# ELEC-313
# Lab 6: MOSFET Characterization

November 5, 2013

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| Date Performed: | October 30, 2013 |
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# 1 Objective

The objective is to construct and observe the operation of a CMOS inverter and NAND gate.

# 2 Equipment

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

# 3 Schematics

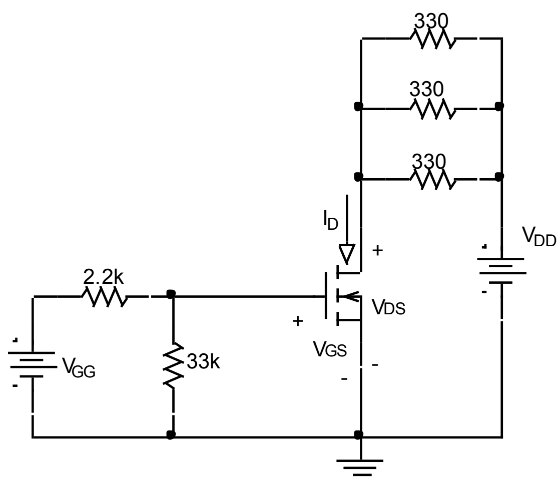


Figure 1: Circuit used in this lab.

# 4 Procedure

## 4.1 DC Characteristics

1. Obtain the 2N7000 MOSFET transistor and resistors needed to build the circuit shown.
2. Construct the circuit of figure 2. Use the HP multi-meter to measure the drain current, $I_D$ , and the Fluke multi-meters to measure $V_{DS}$ and $V_{GS}$. Use the +6 V power supply for $V_{GG}$ and the +25 V supply for $V_{DD}$.
3. Set $V_{GG}$ to 0 V and $V_{DD}$ to 5 V and measure $V_{DS}$ and $I_D$.

4. 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, $V_{TN}$.

5. 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).

6. Continue to increase $V_{GS}$ in steps of 0.2 V while maintaining $V_{DS}$ at 5 V. Measure 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.

7. 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

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

Table 1: $k'_n$

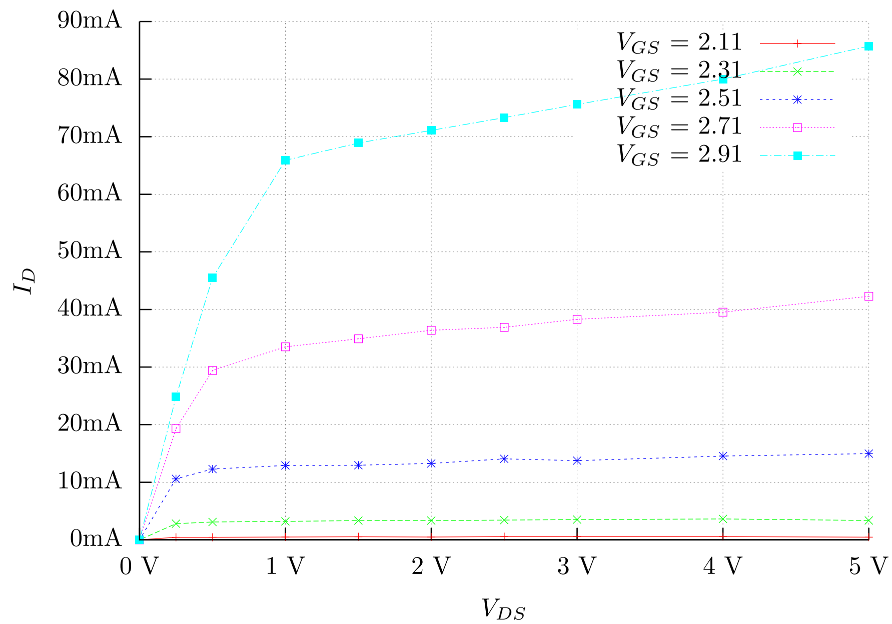


Figure 2: Graph

# 6 Conclusion

# 7 Equations

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

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