ECE 3421 – VLSI Design and Simulation, Spring 2013

Homework Assignment 1

1. Determine the current I_{ds} for the following cases. Assume the standard model not including short channel effects and channel-length modulation. Unless specified explicitly, the body (substrate) of MOS transistor is connected to the source, i.e., $V_{sb} = 0$ thus no body effects. Some of device parameters are given below:

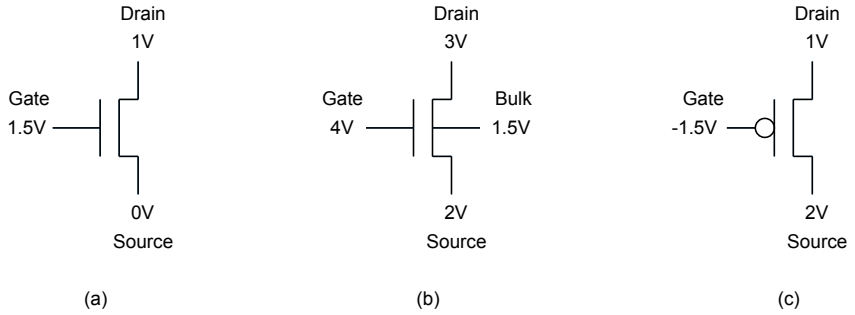
$W_n = 1\ \mu$m, $W_p = 2\ \mu$m, $L_n = L_p = 0.25\ \mu$m

$\gamma_n = 0.82\ V^{1/2}$, $\gamma_p = -0.82\ V^{1/2}$

$\phi_{sn} = -1.6$ V, $\phi_{sp} = 1.6$ V

$V_{tn0} = 0.6$ V, $V_{tp0} = -0.6$ V

$\mu_n = 600\ cm^2/Vs$, $\mu_p = 280\ cm^2/Vs$, $Cox = 7\times10^{-8}\ F/cm^2$



2. A CMOS inverter has a V_{DD} of 5V and V_{SS} of 0V. Assume that $V_{tn} = -V_{tp} = 0.8$V and other parameters are similar to one used in question 1. Also assume the standard model not including short channel effects and channel-length modulation.

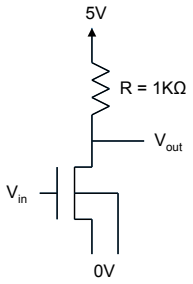
(a) What width(s) should we use for either or both transistors to accomplish a switching threshold of 2.5V? Explain why this inverter is considered balanced?

(b) We want to decrease the switching threshold to 1.5V by change the width(s) of either or both of the transistors. What should we do? Why is this inverter considered imbalanced?

3. What is the maximum drain current that can flow in a CMOS inverter with the following parameters: $V_{DD} = 5$ V, $V_{tn} = 1$ V, $V_{tp} = -1.2$ V, $\beta_n = 100\ \mu A/V^2$, $\beta_p = 40\ \mu A/V^2$.

4. Derive an expression for the switching threshold (V_M) in a resistive-load inverter in terms of V_{DD}, R_L, β_n, and V_T.

5. Consider the inverter shown in figure below, such that $V_{OL} = 0.6$V. The enhancement-type NMOS driver transistor has the following parameters: $V_T = 1.0$V, $\gamma = 0.2\ V^{1/2}$, $\lambda = 0$, $\mu_n C_{ox} = 22\ \mu A/V^2$.



(a) Determine the NMOS aspect ratio, W/L

(b) Determine V_{IL} and V_{IH}

(c) Determine noise margins NM_L and NM_H