ECE 3421 – VLSI Design and Simulation, Spring 2013

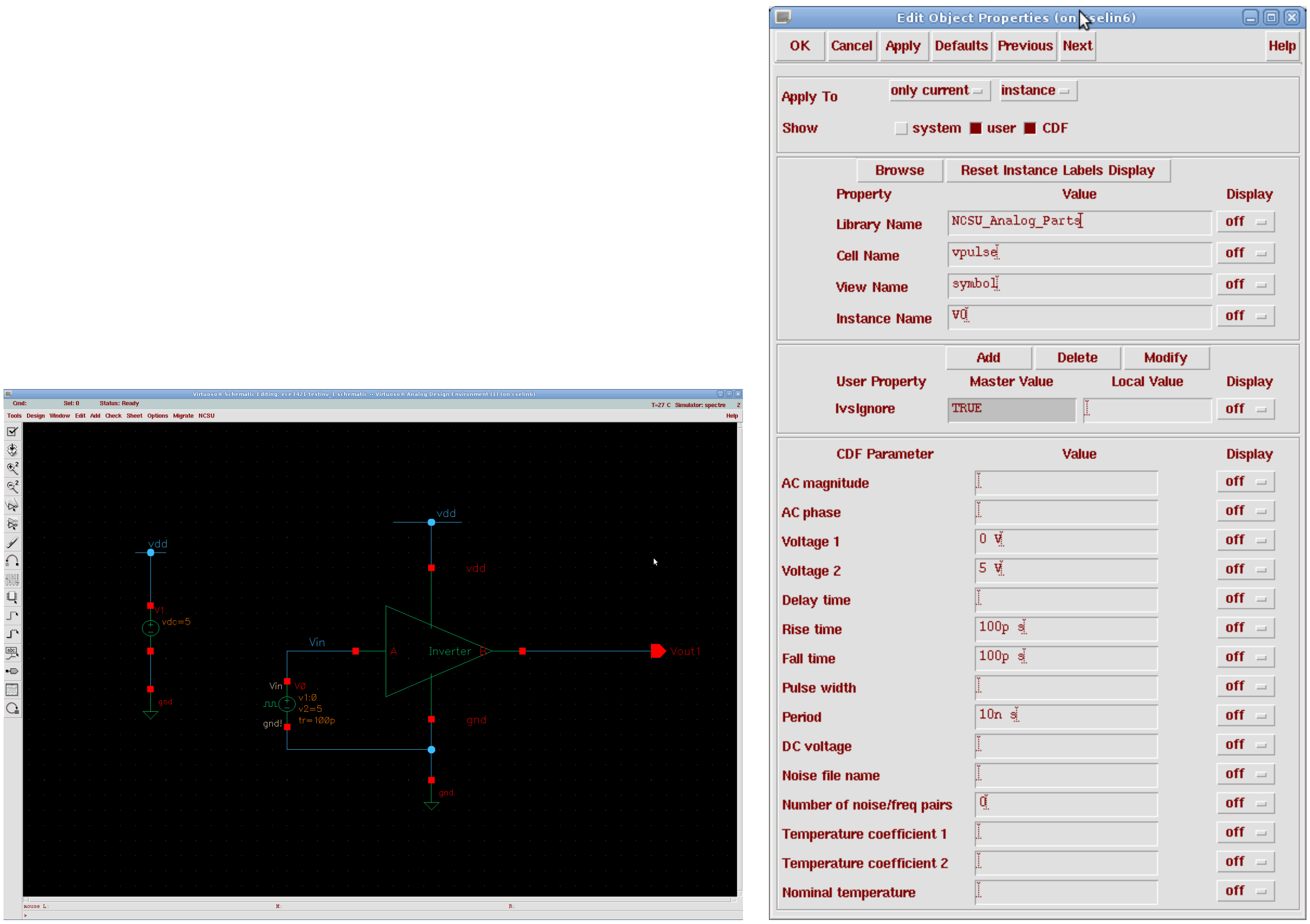
Lab Assignment 5
Power and Energy Analysis

1. Introduction

This lab will introduce you to concepts of power and energy analysis of VLSI circuits. In this lab, assuming this inverter is working under a clock cycle of 5ns, the dynamic(switching) and static(non-switching) power/energy will be measured.

2. Power/Energy Measurement of Inverter

[STEP 1:] Create a new Cellview Schematic in the ece3421 library, as shown in Figure 1a. This should be similar to testinv schematic in lab 1. For the inverter, set the “Wn” and “Wp” to 10μm. For the vpulse, set “Voltage2” to 5V, “Rise time” and “Fall time” to 100ps, simulation “Period” to 10ns, as shown in Figure 1b.



