EE 551 Linear Integrated Circuits
Project 3
Small-Signal Transistor Parameters
50 Points

Objective
To understand how different parameters affect a MOSFET's transconductance.

Data
You will use the same transistor data from the previous project. You will only need to use the nFET data (there are no questions about the pFET data).

Part 1 – Transconductance (30 Points)
Use the nFET data from the previous project to determine the transconductance of the transistor (which you will plot versus bias current). Please provide the Matlab code you used to generate the transconductance (this is one of the few times you need to include code – see the Hints below for helpful suggestions). Use this transconductance to plot the following.
- Transconductance vs. Bias Current (log-log)
- Transconductance Efficiency vs. Bias Current (log-log)

Do the following, and answer the following questions.
- Use these plots to determine the *threshold current*.
- Use your knowledge of the threshold current to determine the threshold voltage. How does this value compare to the value of the threshold voltage you calculated from the previous project?
- For the g_m vs. I_{bias} plot (i.e. the first plot), determine where the subthreshold regions and above-threshold regions are (i.e. with respect to the bias current), and clearly indicate them *on* the plot.
- For the g_m/I_{bias} vs. I_{bias} plot (i.e. the second plot), determine where the weak, moderate, and strong inversion regions are, and clearly indicate them *on* the plot.
- What slopes do you see on both of these plots? What are the theoretical values for the slopes in both of these plots (for all interesting regions)? Do the measured/curve-fitted data match with theory? (Hint. There should be two distinct regions with distinct slopes on both of the plots.)
- Which region of operation (weak, moderate, or strong inversion) has the highest transconductance?
- Which region of operation (weak, moderate, or strong inversion) has the highest transconductance efficiency?
- How do the transconductance values match with theory? (Compare with our modeling equations from class and extracted parameters from the previous project.)

Part 2 – Comparison of Simulation Models (15 Points)
You must read through the following paper to answer these questions.

> S. C. Terry, J. M. Rochelle, D. M. Binkley, B. J. Blalock, and D. Foty, "Comparison of a BSIM3V3 and EKV MOST Model for a 0.5µm CMOS Process and Implications for Analog Circuit Design," *IEEE Transactions on Nuclear Science*, vol. 50, no. 4, August 2003, pp. 915 - 920.

You can obtain this paper from IEEE Xplore, which is available through the university library. In this paper, the authors present a comparison of two popular simulations models for MOSFETs – the BSIM and EKV models – with real data from a 0.5µm process. They discuss parameters such as the inversion coefficient, transconductance efficiency, and the output resistance.

- Use their findings to compare and contrast the strengths and weaknesses of the two models. Be specific and thorough.

- If you were going to be simulating a circuit that consists of transistors operating exclusively in the subthreshold regime, which model would you use? Why?
- If you were going to be simulating a circuit that consists of transistors operating exclusively in the above-threshold regime, which model would you use? Why?
- If you were going to be simulating a circuit that consists of transistors operating in all regions of inversion (weak, moderate, and strong), which model would you use? Why?

Quality of Report (5 Points)
Please make sure that all numbers are readable, that the figures are large enough, and that there are no gross errors in terms of grammar, spelling or punctuation.

What to Turn In
You must turn in both a paper copy of your report, as well as an electronic copy of your report.

Helpful Hints
Some interesting MATLAB functions are the following.
- `diff()`
- `gradient()` – This is the one I like the best
- `polyder()`

As a suggestion, you may want to read through the paper for Part 2 before you start on the analysis of Part 1.