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# **ECE 334: Electronic Circuits**

## **LAB 5 – MOSFET Amplifier**

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# 1.0 OBJECTIVES

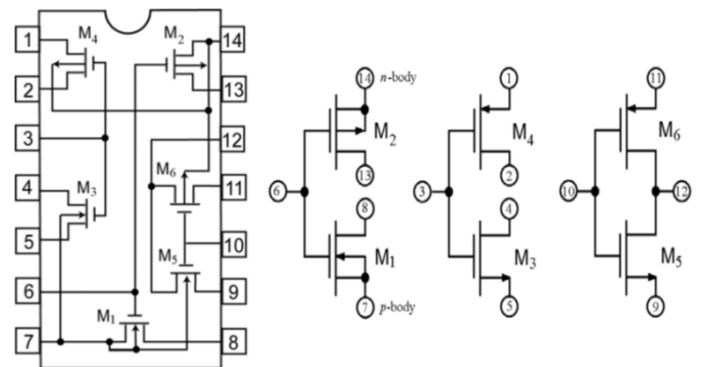
The objective of this lab is to study the operation of MOSFETs as an amplifier. Upon finishing this lab, students should be familiar with:

- 1) Self-biased topology and the usage of feedback resistance.
- 2) Measuring the amplifier gain & comparing it with theoretical results.
- 3) The effect of load resistance on the amplifier gain.

# 2.0 REQUIRMENTS

To proceed with this lab, the following components are required:

- Resistor: 10 MΩ (1x).
- Resistor: 10 KΩ (2x).
- MOSFETs IC: CD4007UB (1x).
- Experiment Board (1x).
- Avometer (1x).
- Jumper wires & crocodile-wiring.



MOSFET Chip: CD4007UB

# 3.0 INTRODUCTION

In this lab, students will work with NMOS transistor **M3** in the IC “CD4007UB” just like the previous lab.

Note that **pins (3, 4, 5 & 7) are (Gate, Drain, Source, Bulk)** of the NMOS. Students need to make sure that the bulk of the NMOS is connected to the lowest potential in the circuit (Usually grounded at 0V) in order to make the bulk-diffusion PN-Junction reversed.

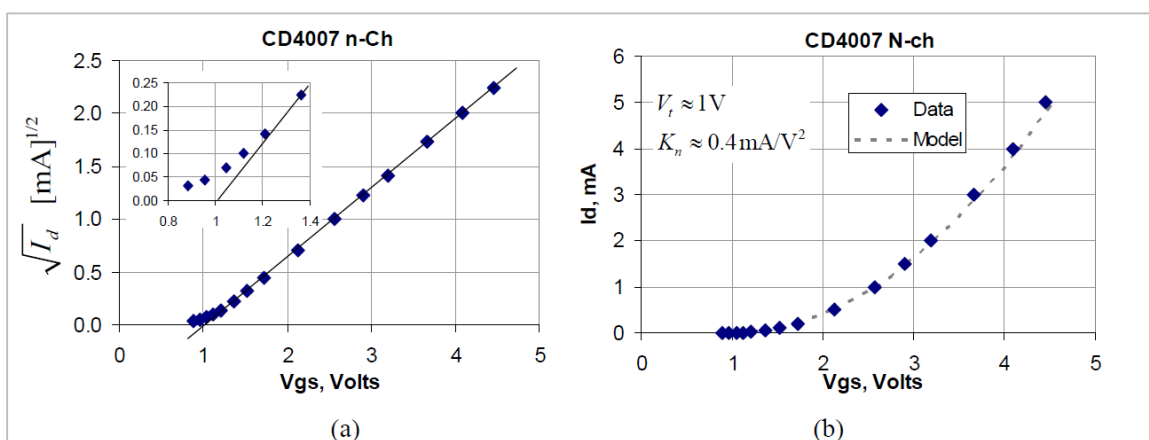


Figure (1): IV Characteristics of the NMOS in CD4007UB IC

Recall that in the previous lab, the measurements of the NMOS agreed with the MOSFET-IC results shown in figure (1). The results are summarized below:

- $V_{th} = 1$  Volt
- $K_n = \mu_n C_{ox} \frac{W}{L} = 0.4\text{m (A/V}^2\text{)}$ .
- $g_m = 0.8$  mS
- $r_o = 100$  K $\Omega$

Students will construct the circuit shown in figure (2); which is a common source with feedback resistance  $R_f$ . This topology is useful because it is self-biased; meaning that the gate is biased by the drain, hence there is no need for an additional voltage supply.

