UM-SJTU Joint Institute

VE311

Laboratory Report

Excercise 3

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Date: August 7, 2025

[rev4.1]

1 Objective

In this lab, we will explore the properties of MOSFET circuits, source degenration, and implement the design of a common-source amplifier.

2 Experiment Results

2.1 I-V Characteristic

Table 1: I-V Characteristics with fixed V_G

$V_G = 2.0V$					
V_D (V)	0.1	0.2	0.3	0.4	0.5
I_D (mA)	5.42	8.60	9.67	10.10	10.34
$V_G = 2.1V$					
V_D (V)	0.1	0.3	0.5	0.7	1.0
I_D (mA)	8.41	16.07	17.81	18.45	19.00

Table 2: I-V Characteristics with fixed V_D

$V_D = 2V$					
V_G (V)	0.1	0.3	1.0	2.0	2.5
I_D (mA)	0	0	0	11.75	32.5
$V_D = 1.5V$					
V_G (V)	0.1	0.3	1.5	2.0	2.2
I_D (mA)	0	0	0	11.3	31.1

In this part, we have measured the $V - I$ property and get the following result.

2.2 Common Amplifier

In this lab, we have built the following circuit, adn use the corresponding value.

I	V_{DD}	V_{IN}	R_D	R_S
1 mA	5 V	2 V	650 Ω	100 Ω

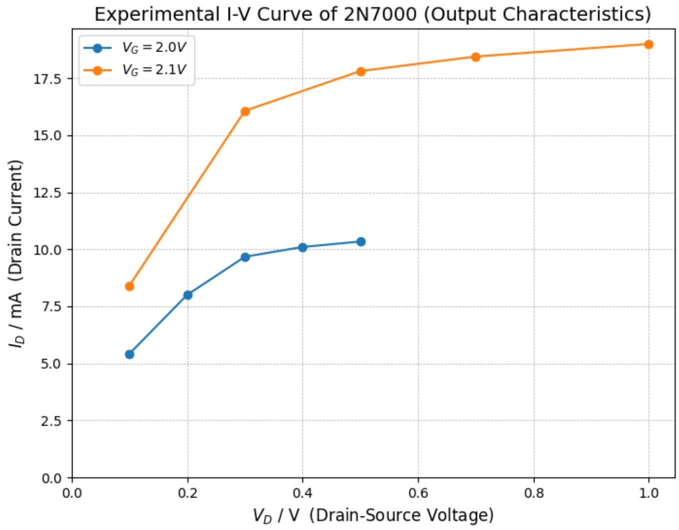

Figure 1: IV Curve for 2N7000 (I)

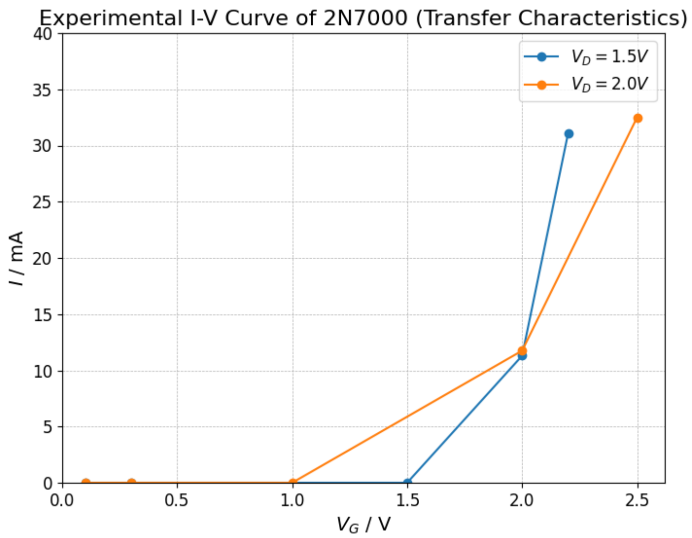

Figure 2: IV Curve for 2N7000 (II)

