The George Washington University
School of Engineering and Applied Science
Department of Electrical and Computer Engineering
ECE 20 - LAB

Experiment # 10

N-Channel Enhancement MOSFETs
Testing & Characteristics

Equipment:
You must make up a complete equipment list and have your instructor review it before you start.

Components:
Q1 - 2N7000 MOSFET
R1 - 12 kΩ
R2 - 20 Ω

Objectives:

- To obtain device characteristics from technical data
- To obtain several device characteristics by direct test and measurement
- To obtain several characteristic curves by plotting the information taken from a test circuit
- To obtain the IV Characteristic Curves for a MOSFET by using a Tektronix Model 571 Curve Tracer
- To obtain several characteristic curves by changing model parameters of the transistor in Microsim
- To verify manufacturer specifications

1.- (HW) Transistor specifications, ratings and symbols

a) Refer to the specifications for the 2N7000 and find the following information:

- Transistor type
- The maximum total power it can dissipate at 250C (PD)
- Its maximum continuous drain current rating (ID)
- The maximum gate-source voltage rating (VGS)
- Its operating temperature range (TJ)
- Its maximum drain-source voltage rating (VDSS)
- Its maximum zero gate voltage drain current IDSS when VDS = 48 V & VGS = 0
- Its maximum drain-gate voltage when RGS = 1 mW
- Its maximum static drain-source on-resistance (rDS) when VGS = 10VDC & ID = 0.5 ADC
- Its maximum and minimum gate threshold voltage (VGS(th)) when VDS = VGS & ID = 1mA
- Its minimum forward transconductance (gfs) when VDS = 10 V & ID = 200 mA
- Its drain-source on-voltage (VDS(on)) when VGS = 10 V & ID = 0.5 ADC
- Its minimum on-state drain current (ID(on)) when VGS = 4.5 V & VDS = 10 V

Place all this information in **Data Table A - 2N7000 Specifications & Ratings.**

b) Identify the gate, drain and source pins of the 2N7000. Draw a pin out diagram of this device and call it **Figure A - Pin Out Diagram of 2N7000**.

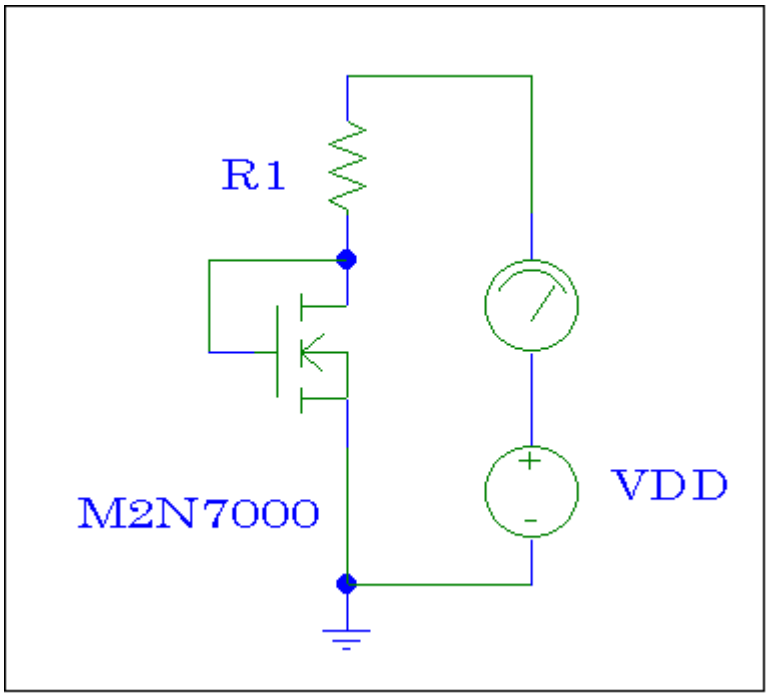
c) Draw the internal circuit of the 2N7000 chip. Label this as **Figure B - Internal circuit of the 2N7000 chip**

d) Draw and label the electrical symbols for a depletion N-Channel MOSFET and depletion P-Channel MOSFET. Draw and label the electrical symbols for an enhancement N-Channel MOSFET and enhancement P-Channel MOSFET. Place this information in **Figure C -Types of MOSFETs & Their Electrical Symbols**.

2.- Static Measurements

Set the ohm meter to its highest scale. Measure and record the resistance between the gate and source, between the gate and drain and between the drain and source. Place this information in **Data Table B - 2N7000 Static Characteristics**. Test the built-in diode protection of Q1 with the diode test feature found on the Keithley Model 175. Measure and record the forward and reverse biased readings of Q1. Include this information in Data Table B.

