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1. Objective

This Tutorial contains a step-by-step procedure for simulating a common source amplifier circuit in the Mentor Graphics Design Architect tool. It covers DC Analysis, Transient Analysis, DC Operating Point Analysis and AC Analysis simulation of the amplifier.

re eaghean chunch chunch chunch coonidean chunch c This tutorial assumes that the schematic of the amplifier has already been created. For help with creating schematic and symbol, please refer to the Analog IC Schematic Entry

2. Basic Test Circuit Creation

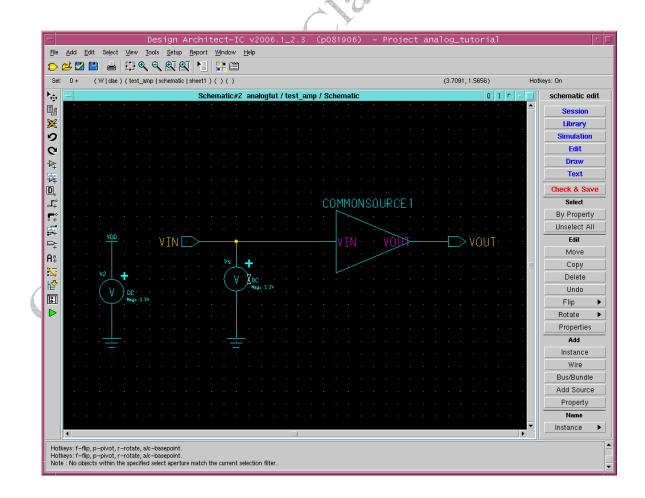
- Open icstudio from the command prompt as in the Schematic Entry tutorial
- Create a **new view** in the created library (**analogtut**) and name it **test_amplifier** with **view type** as **Schematic**. We will use this sheet to create basic test circuit required for the simulations.



1. Adding an Instance to the test circuit

A new schematic entry sheet opens in DA-IC. In the test_amp schematic:

- Add the symbol for the amplifier that you generated in the schematic entry tutorial.
 - Click Add > Instance from schematic_edit palette on RHS.
 - In the **Choose Symbol** popup window, click **Browse**, navigate and select **CommonSource** and click OK. Place this symbol of the inverter in the sheet as shown in the figure below.
- Add PORTIN, PORTOUT, VDD and Ground from the Generic Lib
- Name the ports as **VIN** & **VOUT**, and wire them to the **VIN** and **VOUT** pins of the amplifier symbol as shown in the figure.
- Add a **DC** source by selecting **IC_Library > Sources Library > DC**
- Highlight the DC source, right click mouse, **Properties > Edit** to modify the voltage value of the source from **1V** to **3.3V**.
- Connect the positive node of the **DC source** to **VDD** symbol and negative terminal to the **Ground** symbol.
- Add second DC source for the input, and connect to VIN. Edit the properties to set INST = Vs
- Click Check & Save. If there are any errors, correct them before moving on.



Click on **simulation** from the **schematic_edit** palette on the RHS to enter the simulation mode. A popup window appears with a Warning message, indicating that the schematic will be closed. Click **OK** to accept default options.

In the simulation mode (schematic_sim palette):

- On the simulation palette, click the button **Lib/Temp/Inc > Library**.
- Type /opt/mentor-2004.3/sol/adk2_5/technology/ic/models/tsmc035.mod in Library path box and click OK.
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This includes the TSMC0.35 micron BSIM model for the simulations.

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The screen should look like the figure below:

3. Setting up the Simulator / Viewer

In the simulation mode (schematic_sim palette),

- Click Session > Simulator / Viewer.
- Select Eldo under Simulator and EZwave under Viewer and click OK.

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Click on Check & Save. You are now ready to run an analysis on the amplifier.

2. DC Analysis

For a DC analysis, we will sweep the input voltage, Vs, from 0V to 3.3V and view its effect on the output.