Then, plug in the data, we can get

$$
\begin{aligned}
V_D &= V_{DD} - I_D R_D = 3.5\,\mathrm{V} \\
V_S &= I_D R_S = 1.0\,\mathrm{V} \\
V_{DS} &= V_D - V_S = 2.3\,\mathrm{V} \\
V_{GS} &= V_{IN} - V_S = 0.8\,\mathrm{V}
\end{aligned}
$$

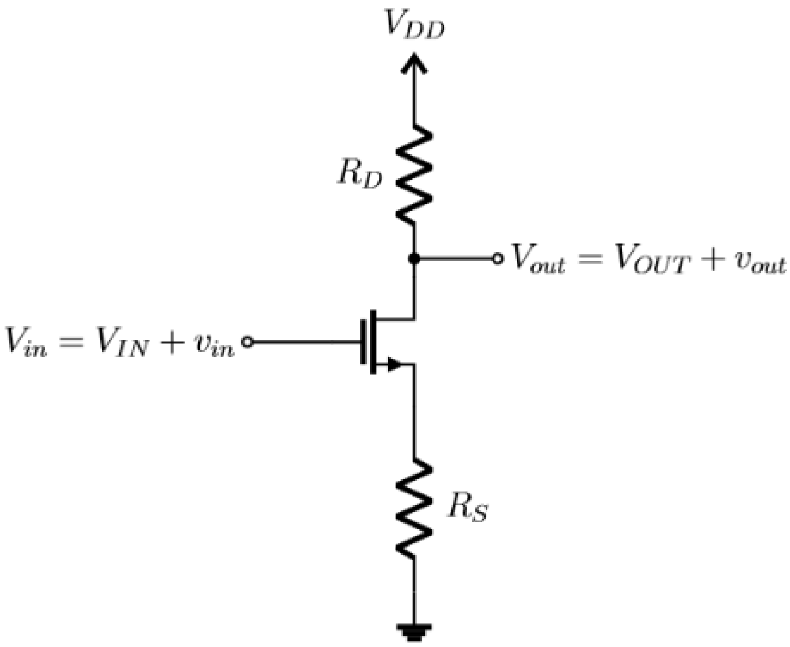

Figure 3: Common Source Amplifier

We have obtained the following measured data in the lab:

	V_D	V_S	V_{DS}	V_{GS}
Theoretical	3.5 V	1.2 V	2.3 V	0.8 V
Actual	7.2 V	1.7 V	2.8 V	1.9 V

