HO CHI MINH CITY UNIVERSITY OF TECHNOLOGY

FACULTY OF ELECTRICAL AND ELECTRONICS

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COURSE: ELECTRONIC CIRCUITS

PROJECT REPORT

Lecturer – Prof. Huỳnh Phú Minh Cường

COMMON SOURCE MOSFET AMPLIFIER NUMERICAL AND LTSPICE SIMULATION

Name	ID	Class
Nguyễn Phạm Minh Khôi	2151105	TT01

I. INTRODUCTION

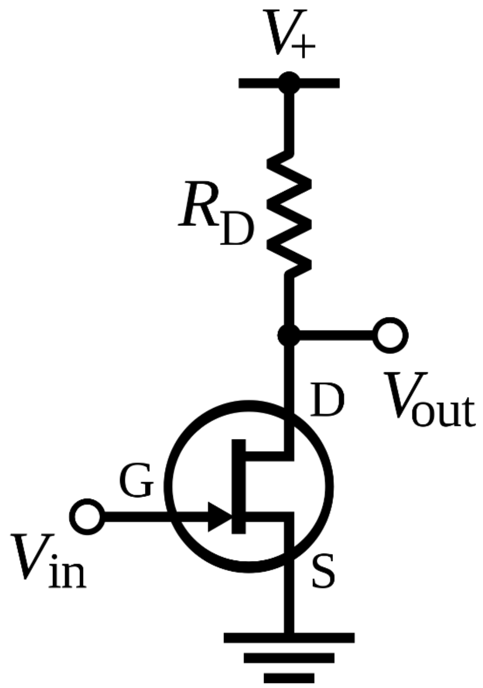
1. Common Source Amplifier

A common-source amplifier is one of three basic single-stage field-effect transistor (FET) amplifier topologies used as a voltage or transconductance amplifier in electronics. The simplest way to determine whether a FET is a common source, common drain, or common gate is to look at where the signal enters and exits. The remaining terminal is referred to as "common." The signal enters the gate and exits the drain, the source is the only remaining terminal.

2. FET Common Source Amplifier Circuit

The common source amplifier circuit diagram with N-channel FET coupling and biasing capability is shown below. This circuit will be similar to a Bipolar Junction transistor's common-emitter follower. The polarity of the input voltage will be reversed if we use a P-channel FET.

Among other JFET configurations, the common source amplifier configuration is widely used because it can provide both high voltage gain and a large input impedance.



There are three terminals on the common source FET amplifier. They are as follows: source, gate, and drain.

Source: receives the majority of the carriers required by the device. Current enters the channel via a source terminal, which is denoted by IS.

Drain: This terminal is where the majority of the carriers in the channel exit. That is exhausting. As a result, conventional current enters the channel, denoted by I_D.

Gate: This terminal is always in charge of the channel's conductivity. As a result, the flow of current in the output is controlled by a voltage level across the gate.

This amplifier can provide medium input Impedance, medium output impedance, medium current gain, medium voltage gain, and reverse output concerning input which means the output signal will be in 180 degrees phase change. From these characteristics, we can conclude that this amplifier can give high-level performance over other amplifier circuits like a common drain (source follower) and common gate. Hence it is most widely used than other amplifier circuits.

3. Applications of FET Common Source Amplifier Circuit

- Used in sensor signal amplification.
- RF signal amplification with low noise.
- Used in communication systems such as television and FM receivers.
- In op-amps, they are used as voltage-controlled devices.
- Cascade amplifiers and RF amplifier circuits are examples of their applications.

4. Common Source Amplifier Working

This amplifier can function as a transconductance amplifier or a voltage amplifier. If the amplifier is acting as a transconductance amplifier, the input signals are amplified and modulate the current flowing to the load. If the amplifier is acting as a voltage amplifier, the input signal is amplified and modulated, changing the voltage across the load resistor according to Ohm's law.

When the input signal is routed through the capacitor C1 to the gate terminal. This capacitor is used to determine whether the gate terminal is affected by any DC voltage from the previous stage. The potential is held by the resistor R2 of around 1Mega ohms located between the gate and the ground. The voltage is generated across the resistor R2, which keeps the source above ground. The bypass capacitor C2 adds gain to the alternating current signal.

