ECE 3050 Analog Electronics Quiz 10

October 28, 2009

Professor Leach Name_____

Instructions. Print your name in the space above. Place a box around your answers. Points will be subtracted if you do not express each numerical answer as a decimal number and if you do not put a box around answers. **Honor Code Statement:** *I have neither given nor received help on this quiz.* Initials _____

1. The figure shows a common-drain amplifier with body effect. It is given that $r_0 = 50\,\text{k}\Omega$ and $g_m = 2\,\text{mA/V}$ for each MOSFET. For M_1, it is given that $g_{mb} = 0.5\,\text{mA/V}$. Reference equations: $r_s = g_m^{-1}$, $r_{sb} = g_{mb}^{-1}$, $g_{mb} = \chi g_m$, $r_s' = r_s/(1+\chi)$
   (a) Solve for the small-signal Norton current $i_{o(sc)}$ as a function of the small-signal input voltage v_i.

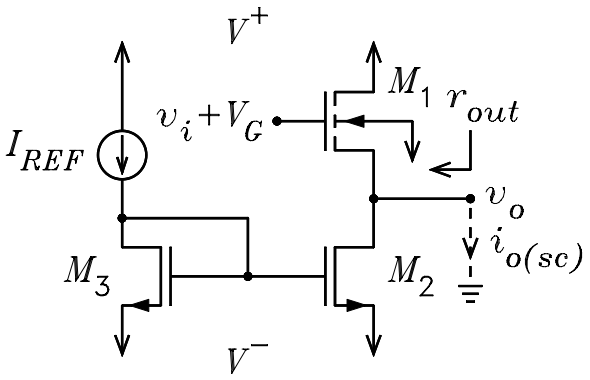
$$i_{o(sc)} = \frac{\dfrac{v_i}{1+\chi}}{r_s'} = g_m v_i = 0.002 v_i = \frac{v_i}{500}$$

   (b) Solve for the output resistance r_{out}.

$$r_{out} = r_{o1} \| r_{s1}' \| r_{o2} = 394\,\Omega$$

   (c) A load resistor $R_L = 5\,\text{k}\Omega$ is connected from the output node to ac signal ground. Use the results from the preceding parts to solve for the small-signal output voltage v_o as a function of the small-signal input voltage v_i. Draw and label any circuits you use to solve for v_o.

$$v_o = i_{o(sc)} r_{out} \| R_L = 0.73 v_i$$



2. It is given that $v_i = 2\,\text{V}$, $R_1 = 10\,\text{k}\Omega$, $R_2 = 20\,\text{k}\Omega$, $R_3 = 6\,\text{k}\Omega$, and $R_4 = 4\,\text{k}\Omega$.
(a) Solve for the current i. Hint: write a single loop equation through the virtual short circuit.

$$i = \frac{v_i}{R_1 + R_3} = \frac{1}{8}\,\text{mA} = 0.125\,\text{mA}$$

(b) Use the results of the preceding part to solve for v_o and the voltage at each of the other 4 nodes in the circuit.

$$v_o - i\,(R_2 + R_4) = 3\,\text{V}$$

$$v_+ = v_- = -iR_4 = -0.5\,\text{V}$$

$$v_{R_3} = -i\,(R_3 + R_4) = -1.25\,\text{V}$$

$$v_{R_1} = v_{R_3} + v_i = 0.75\,\text{V}$$