Lab 10. MOSFET Amplifier

You are required to design and simulate a transistor amplifier for the lab 10. Your objective is to amplify a small AC signal into larger AC signal using a MOSFT. You are free to choose any components and parameters. As for the lab report, you are required to submit simulation results and experimental results. Brief explanations of design and procedure are also required.

Required Tools and Technology

Platform: NI ELVIS II/II+ Instruments used in this lab: ● Instrument 1: Function Generator ● Instrument 2: Oscilloscope ● Instrument 3: Variable Power Supply **Note:** The NI ELVIS III Cables and Accessories Kit (purchased separately) is required for using the instruments.	View User Manual: https://bit.ly/36DFFrv https://bit.ly/36CnQZH (Credit to Clemson University) View Tutorials: https://bit.ly/35Ae9Kc (Credit to Colorado State University) Install Soft Front Panel support: https://bit.ly/2NbhTv6
Hardware: NI ELVIS II/II+ Default Prototyping Board	View Breadboard Tutorial: http://www.ni.com/tutorial/54749/en
Hardware: Electronics Kit	• Various values of resistors • MOSFET
Software: NI Multisim Live	Access online http://multisim.com View Help http://multisim.com/help/

1. Background

Three terminal devices can be used to implement a controlled source. This property makes them suitable to be used in amplifiers. A transistor is an example of a device of this kind. In particular, MOSFET (metal-oxide-semiconductor field-effect transistor) is a widely used three terminal devices. The working principle of a MOSFET amplifier is controlling the current flowing through drain terminal by setting the gate-to-source voltage. This property can be achieved by operating the MOSFET in the saturation (active) region.

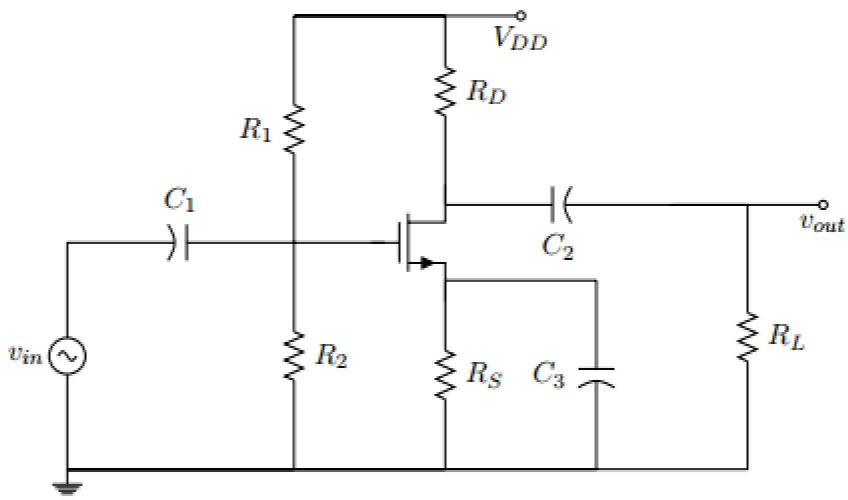

Figure 1: Common-source amplifier

The common source is the most commonly used MOSFET amplifier. The name "common source" comes from the fact that when the source terminal is grounded, it becomes a common terminal for both drain and source terminals. To cancel the nonlinear relationship of v_{GS} versus i_D biasing techniques are used. In this experiment voltage-divider bias technique will be implemented. In voltage divider bias (see Figure 1),V_G and V_{GS} can be found using Equation 1.

$$\begin{aligned} V_G &= \frac{R_2}{R_1 + R_2} V_{DD} \\ V_{GS} &= V_G - I_D R_S \end{aligned} \tag{1}$$

Transconductance of a transistor is an important characteristic of the transistor. Transconductance can be explained simply as the deviation of drain current with respect to the deviation of gate voltage. With the Equation 2 the transconductance depends on the bias current I_D.

$$g_m = \frac{\Delta i_D}{\Delta v_{GS}} = \frac{2 I_D}{V_{GS} - V_t} \tag{2}$$

The gain A_v can be calculated as:

$$A_v = -g_m (R_D \parallel R_L \parallel r_o) \approx -g_m (R_D \parallel R_L) \tag{3}$$

under the condition $r_0 \gg R_D || R_L$

2.1. Part 1: DC Analysis

1. Construct the network of Figure 1 using Multisim and circuit breadboard. Use the following resistances and capacitances (V_{DD}=15V):
   $R_1 = 3k\Omega$
   $R_2 = 1k\Omega$
   $R_D = 10k\Omega$
   $R_S = 3.3k\Omega$
   $R_L = 10k\Omega$
   $C_1 = C_2 = C_3 = 100\mu F$
   Suggested MOSFET 2N7000 (Vt = 25mV)
2. Remove the Vin AC source
3. Measure the DC values of V_G, V_S, V_D, I_D, V_{GS} and V_{DS}.
4. Calculate the transconductance (g_m) using measured values of I_D, V_{GS} and V_t. (Hint: Use Equation 2).
5. Calculate the Voltage Gain (A_v) using Equation 3

2.2. Part 2: AC Analysis

1. Apply 10mV peak sinusoidal signal (V_{in}) at 1kHz to the circuit of Figure 1.
2. What is the measured voltage gain? (Hint: Use $A_v=V_{out}/V_{in}$)

How can we control the gain? How can you decrease the gain (without changing the bias point) so it works with larger input signals?

APPENDIX

The following is the template of the ECE 3313 report. Note that the report must be typed using Microsoft Words/Excel. Please download the template from the Canvas website.

ECE 3313 Lab X Report   Your Name

Title: Lab 1: Observation, Modeling, and Communication

NAME: **Partner:**

General Objective: One or two sentences that describe the objective of this specific lab.

1.0 Prelab Activities: If there is any

2.0 Background Activities: Read background information and summarize important theory, equation, etc.

3.0 Procedure: Describe step-by-step procedure, including circuit schematic, calculation, and etc.

4.0 Results: A lab often includes questions. Please include your answer under the result sections.
- **4.1 Simulation Results:** Make sure to fully discuss about the results, figure, etc.
- **4.2 Experimental Results:** Make sure to fully discuss about the results, figure, etc.

5.0 Conclusions

Remark: Your lab report should include ALL relevant calculations, pictures and work needed for completion of the experiment. Circuit output validation using Multisim is also required. Detailed explanations for decisions made throughout the lab need to be included in the Discussion section of your report as outlined in the Report Guidelines.