(a) Inverter. (b) vpulse property.

Figure 1: Inverter schematic and vpulse setup.

[STEP 2:] Open Analog Environment, go to Output → Save all. Click the appropriate checkboxes, as shown in Figure 2. Then click OK. This allows us to save the power signals as well.

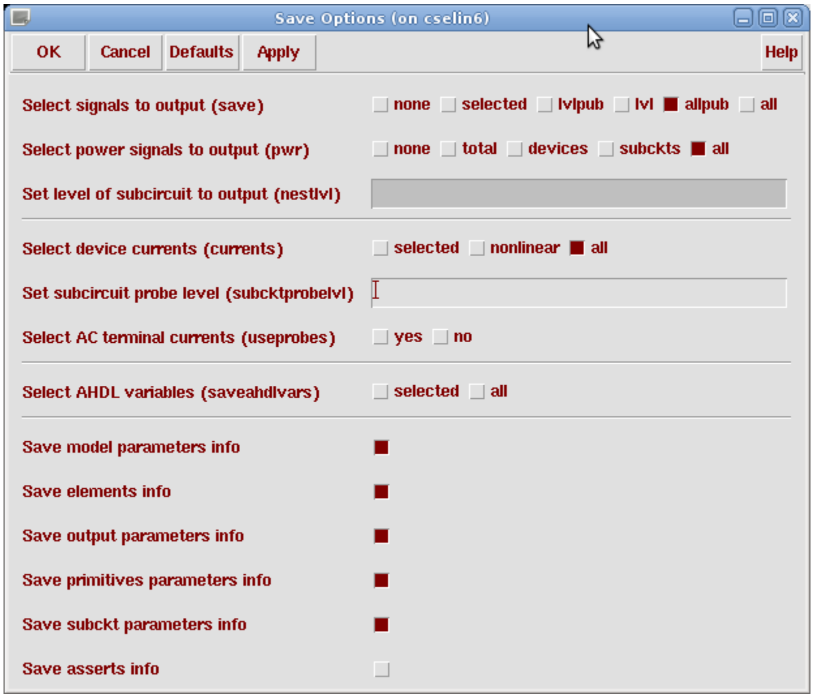


Figure 2: Save Options.

[STEP 3:] Start a transient simulation with Stop Time is 10ns. Plot the input and output.

[STEP 4:] In the Graph Window of the plot, go to Tools → Browser, then a Results Browser window appears. Set the drop list at upper right to "Append". Select "tran-tran" on the left, then double click pwr, as shown in Figure 3. Then a plot of pwr should be added to the Graph Window, as shown in Figure 4. (Hint: you can always go to Axis → Strips, to separate the waveforms.)

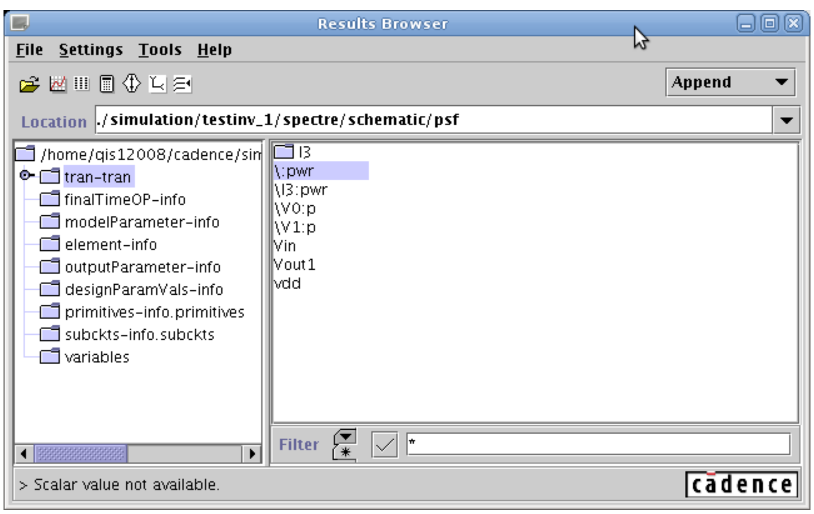


Figure 3: Result Browser.

