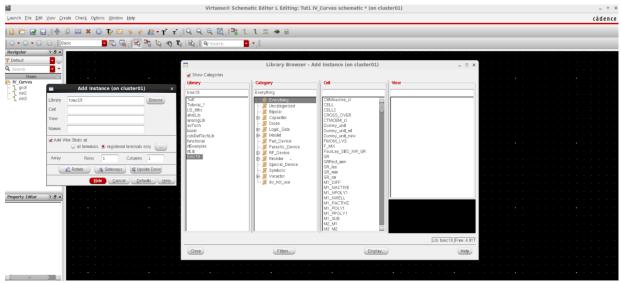
## DC Operating Point, I-V Curve Trace

Author: Nate Turner

**Description:** This tutorial demonstrates how to print the DC-Operating Point as well as trace the I-V curves for a transistor in the tsmc 180nm process. Also, it demonstrates how to save a state for the ADE.



## 1. Press i to Add Instance $\rightarrow$ Browse $\rightarrow$ tsmc18 under Library column

ibrary	Category	Cell	View	
smc18	Mosfet_4T	nmos3v	symbol	
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 Under Category select Mosfet → Mosfet\_4T → nmos3v → Symbol, after selecting symbol an outline of the device will appear on the schematic. Left click to place in the schematic

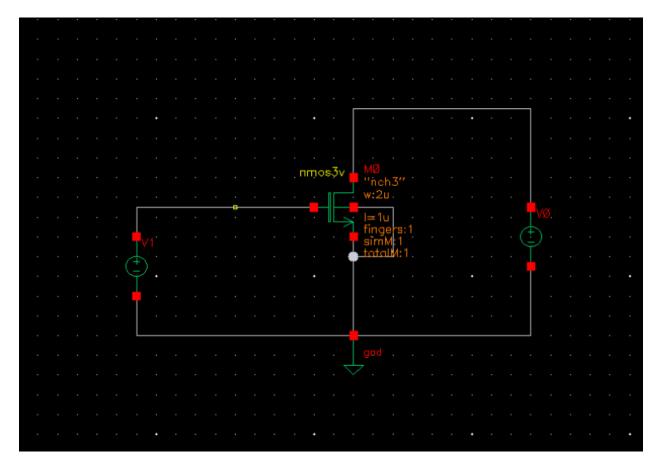
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nm <u>os3v –</u> MØ	CDF Parameter Va	alue Display	
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	OK Cano	cel <u>Apply</u> Defaults Previous	Next <u>H</u> elp

3. M0 will appear on the schematic, hit ESC to prevent placing copies. Select the transistor and press **q**, change the length to **1u**, and the width to **2u**, as seen in the picture above and hit **OK** 

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- 4. Now press  $i \rightarrow Browse \rightarrow analogLib \rightarrow Sources \rightarrow Independent \rightarrow vdc \rightarrow symbol \rightarrow place two of these on the schematic.$
- 5. Repeat step (4) but go to **analogLib** → **Sources** → **Globals** → **gnd** → **symbol** → place on schematic.

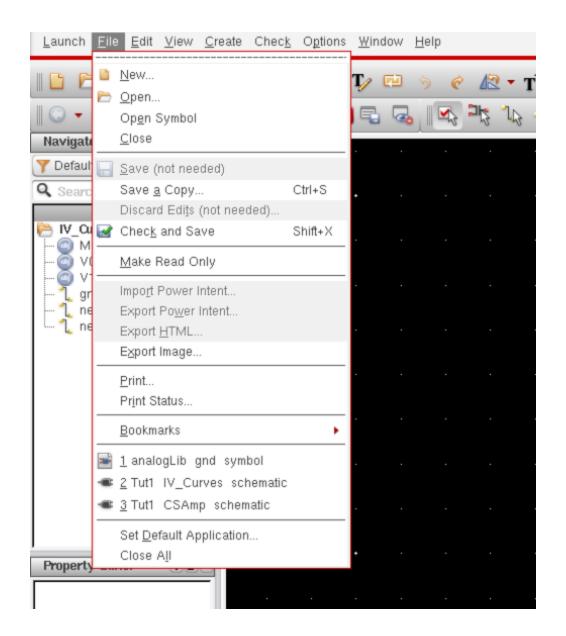
\*\*Tip: If you accidently hit a bindkey, and you're not sure what is happening try hitting ESC a few times to reset.



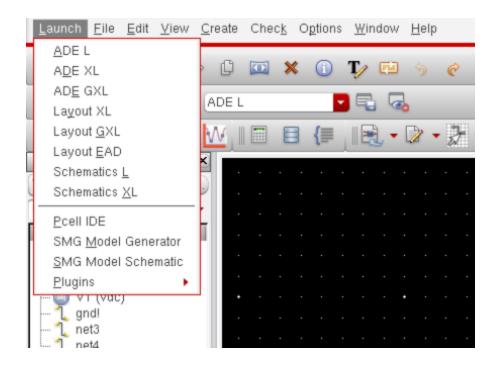
6. Press **w** (wire) to draw the connections between the two voltage sources and the transistor as shown in the picture above.

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- 7. Select voltage source V1 and press **q** and change the DC Voltage to **VGS**
- 8. Repeat step (7) for source V0, but label the DC Voltage as **VDS**



9. Go to File -> Check and Save, or hold shift and hit x (Shift+X)



10. Go to Launch  $\rightarrow$  ADE L. If a prompt appears asking whether you want to check out a license for ADE XL, select Always.