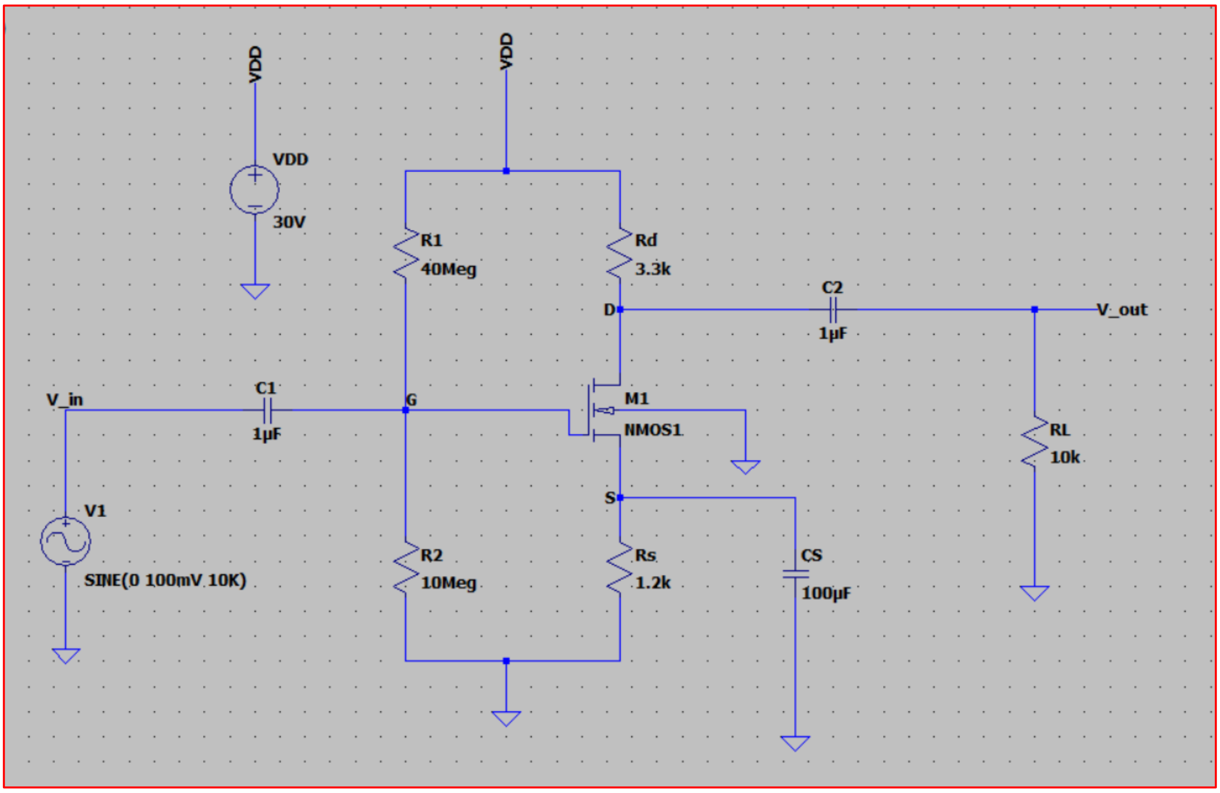
The amplified output voltage is obtained by crossing the resistor R3 at the load at the circuit's drain terminal. The capacitor C3 couples the amplified output voltage to the AC signal of the next stage by blocking or eliminating the DC components. This amplifier's amplified output signal is 180 degrees out of phase concerning the input signal and produces a high power gain.

The operation of the P-channel common source amplifier FET is similar to that of the N-channel common source amplifier FET, with the exception that the voltage polarities are reversed. There will be no current flowing between the gate and the source in the reverse-biased state. As a result, the gate current is zero.

II. EXAMPLE OF COMMON SOURCE AMPLIFIER CIRCUIT

For the given amplifier, find the Voltage gain A_V, Input Impedance Z_{in}, and Output Impedance Z_{out}.

