ELEC-313
Lab 6: MOSFET Characterization

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1 Objective

The objective is to observe the voltage-current characteristics of an N-type MOSFET.

2 Equipment

Transistor: 1N4007	Power supply: HP E3631A
Resistors: 330 Ω (x3), 2.2 kΩ, 33 kΩ	Multimeters: Fluke 8010A (x2)

3 Schematics

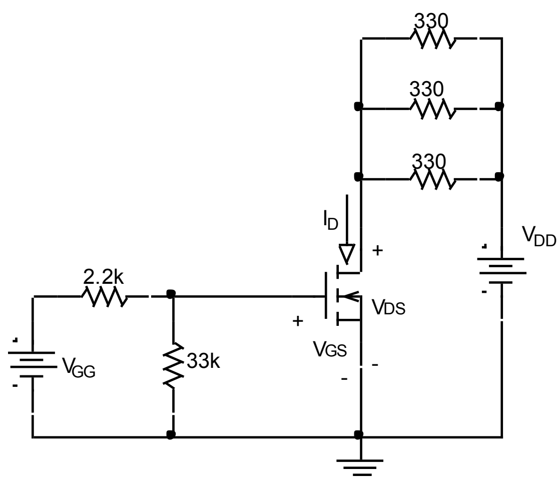

Figure 1: Circuit used in this lab.

4 Procedure

4.1 DC Characteristics

1. Construct the circuit shown in Figure 1. Use the HP multimeter to measure the drain current, I_D , and the Fluke multimeters to measure V_{DS} and V_{GS}. Use the +6 V power supply for V_{GG} and the +25 V supply for V_{DD}.

2. Set V_{GG} to 0 V and V_{DD} to 5 V and measure V_{DS} and I_D.

3. Slowly increase V_{GG} until the transistor just begins to conduct current as evidenced by a small drop in V_{DS}. Record the value of V_{GS} as the Gate Threshold Voltage, V_{TN}.

4. Adjust V_{GG} to increase V_{GS} by 0.2 V above the threshold. Readjust V_{DD} to return V_{DS} to 5 V, and then measure the drain current (I_D). Record the values of V_{GS} and I_D.
5. Continue increasing V_{GS} in 0.2 V steps while maintaining V_{DS} at 5 V, measuring the drain current at each step. Record the values of V_{GS} and I_D. Stop this process when the drain current reaches approximately 80mA.
6. Repeat this process for V_{DS} = 4, 3, 2.5, 2, 1.5, 1, and 0.5 V.

4.2 Small-Signal Transconductance

1. Adjust V_{GG} and V_{DD} to obtain $V_{DS} = 5\,\text{V}$ and $I_D = 10\,\text{mA}$.
2. Record the value of V_{GS} as V_{G1}.
3. Record the exact measured value of I_D and assign it to I_{D1}. Use the full resolution of the HP multimeter.
4. Increase V_{GS} by 10 mV and record it value as V_{G2}.
5. Measure I_D , recording it as I_{D2}.
6. Compute the small signal transconductance (Eq 1).

5 Results

The following table shows several V_{GS} values that are just slightly over the overdrive voltage V_{OV} and gives an idea of the amount of variation for values resulting from Equation 2.

$V_{TN} = 2.11\,\text{V}$	$V_{DS} = 0.5\,\text{V}$	$V_{DS} = 1\,\text{V}$	$V_{DS} = 1.5\,\text{V}$
$V_{GS} = 2.91\,\text{V}$			0.1078
$V_{GS} = 2.71\,\text{V}$		0.0931	
$V_{GS} = 2.51\,\text{V}$	0.07688		

Table 1: k'_n

6 Conclusion

Its hard to compare the Figure 2 plot with the 2N7000 data sheet because the data sheets lowest V_{GS} curve is 3 V, which is still higher than the highest V_{GS} curve in Figure 2. However, it is still apparent that the V_{GS} curve of 2.91 V in Figure 2 is similar to the 3 V curve because the V_{OV} points are roughly the same with a V_{DS} value of 1 - 1.5 V. After the V_{OV} point, both curves taper off and have a very slight positive slope.