This topology has two operating modes; either cutoff or saturation. We'll use the saturation mode to make the MOSFET operate as an amplifier.

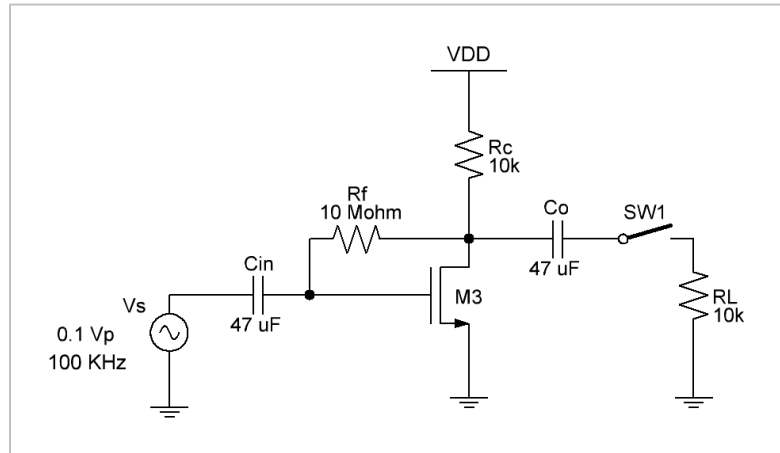


Figure (2): CS-Amplifier with feedback resistance

Upon analyzing the circuit gain, students will conclude that the resistance  $R_f$  is of a large value in order to make the input current very small. Hence, the analysis will be very easy considering the nodes of drain-gate as open circuit. The final approximate expressions are summarized below:

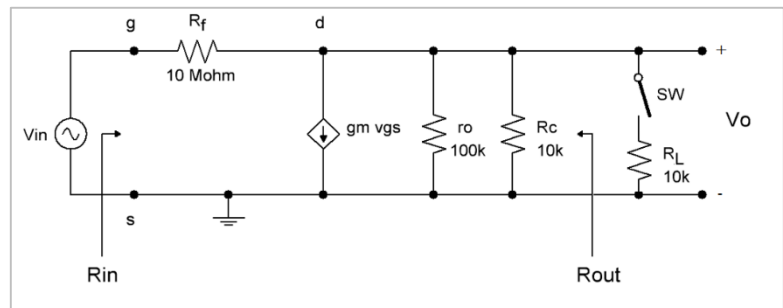


Figure (3): Small Signal Model of CS-Amplifier with feedback resistance

$$A_v = -\frac{(\frac{1}{R_f} - g_m)}{(\frac{1}{R_f} - \frac{1}{r_o \parallel R_C})} = -g_m (r_o \parallel R_C) \quad \text{(With switch SW1 opened)}$$

$$A_v = -\frac{(\frac{1}{R_f} - g_m)}{(\frac{1}{R_f} - \frac{1}{r_o \parallel R_C \parallel R_L})} = -g_m (r_o \parallel R_C \parallel R_L) \quad \text{(With switch SW1 closed)}$$

Immediately, one can conclude that the load resistance affects the gain of the circuit. If  $R_L$  was large enough compared to  $(r_o \parallel R_C)$ , then the gain will not be affected. The situation here is the opposite;  $R_L$  is comparable to  $(r_o \parallel R_C)$ , hence the gain is expected to decrease.

