

## COE 360, Principles of VLSI Design, Term 032

### Quiz# 6 (Take Home)

**Due date: Tuesday, April 27**

**Q1.** Using MAGIC tool, draw the layout of a 3-input CMOS NOR gate  $Y=(A + B + C)'$ .

- (i) Draw the stick diagram of the 3-input **NOR** gate.
- (ii) Draw the layout of the 3-input **NOR** gate assuming that the W/L ratio for both the nmos and pmos transistors =2. Label the inputs with A, B, C and the output with Y, Vdd with Vdd! and GND with GND!. Save the layout in file *nor3* (you will get *nor3.mag*). Then, while you are still in magic, type the command *extract*. This should generate for you the file *nor3.ext*.
- (iii) Exit magic, then type the command *ext2sim -t! nor3.ext*. This step will create for you a file named *nor3.sim*.
- (iv) Simulate the 3-input **NOR** gate using the command *irsim scmos150.prm nor3.sim*. This will start the irsim simulator. Read [tutorial 11](#) and use the irsim manual in your magic directory (irsim.doc) to know how to use the simulator. Illustrate that the 3-input **NOR** gate is working properly. Include printouts of the layout and the simulation waveforms.
- (v) Extract the spice model of the 3-input **NOR** gate from the layout using the command *ext2spice -f spice2 nor3.ext*. Then, determine the propagation delays  $t_{PHL}$  and  $t_{PLH}$  across the 3-input **NOR** gate for the input patterns given in the table shown below. Note that R indicates a rising transition on the input or output and F indicates a falling transition.

A	B	C	Y
R	0	0	F
0	R	0	F
0	0	R	F
R	R	R	F
F	0	0	R
0	F	0	R
0	0	F	R
F	F	F	R

Comment on your observations and determine the worst case  $t_{PHL}$  and  $t_{PLH}$ . Include printout of the worst case  $t_{PHL}$  and  $t_{PLH}$ . Use the following models for the **nfet** and **pfet** transistors in the extracted spice file:

*.Model nfet nmos (vto=0.8 lambda=0 gamma=0 cj=1.4e-4 cjsw=4.5e-10  
ld=0.1e-6 phi=0.6 tox=100e-9 rsh=3)*

*.Model pfet pmos (vto=-0.8 lambda=0 gamma=0 cj=5.6e-4 cjsw=7.1e-11  
ld=0.1e-6 phi=0.6 tox=100e-9 rsh=3)*

**Note that this Quiz will be counted and will carry the weight of two quizzes.**