Lab 4: Transistor Application: Amplifier

1. Task:

As shown in the previous lab, the large tranconductance of the transistors, BJT and MOSFET makes them a good amplifier.

In this lab, you will be working on common source amplifier and common gate amplifier using NMOS. This lab shows: a) how to bias the MOSFET properly to ensure signal amplification without causing distortion; b) common gate amplifier.

2. Pre-Lab:

Amplification using MOSFET:

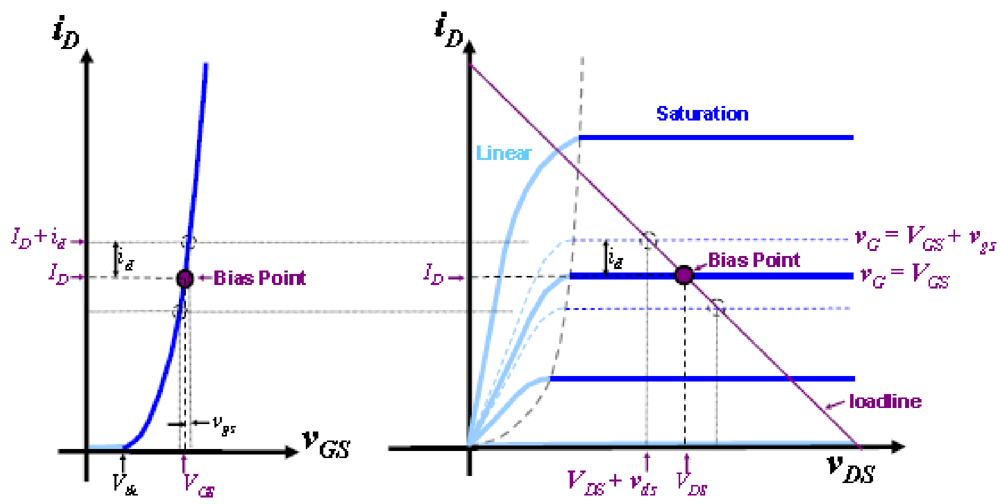

Figure 1: DC Bias for small signal amplification using NMOS

As shown in Figure 1, in order to provide amplification without causing distortion to the amplified signal, it must be ensured that the MOSFET is properly biased in the saturation region and the input signal v_{gs} is small. V_{GS} determines the DC current bias I_D, while V_{DS} should be chosen carefully to allow a large voltage swing without forcing the transistor out of saturation region.

3. Hardware and software:

Table 1: List of hardware and software

Name	Qty	Description
PC	1	For NI ELVIS II
NI ELVIS II	1	Hardware test platform
DC Power Supply	1	Provide a constant voltage supply
Signal Generator	1	Generate small AC signal
Oscilloscope	1	Waveform observer

Table 2: Component list

Name	Qty	Description
2N7000	1	Optional (discrete NMOS)
CD4007	1	Inverter with multiple NMOS and PMOS
1/4W resistor	-	1k, 10k, 1M and others by design
10μF capacitors	2	Electrolytic capacitor, pay attention to the polarity
1μF capacitors	2	Electrolytic capacitor, pay attention to the polarity
100μF capacitors	1	Electrolytic capacitor, pay attention to the polarity

4. Lab procedure and analysis:

4.1. Common Source Amplifier:

DC bias of MOS

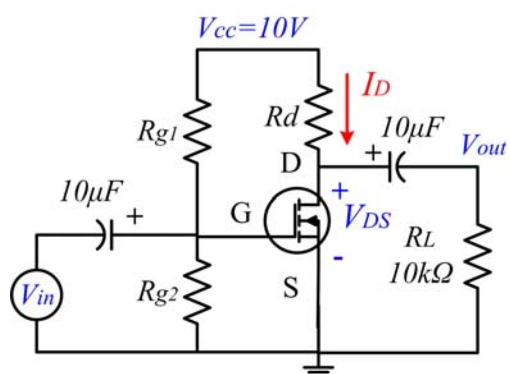

Figure 2: Common Source Amplifier

1. Build the circuit on breadboard as shown in Figure 2 using 2N7000. Choose R_{g1} and R_{g2} to setup I_D to around 5mA. Find out R_d to make $V_{DS} = V_{CC} / 2$.

2. Connect signal generator to generate V_{in}: a sinusoidal signal with amplitude of 0.1V and

frequency 1kHz. Use oscilloscope to measure V_{in} and V_{out}.