# 4.0 EXPERIMENT PROCEDURE

Follow these steps to complete the lab:

- Step 1:
  - Construct the circuit as in figure (4) on your breadboard.
  - Use  $V_{DD} = 12 \text{ Volt}$ , from the DC variable supply in the lab.
  - Use the MOSFET M3 from IC CD4007UB.
  - The pins of M3 are (G, D, S, B) -> (3,4,5,7).
  - Connect pin (7) "Bulk node" to ground node.
  - Use minimum number of wiring & jumpers.

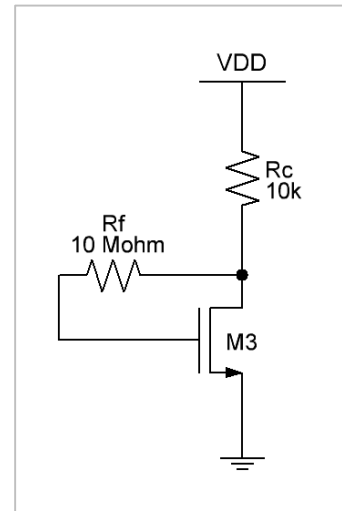
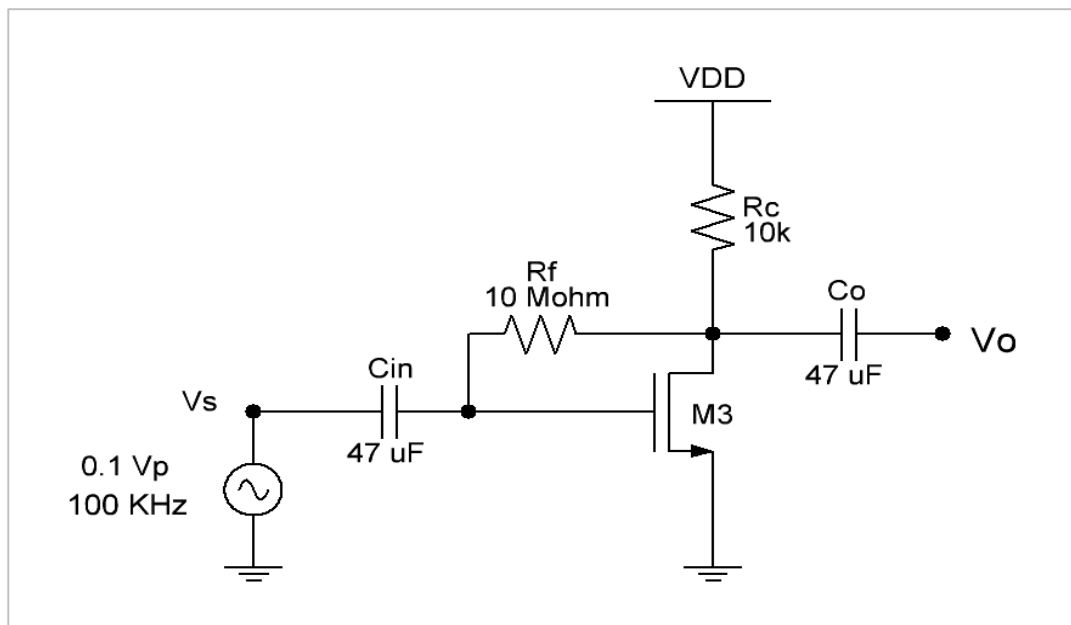


