right)^2$. Describe how this equation is used to solve for the parameters g_m and r_0 in the hybrid-pi model. Assume the Q-point values I_D, V_{GS}, and V_{DS}. You should use graphs and equations, as appropriate, in your description. Label on the graphs how the parameters are defined.
Answers: g_m is the slope of the i_D versus v_{GS} curve at the Q point with v_{DS} held constant. r_0 is the reciprocal of the slope of the i_D versus v_{DS} curve at the Q point with v_{GS} held constant.