1. Editing and simulating the test circuit

- Open the test amp schematic sheet and make sure that you are in schematic edit mode.
- From the steps above, the input to the amplifier should already be a **DC** voltage source between VIN and Ground. If not, change the input source to a DC voltage source. The source should be named **Vs**. (Note that the value of the DC voltage source is 1V, by default. For the DC sweep we will be doing, this value does not matter and so you can leave it as it is.)
- Click **Check & save** the sheet and then enter the **simulation** mode by clicking on simulation from the schematic_edit palette on the RHS. Click OK to accept the default options in the Warning popup window that appears.

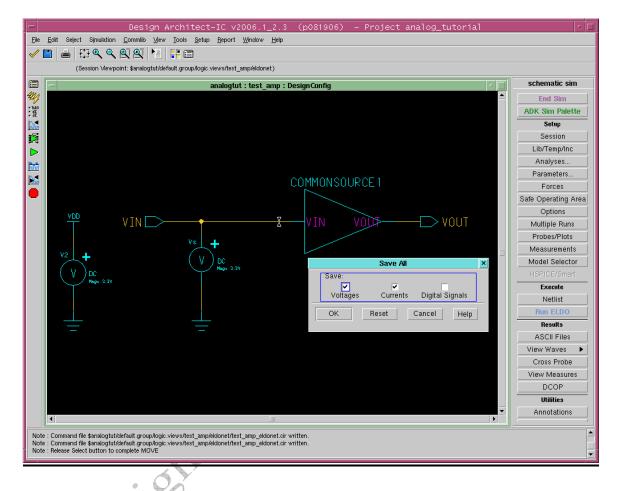
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On the **schematic_sim palette:**

- Click on Lib/Temp/Inc > Library to make sure that /opt/mentor-2004.3/sol/adk2_5/technology/ic/models/tsmc035.mod appears in library path box and click OK.
- Click **Setup > Analyses**.
- In the **Setup Simulation Analysis** window that appears, select **DC** and click on **Setup** associated with **DC**. In the **Setup** box that appears, select **Source** and select **VS** for **Voltage source**, put **0** in the **start field**, **3.3** in the **stop** field and **10m** in the **step** field and then click **OK**.

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- Click **Probes/Plots > Save All...** from the **Palette**. This opens a dialog box for choosing which signals should be saved for later analysis.
- Make sure the Voltages and Currents boxes are checked, and click OK.



3. Executing the simulation setup

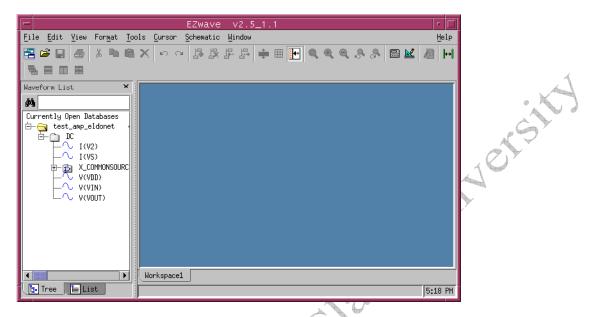
On the schematic_sim palette:

- Click Execute > Netlist. This opens up a new window that starts netlister. Check the netlist created for any errors. If there are any errors, correct them before proceeding further. Else close the window by pressing Enter key.
- Click **Execute** > **Run Eldo**. This starts Eldo in a new shell window and it may take few seconds before the simulation is complete. You may scroll down the window to see the DC simulation results. Press **Enter** key to close the Shell Window.

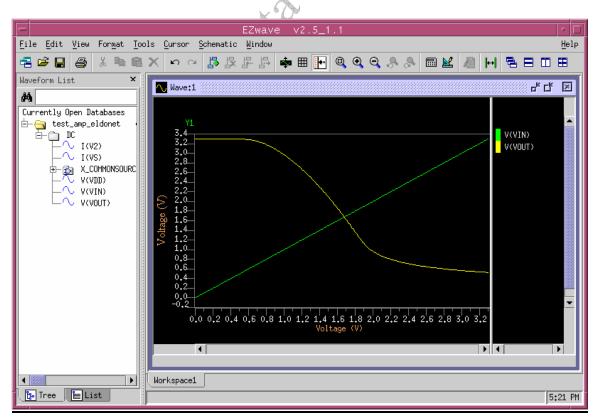
4. Viewing the results using EZWave viewer

To view the results of your DC analysis in EZWave, do the following: On the **schematic_sim palette:**

Click **Results > View Waves**. A new window will open as shown below.