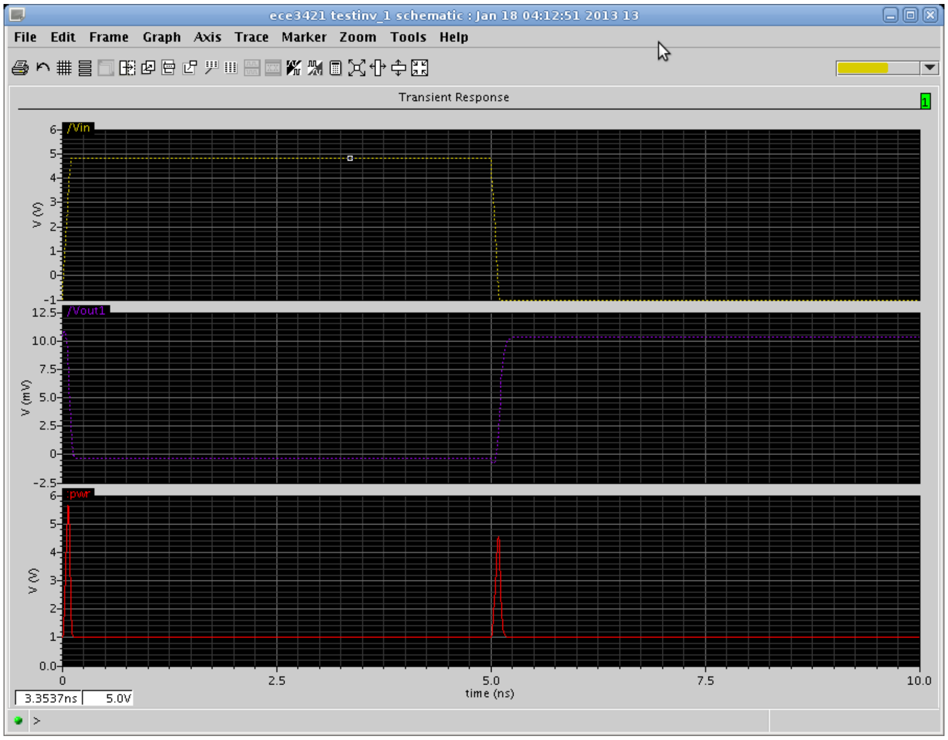
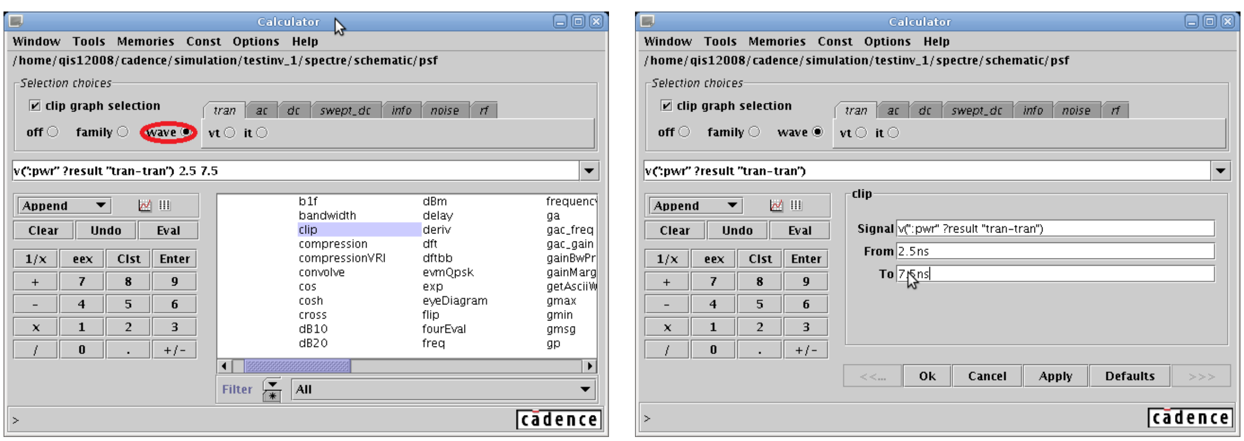


Figure 4: Plots with Power.

[STEP 5:] Go to Tools → calculator. A calculator window should appear, as shown in Figure 5a. Click checkbox "wave" , then select the pwr curve from Graph Window. Find function "clip" (select portion of the waveform) from lower right box, as shown in Figure 5a. Double click "clip", then set "From" = 2.5ns, "To" = 7.5ns, as shown in Figure 5b, note: the signal name may be different, then click Ok.

