

POWER MEASUREMENT

POWER MEASUREMENT IN CADENCE SPECTRE

The methodology to measure power using Cadence Spectre is described in this document.

Assumptions:

The technology used in the project is 0.35um CMOS technology. In this technology, gate tunneling leakage current is negligible. The current drawn from the input terminals is, therefore, assumed to be zero. The power consumed by the circuit is primarily due to the current drawn from the power supply (vdd!). The methodology described below, is therefore, valid only with this assumption.

Circuit:

The 2-bit inverter is used as an example to show how power measurement is done in cadence spectre. The 2-bit inverter we developed during the Tutorial-I is shown in Fig. 1.

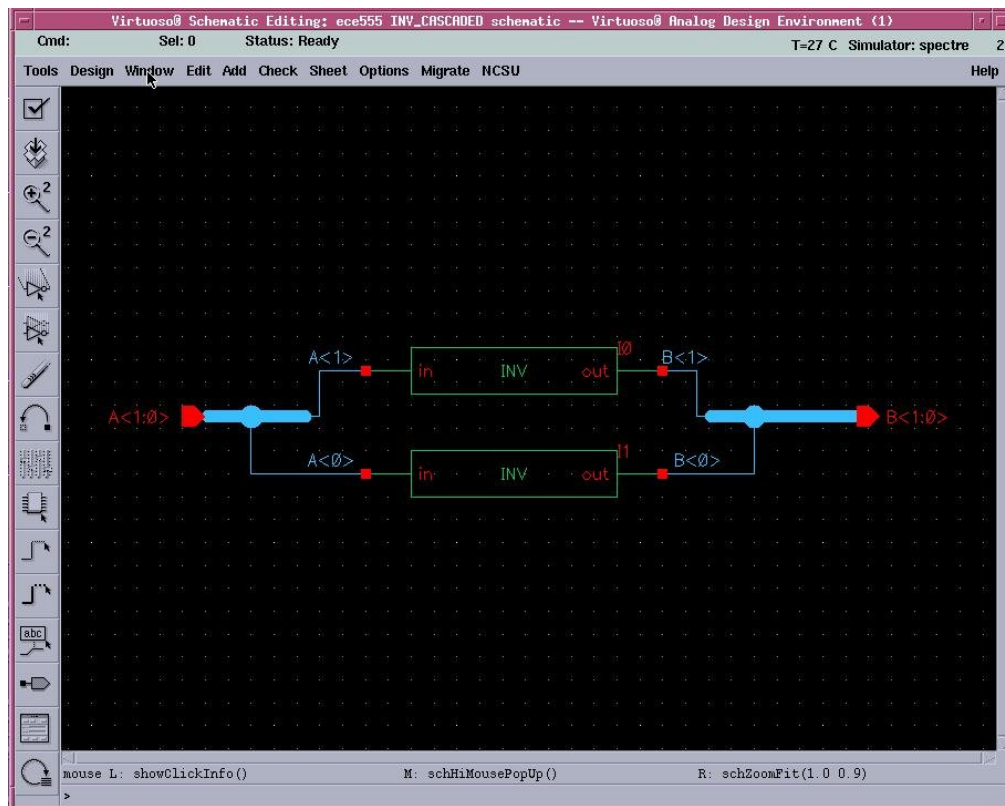


Fig. 1. 2-bit inverter developed during the tutorial.

To simulate this 2-bit inverter, we discussed two different techniques. (refer Tutorial-I)

- 1) Writing the stimuli (in the analog environment window)
- 2) Writing a stimulus file and adding the stimulus file during the simulation in the analog environment window.

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A sample stimulus file for the 2-bit inverter is given below.

```
V1 vdd! 0 DC 3.3
V2 gnd! 0 0
V3 A_1 0 pulse (3.3 0 0 0.1n 0.1n 4n 8n)
V4 A_0 0 pulse (0 3.3 0 0.1n 0.1n 4n 8n)
```

Power Measurement

Instantaneous Power Consumption

$P(t) = \text{Power supply voltage (vdd)} * \text{current drawn from power supply at time (t)}$

Average Power Consumption

$\text{Average Power} = \text{Integration(Instantaneous Power)} / \text{Time Period}$

Changes to the Existing Schematic:

The following changes need to be done for the smooth measurement of the power drawn from the power supply.