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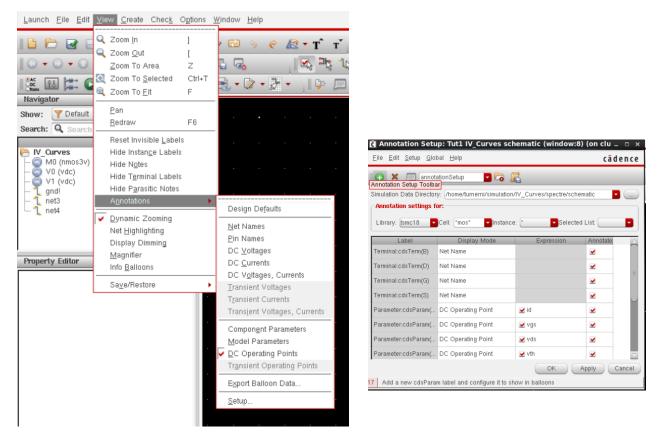
11. Once the Analog Design Environment (ADE) has been launched, select Variables → Copy from Cellview, notice that in the Design Variables, VDS and VGS have now appeared. Click on the Value column for each of the variables and set them both to 2 V.

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- 12. Go to Analyses  $\rightarrow$  Choose  $\rightarrow$  dc  $\rightarrow$  Save DC Operating Point  $\rightarrow$  OK
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- 13. Click the Green Arrow (Netlist and Run)

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cddbo	3.	42277a		
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cdgbo		73809a		
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cdsbo		65249a		
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cgđ	-745.			
cgdbo		55347a		
cgg		13037f		
cggbo		58252f		
cgs		31345f		
cgsbo		51907f		
cjd		1438f		
cjs		74209f		
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covlgd		471a		
covlgs		377a		
csb		06412f		
csd		6386a		
csg		98307f		
CSS		0598f		
gbd		00117p		
16 Help/	Action			

14. After the simulation finishes go to **Results**  $\rightarrow$  **Print**  $\rightarrow$  **DC Operating Points**, and then on the schematic select M0. The Results Display Window should now display all the of the operating parameters for the transistor. This is very useful in determining region of operation, current, threshold voltage, parasitic capacitances, etc.



15. Additionally, you can then annotate these parameters on the schematic by going to **Results**  $\rightarrow$  **Annotate**  $\rightarrow$  **DC Operating Points**. The default annotations will show up next to the transistor. To change these defaults you can go to **View**  $\rightarrow$  **Annotations**  $\rightarrow$  **Setup**, selecting in the Annotation Settings for the following Library: tsmc18, Cellview: type \*mos\* (wildcard mos wildcard)

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16. Then go to **Global**  $\rightarrow$  **Parameters**  $\rightarrow$  **DC Operating Point**. After selecting this you can change which parameters are displayed by clicking in the "Expression" column. You need to double click to get the down-arrow to appear to select which parameter to display.

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17. Go back to the ADE and Click **Outputs**  $\rightarrow$  **To Be Plotted**  $\rightarrow$  **Select on Design**. And then click the drain terminal of the M0 Transistor. A red circle will appear around the terminal and in the Outputs section of the ADE you will see MO/D appear – This is the current through the drain of the MOSFET.

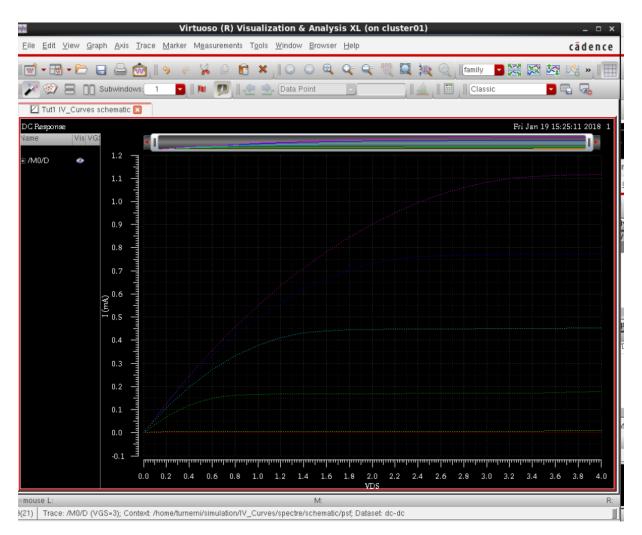
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18. Now double click on the dc analysis and select **Design Variable** under sweep. Then click **Select Design Variable**  $\rightarrow$  **Click VDS**  $\rightarrow$  **OK**. Under Sweep Type Select Linear  $\rightarrow$  Start-Stop  $\rightarrow$  Start = 0, Stop = 4  $\rightarrow$  Step Size = 0.2  $\rightarrow$  OK.

Parametric Analysis - spectre(0): Tutl IV_Curves schematic (on cluster01)  File Analysis - Iden	_ 0 X	Launch Session Setup Analyses Mariables Qutputs Simulation Results	<u>Tools Help</u> cādence
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10055 Infr: Parametric Similation Commisted 18 Run Selected Sweeps	<b></b>	Results in /home/turnerni/simulation/IV     Plot after simulation: Auto     Plot after simulation: Auto     Status: f	Plotting mode: Replace

19. Go to **Tools** → **Parametric Analysis.** Make the settings match what is shown in the picture above – Variable: VGS, Range Type: From/To, From: 0, To: 5, Step Mode: Linear Steps, Step Size: 1.

20. Click the Green Arrow In the Parametric Analysis Window



21. A plot with several traces of Id vs. VDS should appear.

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Description Plots I-V DC Curves What to Save	110	Select All Clear All	
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22. Exit the graph, and go back to the ADE and go to Session  $\rightarrow$  Save State  $\rightarrow$  Cellview. Under Cell, select the name of the cell you are in. The name of the state is whatever you want it to be, in this example it is labeled IV\_Curve\_Tracer. Additionally, you can add a description.

\*\* Some useful bindkeys: f – fit, right-click and drag a box around area you want to zoom into, m – marker