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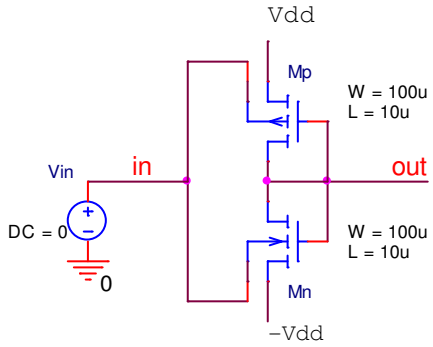
ENEE 303H Final Exam – Fall 2011 Take Home

150 points, open book, open notes. Good luck! Your signature certifies that the work is your own [due by the end of the scheduled final time in Room AVW 1364 with notebook]

1. (50 points)

   The following is possibly a new kind of inverter having its input at the bulks (called body in the text; structure on p. 233, model on p. 324). Assume that the transistors are completely complementary along with |VTO|=0.1, Vdd=-Vss=0.2, |γ|=0.4, KP=10E-5, λ=0, φ_f=0.6, W/L=10

   a) Give the Q point NMOS drain current, IDn and small signal equivalent circuit and find the small signal DC voltage gain Vout/Vin.
   b) Assuming the bulk diodes satisfy the law of Figure 4.8, page 174 (that is, are turned off for |Vdiode|<0.5), give Vout over -0.2<Vin<0.2.
   c) Discuss if this is a good inverter for low power systems.



2. (50 points)

   Use a 4007 PMOS transistor in the single ended Colpitts oscillator circuit of the next page (similar to that presented by Kyle Werner). Use equal capacitors C1=C2=1uFd, L, and gm to give ω_0=1KHz, R~~=10 =~~ -10KOhm and Vdd=5V; ~~set Ibias at 100uA~~. That is find L, Vbias, Ibias, and gm. Ignore transistor capacitors and the Early effect. You should find the new oscillation condition placed on gm.

   The 4007 Spice model parameters to be used are:

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.model M4007N nmos(Level=1 Tox=300n KP=20.54u W=144u L=8u VTO= 1.3
+ LAMBDA=15m Cbd=4p Cbs=4p)
.model M4007P pmos(Level=1 Tox=300n KP=10.32u W=328u L=8u VTO=-1.5
+ LAMBDA=15m Cbd=8p Cbs=8p)
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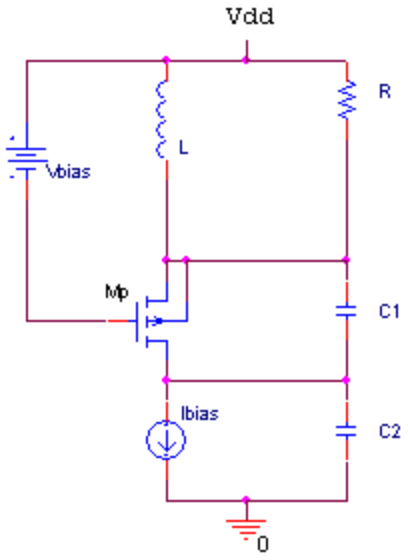

3. (50 points)
Use the following ideal model for the OTA (with also zero currents into the + & - leads) for which IT and VS are real and positive.

$$Io = \begin{cases} IT & \text{for } VS \le Vid \\ GmVid & \text{for } -VS \le Vid \le VS \\ -IT & \text{for } Vid \le -VS \end{cases}$$

For the following circuit:
a) Give the equation for the load curve of IL versus Vo and graph the curve.
b) Graph -IL on the OTA curve of Io versus Vo when Vi = 0 for the two cases of Gm<G=1/R and Gm>G=1/R
c) The circuit has hysteresis for certain values of G=1/R. Determine the range of those values.
d) Graph Vo versus Vi to show the hysteresis for the values of R of part c) and give the hysteresis output values and input voltage jump point values. .