ELEC-313
Lab 7: MOSFET Amplifier Circuits

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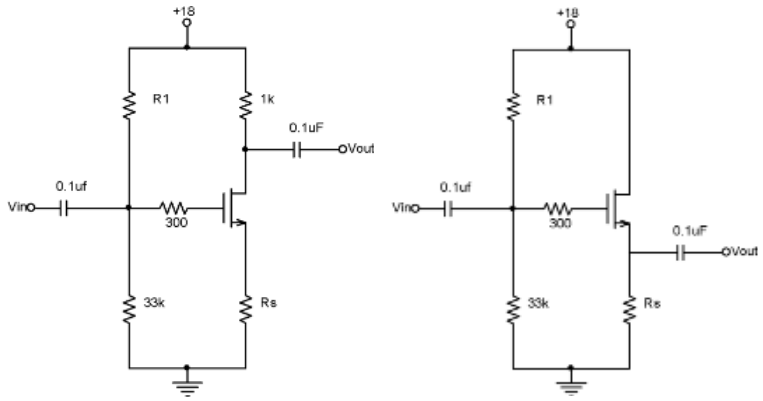
1 Objective

2 Equipment

Transistor: 2N7000	Power supply: HP E3631A
Function generator: HP 33120	Multimeter: HP 34401A
Oscilloscope: Agilent 54622D	Capacitors: 0.1 µF
Resistors: 100 Ω, 300 Ω, 470 Ω, 1 kΩ (x2) 33 kΩ, 100 kΩ (x2)	

3 Schematics



(a) Common-source amplifier (b) Source-follower amplifier

Figure 1: Circuits used in this lab. $R_1 = 100\,\text{k}\Omega$, $R_s = 470\,\Omega$

4 Procedure

The following procedures were identified to observe the basic operation of MOSFET amplifier circuits.

4.1 Common-Source Amplifier

1. Build the circuit shown in Figure 1a. Use the closest resistor values available for R1 and Rs.

2. Measure and record the drain current and DC voltages at all terminals of the MOSFET.

3. Set the function generator for a $200\,\text{V}_{\text{pp}}$, 20 kHz sine wave with 0 VDC offset. Connect it to V_{in}.

4. Connect a 100 kΩ load resistor from V_{out} to ground. This will be considered a no-load scenario.

5. Connect channel 1 of the oscilloscope to V_{in} and channel 2 to V_{out}. Set the scope to trigger off of channel 1.

6. Adjust the function generator to an amplitude of 200 V_{pp} as measured on channel 1 of the oscilloscope.

7. Measure the peak-to-peak output voltage on channel 2 of the oscilloscope.

8. Repeat step 6 for input voltages of 300, 400, 500, 600, 700, 800, 900, and 1000 mV_{pp}.

9. Replace the 100 kΩ from V_{out} to ground with a 1 kΩ load resistor.

10. Reset the function generator to an amplitude of 200 V_{pp} as measured on channel 1 of the oscilloscope.

11. Measure the peak-to-peak output voltage on channel 2 of the oscilloscope.

4.2 Source-Follower Amplifier

1. Construct the circuit shown in Figure 1b by removing the 1 kΩ drain resistor and moving the output capacitor to the source of the MOSFET.

2. Measure and record the drain current and DC voltages at all terminals of the MOSFET.

3. Connect a 100 kΩ load resistor from V_{out} to ground. This will be considered a no-load scenario.

4. Adjust the function generator to an amplitude of 200 V_{pp} as measured on channel 1 of the oscilloscope.

5. Measure the peak-to-peak output voltage on channel 2 of the oscilloscope.

6. Repeat step 4 for input voltages of 300, 400, 500, 600, 700, 800, 900, and 1000 mV_{pp}.

7. Reset the function generator to an amplitude of 200 V_{pp} as measured on channel 1 of the oscilloscope.

8. Replace the 100 kΩ resistor from V_{out} to ground with a 1 kΩ resistor and measure the peak-to-peak output voltage on channel 2 of the oscilloscope.

9. Now replace the 1 kΩ load resistor with a 100 ohm load resistor and measure the peak-to-peak output voltage on channel 2 of the oscilloscope.

	V_G (V)	V_D (V)	V_S (V)	I_D (mA)
Measured	4.391	13.498	2.11	4.52
Theoretical	4.466	14.000	2.4214	4.00
% Difference	1.712%	3.719%	14.800%	11.500%

Table 1: Transistor characteristics

V_{in} (mV)	V_{out} (V)	A_V
200	0.382	1.91
300	0.566	1.89
400	0.760	1.90
500	0.939	1.88
600	1.140	1.90
700	1.340	1.91
800	1.530	1.91
900	1.721	1.91
1000	1.90	1.90

Table 2: Common-source amplifier

5 Results

5.1 Common-Source Amplifier

5.2 Source-Follower Amplifier

V_G	V_D	V_S	I_D
4.391 V	18.003 V	2.12 V	4.579 mA

Table 3: Transistor characteristics

6 Conclusion

The mean voltage gain (AV) for the Common Source Amplifier (CSA) is 1.90 (as shown in Table ??) and the output resistance (RO) is 990 ohms or roughly the same as the 1k ohm drain resistor (RD). The output voltage is 180 out of phase from the input voltage. The mean AV for the Source Follower Amplifier (SFA) is 0.903 (as shown in Table ??) and the output resistance is relatively low at 43.6 ohms. The input and the output voltages are also in phase. The input resistance is much higher thatn the output resistance therefore the output current is much higher. A CSA is useful when a voltage gain is desired and when an output voltage is needed to be 180 out of phase. An SFA is useful when no voltage gain is desired, a large current gain is desired, and the output voltage is needed to be in phase with the input voltage.

V_{in} (mV)	V_{out} (mV)	A_V
200	182	0.910
300	268	0.893
400	360	0.900
500	451	0.902
600	541	0.902
700	634	0.906
800	725	0.906
900	813	0.903
1000	906	0.906

Table 4: Source-follower amplifier

7 Equations

$$V_{o,L} = V_{o,NL} \frac{R_L}{R_o + R_L} \tag{1}$$

$$V_G = \frac{V_{DD} \cdot 33\,\mathrm{k\Omega}}{100\,\mathrm{k\Omega} + 33\,\mathrm{k\Omega}} \tag{2}$$

$$V_S = V_G \cdot \sqrt{\frac{I_D}{K_N}} - V_{TN} \tag{3}$$

$$V_D = V_{DD} - I_D \cdot 1\,\mathrm{k\Omega} \tag{4}$$

$$I_D = \frac{V_S}{R_S} \tag{5}$$

$$A_V = \frac{V_{out}}{V_{in}} = \frac{-g_m \cdot R_D}{1 + g_m \cdot R_S} \tag{6}$$

$$\%_{diff} = \frac{|measured - theoretical|}{theoretical} \times 100\% \tag{7}$$