Under test_amp_eldonet > DC > X_COMMONSOURCE, Highlight both V(VIN) and V(VOUT), then right click, and select Plot (Overlaid)

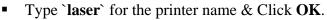


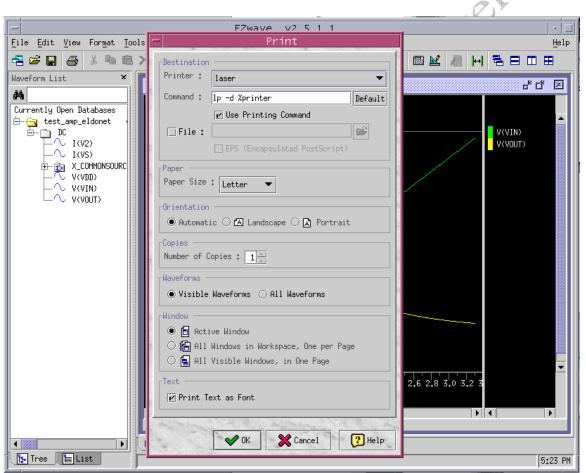
This DC analysis shows you where to set the DC bias point of the transistor. From the input/output plot, we see that the high gain region corresponds to a DC input voltage of about 1.0V to 1.8V. In the subsequent analyses, you will set a DC bias voltage of 1.5V at the gate of the transistor, ensuring that the device is operating in the the correct region.

5. Printing the plots

To Print your waveform:

• Click **File > Print**.





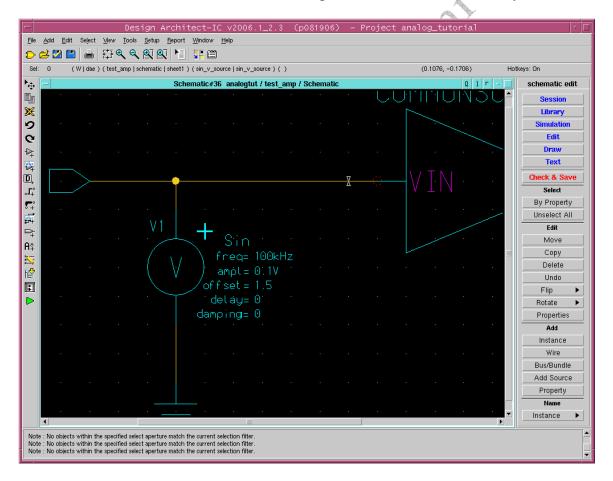
4. Transient Analysis

In this section, you will provide a sinusoid at the input and view the input & output waveforms.

1. Editing and simulating the test circuit

- Open the **test_amp** sheet that you have created with the symbol of your amplifier and make sure that you are in **schematic_edit** mode.
- Remove any existing input sources and add a SIN voltage source between the VIN pin and Ground as shown in the following figure.
- Name this sourse as **Vs** and change the attributes as:
 - ampl0.1V(AC amplitude of the input)freq100kHz

offset 1.5V (DC bias point, as found in the DC analysis)



• Check & save the sheet and then enter the simulation mode by clicking on simulation from the schematic_edit palette on RHS. Click OK to accept default options in the Warning popup window appeared.

On the **schematic_sim palette:**

- Click on Lib/Temp/Inc > Library to make sure that /opt/mentor-2004.3/sol/adk2_5/technology/ic/models/tsmc035.mod appears in library path box and click OK.
- Click **Setup -> Analyses**. In the **Setup Simulation Analysis** window that appears, select **Transient** and click on **Setup** associated with it.
- In the **Setup** box that appears type **100u** in the **Stop Time** field and **100n** in **Max Time Step** field. Then click **OK**.

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3. Setting up the signals to be probed

- Click **Probes/Plots** > **Save All...** from the **Palette**. This opens a dialog box for choosing which signals should be saved for later analysis.
- Make sure the Voltages and Currents boxes are checked, and click OK.