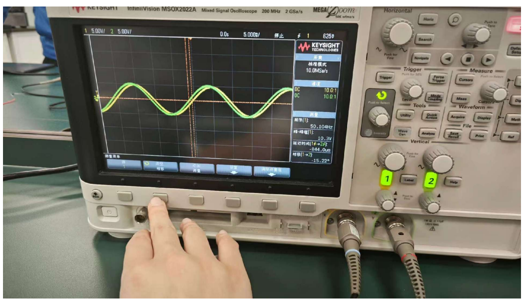

Figure 4: V_{in1-1}

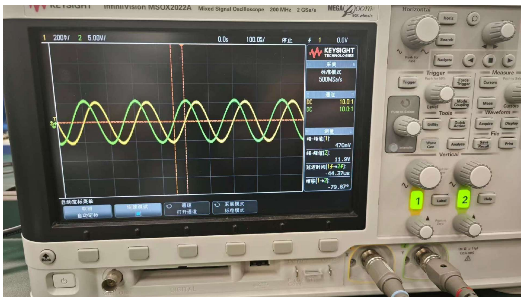

Figure 5: V_{in1-2}

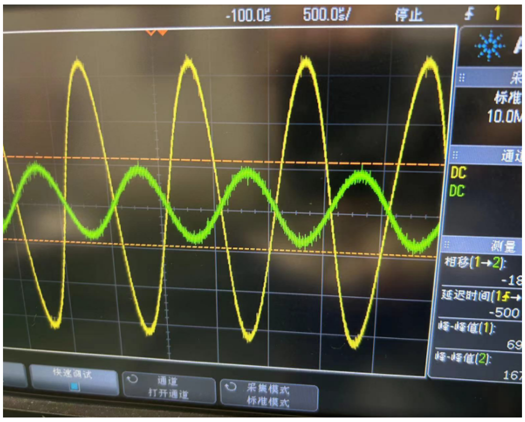

Figure 6: V_{in1-3}

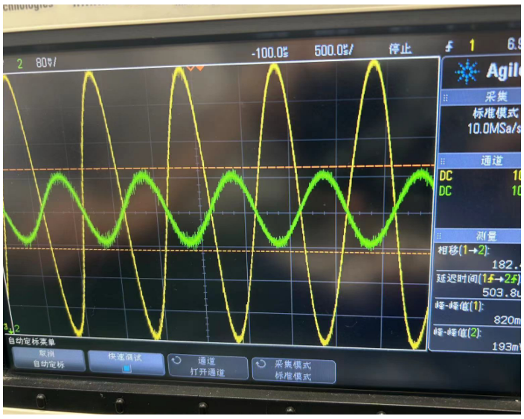

Figure 7: V_{in1-4}

$v_{in}(mV)$	10	20	30	40
$v_{out}(mV)$	80	92	120	141
A_v	8	4.6	4	3.5

Table 3: A_v for the circuit with both sides resistor

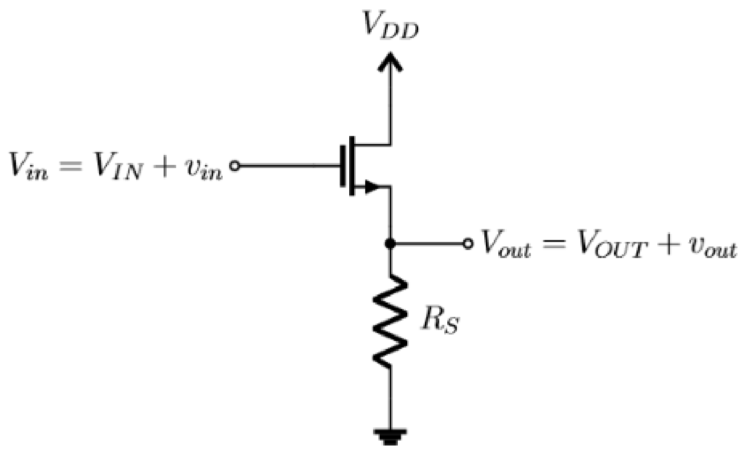

Figure 8: Source Follower

2.3 Source Follower

In this lab, we have built the following circuit, adn use the corresponding value

$$V_S = I_D R_S = 1V$$
$$V_{DS} = V_{DD} - V_S = 4V$$
$$V_{GS} = V_{IN} - V_S = 1V$$

I	V_{DD}	V_{IN}	R_S
10 mA	5 V	2 V	100 Ω

	V_S	V_{DS}	V_{GS}
Theoretical	1	4	1
Actual	0.8	6.8	1.4

We have obtained the following measured data in the lab:

