EE 40 – Introduction to Microelectronic Circuits

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Problem Set # 10

Due: 5 PM Tuesday, Nov. 15th, 2005 in 240 Cory

10.1 MOS Physics

An NMOS device produces a current of 50 μA when operated at V_{GS}=3V and V_{DS}=3V. The device has W/L=2, V_T=1V, and p-substrate doping $N_A=10^{16}$ cm^{-3}. The electric permittivity of Silicon dioxide is about $\varepsilon_{ox}=3.9*\varepsilon_0$, where ε_0 is the electric permittivity of free space.

a. Find the device parameters μ_n, C_{ox}, and t_{ox}, assuming a pinch-off saturation behavior.
b. Find the device parameters μ_n, C_{ox}, and t_{ox}, assuming a velocity saturation behavior with V_{DSAT}=1.5V.
c. Compare the current in the two devices from parts (a) and (b) when operated at V_{GS}=1.5V and V_{DS}=3V. (Hint: Remember that MOSFET current saturates for $V_{DS} \geq \min(V_{GS}-V_T, V_{DSAT})$, where $V_{GS}-V_T$ is the condition for pinch-off and V_{DSAT} is the condition for velocity saturation.)

10.2 NMOS Inverter

For the circuit shown in Figure 1, answer the following questions, using the NMOS_4XVS model given in Lecture 27.

a. Plot I_O vs. V_{OUT} for both the pull-up and pull-down devices for V_{IN} = 1V, 2V, and 3V.
b. Plot the voltage transfer characteristic (VTC), V_{OUT} vs. V_{IN}. What is the minimum V_{OUT} for this inverter? How can you change R_D to lower this value?
c. Find the power in the pull-up and pull-down devices when V_{IN}=0V and V_{IN}=3V.

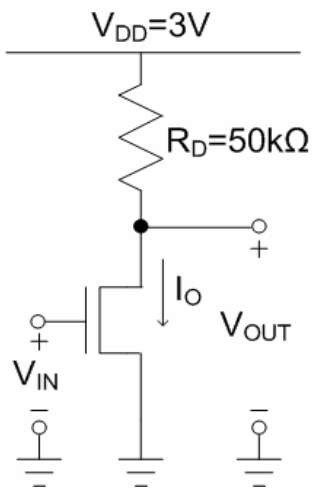

Figure 1 – NMOS Inverter

10.3 CMOS Inverter

For the circuit shown in Figure 2, answer the following questions, using the NMOS_4XVS model given in Lecture 27 and the PMOS_4XVS model given in Lecture 28.

a. Plot I_O vs. V_{OUT} for both the pull-up and pull-down devices for V_{IN} = 1V, 1.25V, 1.5V, 1.75V, and 2V.
b. Plot the voltage transfer characteristic (VTC), V_{OUT} vs. V_{IN}. What is output voltage range for this inverter?
c. Find the power in the pull-up and pull-down devices when V_{IN}=0V and V_{IN}=3V. How does the power consumption of the CMOS inverter compare to the NMOS inverter?

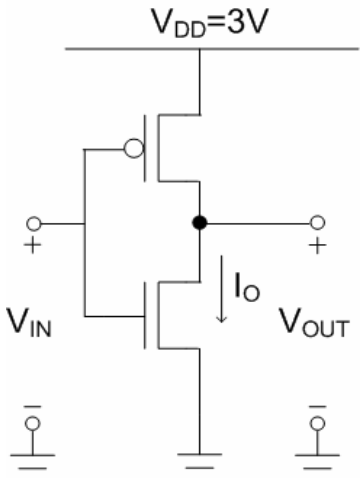

Figure 2 – CMOS Inverter