- On the top-level of your schematic, add a V_{dc} source (from the analog library) and connect its positive terminal to our global $V_{dd!}$ and its negative terminal to our global $GND!$.
- The connection made for the 2-bit inverter is shown in Fig. 2.
- Select the V_{dc} source (a white box appears around the selected item), and press Q.
- An edit object properties window will appear as shown in Fig. 3.
- Type 3.3V (the power supply for the project) across DC Voltage (as shown in the Fig. 3)
- Press OK.
- The new schematic with the defined voltage will appear as shown in Fig. 2.
- This addition of the V_{dc} source has to be done only to the top-level of your schematic and **SHALL NOT** be done for each of the blocks in your project.
- This is the only change that needs to be done in the schematic for the power measurement.
- Save the sheet (check and save) and go to the analog-environment window for performing the simulation.

Simulation:

- We will do the circuit simulation using the stimulus file method. (Refer Tutorial – I)
- Make all the necessary set-up for the simulation.
- Since the V_{DD} is explicitly defined in the schematic using a V_{dc} source, the definition for V_{DD} can be removed from the stimulus file.
- A new version of the stimulus file after removing the VDD definition is given below.

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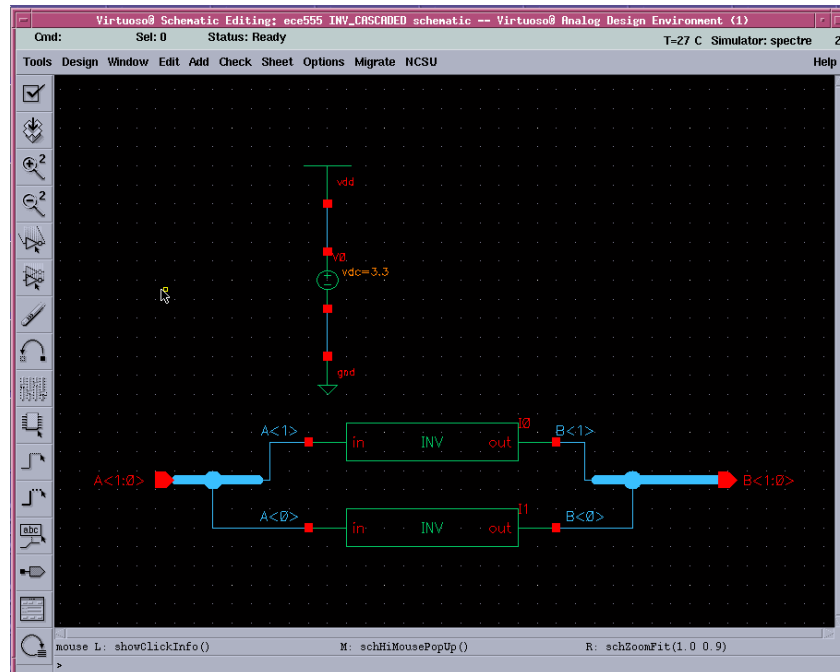


Fig. 2. 2-bit Inverter with a VDC source.

The 'Edit Object Properties' window is shown. It has tabs for 'OK', 'Cancel', 'Apply', 'Defaults', 'Previous', 'Next', and 'Help'. The 'Apply To' section has 'only current' and 'instance' buttons. The 'Show' section has checkboxes for 'system', 'user', and 'CDF'. The 'Browse' and 'Reset Instance Labels Display' buttons are also present. The 'Property' table lists the following properties and their values:

Property	Value	Display
Library Name	analogLib	off
Cell Name	vdc	off
View Name	symbol	off
Instance Name	v0	off

The 'User Property' section has 'Add', 'Delete', and 'Modify' buttons. The 'Master Value' and 'Local Value' columns are shown. The 'Display' column is 'off'.