V_T = 3V, k_n = 0.4 mA/V^2



Solution:

Step 1: DC Analysis → Consider all external capacitors as open circuit

$I_G = 0$

$$V_G = \frac{R_2}{R_1 R_2} \times V_{DD} = \frac{10 \times 10^6 \times 30}{40 \times 10^6 + 10 \times 10^6} = 6V$$

$V_S = I_D R_S = 1200 \times I_D$

$V_{GS} = V_G - V_s = 6 - 1200 \times I_D$

Assuming that MOSFET is working in saturation region,

$I_D = k_n \times (V_{GS} - V_T)^2 = 0.4 \times 10^{-3} \times (V_{GS} - 3)^2$

$\rightarrow\ V_{GS} = 6 - 1200 \times I_D = 6 - 1200 \times [0.4 \times 10^{-3} \times (V_{GS} - 3)^2]$

$\rightarrow\ V_{GS} = 4.667(V)\ \rightarrow accepted \quad or \quad V_{GS} = -0.75(V) \rightarrow rejected$

$\rightarrow\ I_D = 0.4 \times 10^{-3} \times (V_{GS} - 3)^2 = 0.4 \times 10^{-3} \times (4.667 - 3)^2 = 1.111(mA)$

Step 2: Small-signal parameter

$$g_m = 2k_n(V_{GS} - V_T) = 2 \times 0.4 \times 10^{-3} \times (4.667 - 3) = 1.333 \frac{mA}{V}$$

Step 3: Draw small-signal equivalent circuit

$\rightarrow Zin = (R_1 \,//\, R_2\,) = \;8\;M\Omega$

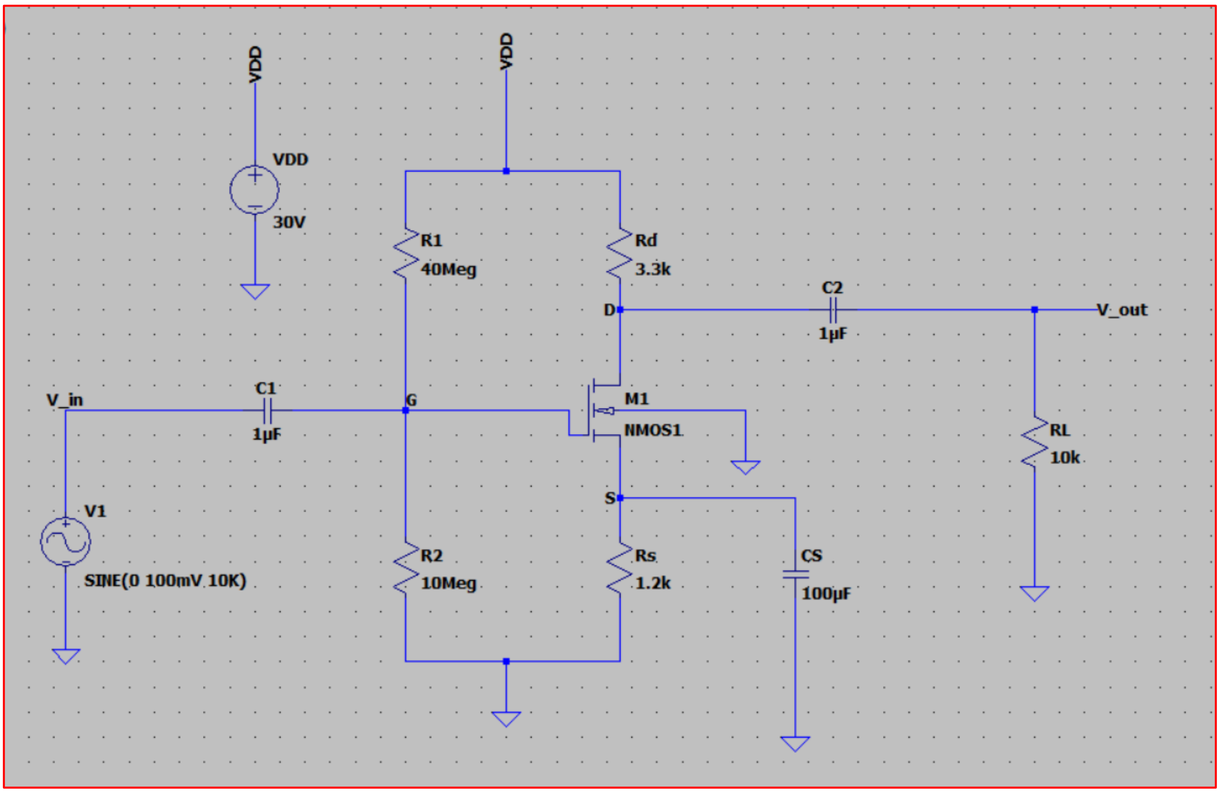
$\rightarrow Zout = (R_D \,//\, R_L) = \;2.4812\;k\Omega$

