Collin Heist
ECE 311
Lab #7

Objective

The objective of this lab was to characterize the fundamental behavior and characteristics of MOSFETs, and extract those parameters. In particular, we'll be 'extracting' the Threshold voltage, lambda, beta, and input capacitance for our MOSFETs.

Procedure

To begin our lab, we assembled the circuit in Figure 1 in the lab worksheet, which was a MOSFET with the Drain and Gate wired together off of one DC voltage source. We then varied the applied DC voltage between 1 and 3 Volts (in increments of .1V), and recorded the current through the transistor at each point. Doing this, we were able to then plot how the current through the transistor changed as a function of the V_{GS} voltage.

Next, we worked to extract the lambda parameter. Using the circuit in Figure 2 of the labsheet, where two separate voltage are applied to the gate and the drain. Using the previously derived threshold voltage (detailed in **Results**), we set the transistor to .5V on, meaning the V_{GS} was set to about 2.3 V. We then changed our V_{DS} between 0 and 1.5 V, in increments of .1 V each time. At each increment, we once again measured the I_{DS} current through the transistor. This proved to be somewhat difficult, as it seemed our configuration was not allowing us to measure the current through the transistor, for some reason. After a bit of tinkering, we looked instead at the current leaving the source as an indicator for the drain-to-source current.

Using the incremental calculation outlined in the labsheet, we calculated a Lambda foreach sequential pair of two V_{DS} and I_{DS} data points. After this, we repeated the test and calculations for a 1V V_{OD} this time, meaning our V_{GS} was set to 2.8 V.

Finally, we began the test to determine the input capacitance of the transistor. We built one last circuit, this one shown in Figure 3 of the labsheet. We used a 10 Mega-ohm resistor (actually 9.926 Mega-ohms) as our R. We then applied a square wave, and measured the Gate voltage on the oscilloscope. Looking at the rising / falling times of the square wave, we picked points along the wave and recorded the change in voltage and time for three different V_{stop} values (we chose 5, 3.3, and 2 V). Using the given formula, we calculated the in-line capacitance of the transistor with these values.

To end, we used all of these collected data points to calculate a beta (β).

Questions & Calculation

More relevant calculations are attached to the back of the lab write up.

$$\lambda = \frac{I_{DS2}-I_{DS1}}{I_{DS1}V_{DS2}-I_{DS2}V_{DS1}}$$

$$C = \frac{\Delta t}{R \cdot ln(\frac{1}{1-\frac{\Delta V}{\Delta V_{step}}})}$$

Results

Analyzing the pattern of data in our first result gave a very clear threshold voltage of about 1.9 V. Although this sort of analysis is subjective, the current (I_{DS}) through the transistor was essentially zero, at 3 mA, until about 1.9 V applied between the gate and source.

This matches the datasheet of the ZVN2106A transistor, because the listed threshold voltage is said to be between .8 and 2.4V (with 1.8 falling within that range).

The Lambda calculations were less than ideal. Our simulations resulted in an average Lambda of about .0014699, while our measured / calculated values were closer to .15-.3. Which is obviously a few orders of magnitude off. We suspect this has to due with the myriad of imperfections in our data collection, between having to take the I_{DS} measurements in a roundabout way, to only having a small amount of precision, when the Lambda calculation is very sensitive to incremental changes. Nonetheless, for both the .5 and 1 V V_{OD} tests, we were consistent in our values (which is good), but not near our idealized simulations.

Our third test, the in-line capacitance of the circuit came out very well. Our three values averaged out to about 88 pF. Initially we thought this value was quite high, given the datasheet and our calculations showed an expected value of about 60 pF, but when we account for the capacitance of the probe and oscilloscope, which model out to about 13 and 20 pF respectively, we can deduct those values from our measurement. This give a much closer value of 55 pF. This is **very** close to the datasheet listed value of just below 60 pF.

Conclusion

This lab went very well. Aside from the lambda calculations being quite a bit off, compared to what I simulated, all of my other data was nearly exactly what I expected. Although, I did run into a little snag with regards to measuring the current through the transistor, I_{DS}, which neither the TA or any other students knew how to remedy. This was minor and eventually fixed.

I think this way of feature-extraction is somewhat tedious, but it did produce reliable and accurate results, especially for the capacitance of the MOSFET.