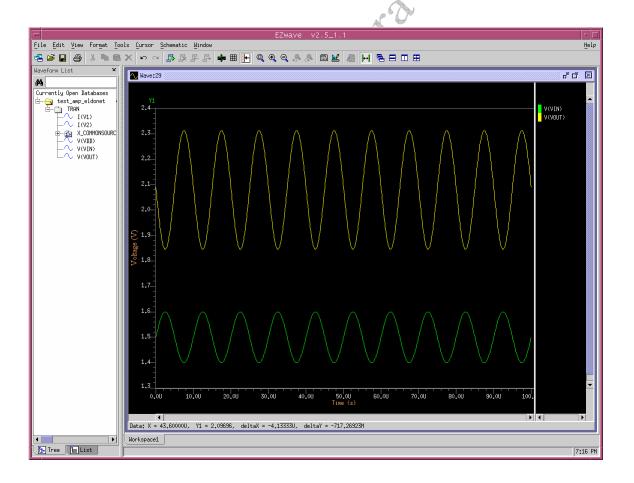
4. Executing the simulation setup

- Click **Execute** > **Netlist**
- Click Execute > Run ELDO

5. Viewing the results using EZWave viewer

To view the results of your transient analysis in EZWave, do the following: On the **schematic_sim palette:**

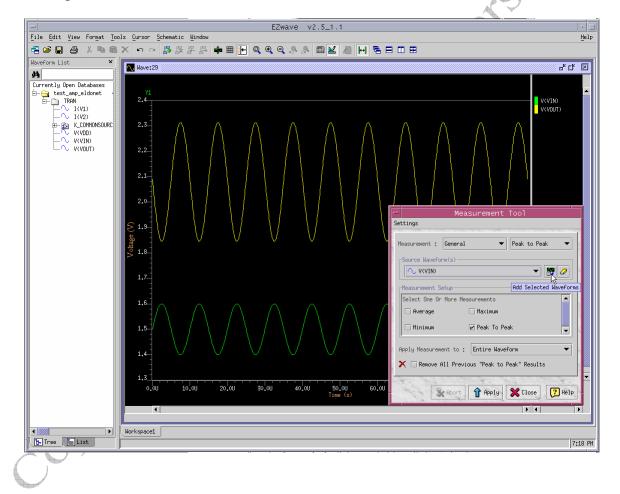
- Click **Results > View Waves**. A new window will open as shown below.
- Under test_amp_eldonet > TRAN > X_COMMONSOURCE :
 - Highlight both V(VIN) and V(VOUT), then right click, and select : Plot (Overlaid)

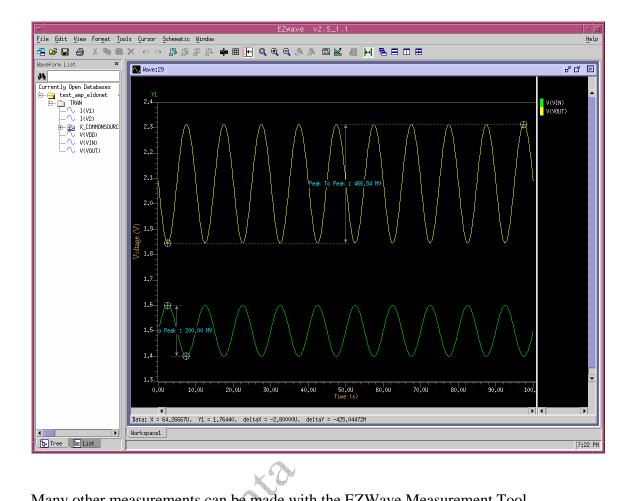


6. Measuring Gain with the EZWave Measurement Tool

To measure the gain of the circuit from the transient analysis in EZWave, do the following:

- Select **VOUT** by clicking the yellow trace.
- From the menu, select **Tools > Measurement Tool**
- Click the Add Selected Waveform button
- Select V(VOUT) as the Source Waveform
- Select General > Peak-to-Peak as the Measurement
- Click Apply
- Repeat for the **VIN** waveform





Many other measurements can be made with the EZWave Measurement Tool.