User Property	Master Value	Local Value	Display
lvignore	TRUE		off

The 'CDF Parameter' table lists the following parameters and their values:

CDF Parameter	Value	Display
AC magnitude		off
AC phase		off
DC voltage	3.3 V	off
Noise file name		off
Number of noise/freq pairs	0	off
XF magnitude		off
PAC magnitude		off
PAC phase		off
Temperature coefficient 1		off
Temperature coefficient 2		off
Nominal temperature		off

Fig. 3. Edit Object Properties Window

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V2 gnd! 0 0

V3 A_1 0 pulse (3.3 0 0 0.1n 0.1n 4n 8n)

V4 A_0 0 pulse (0 3.3 0 0.1n 0.1n 4n 8n)

- Add the new stimulus file (Set-up -> Simulation File -> Stimulus File) to the analog environment window. Make all other necessary set-ups (refer Tutorial-I).
- To plot the current drawn from the V_{DD} , select Output-> To Be Plotted -> Select on Schematic in the analog-environment window and then select the +ve terminal of the V_{dc} source in the schematic.
- A circle appears in the schematic as shown in Fig. 4. Make sure the circle appears. If it does not appear, then you are plotting the voltage and not the current.
- The analog environment window after all the necessary set-up will resemble Fig. 5.

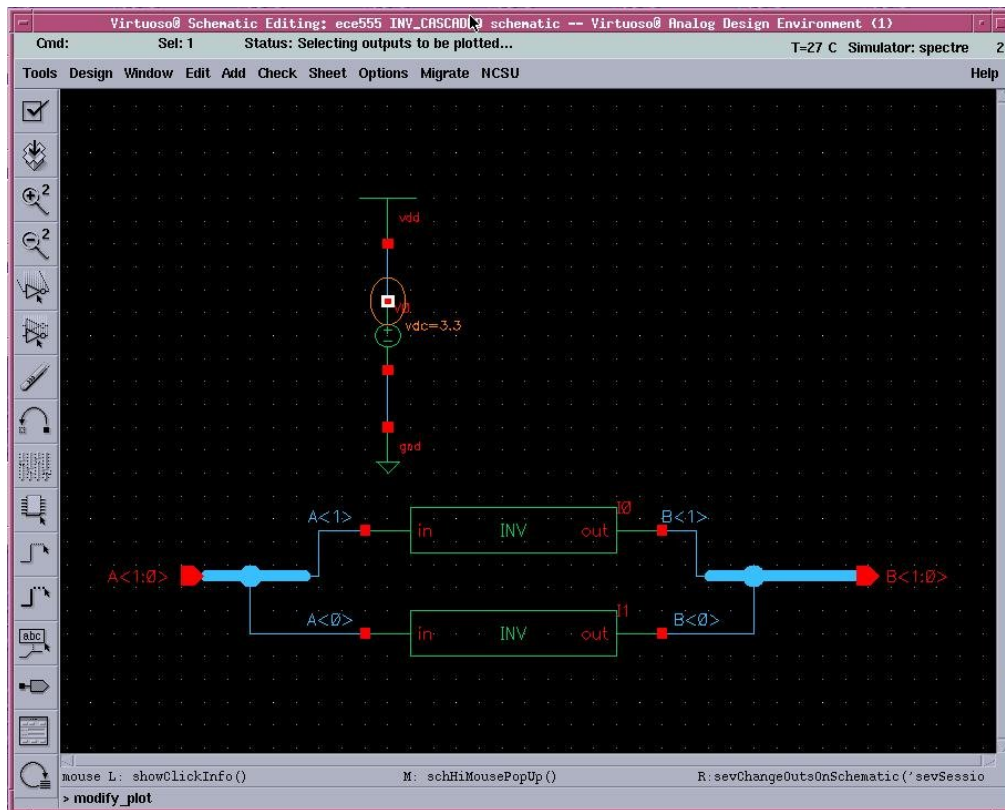


Fig. 4. Outputs to be plotted. The current drawn from VDD.

