High Speed CMOS VLSI Design

Problem Set 3

The objective of this assignment is to become familiar with the HSPICE circuit simulator and to use it to extract RC parameters for gate models.

Readings:

- Skim section 6.6 of W&E.
- You may find the HSPICE User's Manual a useful reference.

1.0 Inverter Delay Simulation

In this problem, you'll learn to run HSPICE if you have never used it before and to modify a SPICE deck. The objective will be to measure inverters of various fanouts to find an equation for delay vs. fanout and to obtain the delay of a FO4 inverter.

Copy the file ~harris/ps/inv.hsp to your directory. It contains a SPICE deck with two inverters and some instrumentation statements to measure the unloaded delay of the second inverter.

a) Modify the deck to model the circuit shown in Figure 1 on page 6 of Lecture Notes 3.

b) Run HSPICE with the command

hspice inv.hsp > inv.out

and find the average delay of a FO4 inverter in the output file.

c) Modify the deck to measure delay of FO1, FO2, FO6, and FO8 inverters. You can use the SWEEP capability if you prefer.

d) Find a and b which best fit match the measured delays to t = a + bf. How good of a match is it for your process?

2.0 RC Parameter Extraction

In this problem, you will find the intrinsic transistor delay t and the capacitance/micron of a transistor. From this, you will compute the resistance of a transistor for hand calculations.

a) If the delay of a FO4 inverter is 15 τ, find τ using your result from question 1b.

b) Now we want to extract the capacitance per micron of a gate. The circuit shown in Figure 2 on page 7 of Lecture Notes 3 uses HSPICE's powerful optimization features to adjust a linear capacitor until the delay through the lower inverter is the same as the delay through the upper inverter. This gives the effective capacitance per micron of an inverter load, averaged over the switching transitions.

Copy ~harris/ps/cap.hsp into your directory. Several parts of the deck have been replaced with question marks. Fill in the appropriate values where the question marks are to complete the deck. Run it and read out CperMicron. Is it what you would expect?

c) Given the results of the two previous parts, find R for your process.