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5. DC Operating Point Analysis

In this section, you will find the DC operating point of several nodes in the circuit. The input of the amplifier should be configured as in the above transient analysis.

1. Editing and simulating the test circuit

- Open the **test_amp** sheet that you have created with the symbol of your amplifier and make sure that you are in **schematic_edit** mode.
- Remove any existing input sources, and add a SIN voltage source between the VIN pin and Ground as shown in the following figure.
- Name this sourse as **Vs** and change the attributes as:

ampl	0.1V (AC amplitude of the input) $$
freq	100kHz
offset	1.5V (DC bias point, as found in the DC analysis)

2. Setting up the simulation parameters

On the **schematic_sim palette:**

• Click Setup > Analyses. Select DCOP in the dialog box that appears, and then click OK.

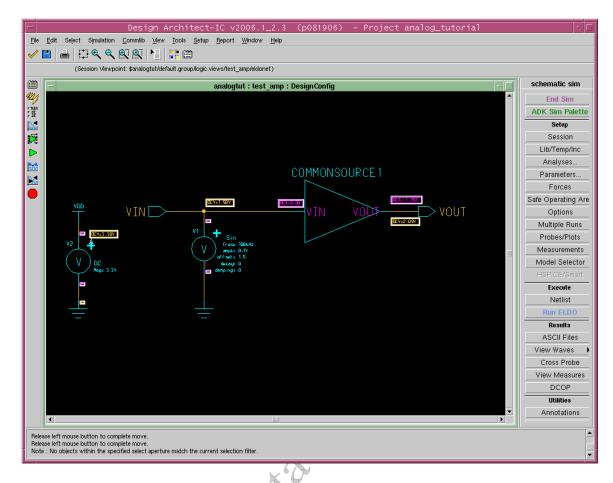
3. Executing the simulation setup

- Click **Execute** > **Netlist**
- Click Execute > Run ELDO

4. Viewing the results using Monitors

The next step is to view the results of your simulation run. To see all the DC voltages and currents in your schematic,

- Click Results > DCOP > Add monitor > All Nets Voltages
- Again click DCOP > Add monitor > All Pins Current



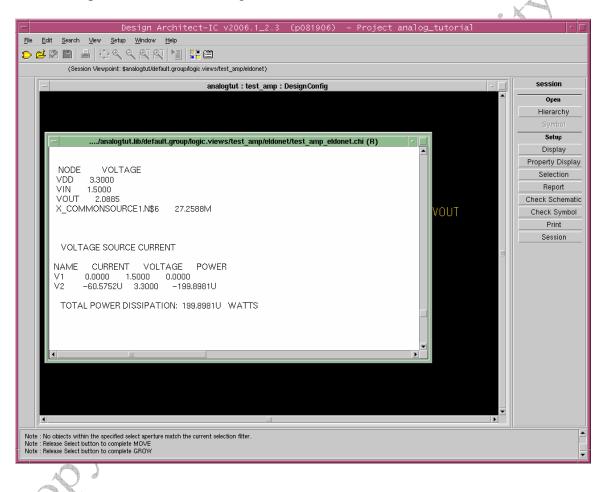
Current and Voltage values at various nodes will be displayed as shown in the above figure.

Alternately, you can select voltages or current option, if you want to see only voltages or currents.

5. Static Power consumption of the circuit

The static (DC) power consumption of the circuit for the given operating point is calculated during the DCOP simulation.

- Click on **Results > ASCII Files, right click mouse button > View Log**.
- Scroll down in the log window to find the information about the power consumption as shown in the figure below:



6. AC Analysis

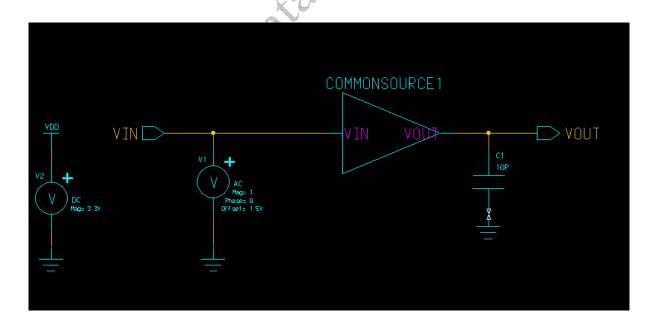
In this section, you will run AC analysis and trace and measure your results. In AC Analysis, the input signal is swept over a range of frequencies.