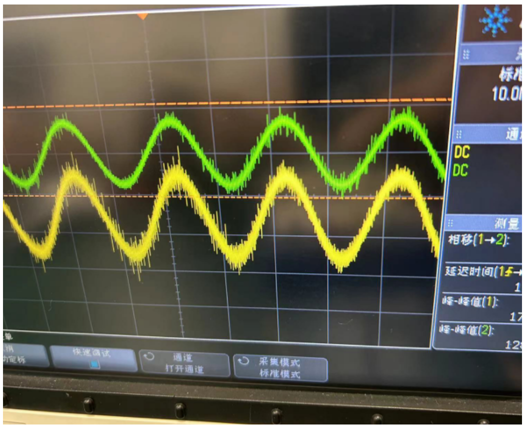

Figure 9: V_{in2-1}

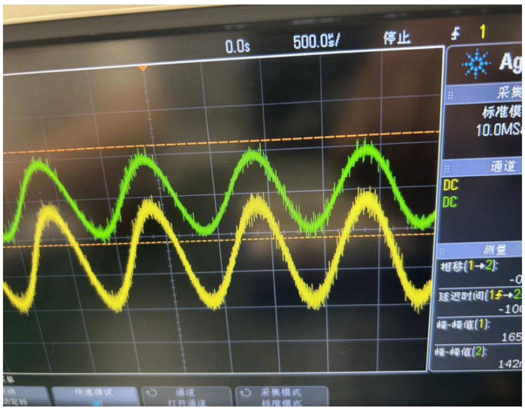

Figure 10: V_{in2-2}

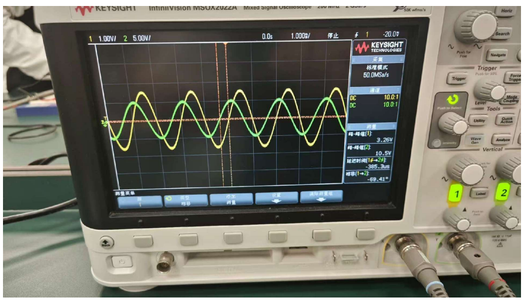

Figure 11: V_{in2-3}

v_{in}	100	150	200	300
v_{out}	102	120	130	155
A_v	1.02	0.8	0.65	0.52

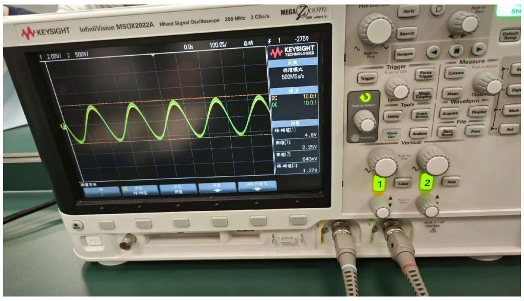

Figure 12: V_{in2-4}

3 Simulation Result

3.1 I-V characteristic

We have built the simulation circuit and get the following result

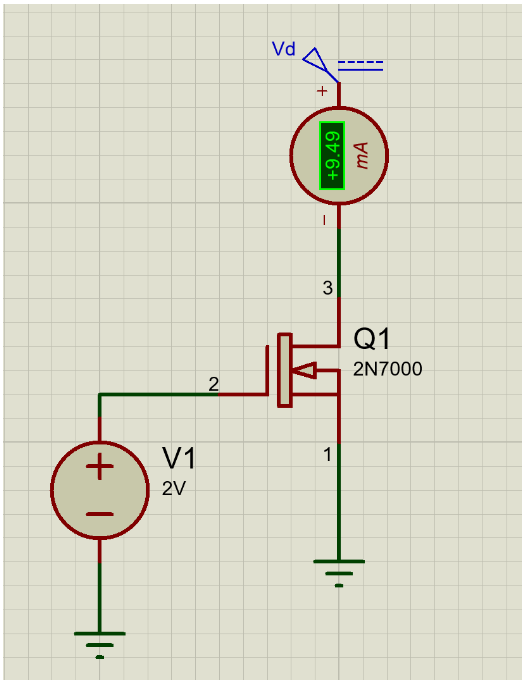

Figure 13: Simulation Circuit

Vg=2					
Vd(V)	0.1	0.2	0.3	0.4	0.5
I(mA)	9.49	18	25.5	32	37.5
Vg=2.1V					
Vd(V)	0.1	0.3	0.5	0.7	1
I(mA)	10.4	28.1	41.9	51.6	58.6
Vd=2V					
Vg	0.1	0.3	1	2	2.5
I	0	0	0.43	49.9	104
Vd=1.5V					
Vg	0.1	0.5	1.5	2	2.2
I	0	0	14.9	49.7	69.1