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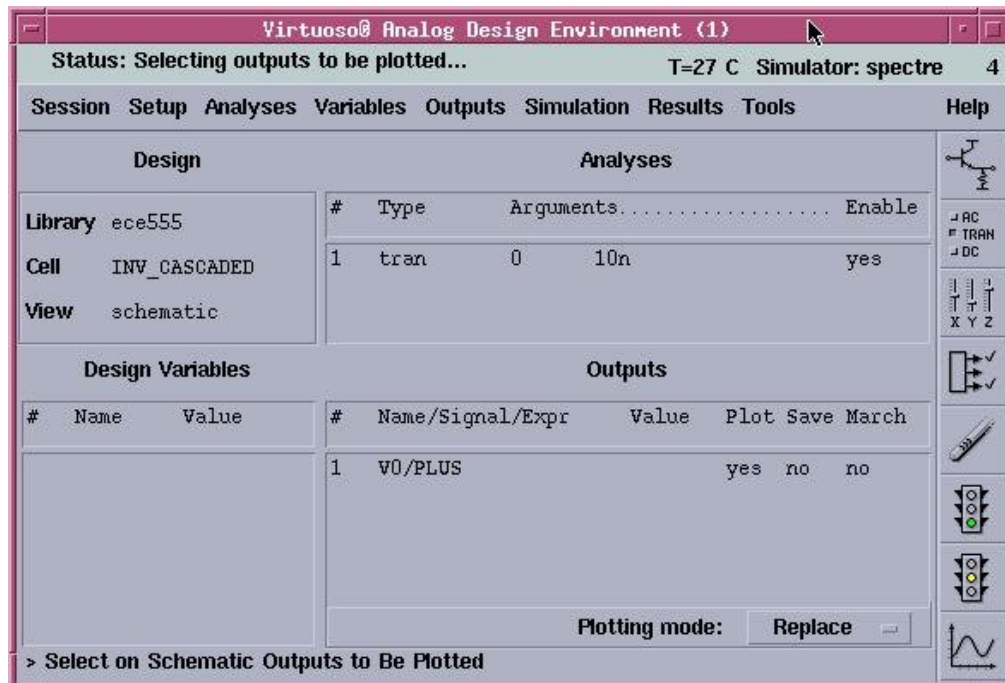


Fig. 5. Analog Environment Window

- Simulate the circuit and the current plot of the VDD will pop-up as shown in Fig. 6.