1. Editing and simulating the test circuit

- Open the **test_amp** sheet that you have created with the symbol of your amplifier and make sure that you are in **schematic_edit** mode.
- Remove any existing input sources, and add an AC voltage source between the VIN pin and Ground
- Name this sourse as Vs and change the attributes as:mag1Voffset1.5VDC bias point, as found in the DC analysis)

Note: While 1V can not be considered a small signal input for this circuit, it is acceptable in the AC simulation since SPICE does not use a large-signal model for the AC simulation. SPICE first runs a DC operating point analysis to construct the small signal model, then uses the specified AC voltage in the linear model. By setting the input to 1V, the output voltage equals the gain directly. ($A_V = Vout/Vin$)

- Add a 10pF capacitor at the output of the amplifier as shown below
- Click **Check & save** the sheet and then enter the **simulation** mode by clicking on **simulation** from the **schematic_edit** palette on RHS. Click **OK** to accept default options in the Warning popup window appeared.



On the schematic_sim palette:

 Click Setup > Analysis. Check AC and click on the Setup box associated with it. Select the Decade button for Sweep type. For this circuit you will perform an AC sweep of input frequency from 1k to 10MEG. Enter 100 in the Points per Decade box. Enter these values in the Start Freq and Stop Freq respectively. Click OK

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3. Setting up the signals to be probed

• Click **Probes/Plots** > **Save All...** from the **Palette**. This opens a dialog box for choosing which signals should be saved for later analysis.

• Make sure the **Voltages** and **Currents** boxes are checked, and click **OK**.

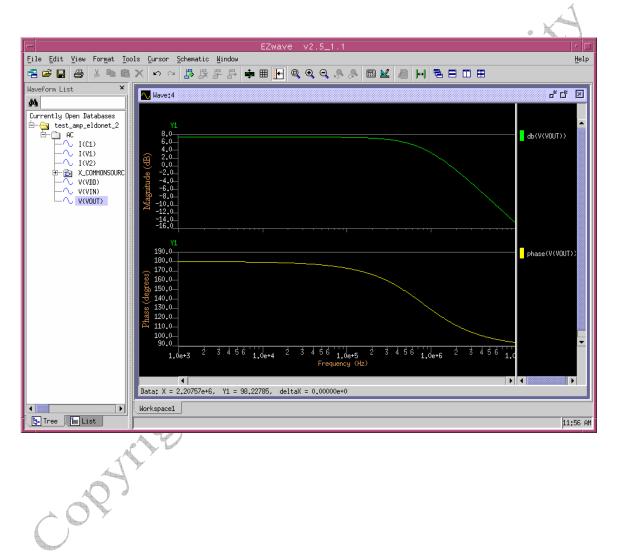
4. Executing the simulation setup

- Click **Execute** > **Netlist**
- Click **Execute > Run ELDO**

5. Viewing the results using EZWave viewer

To view the results of your transient analysis in EZWave, do the following: On the **schematic_sim palette:**

- Click **Results > View Waves**. A new window will open as shown below.
- Under test_amp_eldonet > TRAN > X_COMMONSOURCE :
- Highlight V(VOUT), then right click, and select : Plot