Figure (4): CS-Amplifier DC

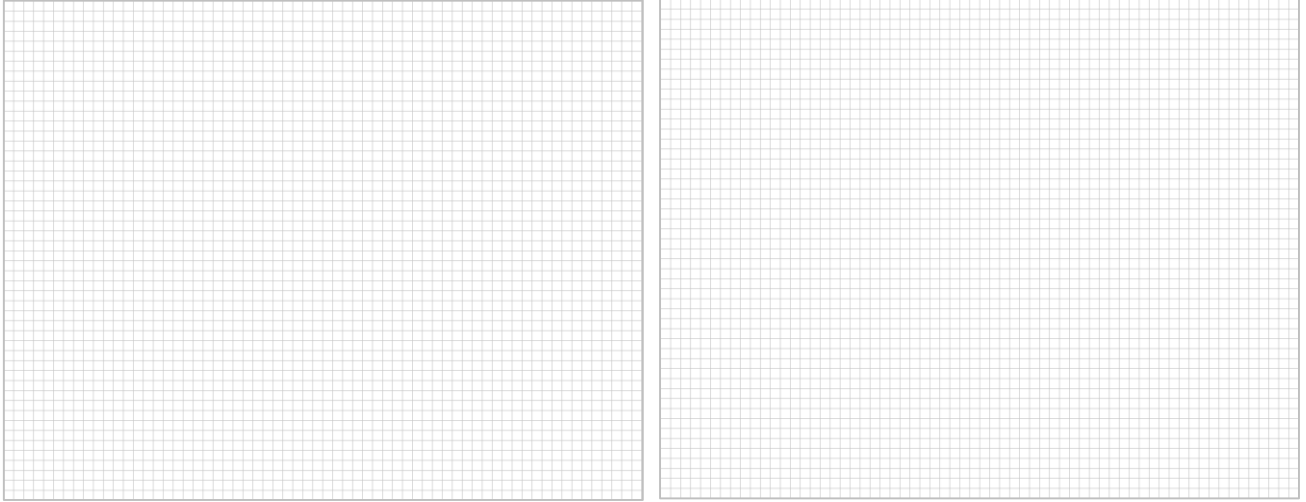
- Step 2:
  - Measure the voltage  $V_{DS}$  to make sure that the circuit is operating in saturation mode correctly.
  - The expected value of  $V_{DS}$  is around 3 Volt. (Results may vary from one IC to another).
- Step 3:
  - Complete the circuit by adding the input & output capacitors as shown in figure (5).
  - Set the function generator on  $0.1 V_p$  at 100 KHz.



○ Step 4:

- Use **both oscilloscope channels (CH1 & CH2)** to plot the input & output waveforms at nodes  $V_S$  &  $V_o$ .

Plot both  $V_S$  &  $V_o$  VS. time below:



- Calculate the gain:  $A_V = \frac{V_o}{V_S} = \dots\dots\dots$

○ Step 5:

- Connect the resistor  $R_L$  shown in figure (2); (with SW1 closed).
- Recalculate the gain:  $A_V = \frac{V_o}{V_S} = \dots\dots\dots$
- By what factor did the gain change? Why?

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## 5.0 Report (Assignment)

Use Multisim circuit simulator & construct the circuit shown in figure (2), then do the following procedure:

- 1) Read the report introduction section well.
- 2) Construct the circuit as shown in figure 1 on your simulator, then put a screen shot in your report. (1 Mark)
- 3) Set the input signal to 100 mV.
- 4) Plot the input & output signal when the switch SW1 is **opened**, then put a screen shot with this plot. Calculate the gain  $A_v = V_o / V_s$ . (**You should show the signal magnitude clearly on you report**) (1 Marks)
- 5) Plot the input & output signal with the switch SW1 **closed**, then put a screen shot with this plot. Calculate the gain  $A_v = V_o / V_s$  in this case. (1 Mark)
- 6) Compare your simulated results with the lab results. (1 Mark)
- 7) Change the value of  $R_L$  to 100 K $\Omega$ , then re-calculate the gain in this case. State what happened to the gain & why. (1 Mark)

Notes:

- Reports without cover pages or neat plots **will not be marked**.
- Copied reports will receive zero grade for all students involved.
- Cover page should include the college logo, experiment name/number, your name & your **ID**.
- Plot only 2 cycles (periods) of the input/output waves. No need to show multiple periods!

Student Sheet:

	Student Name	Group Number	Experiment Mark
1			
2			
3			
4			
5			
6			



Instructor Sheet

	Student Name	Group Number	Experiment Mark
1			
2			
3			
4			
5			
6			