

ECE 3040 Quiz 6 – June 29, 2005

Professor Leach

Name _____

Instructions. Print your name in the space above. The quiz is closed-book and closed-notes. The quiz consists of 1 problem. **Honor Code Statement:** *I have neither given nor received help on this quiz.* Initials _____

1. The figure shows a MOSFET differential amplifier. It is given that $i_D = K(v_{GS} - v_{TH})^2$, $g_m = 2\sqrt{KI_D}$, $g_{mb} = \chi g_m$, $r_s = 1/g_m$, $r_{sb} = 1/g_{mb}$, $r_0 = (\lambda^{-1} + V_{DS})/I_D$, $V^+ = 24\text{ V}$, $V^- = -24\text{ V}$, $I_Q = 4\text{ mA}$, $R_D = 10\text{ k}\Omega$, and $R_G = 50\text{ k}\Omega$. At the bias or Q point, it is known for each MOSFET that $K = 5 \times 10^{-4}\text{ A/V}^2$, $V_{TH} = 1.5\text{ V}$, $\lambda = 0$, and $\chi = 0.4$.

(a) With $v_{I1} = v_{I2} = 0$, solve for V_{GS} and V_{DS} . Verify that each MOSFET is in the saturation state at the Q point.

$$\begin{aligned} V_{GS} &= \sqrt{\frac{I_D}{K}} + V_{TH} = 2.914\text{ V} \\ V_{DS} &= \left(V^+ - \frac{I_Q R_D}{2} \right) - V_S = \left(V^+ - \frac{I_Q R_D}{2} \right) + V_{GS} = 6.914\text{ V} \\ V_{GS} - V_{TH} &= 1.414\text{ V} < V_{DS} \implies \text{Saturation mode} \end{aligned}$$

(b) For $v_{I2} = V_{I2} + v_{i2} = 0$, use either the π or the T model to solve for the ac small-signal voltages v_{o1} and v_{o2} as functions of v_{o1} .

$$\begin{aligned} i_{d1} &= i_{s1} = \frac{g_m}{2} v_{i1} = \frac{v_{i1}}{2r_s} \\ i_{d2} &= -i_{d1} = i_{s2} = -i_{s1} \\ r_s &= \frac{1}{g_m} = \frac{1}{2\sqrt{KI_D}} = 707.1 \\ v_{o1} &= -v_{o2} = \frac{v_{i1}}{2r_e} R_D = -7.071 v_{i1} \end{aligned}$$

(c) If $v_{I1} = V_{I1} + v_{i1} = 0$, using the preceding answer and the concept of symmetry, write by inspection the solutions for v_{o1} and v_{o2} as functions of v_{i2} .

$$v_{o2} = -v_{o1} = \frac{v_{i2}}{2r_e} R_D = -7.071 v_{i2}$$

