Cadence Calculator Basics

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Introduction:

The Cadence Calculator is a powerful tool inside Virtuoso that allows you to apply a wide variety of mathematical formulas and functions to signals from your schematic. This document is meant to be a quick introduction to the basic use of this calculator by going over a basic application.

Example Application:

The example circuit used for this document will be a single transistor amplifier as shown in figure 1. Using the Cadence calculator, the voltage gain from Vin to Vout of the circuit can be found. If it has not already been explained in class, the DC gain of this single transistor circuit can be approximated as the transistor's transconductance (this is called gm inside virtuoso) multiplied by the resistors value (in this case 20Kilo Ohms). While there are a few ways for this to be done, this document will focus on two different strategies. The first is to apply the general equation for gain which is Vout over Vin and the other applys the calculation for the gain of a single transistor amplifier.

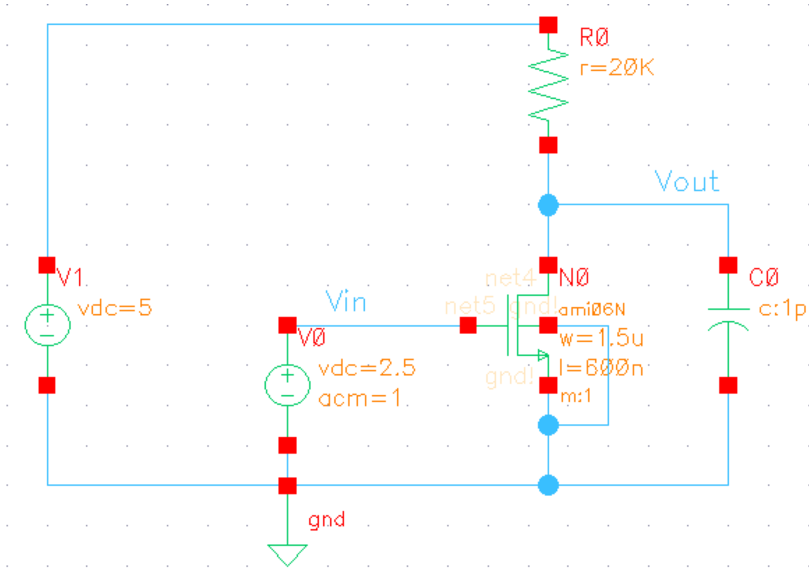

Figure 1: Single Transistor Amplifier Circuit

First, make the circuit shown in figure 1. Use the vdc, res and cap components from the analog library for the voltage sources, resistor and capacitor. The NMOS transistor N0 needs to be instantiated from the NCSU_Analog_Parts Library. For the voltage source V0, ensure that it has been given both a DC voltage of 2.5V and an AC magnitude of 1V.

Next, you will need to set up the simulations that will allow you to find the values required for the gain calculations. This is done through the ADE L window which an be opened by clicking on launch in the top menu bar and selecting ADE L. This should bring up the window in figure 2. Open the analyses window by clicking on the button that say AC,DC, Trans on the side of the window shown in figure 2 or by clicking on Analyses in the menu bar and clicking choose. There will be two analyses that will be set up: a DC Analysis as shown in figure 3 and an AC analysis shown in figure 4. The DC analysis enables Virtuoso to find the transconductance of the transistor and the AC analysis will enable us find the AC values for the Vin and Vout voltages.