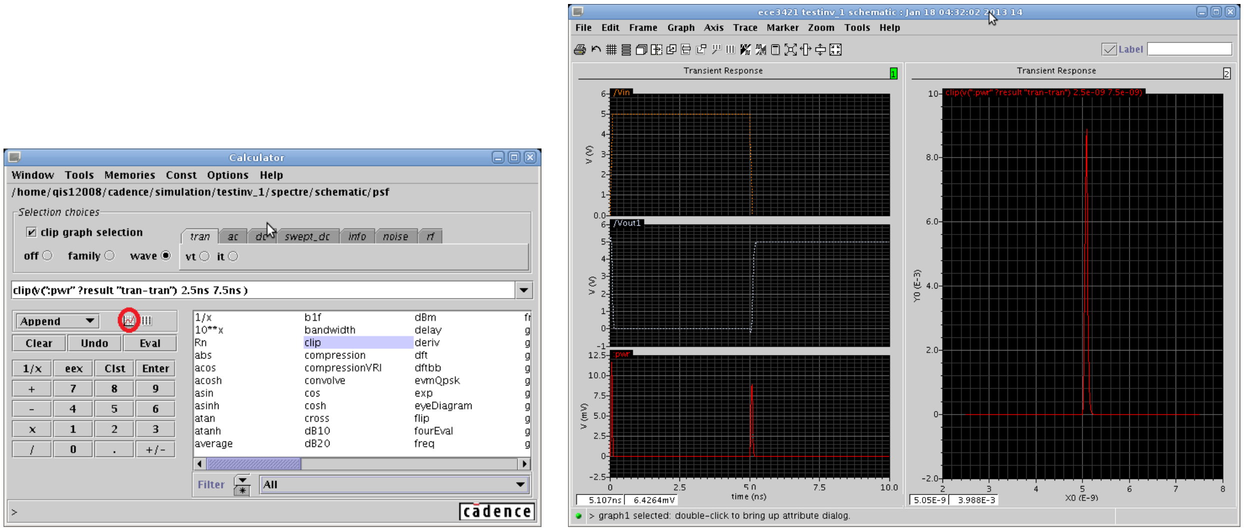


(a) Calculator —- select waveform.

(b) Calculator —- clip function.

Figure 5: Calculator.

[STEP 6:] Click the icon "Plot", as shown in Figure 6a. The power plot from 2.5ns to 7.5ns (one assumed clock period) should be added to Graph Windows, as shown in Figure 6b.



(a) Calculator —- plot icon.

(b) Plots with Power from 2.5ns to 7.5ns.

Figure 6: Power plot.

[STEP 7:] Go to Tools → calculator, click “wave” to select the new power plot (2.5ns to 7.5ns), click function “average” (average value). Then click the plot icon. A value of average power during the time period of 2.5ns to 7.5ns should appear, as shown in Figure 7. Record the average power value.

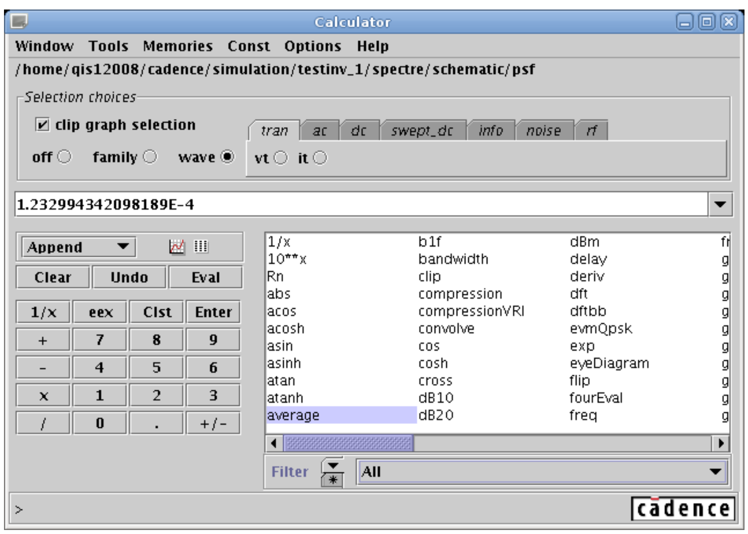


Figure 7: Calculator —- average power

[STEP 8:] Clear the input textbox, then click “wave” to select the new power plot (2.5ns to 7.5ns) again, click function “iinteg” (calculate integral), then click the plot icon. The plot of energy during the time period of 2.5ns to 7.5ns should appear, as shown in Figure 8.