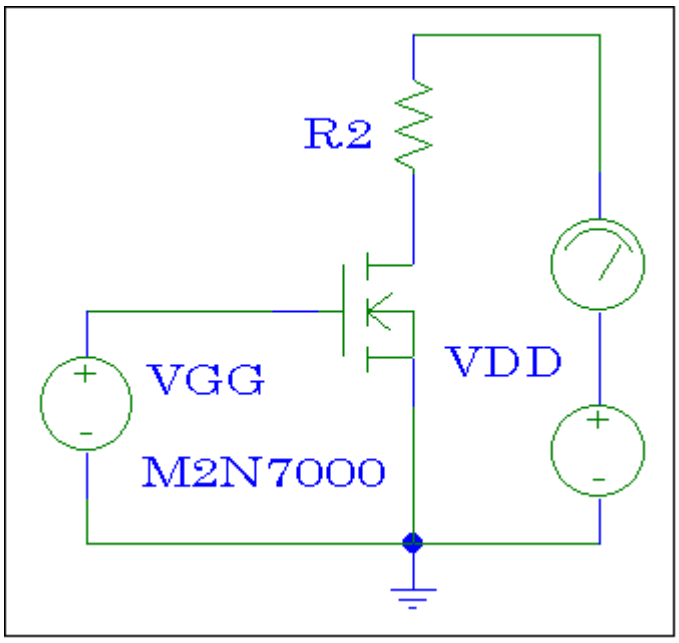
3.- Find VGS(th) when VDS = VGS & ID = 1 mA



Test Circuit #1

Assemble the circuit depicted above and then adjust VDD until the drain current (displayed on the ammeter) is equal to 1.00 mA DC. Record the value of VGS(th).

4.- Find VDS(on) when VGS = 4.5 V & ID = 75 mA



Test Circuit #2

Completely assemble this circuit above; adjust VGG to 3.5 VDC and then adjust VDD until the drain current (displayed on the ammeter)
is equal to 75.0 mADC. Record the value of VDS(on).

5- (HW) Transfer Characteristics (ID vs. VGS) for different transistor parameters using SPICE

With the help of SPICE plot ID vs. VGS for VDS = 10 Volts DC. Vary the value of VGS in the 0 to 4 Volts range.
Repeat this experiment for the following conditions:

a) β (named 'KP' in Microsim) is twice, three times and four times its default value. Do not change the value of any of the other parameters.

b) W (width of the transistor) is twice, ten times and twenty times its default value. Do not change the value of any of the other parameters.

c) tox (gate oxide thickness) is twice, ten times and twenty times its default value. Do not change the value of any of the other parameters.

6.- Find the Transfer Characteristic Curve (ID vs. VGS)

Using Test Circuit # 2 place one voltmeter between the drain and source of Q1 to measure VDS and place a second voltmeter between the gate and source to measure the VGS of Q1. Completely assemble this circuit. Keep VDS set to 10 VDC while you step VGG in 0.1 VDC increments starting at VGS(th)+0.05VDC and stopping VGS(th)+1.05VDC. Measure and record ID for each increment of VGS. Place this information in **Data Table B - 2N7000 Transfer Characteristic Curve Data (ID vs. VGS)**. Make a plot using the data collected.

7.- ID vs. VDS Characteristics Using a Curve Tracer

Obtain a copy of a family of 10 curves for the 2N7000 from the Tektronix Model 571 Curve tracer. Set ID to be no greater than 50 mA, VDS to be no greater than 10 V, VG to step 10 times in 0.1 V steps, the offset voltage to 0.05 V more than VGS(th) and Pmax to .5 Watt.

8 - Analysis

a. Explain what your tests would indicate if either the gate-source or gate-drain junctions were good, open or shorted.

b. Compare the value of VGS(th) you measured to the value specified in Data Table A.

c. Plot the data contained in Data Table B and calculate K for the 2N7000 (its units will be in amps/volts2.)

d. Compare the data in Data Table B to the curves you obtained from the curve tracer when VDS = 10.

e. Use the ID vs. VDS characteristic curves to find gm @ VDS=5VDC and VGS= Vth+1VDC.

f. Use ID vs. VDS characteristic curves to find the early voltage (VA).

g. Draw the small signal equivalent circuit model for this MOSFET and indicate the values of the small signal parameters gm and ro for the operating point VDS=5VDC and VGS=Vth+1VDC.