3. Change R_d as given below, repeat Step 1 and 2. Record V_{GS} and V_{DS}, sketch the input and output voltage waveform.
   - Increase the value of R_d by 50%;
   - Reduce R_d by half;

4. Change R_{g2} as specified below. Choose R_d to make sure $V_{DS} = V_{CC}/2$, repeat Step 2. Sketch the input and output voltage waveform and voltage gain.
   - $I_D = 10mA$
   - $I_D = 2.5mA$

4.2. Common Gate Amplifier

Figure 3 illustrates the circuit of a common gate amplifier. A bypass capacitor is added on the gate to provide an AC ground in small signal operation. A source resistor R_s is added in the bias circuit. The input signal is connected through a decoupling capacitor to the source.

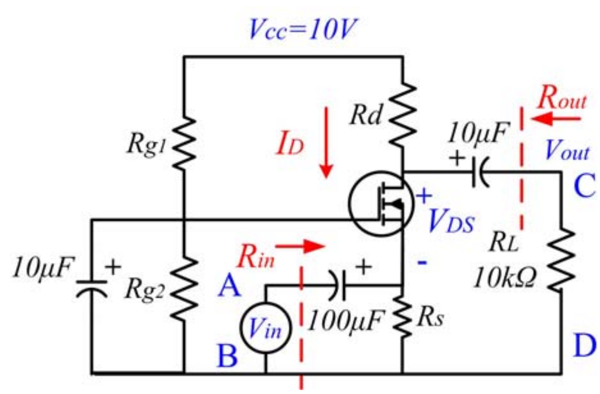

Figure 3: Common gate amplifier

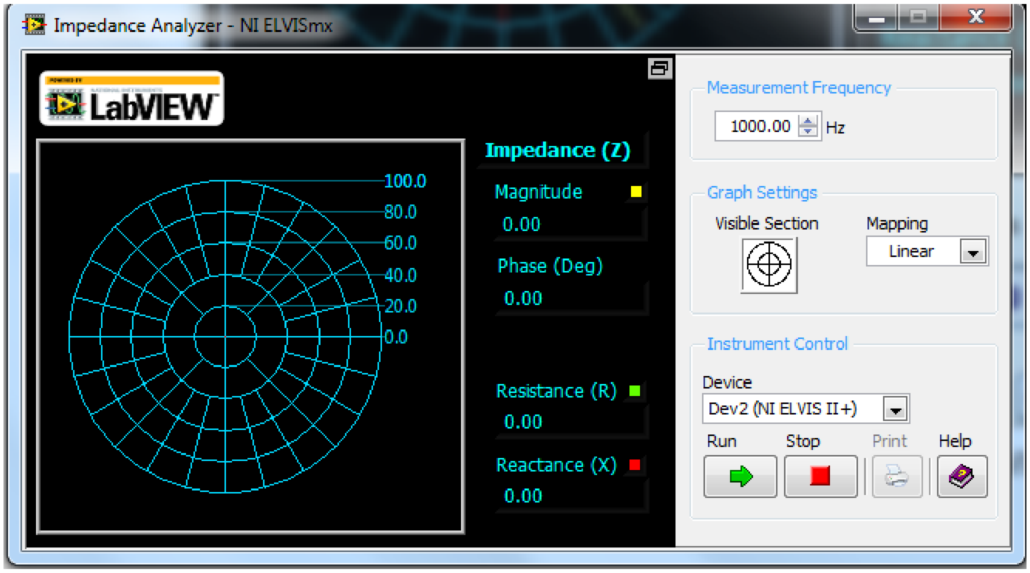

Figure 4: Front Panel of Impedance Analyzer on NI ELVIS II

1. Build the circuit on the breadboard as shown in Figure 3 using 2N7000. Use $R_s = 100\Omega$, Rg1=10k and find the value of R_{g2} to make sure $I_D = 5mA$. Find R_d to make $V_D = Vcc/2$.

2. Remove the voltage source V_{in}. Connect A to DUT+ and Connect B to DUT- of DMM of NI ELVIS II. Setup the switching frequency to 1 *kHz* on the Impedance Analyzer as shown in Figure 4. Press ***run*** button. The impedance including the resistance is displayed on the window.

3. Similarly, remove the load resistor R_L. Connect C to DUT+ and Connect D to DUT- of DMM of NI ELVIS II. Setup the switching frequency to 1 *kHz* on the Impedance Analyzer as shown in Figure 4. Press ***run*** button.