$V_{out} = -(g_m V_{gs}) \times (\,R_D \,//\, R_L)$

$V_{in} = V_{gs}$

$$A_V = \frac{V_{out}}{V_{in}} = -g_m \times (\,R_D \,//\, R_L) = -1.333 \times 10^{-3} \times 2.4812 \times 10^{3} = -3.3082$$

III. SIMULATION ON LTSPICE



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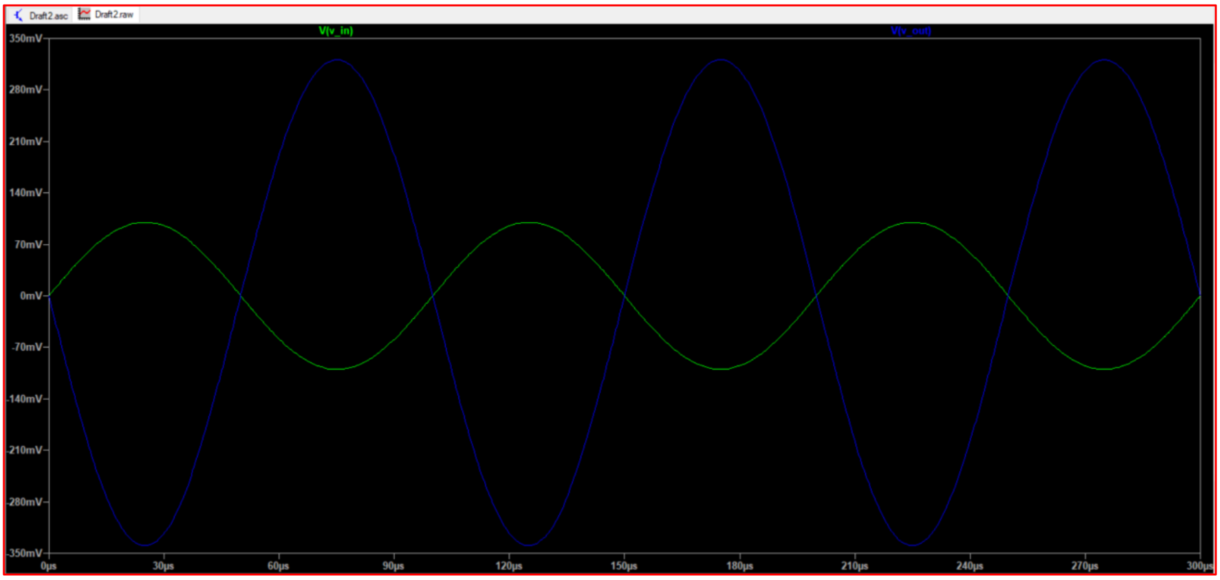
--- Operating Point ---

V(vdd):	30	voltage
V(g):	6	voltage
V(d):	26.3333	voltage
V(s):	1.33333	voltage
V(v_in):	0	voltage
V(v_out):	2.63333e-13	voltage
Id(M1):	0.00111111	device_current
Ig(M1):	0	device_current
Ib(M1):	-2.76867e-11	device_current
Is(M1):	-0.00111111	device_current
I(C1):	6e-18	device_current
I(C2):	-2.63333e-17	device_current
I(Cs):	1.33333e-16	device_current
I(R1):	6e-07	device_current
I(R2):	6e-07	device_current
I(Rd):	0.00111111	device_current
I(Rs):	0.00111111	device_current
I(Rl):	2.63333e-17	device_current
I(V1):	6e-18	device_current
I(Vdd):	-0.00111171	device_current



→ This amplifier's amplified output signal is 180 degrees out of phase concerning the input signal and produces a high power gain.