ECE 415/515 Fundamentals of Semiconductor Devices, Winter 2005

Device Characterization Project 2: CMOS transistor

Summary
In this project you will be characterizing the current voltage characteristics of an n-channel MOSFET. To do this, you will use the MIT Microelectronics WebLab. Refer to the User Manual for instructions on how to use the system. For this project you are encouraged to work together in groups of up to three people. Each should turn in an assignment, but note the students with whom you have worked.

Background: For background, learning goals, and help getting started please see the PN project.

Assignment[1]
This problem is about characterizing an n-channel MOSFET that is currently connected to the MIT Microelectronics WebLab. The terminal connection configuration is available on line. This exercise involves three separate phases: measurement, graphing, and analysis.

I recommend downloading and graphing the data as you go, so that you can identify and fix any errors.

Important note:
For all measurements, hold V_{GS} between 0 and 3 V, and V_{DS} between 0 and 4 V. As inputs to this exercise, you need the dimensions of the MOSFET: L =1.5 μm and W =46.5 μm.

Assignment:

1. Obtain the *output characteristics* of the MOSFET. This is a plot of I_D vs. V_{DS} with V_{GS} as a parameter. From now on I'm going to write ID for I_D! Use ΔV_{GS}=0.5 V. You might want to take a screen shot of these characteristics for later use.
    a. Download the data and graph (Excel, Matlab, …)
    b. Obtain a rough estimate of Vt from this graph.
    c. Does this transistor seem to exhibit short channel effects? Explain.

2. Obtain the *transfer characteristics* of the MOSFET for two different drain voltages. This is a plot of ID vs. V_{GS} with V_{DS} as a parameter. Using the output characteristics above choose two different values of Vd so that you obtain one plot in saturation and one plot in the linear region. You might want to take a screen shot of these characteristics for later use.
    a. Download the data and graph. Note that in saturation you will want to plot the square root of Id. Why?
    b. Obtain a graphical estimate of Vt in the linear and the saturation region. Do they agree?
3. From the transfer characteristics extract (μ_n Cox) and the threshold voltage, V_T, for this MOSFET. Fit a line to one of your transfer curves to obtain this estimate. Note that we cannot separate the mobility from the oxide capacitance using this data.
4. Use these parameters in a model and compare graphically with one of the above curves, whichever seems the most convenient.
5. Feedback: Please give feedback on the project. Anonymous feedback can be delivered to my mailbox if you prefer, or you can just attach it to your homework. Was this project

instructive? Did you experience major problems or frustrations with WebLab, understanding the instructions, or completing the assignment?

Additional information and assorted advice

- The required graphs need not be too fancy, just simply correct. They must have proper tickmarks, axis labeling and correct units. When there are several lines, each one should be properly identified (handwriting is OK).
- It will be to your advantage to make good use of the Set-up management functions that are built into the tool under the File menu.
- For research purposes, the system keeps a record of all logins and all scripts that each user executes.

1 This material was created by or adapted from material created by MIT faculty members, Jesús del Alamo, Dimitri Antoniadis, Judy Hoyt, Charles Sodini, Pablo Acosta, Susan Luschas, Jorg Scholvin, Niamh Waldron, 6.012 Microelectronic Devices and Circuits, (2003).

This particular project was written by Professor Jesus del Alamo for his class at MIT and modified for ECE 415/515.

2 Streetman, B.G. *Solid State Electronic Devices*, Prentice Hall, Fifth Edition, 2000.