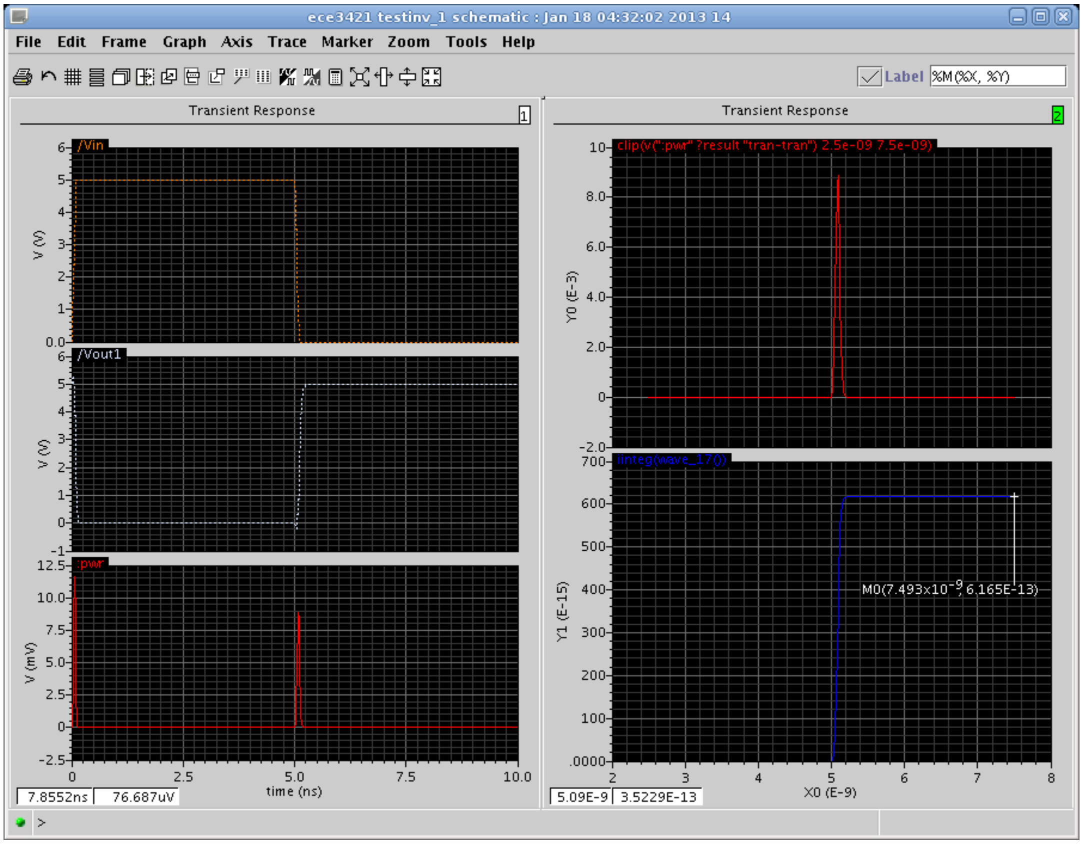


Figure 8: Plots with power and energy

[STEP 9:] Mark the energy consumption and save the plot. You have successfully captured the average power and energy consumption of the inverter circuit with input transitioning from 1 $\rightarrow$ 0 (assuming clock period of 5ns). Note: You may verify the measured energy consumption by taking the product of the measured average power (also shown in Figure 7) and the 5ns assumed clock period.

[STEP 10:] Repeat the previous steps to measure/plot the power, average power and energy in one assumed clock cycle (5ns) for the other input scenarios: input switching from 0 $\rightarrow$ 1, input stays at 0, input stays at 1.

Assignment

1. Why is the dynamic (switching) power/energy much larger than the static (non-switching) power/energy?
2. Why is the dynamic power/energy of 1 $\rightarrow$ 0 and 0 $\rightarrow$ 1 input transitions different?
3. Design a 2-input NAND gate in cadence using Wn = Wp = 2μm, and L = 0.6μm for both NMOS and PMOS transistors. Complete the energy column in Table 1. Discuss why energy is different for various input combinations.

Input A	Input B	Output	Energy per clock period
0	0→1	1	
0	1→0	1	
1	0→1	1→0	
1	1→0	0→1	
0→1	0	1	
1→0	0	1	
0→1	1	1→0	
1→0	1	0→1	
0→1	0→1	1→0	
0→1	1→0	1	
1→0	0→1	1	
1→0	1→0	0→1	

Table 1: Energy measurement of a 2-input NAND gate.