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303H Fall 2013

Homework 6 – due Tu 10/22/13

1. 50 points (CMOS inverter V_{IH} & V_{IL})
   For the CMOS inverter using 4007 transistors
   a) Run Spice with V_{DD}=5V and determine from the curves V_{IH} & V_{IL}. And compare the results with {Eqs. (4.148)&(4.149) [p. 341] see also Eq. (10.11)[p. 957]}
   $V_{IH}=(1/8)(5V_{DD}-2VTOn)$
   b) Repeat part a) for V_{DD}=9V.
   c) Compare the two cases (of V_{DD}=5 vs V_{DD}=9) and explain differences between them and Eq. (10.11).

2. 50 points (inverter small signal & frequency response)
   For the inverter of problem 1, assume v_{in} is a small signal applied at the common gates with the circuit Q point at $V_{IN}=V_{OUT}$.
   a) Determine V_{IN} for $V_{IN} = V_{OUT}$ and apply that as bias to the gates.
   b) From the equivalent circuit find the low frequency gm (=y21) and go (=y22) for the inverter as a 2-port biased as in part a).
   c) Add to the equivalent circuit the transistors Cgs terms and obtain the transfer function $T(s)=v_{out}(s)/v_{in}(s)$. Give its zeroes and poles.
   d) Run a frequency response in Spice from 100Hz to 100MegHz and check how this agrees (or disagrees) with the result of part c).

[research & open problem] Develop an equation for V_{IH} with nonzero λ and not completely complementary transistors.