EE 551 Linear Integrated Circuits
Project 2
Subthreshold Large-Signal MOSFET Characterizations
50 Points

Objective
To understand the large-signal operation of MOSFET transistors in the subthreshold regime, including both saturated and ohmic operation.

Data
The data on the class website are from voltage-current measurements from real integrated-circuit transistors (both an nFET and a pFET). The supply voltage is V_{dd}=3.3V. All data are contained in one .mat file. When you load the data, four matrices will be loaded into the workspace named nfet_gatesweep, nfet_drainsweeps, pfet_gatesweep, and pfet_drainsweeps. For the gate sweeps, the first column contains the values of the gate voltage, and the second column contains the values of the current. For the drain sweeps, the first column contains the values of the drain voltage, and the other columns contain the values for the current, each for a different gate voltage.

Part 1 – nFET Characterization (30 Points)

Gate Sweep (10 Points)
The gate of an n-channel MOSFET was swept from ground to V_{dd} while the source was connected to ground and the drain was connected to V_{dd} through a picoammeter. Assume that the data were taken under room-temperature conditions (T=300K).

Determine the following values from the measured data

- kappa
- I_0

You will need to plot the I-V values on a “semiology” plot (or a log-linear plot). Include your curve fits and show where the exponential region of operation is.

Drain Sweeps (20 Points)
Data for six different drain sweeps are provided. During this experiment, the source was grounded, the gate voltage was biased at a fixed voltage, and the drain was swept from ground to V_{dd}. This experiment was repeated five more times, each with a different voltage on the gate.

Determine the following.

- Which data sweeps are for subthreshold biases? Explain how you know. Plot all of the subthreshold sweeps on the same plot.
- What is the saturation current for each of the three subthreshold cases?
- Determine what the gate voltage is for each of the three subthreshold cases.
- Determine the Early voltage for each of the three subthreshold cases (and include your curve fits). Do the subthreshold values agree with each other?
- Determine where each drain sweep transitions from the ohmic/triode region to the saturation region for each of the three subthreshold cases. Clearly display these transitions on the plots. How well do these dividing lines agree with theory?

Part 2 – pFET Characterization (10 Points)
Data sets for pFETs include both a gate sweep and six drain sweeps. You do not need to do anything with the drain sweeps, but they are included in case you are interested and would like to look further into device characterizations.

Gate Sweep (10 Points)
The gate of a p-channel MOSFET was swept from ground to V_{dd} while the source was connected to V_{dd} and the drain was connected to ground through a picoammeter.

Repeat the steps from the nFET gate sweep for the pFET data that have been provided.

Drain Sweeps (0 Points)
There is no need to do anything here, but the data are included in case you are interested.

Part 3 – Comparisons and Thought Questions (5 Points)

1. How well do the various extracted parameters from the nFET agree with the extracted values from the pFET (specifically kappa and I_0)? Where do they agree, and where do they disagree? WHY do they disagree (use what you have learned about device physics to determine the root causes for similarities and differences)? Be thorough. (5 Points)

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
Hold on to these data and your analyses. They may prove very useful in subsequent projects.