UNIVERSITY OF CALIFORNIA AT BERKELEY
College of Engineering
Department of Electrical Engineering and Computer Sciences

EE105 Lab Experiments

Experiment 9: MOS Characterization and Amplifiers

1 Objective

The MOS transistor is another circuit element typically used in integrated circuits. Although they are functionally similar to BJTs and can be put into several topologies analogous to BJT circuits (such as the cascode, common drain, common gate, and common source configurations), MOS transistors are completely different in terms of their characteristics and the laws that govern their behavior. This lab will explore the differences between BJTs and MOSFETs and analyze their advantages and disadvantages.

2 Materials

Component	Quantity
BS170 NMOSFET	2
8 Ω speaker	1
51 Ω resistor	1
100 Ω resistor	1
5.1 kΩ resistor	1
51 kΩ resistor	1
10 μF capacitor	1

Table 1: Components used in this lab

3 Procedure

3.1 The Three Regions of Operation

Similar to a BJT, a MOSFET also has several different regions of operation.

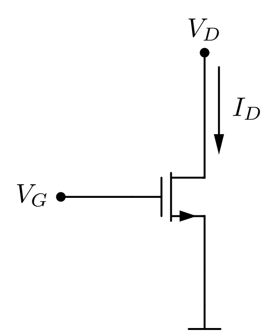

Figure 1: Setup for obtaining the I-V characteristics of an NMOS

1. Set up an NMOS transistor on the breadboard as shown in Figure 1.
2. Using ICS, step V_G from 2 V to 2.3 V in 0.05 V increments and sweep V_D from 0 V to 2 V to obtain the MOSFET I-V characterization curve. Print this out.
3. On your printout, clearly label the cutoff, triode, and saturation regions. Attach this sheet to your lab report. Approximately what criterion (i.e., what is V_{GS} in relation to V_{DS}) determines the boundary between the saturation and triode regions?
4. Given a bias of $V_{GS} = 2.1$ V and $V_{DS} = 1.5$ V, extract the transconductance g_m and the small signal resistance r_o from your plot. What region of operation is this?
5. Given a bias of $V_{GS} = 2.1$ V and $V_{DS} = 0.06$ V, extract the transconductance g_m and the small signal resistance r_o from your plot. What region of operation is this?

3.2 MOSFET Model Parameters

The model for the MOSFET consists of several parameters. This section will attempt to extract the threshold voltage V_{TH}, the channel length modulation factor λ, and the constant $K_n = \frac{W}{L}\mu_n C_{ox}$.

1. Using the I-V characteristic plot from before, extract λ from the slope of the plot. Note that this will vary somewhat depending on which V_{GS} you use.

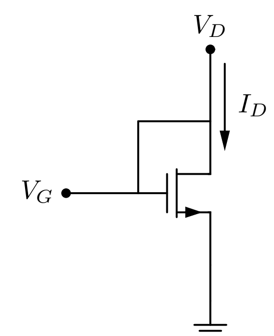

Figure 2: Diode connected MOSFET

2. Now, diode connect the NMOS as shown in figure 2. Sweep V_G from 0 V to 2.5 V and measure the current I_D.
3. Using Excel, plot $(I_D)^{\frac{1}{2}}$ vs. V_G. Print and attach this plot to your report.
4. $(1/2K_n)^{1/2}$ is the slope of the linear portion of the curve. Find K_n. *Hint: If you are an Excel guru, you can probably find the slope and intercept easily in Excel. For the rest of you, it is probably easier to do it by hand.*
5. The threshold voltage V_{TH} can be found by measuring where the linear portion of the $(I_D)^{\frac{1}{2}}$ vs. V_G curve would hit the V_G axis if it was extended. Find V_{TH}.

3.3 Simple Two-Stage Microphone to Speaker MOS Amplifier

If you haven't noticed by now, finding input and output impedances is boring. So instead, we will build a two-stage MOS microphone to speaker amplifier and analyze its performance.

1. Set up the circuit shown in Figure 3. Let $V_{DD} = 6$ V, $R_D = 51$ kΩ, and $R_S = 51$ Ω.
2. Identify the transistor configurations of the two stages (e.g., common base, common source, etc.).

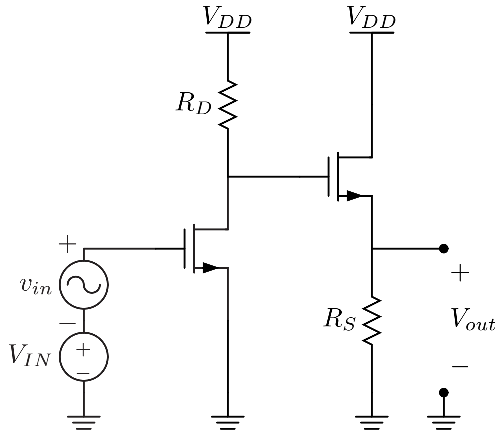

Figure 3: Microphone to speaker amplifier

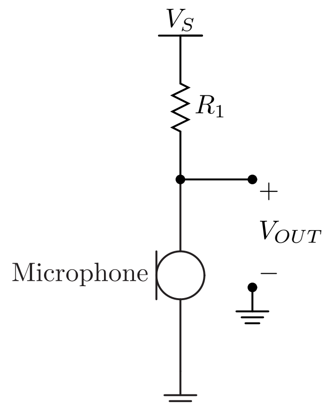

Figure 4: Microphone input

3. Using ICS, find the DC bias of V_{IN} for maximum voltage gain. Find the gain and the output voltage swing at this DC bias point. What problems might we encounter with biasing exactly at the point of maximum gain?

4. The microphone needs a bit of DC current flowing through it in order to function. Set up a resistive divider for the microphone as shown in Figure 4. Let $R_1 = 5.1\ \text{k}\Omega$. What problems might we run into if the resistor was too big or too small?

5. Adjust the supply voltage V_S (using the analog knob on the DC power supply) until V_{OUT} of the voltage divider is at the $V_{IN} = 1.95$ V.

6. Attach the output of this resistive divider to the input of the amplifier and attach the speaker to the output of the amplifier. Remember to capacitively couple the output!

7. If you built it all correctly, you should be able to hear some sounds from the speaker when someone speaks into the microphone.