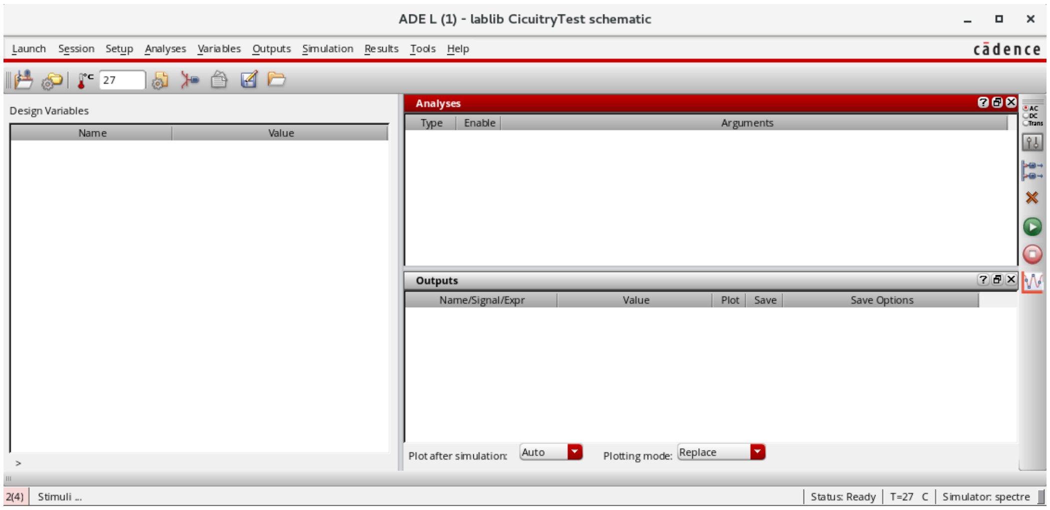

Figure 2: ADE L Window

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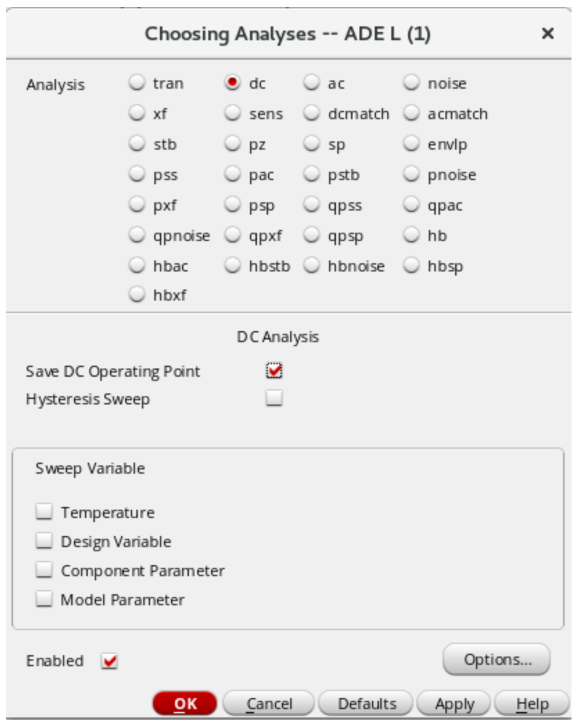

Figure 3: DC Analysis Setup

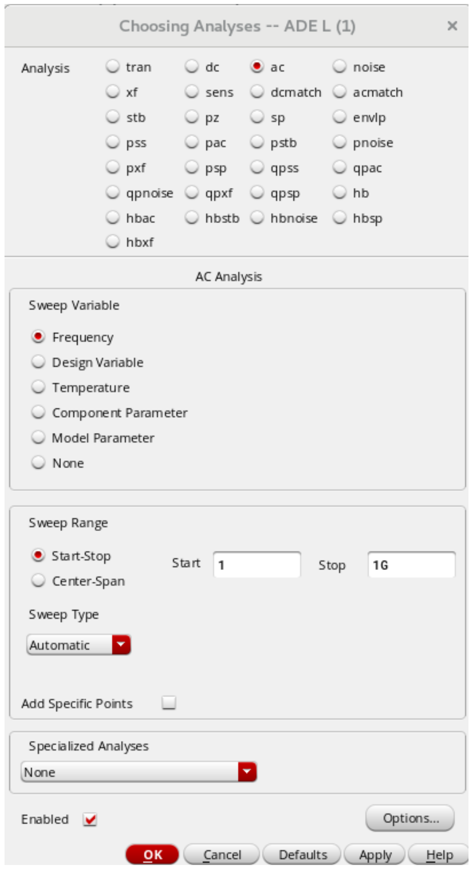

Figure 4: AC Analysis Setup

Next, right click in the Outputs sub-window in the ADE L window and click edit to open the Setting Outputs window as shown in figure 5. Click Open to open the calculator. This will open the window seen in figure 6.

