UNIVERSITY OF CALIFORNIA AT BERKELEY
College of Engineering
Department of Electrical Engineering and Computer Science

R.W. Brodersen	**Homework #4**	**EECS 140**
Mike Chen	**(Due 2/19/04)**	**Spring 2004**

1) Given the differential amplifier in figure 1, $(W/L)_{3,4}$=5u/1u, $(W/L)_{1,2}$=10u/1u, $(W/L)_5$=20u/1u, R1=1 MΩ, input common mode voltage, Vic = 0.9 V, Vdd=1.8 V. Answer the following questions, assuming Vbs=0 for all transistors:
   a) Calculate the voltage, Vb, such that the tail current is 10 uA. And compute all the DC biasing voltage of all the nodes.
   b) Plot Voc vs. Vic, as Vic sweeps from 0 to Vdd, and Vid=0V. Label all the breakpoints, and indicate operation regions of all the transistors. [Def: Voc=(Vo1+Vo2)/2, Vic=(Vi1+Vi2)/2]
   c) Plot Vod vs. Vid, as Vid sweeps from –Vdd to Vdd, and Vic=0.9V. Label all the breakpoints. [Def: Vod=(Vo1-Vo2), Vid=(Vi1-Vi2)]
   d) Calculate output common mode resistance, Roc, and common mode gain, Acm.
   e) Calculate output differential mode resistance, Rod, and differential mode gain, Adm.
   f) Use HSPICE to verify (a)-(e), and print out the results.

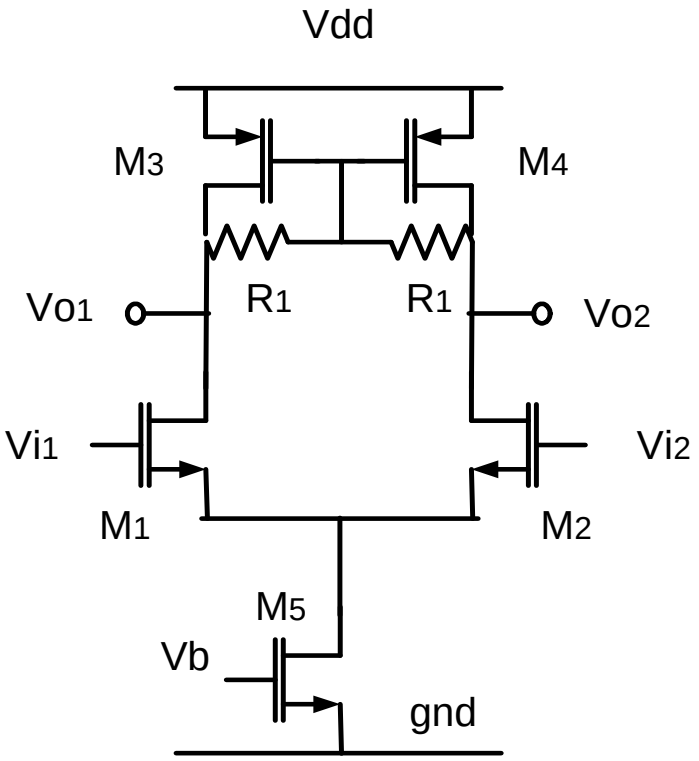

Figure 1

Device model for problem (1):
.model nch nmos LEVEL=1 TOX=25 VTO=0.4 KP=100.0e-6 LAMBDA=0.2
+GAMMA=0.01 PHI=0.6
.model pch pmos LEVEL=1 TOX=25 VTO=-0.4 KP=60.0e-6 LAMBDA=0.15
+GAMMA=0.01 PHI=0.6

[SPICE hint: 'e' element (voltage control voltage source) can be used to sweep a differential voltage. 'e1 out1 out2 in1 in2 gain']

2) A current source is shown in figure 2, with $(W/L)_{1,2}$=10u/1u, Vbs=0, Vdd=1.8V.
   a) Choose R1 and R2, such that Iout = 100 uA, and Iin = 400 uA.
   b) Calculate the output resistance of this current source, Rout.
   c) Plot Iout vs. Vout, which is the voltage at the output node. Label the breakpoints and indicate operation region of M2.
   d) Use HSPICE to verify (a)-(c), and print out the results.

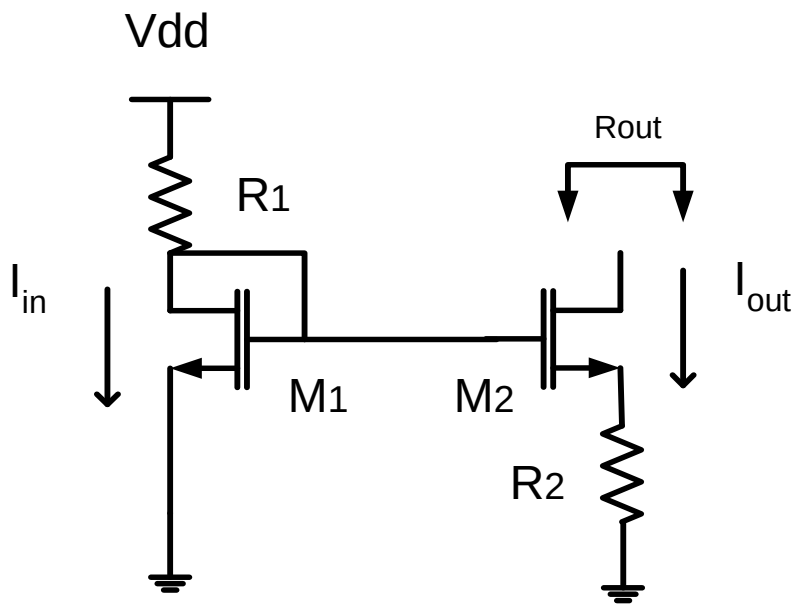

Figure 2

Device model for problem (2):
.model nch nmos LEVEL=1 TOX=25 VTO=0.4 KP=100.0e-6 LAMBDA=0.1
+GAMMA=0.01 PHI=0.6

[SPICE hint: Put a voltage source Vout at output node to sweep output voltage, and '.tf i(M2) Vout' gives the output resistance.]