IV. FET Characterization

A. Objective
In this assignment, you will familiarize yourself LabView/Matlab, and then use it to characterize a pFET, an nFET, and a jFET.

B. Needed Hardware
- 1 J309 JFet
- 1 ALD1106 nFET chip
- 1 ALD1107 pFET chip
- Your buffer circuit from Lab 2
- Breadboard
- Wire
- Cutter/Stripper

C. Pre-Lab
- Read the Lab
- Analyze at the LabView VI HOST_V_I$weep_H$P34401 from Lab 1
- Determine how modify it to output 2 different voltages
- Wire up the circuits for test
- Write the netlists to simulate the following 6 sweeps.

D. Background Info
The various field effect transistors are very useful transistors for many different kinds of circuits. However finding discrete n/p FETs can sometimes be difficult. The ALD1106 and ALD1107 provide for you 4 matched transistors in a single package. These will be useful to you in classes to come.
The ALD1106 is a chip with 4 nFETs on it. You do not need to apply a VDD voltage to the chip in order to use this chip. (By this I mean that you do not have to apply VDD to the chip itself, however, if you are using one of these transistors in a circuit that requires the drain for instance to be connected to VDD... than you do need to make that connection. However, if you want to, you can apply VDD to pin 11 V+.) A picture of the pinout for this chip can be seen below:

![Figure IV-1 Pinout for ALD1106](image)

For all of the experiments in this lab, make sure that you connect V- (pin 4) to GND!

The ALD1107 is a chip with 4 pFETs on it. You do not need to apply a GND to the chip in order to use this chip. (By this I mean that you do not need to apply GND to the chip itself, however, if you are using one of these transistors in a circuit that requires the drain for instance to be connected to GND... than you do need to make that connection. However, if you want to, you can apply GND to pin 4 V-). A picture of the pinout for this chip can be seen below:
For all of the experiments in this lab, make sure that you connect V+ (pin 11) to VDD!

The J309 is a completely discrete device. It does not come in a DIP package as the other 2 devices do. A pinout for it is below:

**E. Experiment**

1. **Code Modification**
   The code that you used in Lab 1 is suitable for the gate sweeps (i.e. section IV.E.2) in this laboratory. However, in order to properly execute a drain sweep (i.e. section IV.E.3), you are going to need to modify the code in order to output 2 separate voltages.
First, make a new copy of the code `HOST_V_ISweep_HP34401` and call it `HOST_2V_ISweep_HP34401`.

Modify this newly copied version to be able to output the 2 different voltages. In order to do this, you are going to need to change which FPGA VI you use. The FPGA VI used in the original code only allows you to output 1 voltage. If you look in the folder that contains the FPGA VIs, you will see one which allows you to output 2 analog voltages.

You will also need to add blocks which take in a new voltage range and output the appropriate voltages that you need to the FPGA code.

Your TA should be able to help you with this if you have any questions.

2. **NFET Gate Sweep**

![Diagram for NFET Gate and Drain Sweep](image)

Using one of the four available nFETs on the ALD1106 chip perform a gate sweep. To do a gate sweep, you need to connect the Drain to a high voltage. However, you are going to need to buffer this voltage using the buffer circuit you built in Lab II.

While holding the drain voltage constant, sweep the gate voltage in 10mV steps from 0V to VDD.

Measure the current flowing through this device.

From this data, in Matlab, determine $V_{TN}$ and $K_N$.

3. **NFET Drain Sweeps**

Using the same nFET as the previous section, perform a Drain sweep on this device.

You are going to do this for 5 different gate voltages.
To do this, set a voltage on the gate, and sweep the drain in 10mV steps from 0V to VDD while measuring the current through the device. Then set the gate voltage to another voltage and repeat the process. Make sure that all of the gate voltages that you choose are above threshold!

From this data determine \( \lambda \) and \( V_A \).

4. **NFET Simulation**

Simulate both the gate sweep and drain sweep of this device in SPICE using the parameters determined. Note that you may need to change things like W and L in your simulation in order to make the data line up.

You report should contain 2 plots (one gate, one drain) showing the real data plotted with 'o' and the SPICE data as a line through the real data.

5. **PFET Gate Sweep**

Using one of the four available pFETs on the ALD1107 chip perform a gate sweep. To do a gate sweep, you need to connect the Drain to a low voltage (GND). However, you are going to need to buffer this voltage using the buffer circuit you built in Lab II.

While holding the drain voltage constant, sweep the gate voltage in -10mV steps from VDD to 0V.

Measure the current flowing through this device.

From this data, determine \( V_{TN} \) and \( K_P \).
6. **PFET Drain Sweeps**
   Using the same pFET as the previous section, perform a Drain sweep on this device.

   You are going to do this for 5 different gate voltages.

   To do this, set a voltage on the gate, and sweep the drain in -10mV steps from VDD to 0V while measuring the current through the device. Then set the gate voltage to another voltage and repeat the process. Make sure that all of the gate voltages that you choose are above threshold!

   From this data determine $\lambda$ and $g_{1848}$.

7. **PFET Simulation**
   Simulate both the drain and gate sweeps of this device in SPICE using the parameters determined here. Note that you may need to change things like $W$ and $L$ in your simulation in order to make the data line up.

   You report should contain a 2 plots (one gate sweep, one drain sweep) showing the real data plotted with ‘o’ and the SPICE data as a line through the real data.

8. **JFET Gate Sweep**
   Using your J309, perform a gate sweep and measure the current through the device. The setup for this looks like the setup for the nFET above. However, you are going to need to sweep the gate from a negative voltage (say -4V) to a voltage above 0 (say +2V)

   From this data, determine $I_{DSS}$, $K$, and $V_F$.

9. **JFET Drain Sweeps**
   Perform a Drain sweep on the JFET and measure the current through the device for at least 5 different gate voltages.

   From this data determine $\lambda$ and $V_A$.

10. **JFET Simulation**
    Simulate both sweeps of this device in SPICE

    Your report should contain a 2 plots (one gate, one drain) showing the real data plotted with an 'o' and the SPICE data as a line through the real data.
11. **Write-up**

Make sure that you include all of the relevant plots that you created in your write-up. Also, make sure that you include a table of all of those values that you determined for your devices in your write-up. Discuss any deviations that you may have had from the theory, and their possible causes.
TA Check Off Sheet

Gate Sweep of the nFET
Appropriate $V_{TN}$ and $K_N$
Drain Sweep of the nFET
Appropriate $\lambda$ and $V_A$
Gate Sweep of the pFET
Appropriate $V_{TP}$ and $K_P$
Drain Sweep of the pFET
Appropriate $\lambda$ and $V_A$
Gate Sweep of the JFET
Appropriate $I_{DSS}, K, V_P$

TA Signature

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