Figure 14: Simulation Result

3.2 Common Amplifier

We have built the simulation circuit and get the following result

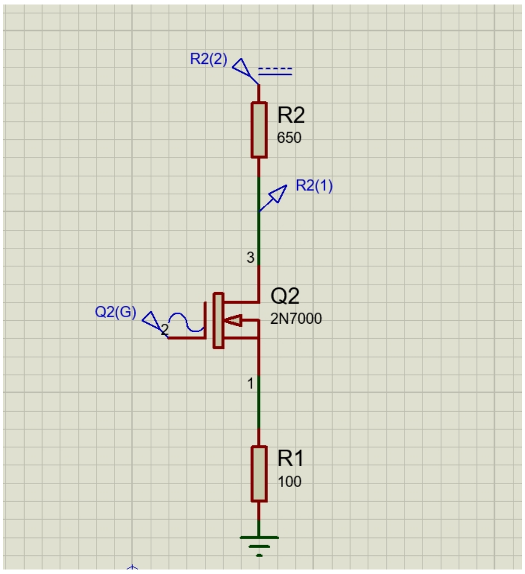

Figure 15: Simulation Circuit

Vin(mV)	10	20	30	40
Vout(mV)	12	26	44	60
Av	1.2	1.3	1.466667	1.5

Figure 16: Simulation Result

3.3 Source Follower

We have built the simulation circuit and get the following result

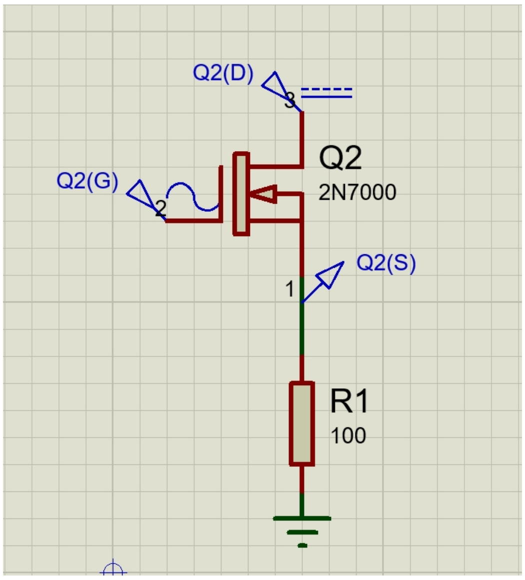

Figure 17: Simulation Circuit

Vin(mV)	100	150	200	300
Vout(mV)	158	230	308	460
Av	1.58	1.533333	1.54	1.533333

Figure 18: Simulation Result

4 Error Analysis

4.1 Errors Introduced by Measuring Instruments and Methods

The measurement process in this experiment is subject to instrumental errors. Systematic errors stem from the digital multimeter's finite internal resistance, which creates a loading effect that can inaccurately lower voltage readings at high-impedance points, and from the oscilloscope probe's intrinsic capacitance, which alters the circuit's frequency response and reduces the measured -3dB cutoff frequency. Additionally, random errors were introduced into dynamic signal measurements by power line noise and ambient electromagnetic interference, which appeared as small fluctuations on the oscilloscope waveform.

4.2 Errors from Circuit Construction and Environmental Factors

The circuit's performance is impacted by both the prototyping medium and thermal effects. The breadboard introduces issues like contact resistance and unreliability, which can cause intermittent connection failures, while long wires add parasitic inductance and capacitance that degrade high-frequency performance. Additionally, as the transistor heats up during operation, its material properties (carrier mobility and threshold voltage) change. This thermal effect causes the DC operating point to drift, leading to inconsistent measurements as the circuit warms up to a stable temperature.

5 Conclusion

This experiment successfully verified the core electrical characteristics of the MOSFET and its application in analog circuits. By measuring the V-A characteristic curves, we grasped the criteria for identifying its different operating regions. Concurrently, the successful construction and testing of the common-source amplifier and source follower circuits demonstrated our understanding of the MOSFET small-signal model and its application in circuit gain design. The experimental results were consistent with theoretical expectations, fulfilling the lab's requirements.