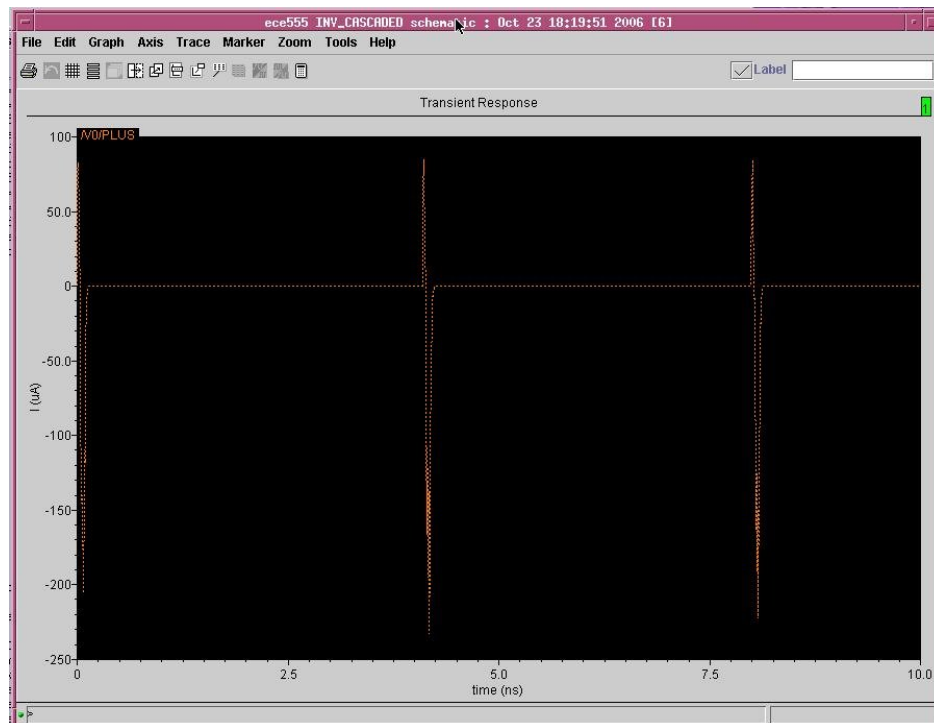


Fig. 6. Current Waveform of VDD

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- Select the calculator from the waveform window (right-most button in the waveform window) and select “WAVE” in the selection choices.
- Select the function “INTEG” from the built-in functions.
- The calculator window will appear as shown in Fig. 7.

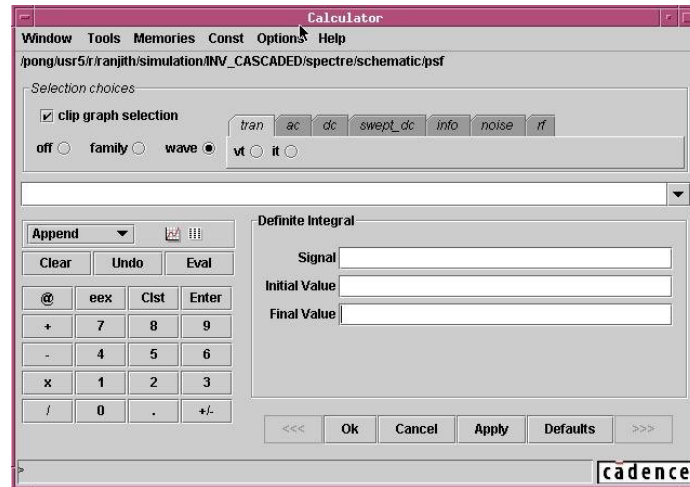


Fig. 7. Calculator Window after “INTEG” function selection

- Keep your cursor on the Text box for Signal and select the current waveform from the waveform viewer window.
- This simulation (for the 2-bit inverter) is done from 0n to 10ns. Let’s find the average power consumed by this circuit from 0ns to 5ns.
 - The time period of integration is 5n for this experiment. In your project, the time period will be the total time period required for completing the execution of the “Test_Full_Unit” file posted in the course web-site.
- In the Signal text box, multiply the current waveform by 3.3 and divide by 5ns.
 - In other words type “*3.3/5n” after the text indicating the current signal
- In the initial value text box type: 0
- In the final value text box type: 5ns
- The waveform window will now resemble Fig. 8.