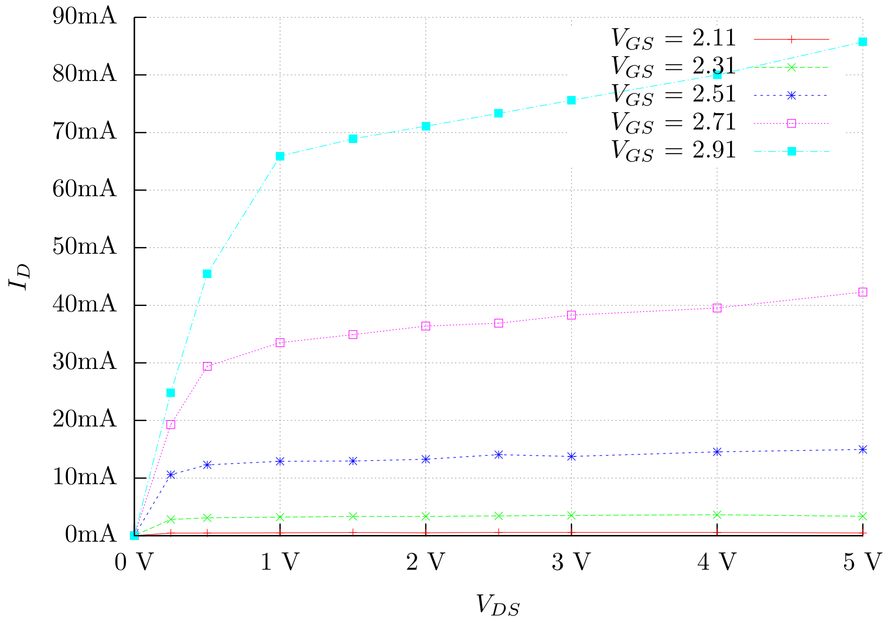

Figure 2: Voltage-Current Relationship

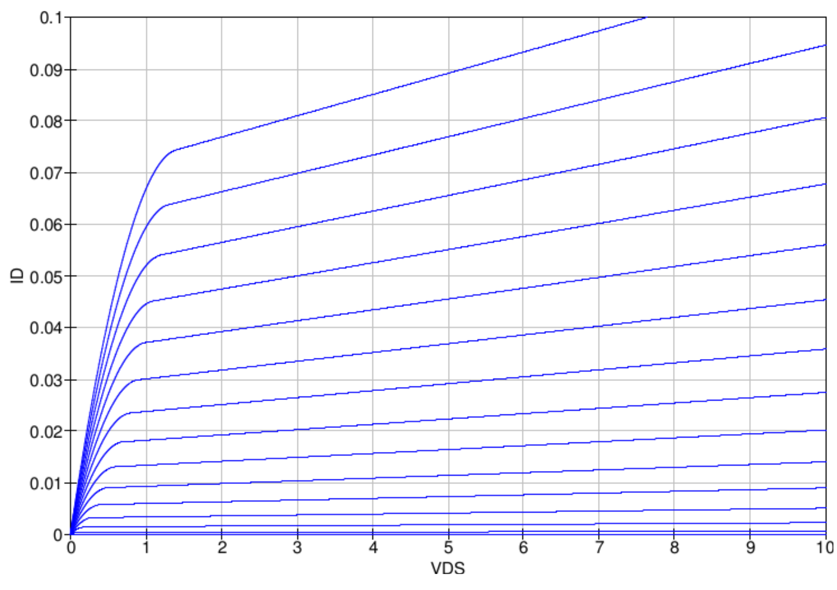

Figure 3: PSpice Simulation. $\lambda = 0.06$

Its easier to compare Figure 2 plot with the PSpice simulation because the V_{GS} are closer to the values seen in Figure 2. Again the V_{OV} values are similar in both the plot and the simulation. But, the PSpice simulation curves are flat at points beyond the V_{OV} instead of sloped like it is in Figure 2.

The second PSpice simulation (Figure 3) is more representative of the Figure 2 plots because the value of λ was changed from 0 to 0.06, which made the V_{GS} curves slope beyond the V_{OV}. Adding the λ also raised the I_D current for the individual V_{OV} points. This is because the λ value represents the slight resistance that is inherent to the transistor a low λ value is a higher resistance and a high λ is a lower resistance because the resistance is the inverse of the λ.

7 Equations

$$g_m = \frac{I_{D2} - I_{D1}}{V_{GS2} - V_{GS1}} \tag{1}$$

$$\frac{k_n'}{2} \cdot \frac{W}{L} = \frac{I_{D1}}{(V_{GS1} - V_{TN})^2} \tag{2}$$