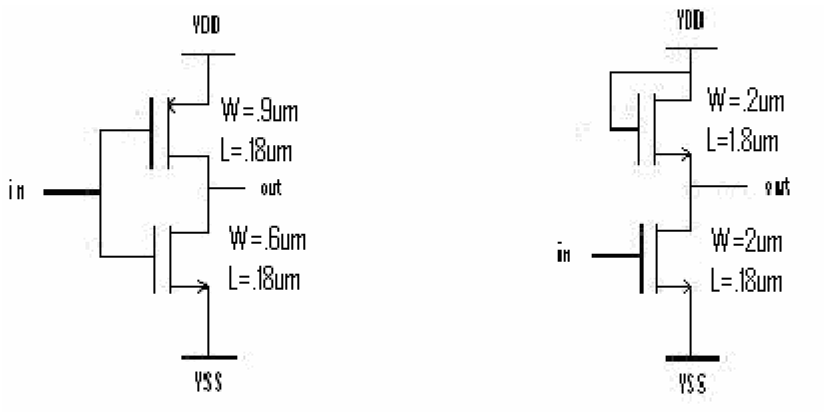
EECS523 HW#1

Goal: The purpose of this homework is to review the concepts of power consumption and speed.
Technology: .18um (tsmc18).
ECAD tool: Spectre (Cadence, Inc.), Signal Scan (Cadence, Inc.).



CMOS gate NMOS gate

Inputs in pwl (piece wise linear) format:
//Fast transient time and high frequency (transient_time = .01n, period = 10n)
//vpwl_ftr_hf (in VSS) wave= [0 1.8 .01n 0 5n 0 5.01n 1.8 10n 1.8] pwlperiod=10n

//Slow transient time and high frequency (transient_time = .6n, period = 10n)
//vpwl_st_hf (in VSS) wave= [0 1.8 .6n 0 5n 0 5.6n 1.8 10n 1.8] pwlperiod=10n

//Fast transient time and low frequency (transient_time = .01n, period = 10u)
//vpwl_ftr_lf (in VSS) wave= [0 1.8 .01n 0 5u 0 5.00001u 1.8 10u 1.8] pwlperiod=10u

//Slow transient time and low frequency (transient_time = .6n, period = 10u)
//vpwl_str_lf (in VSS) wave= [0 1.8 .6n 0 5u 0 5.0006u 1.8 10u 1.8] pwlperiod=10u

Assuming Fan Out =1:

1- Using ECAD tools and by applying the suitable input waveforms, compute
   1.1) The maximum static power consumption of the NMOS inverter.
   1.2) The maximum dynamic power consumption of the NMOS inverter.

1.3) The maximum static power consumption of the CMOS inverter.
1.4) The maximum dynamic power consumption of the CMOS inverter.
1.5) Compare the power consumptions of these gates.

2- Using ECAD tools compute the propagation delay of each of the above gates.

3- Which gate has a better power delay product?
4- Using ECAD tools, compute the propagation delay of an inverter chain in tsmc18 technology composed of 9 CMOS inverter gates.
5- Using ECAD tools, find the oscillation frequency of the above inverter chain. Find the relation between the oscillation frequency and the propagation delay of one inverter gate.
6- Finally compare the two inverters from these aspects: area, speed, power consumption and voltage levels.

Instructions for using the ECAD tools: The tools used here are spectre and signalscan. Spectre is used for simulation and signalscan is used for viewing the output waveforms.
Running the spectre: spectre can be executed from a CAEN Sun workstation. At the shell type:
<u>spectre –format sst2 filename</u>
Filename is the file which spectre uses as input. This file contains the circuit network, analysis type, circuit inputs and some other parameters which are used internally by spectre.
-format specifies the format, in which spectre writes the output. sst2 is the format recognized by the signalscan.
There are 5 files which you need for this home work
si_cmos.inp: the spectre input file which contains the CMOS inverter gate network.
si_nmos.inp: the spectre input file which contains the NMOS inverter gate network.
si_invchain_pd.inp: the spectre input file which contains the CMOS inverter chain network. (Used for question 4)
si_invchain_fr.inp: the spectre input file which contains the CMOS inverter chain network with feedback. (Used for question 5)
tsmc18.scs: the simplified spice model used by the simulation tool.

Copy these 5 files into a directory.
You should use si_nmos for questions: 1.1 and 1.2 and 2. You also need to use si_cmos for questions 1.3 and 1.4 and 2. si_invchain_pd.inp is needed for question 4 and si_invchain_fr.inp is needed for question 5.
si_invchain_pd.inp and si_invchain_fr.inp are complete and don’t need any modification. .
si_cmos.inp and si_nmos.inp are not complete and need some modifications.

Open the file si_cmos.inp. Go to the line: //Spectre Source Statements
Here the network inputs are defined. vdc0 and vdc1 are the power supplies

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vpwl_ftr_hf: Fast transient time and high frequency
vpwl_st_hf: Slow transient time and high frequency
vpwl_ftr_lf: Fast transient time and low frequency
vpwl_str_lf: Slow transient time and low frequency
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Depending on what input you want to apply, you may comment out the others by typing // at the beginning of the line.
Also when you select the input you should change the simulation time accordingly. Simply go to the line //Analysis. Depending on the input frequency (low or high) you should active the appropriate line.
The other line which you should modify is the capacitance connected to the node "out". Assuming fanout=1 you should find the capacitance value which models the gate input capacitance of the subsequent gate.

Signalscan: Can be executed from a CAEN Sun workstation. At the shell type:
signalscan &
Go to the File (in menu bar) ->Open Simulation File… . The waveform data exists in a directory with the name: filename.raw (filename is the name of the spectre input file which might be si_cmos, si_nmos or si_invchain). After selecting the directory, select the file tran1.tran.trn, click the button DesBrows:1. You'll see the list of signals in a window with the title of: Nodes/Variables in Current Context.
Click on each signal you want to see its waveform, then in the menu bar click on the button AddtoWave.
For this assignment you should view these signals:
in: the circuit input waveform.
out: the circuit output waveform.
pwr: the instantaneous power dissipated in the network.
After adding these signals to the waveform window, you should work with the 2 cursors(Cursor1 and Cursor2) to extract the data from the waveforms. E.g. if you want to measure the dynamic power, Cursor1 should point at the time in which pwr begins to change and Cursor2 should point at the time in which pwr has almost reached its final value. Click on the pwr signal name to highlight the waveform. Then go to the menu bar View->Average value between Cursor1 and Cursor2.
A dialog box pops up and you see the average power consumption between the two cursors. Now if you want to compute the dynamic power it would be (*average * transition_time/period)*. You can use the same technique to compute the static power, just put the cursors at the two ends of

the static time (t1, t2) on one side of the transition, computer the average (a1) as mentioned above. Then put the cursors at the two ends of the static time (t3, t4) on the other side of the transition, compute the average (a2). Remember that the transition time shouldn't be included in any of the time intervals when computing the static power.
Now the average static power would be (*a1 * (t2-t1) + a2 * (t4-t3)) / (t2-t1 + t4-t3).*
The static power would be (*average * static_time/period).*
What to turn in: You should turn in your results, calculations along with the print of the waveforms you've used to reach the results.