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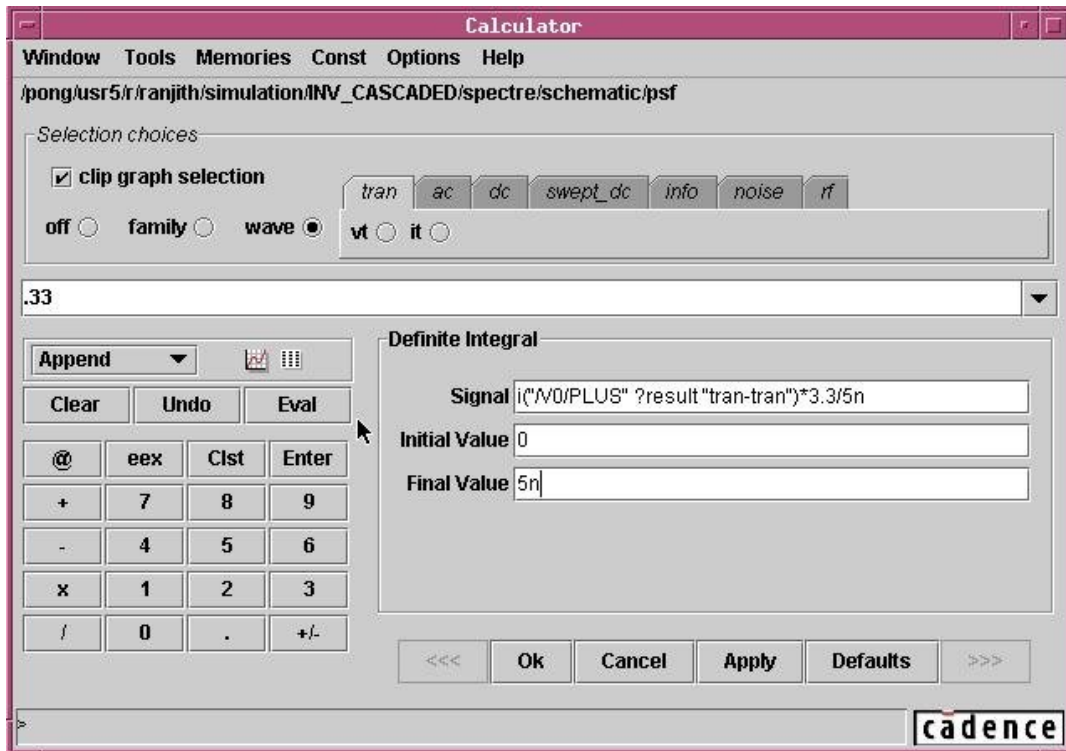


Fig. 8. The Calculator Window after loading all the necessary text-boxes

- Press OK.
- The expression for power calculation appears in the result text-box
- Press “EVAL” from the keypad in the left-hand side of the calculator.
- The average power consumed by your circuit will be displayed in the result text-box, as shown in Fig. 9.

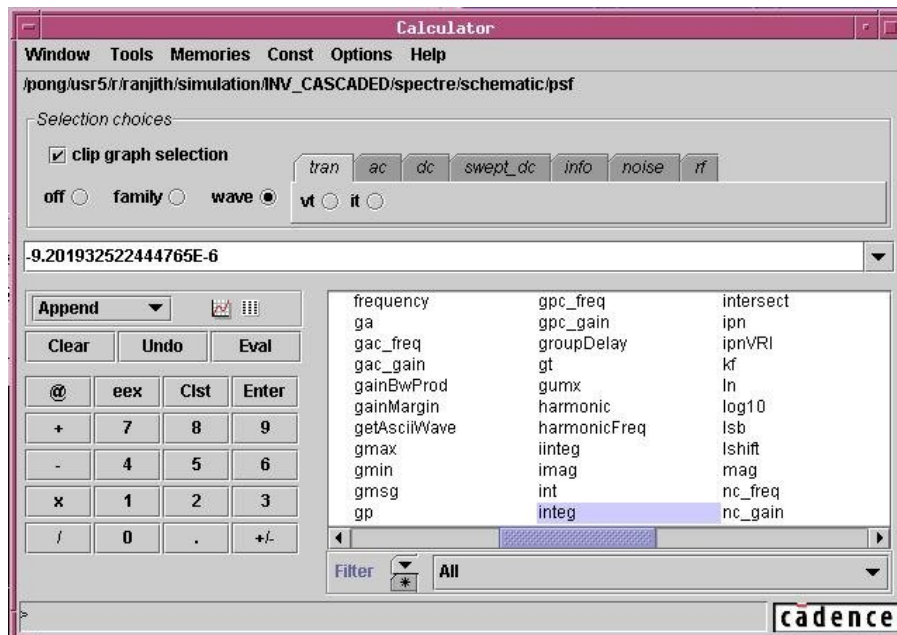


Fig. 9. Average Power Consumed