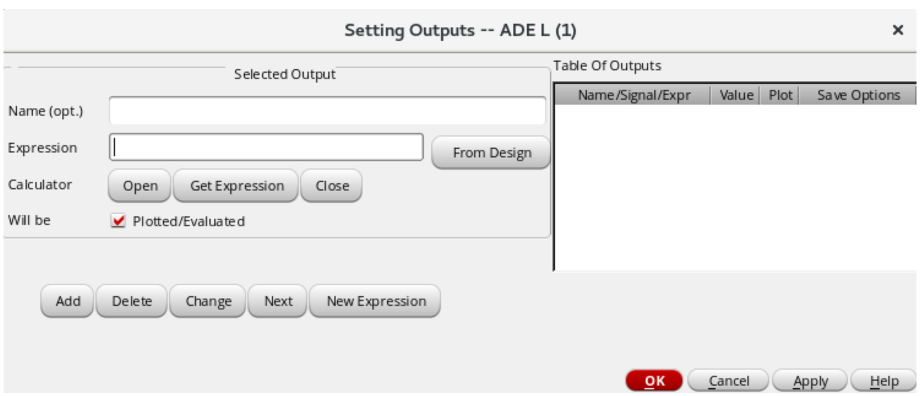

Figure 5: Setting Outputs Window

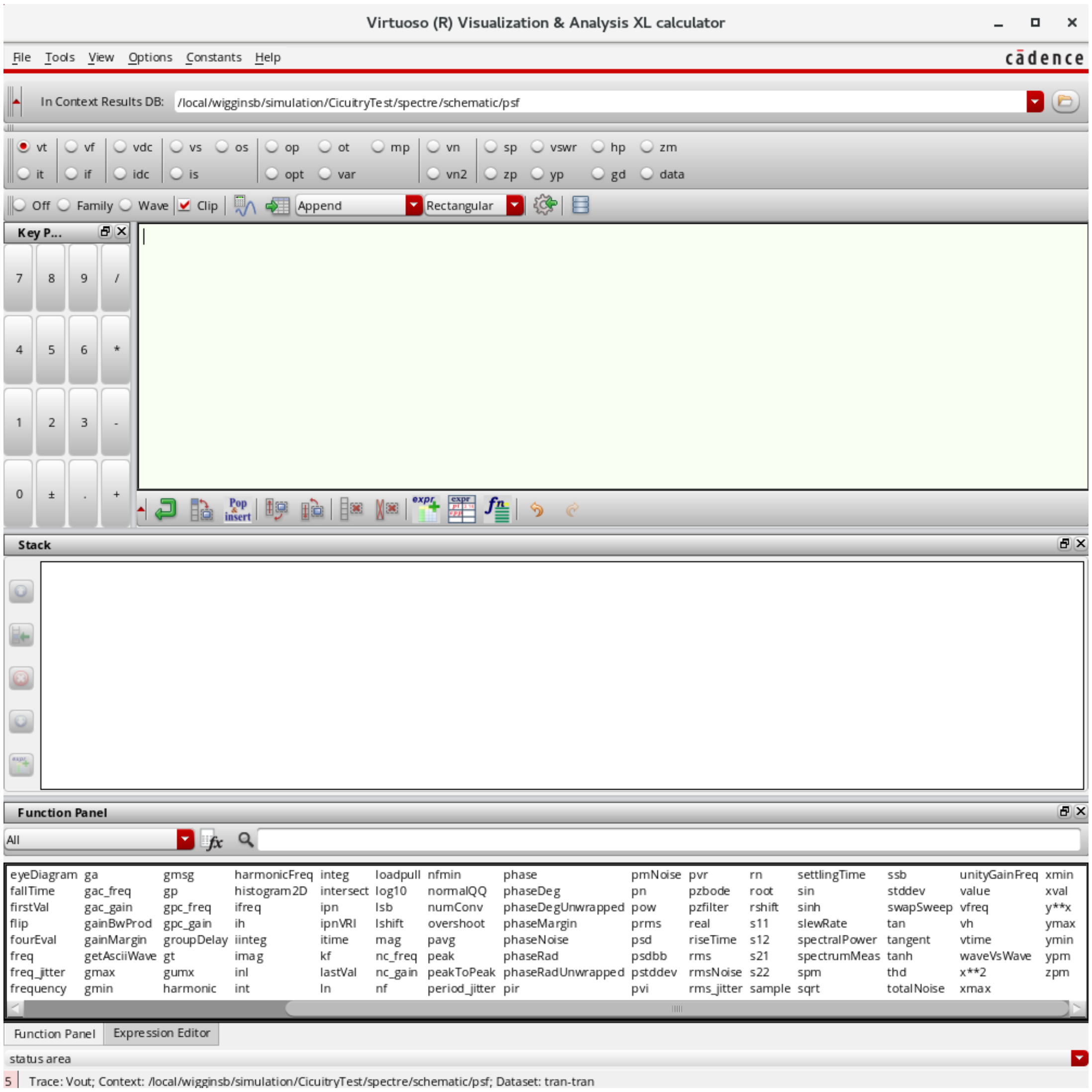

Figure 6: Main Calculator Window

There are a few main parts of the calculator window that I'll go over quick. Near the top of the window are buttons with labels like vt, it, vf, if, vdc, idc and many more. These buttons allows you to specify information from your schematic that you wish to use in the calculator based on what analysis you are using and whether you want a voltage or current. For instance, the vt button will allow you to select a node to access it's transient voltage signal. Of course the transient analysis needs to be set up in the ADE L window in order to use this. If you wish to use a current in the calculator, click on the appropriate button for the analysis you are using and select the terminal of a device whose current you wish to monitor.

Below this bar is a big window which is your display for your equations. Directly below this is a menu bar with icons in it such as a green arrow and a button that says Pop and Insert. This menu allows for interaction between the stack window, which is located below this menu bar, and the display window. The stack works essentially the same as it does in computer memory. Clicking the green arrow stores whatever is in the display window on top of the stack and the Pop and Insert Buttons takes whatever is on top of the stack and puts in the display window. You can also place a value from the stack to the display window by double clicking on it.

Finally, the stack window is the function panel. This panel contains a wide variety of mathematical functions that you can use with signals from your diagram. We will use this in a moment.

