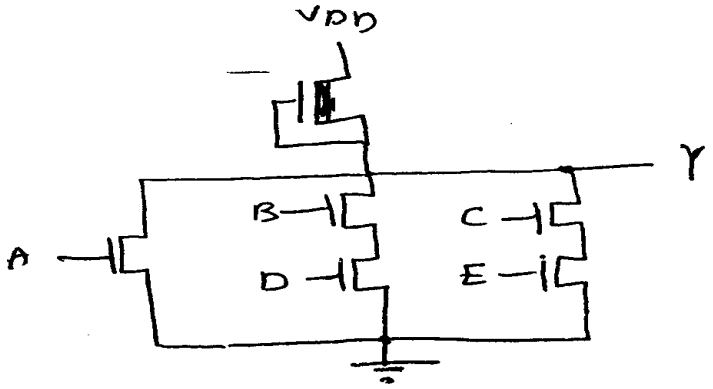
COE 360, Principles of VLSI Design, Term 071
HW# 5

Q.1. Consider a resistive-load inverter with V_{DD}=5V, V_{tn} = 0.8 v, and R_L=120 KΩ. Suppose that the average DC power dissipation of the inverter is 100 μW. Determine the values of V_{IL} and Vout(V_{IL}).

Q.2. Consider the depletion-load gate shown below with the following parameters: V_{tn}=1.0 V, V_{td}=-2.5 V, $\mu_n C_{ox}$=100 uA/V^2, V_{DD}=5 V, γ=0.4 $V^{1/2}$, $2\phi_b$ = 0.6 V, and $(W/L)_{load}$=1/3.

(i) Assuming $(W/L)_A$=2, $(W/L)_B$=4, $(W/L)_C$=3, $(W/L)_D$=6, and $(W/L)_E$=5, compute the best and worst V_{OL}.

(ii) Design the circuit (i.e. determine the W and L for the transistors) to achieve V_{OL}=0.1V (Hint: you need to consider worst case).



Q.3. A CMOS fabrication process has the following parameters:
$\mu_n C_{ox}$=100 uA/V^2, $\mu_p C_{ox}$=40 uA/V^2, V_{DD}=5 V, γ=0.4 $V^{1/2}$, $2\phi_b$ = 0.6 V,
L=1um for both nMOS and pMOS devices and W= 2 um for pMOS devices,
V_{tn}=1.0 V, V_{tp}=-1.0 V.

(i) Design a CMOS inverter such that V_{th}=2.5V for V_{DD}=5V.

(ii) Compute the NM_H and NM_L for the inverter.

Q.4. Using spice, draw a family of voltage transfer characteristics of the depletion-load NMOS inverters having $(W/L)_{pullup}$=1/2 and pulldown transistors with $(W/L)_{pulldown}$=1/1, 2/1, and 4/1 respectively. Use the parameters given in Q1 for the transistors (except W and L). What are your observations ?

Q.5. Using spice, draw a family of voltage transfer characteristics of the CMOS inverters having $(W/L)_{pullup}$=2/1 and pulldown transistors with $(W/L)_{pulldown}$=1/1, 2/1, and 4/1 respectively. Use the parameters given in Q2 for the transistors (except W and L). What

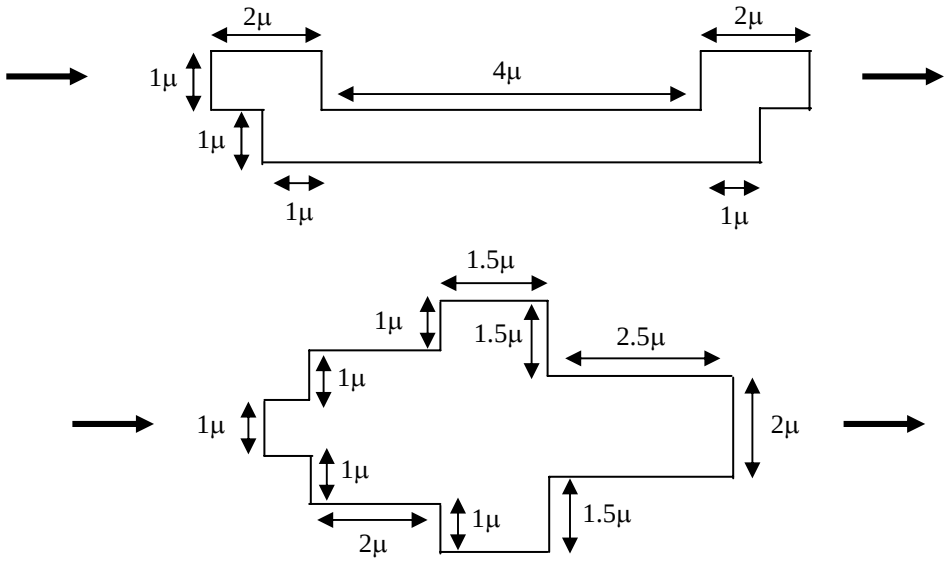
are your observations, and what are the major differences with the VTC of the NMOS inverters in Q3 ?

Q.6. In a standard single metal N-Well CMOS fabrication process, the sheet resistances of various layers are given below:

p-channel: 15X10^3 Ω/SQ
n-channel: 6X10^3 Ω/SQ
polysilicon: 20 Ω/SQ
n-diffusion: 40 Ω/SQ
p-diffusion: 150 Ω/SQ
Metal: 0.05 Ω/SQ

Since the current flow in corner squares is not uniform, it is assumed that the value of a corner square is equal to 0.66 the normal square resistance.

(i) Calculate the resistance of the following shapes for each of the polysilicon, n-diffusion, p-diffusion, and metal material types.



(ii) Calculate the channel resistance of the following transistors.