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ENEE 303H Spring 2009 Final Exam

Open book, open notes. Your signature is required and certifies that the work is solely your own. 150 points total. If stuck be sure to go on to the next problem. Good Luck.

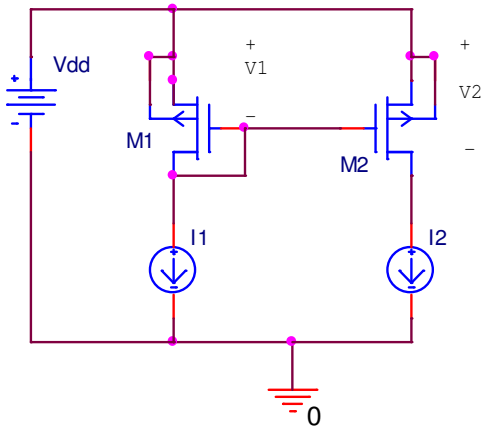
Use the following for transistor model Spice parameters:

For BJTs: $\beta = 99$, $V_T = 0.026V$ = thermal voltage, $|V_{BE}| = 0.7V$

For CMOS:transistors: VTOn = -VTOp=0.5 V, Cgs = 20 pFd, Cgd = 0

KPn=KPp = 10^{-5} A/V^2 ; λn=λp=0.02

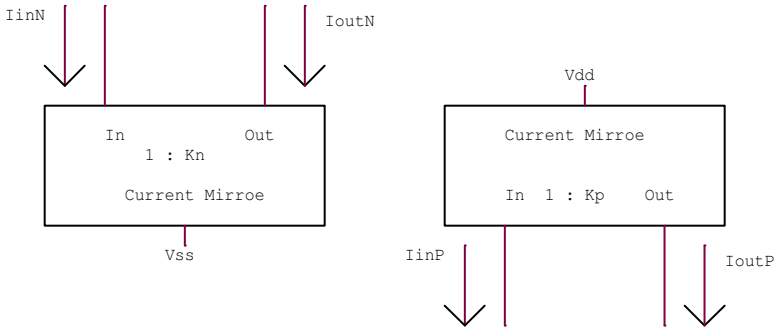
1. (50 pts, 30 min)



For the above circuit M1=M2 and Vdd is assumed as large as needed.
It is desired to have positive V2=2V1.

a) Show that M2 is in saturation.
b) Find I2/I1 as a function of V1.
c) It is desired to design for V2=4; find I1 and I2 when (W/L)=2.

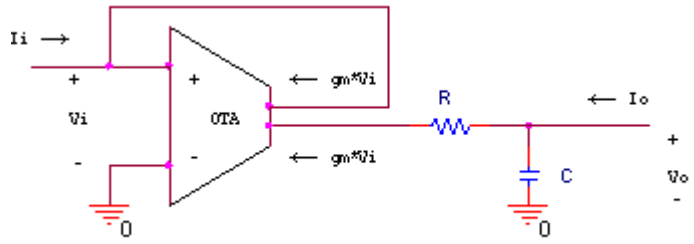
2. (40 pts, 25 min).



The above symbols represent two types of current mirrors for which DC currents can only flow in one direction. Kn and Kp are positive current gains. Assume that Vdd=-Vss = 5V and the input transistors have (W/L)=2.

a) Draw a connection of the two types so that the overall current in and current out can flow in two directions to form a bidirectional current mirror.
b) Draw an MOS transistor version of your bidirectional current mirror.
c) Calculate IinN=IinP when the input current and voltage (wrt ground) are zero, .
d) Discuss what happens when the current gains Kn and Kp differ.

3. (40 pts, 25 min)



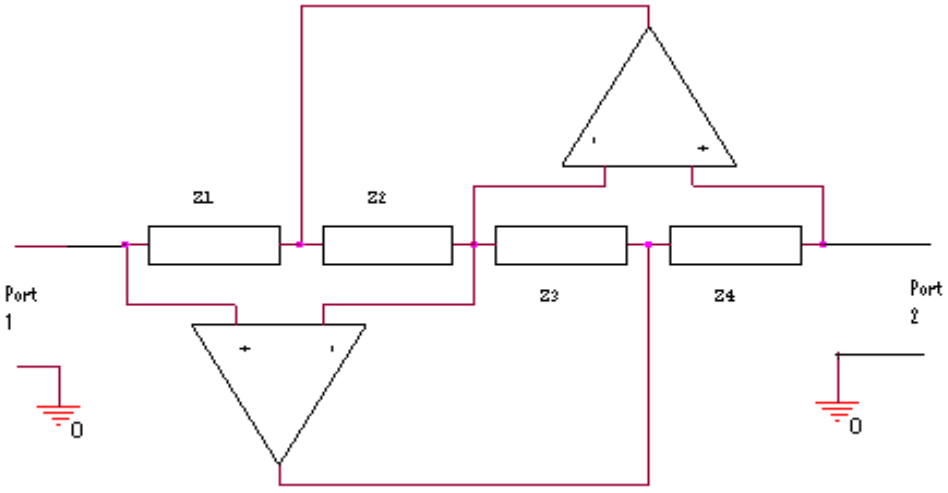
For this circuit assume the two output currents, I_{ota}, of the OTA are identical.

a) If the OTA is described by $I_{ota}=\alpha I_T \tanh(Vi/(2V_T))$ give gm when biased at Vi=0 [where I_{ota} is directed as the OTA output currents shown; I_T is the tail current].

b) Find the 2-port admittance matrix Y(s) [valid for small signal vi] (in terms of gm, R, C). Here port 1 is the input one (on the left) and port 2 is the output one (on the right).

c) If a small step function of voltage vi is applied, vi(t)=Vi1(t),[1(.) = unit step function] and the output is open circuited, Io=0, give the differential equation for vo(t) and solve assuming positive R, C, gm [assume vo(t)=0 for t<0]

4. (20 points, 10 min)



a) Draw a cascade connection of two identical copies of this circuit.
[that is, port 2 of the first circuit directly connects to port 1 of the second with port 1 of the first and port 2 of the second being the new 2-port ports].

b) Give a 2-port description of this cascade.

c) If Z1 and Z3 are for capacitors and Z2 & Z4 are for resistors
find the current gain of the cascade and discuss possible uses of the cascade.