First we will see how to implement the basic Vout over Vin equation in the calcuator. The calculator works using reverse polish notation when the calculators keypad is used, we will need to obtain all of our variables before typing in the function. Because we wish to use a AC voltage in our calculation, click on the vf button. When you do so, the schematic window will open and you simply need to click on the Vout node or the Vout label. Once you do, the calculator window will open again but now the function VF("/Vout") should be displayed in the display window. Next, click the vf button again and this time select the Vin node. Notice that when the calculator window opens again, the function VF("/Vin") is displayed in the display window and VF("/Vout") has been automatically pushed onto the stack. To create the equation Vout over Vin, click on the division symbol on the keypad to the left of the display window. Now the equation VF("/Vout")/VF("/Vin") should be in the display window. Notice that the calculator has automatically converted out of reverse polish notation fo display the equation.

Now that the equation is formed, go back to the setting outputs window and click the get expression button. This copies whatever is in the calculators display window and pastes it into the Expression Field. This also means that once you become more familiar with cadences syntax, you can tyoe your equations in here without opening the calculator. Next give it a name such as Gain and then click the add button in the bottom of the window to add the Gain equation to your list of outputs. Once this is done, notice that Gain is now a listed output in the ADE L window. To view the AC gain of the circuit, click the green play button in the ADE L window. Doing so should give you the graph seen in figure 7.

