

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: $330\ \Omega$ (x3), $2.2\ \text{k}\Omega$, $33\ \text{k}\Omega$

Multimeters: Fluke 8010A (x2)

3 Schematics

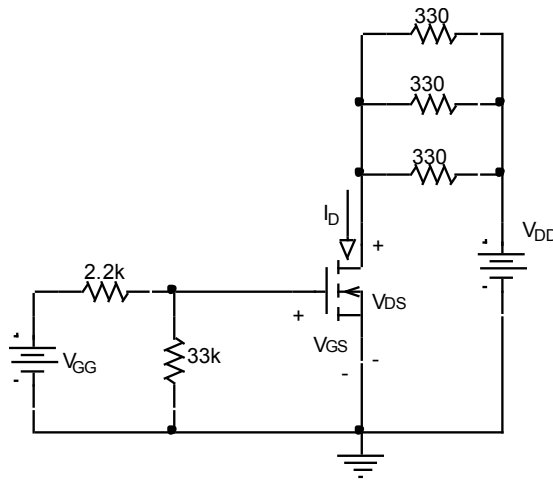


Figure 1: Circuit used in this lab.

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 $+6\ \text{V}$ power supply for V_{GG} and the $+25\ \text{V}$ supply for V_{DD} .
2. Set V_{GG} to $0\ \text{V}$ and V_{DD} to $5\ \text{V}$ 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 value of V_{GS} in the first column of table1, and record the value of I_D in the second column (the $V_{DS} = 5$ V column).
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 in table 1. Stop this process when the drain current reaches approximately 80mA.
6. Complete the entries in table 1 by adjusting V_{DD} and V_{GG} to obtain the various required V_{DS} and V_{GS} values, then measuring I_D at each value. Do not exceed 80mA drain current.

4.2 Small-Signal Transconductance

1. Adjust V_{GG} and V_{DD} to obtain $V_{DS} = 5$ V and $I_D = 10$ 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.

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

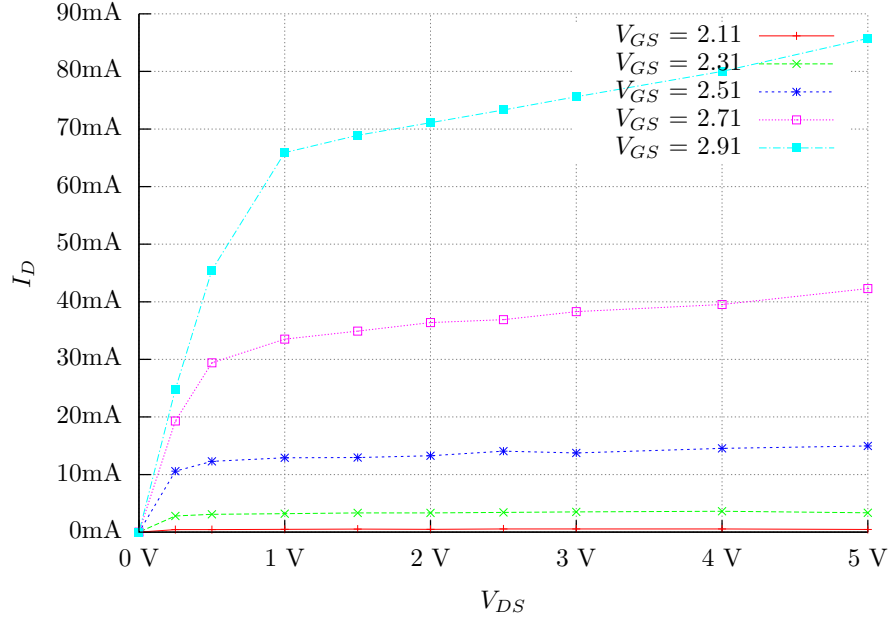


Figure 2: Voltage-Current Relationship

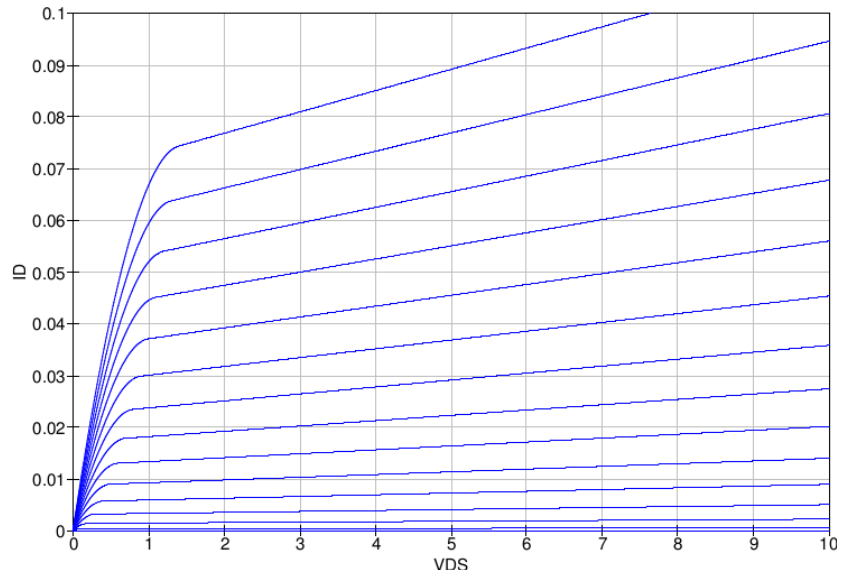


Figure 3: PSpice Simulation. $\lambda = 0.06$

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.

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

$$g_m = \frac{I_{D2} - I_{D1}}{V_{GS2} - V_{GS1}} \quad (1)$$

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