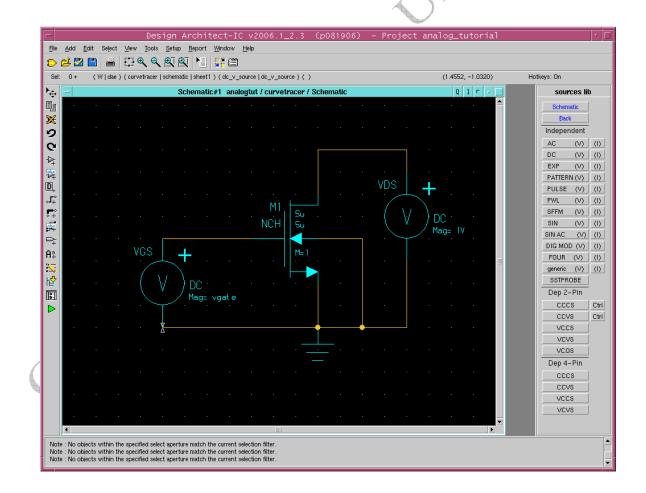


7. Parameter Sweeps

It is often helpful to perform an analysis on one parameter while simultaneously sweeping another parameter. This concept will be demonstrated by generating the ID vs VDS curves for a MOSFET.

1. Editing and simulating the test circuit

- Create a new schematic view and draw the circuit shown below. (Name the gate voltage source VGS and the drain voltage source VDS. Both sources are DC)
- For VGS, set Mag = vgate
- Click **Check & save** the sheet and then enter the **simulation** mode by clicking on **simulation** from the **schematic_edit** palette on RHS. Click **OK** to accept default options in the Warning popup window appeared.



On the **schematic_sim palette:**

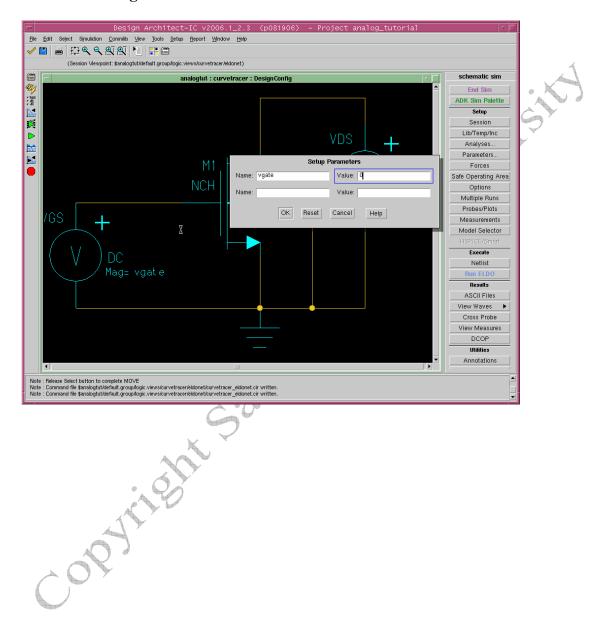
- Click on Lib/Temp/Inc > Library to make sure that /opt/mentor-2004.3/sol/adk2_5/technology/ic/models/tsmc035.mod appears in library path box and click OK.
- Click **Setup > Analyses**.
- In the Setup Simulation Analysis window that appears, select DC and click on Setup associated with DC. In the Setup box that appears, select Source and select VDS for Voltage source, put 0 in the start field, 3.3 in the stop field and 10m in the step field and then click OK.

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- Click **Probes/Plots** > **Save All...** from the **Palette**. This opens a dialog box for choosing which signals should be saved for later analysis.
- Make sure the Voltages and Currents boxes are checked, and click OK.

3. Defining Parameters

• On the simulation palette, click **Parameters**, and enter into the first empty box:



Vgate

0

4. Setting up Multiple Runs

- Click **Multiple Runs > Sweep** to bring up the Sweep List Editor
- Under Multi-Run Mode, select Sweep
- Click Add Sweep
- Select **Param**, and choose **vgate** as the Parameter name
- Setup the sweep for Lin/Num Pts, 0 to 3.3, with about 15 steps. Click OK

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5. Executing the simulation setup

On the schematic_sim palette:

- Click Execute > Netlist.
- Click **Execute > Run Eldo**

6. Viewing the results using EZWave viewer

To view the results of your DC analysis in EZWave, do the following: On the **schematic_sim palette:**

• Click **Results > View Waves**. A new window will open as shown below.

Under curvetracer_eldonet > DC > M1 :

• Highlight I(D) then right click, and select Plot