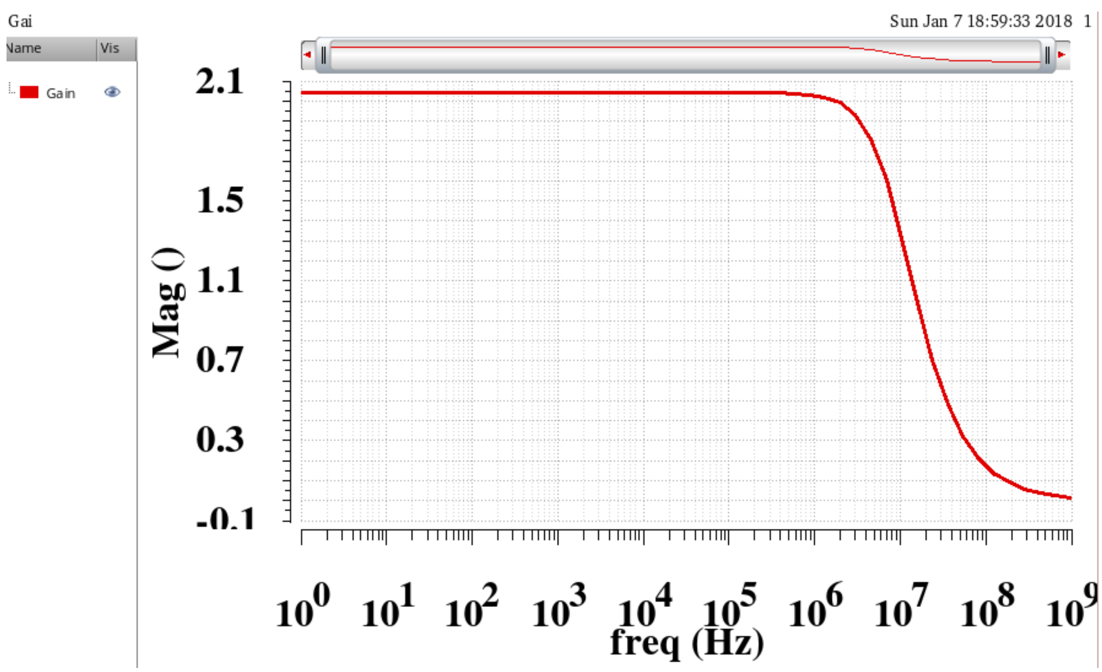

Figure 7: AC Gain of the circuit in figure 1

But our goal was to find the DC gain of the circuit. Fortunatly, the calculator allows us to use previously defined variables in the calculator. The DC gain from this graph can be approximated by using the first point which has a frequency of 1Hz. We will now show how to access this point from the calculator.

Reopen the calculator window and type Gain into the display window. Next, find the absolute value function (abs) in the function panel and click on it. The display window should now contain abs(Gain). Next to access the value at 1Hz, find and click on the value function in the function window. Doing so brings up a window that allows you to fill out fields that represent other arguments for the function. One of these fields will usually be called signal and the calculator will automatically paste whatever was in the display window in this field. The only other required field for this function is the interpolate at field which in this case tells the value function what frequency to use for the output value so type a 1 in this field. For some reason, the value function doesn't like it when this output is negative fo frequencies which is why the absolute function was used first. To finish the function click OK and the function will be placed in the display window. If this was all done correctly, the following should be the function in the display window: value(abs(Gain) 1). Go back to the Setting Outputs window and use the Get Expression button to paste the equation in the Expression field, call this variable DCGain and add it to your Outputs. Click on the green play button and notice that the value of DCGain (if everything was done correctly it should be 2.044) matches the DC gain shown in figure 7. Also, if this is used with a parametric analysis, this variable will be applied to the parametric analysis and will graph the result of the inputted equation based on the sweep variables of the parametric analysis.

The second strategy for calculating the DC gain of the circuit is by using the equation for the gain of a single transistor amplifier. This involves using the transconductance of the NMOS which is a type of variable in Virtuoso that is called an Operating Point. To access this, open up the calculator and find the op button that is in the same bar as the vt, it, vf etc. buttons. Clicking on this button will bring up the schematic window and the select an instance window. Click on the NMOS and the select an instance window's name will change to OP parameters for N0 (you might need to click on the tab to reopen the window). Click on the list box and find the variable gm. Once you click on this variable, the calculator window should pop up and OP("/N0","gm") should be in the display window. Next you could type in the multiplication by 20000 to finish the equation; or you could use the op button again. This time select the resistor and in select the res variable from the list. Now, the calculator will automatically use whatever value is inputted into the resistor in it's calculation meaning you won't need to change your equation if you want to change your resistor value. Click the multiplication sign in the calculator window and use the Setting Outputs window to add the equation to your Outputs under the name CalcDCGain. Clicking the green play arrow should allow you to observe a calculated value of 2.264. This shows there is a little under 10% error from the actual value of gain that we found by using Vout over Vin. Once you learn about this in class, you will learn how to form a more accurate prediction for the DC gain.