Lab 5 – Operational Amplifiers

In this lab session, you will use operational amplifiers and construct and characterise simple circuits that use these components.

Here we assume using the LM741 op-amp. The pin schematic for the circuit is given below. The LM741 requires positive and negative power supplies, and you can use +/- 10V for the supplies for the rest of this experiment (unless otherwise indicated). Your circuit will still need a ground point that should be connected to the 0V terminal on the power supply and to the 0V on the signal generator and the grounding point on any probe that you attach to the circuit.

Note: in case this op-amp is not available in the lab, you may use a different one as long as you update the voltage supply choice and the pin diagram accordingly in your lab book.

NAB Package
8-Pin CDIP or PDIP
Top View

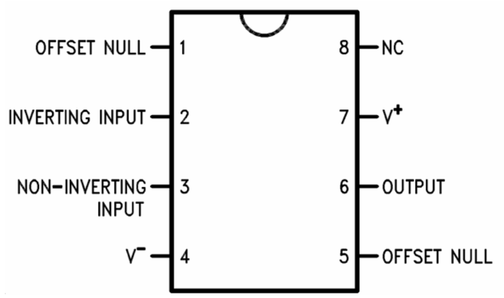

Figure 5-1 Pin diagram of AMP

1. Construct the circuit shown in Figure 5-2. For the input voltage, use a DC input equal to V_{in}= +0.1 V, R=10 Ω. What is the value of Vout?

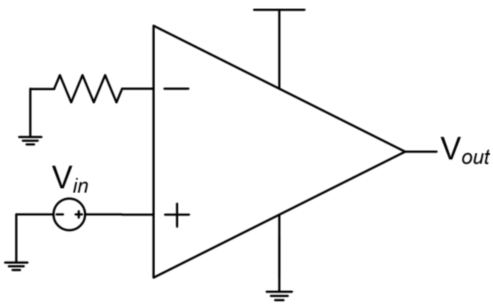

Figure 5-2 AMP Circuit No.1

This question helps students to understand the basic working principle of an Op-amp.

2. Consider the circuit shown in Figure 5-3. What's the ideal gain of this configuration? Please verify your answer through **PSpice** model.

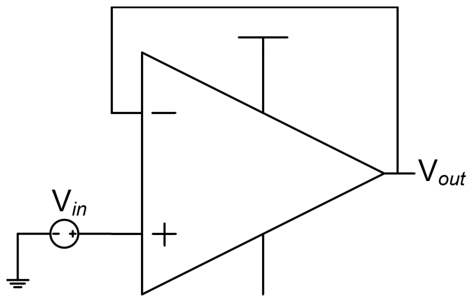

Figure 5-3 AMP Circuit No.2

Inverting configuration

3. Construct the circuit shown in Figure 5-4, where R_1= 1 kΩ and R_2= 2 kΩ. For the input voltage, use a DC input equal to V_{in}= +0.1 V.

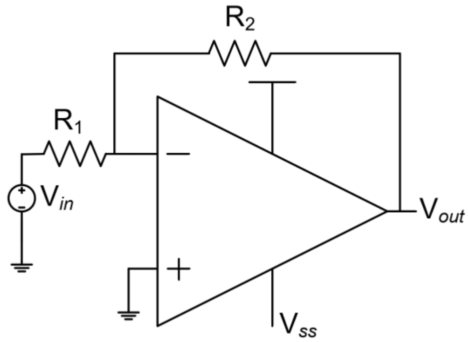

Figure 5-4 AMP Circuit No.3

Recall the formula of the theoretical gain for an operational amplifier in this configuration (in linear scale) and write it down here. Remember that if you want to evaluate the gain in dB, in logarithmic scale, you need to calculate *20 * log10 (|GAIN|)* (for example, if GAIN is 10, it can also be written as 20 dB).

GAIN = _______________

4. Now, calculate the ideal gain value when changing the values for R_2. You may want to use resistors equal to 5 kΩ, 10 kΩ, 50 kΩ, 100 kΩ and 2 MΩ. Then, measure the gain experimentally; you will need to compare the output voltage and the input voltage. You may write the values of the gain for different values of R_2 in the space below.

5. What is the practical value of the gain for R_2= 2 MΩ? Note down the value below here. Do you notice any significant difference between the theoretical value and why?

6. Now change the input voltage to an AC signal, a sine wave with 0.1 V max amplitude (peak-to- peak 0.2 V) and initial frequency equal to 100 Hz. Use R_1= 2 kΩ and R_2= 200 kΩ, measure the gain and take note of that.

7. Now try different values of amplitude for your sine wave, like 50 mV and 0.15 V. Measure the gain and take note of that. Keep the frequency of the input signal at 100 Hz.

Now modify the DC supply voltage V+ and V- given to the operational amplifier and use +15 V and -15 V. How does the output voltage change? Please record your findings in the blank space below.

Non-Inverting Configuration

8. Consider the circuit shown in Figure 5-5, where V_{in} is a DC voltage equal to 0.1 V. Make sure the DC supply voltage for the amplifier is ±10 V. Now, analyse three different combinations of resistances and calculate the gain of this configuration of amplifiers in all three cases. What is the minimum gain that you can obtain?

    - R_1=R_2= 1 kΩ
    - R_1= 1 kΩ and R_2= 5 kΩ
    - R_1= 1 kΩ and R_2= 10 Ω

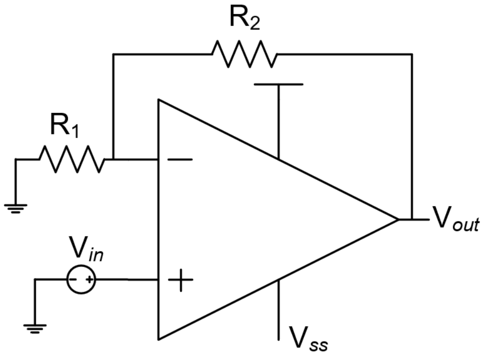

Figure 5-5 AMP Circuit No.4

9. Based on this configuration, when input signal is a sine wave with frequency 1 kHz and maximum value equal to 0.1 V. Use R_1= 1 kΩ and choose R_2 to obtain the gain of your circuit to be 40. What is the value of R_2?

10. Consider the circuit shown in Figure 5-6. Please verify your answer through the PSpice model. Select R_1= 10 kΩ, R_2= 100 kΩ, C_1= 0.05 uF, ± 10 V for the supplies.

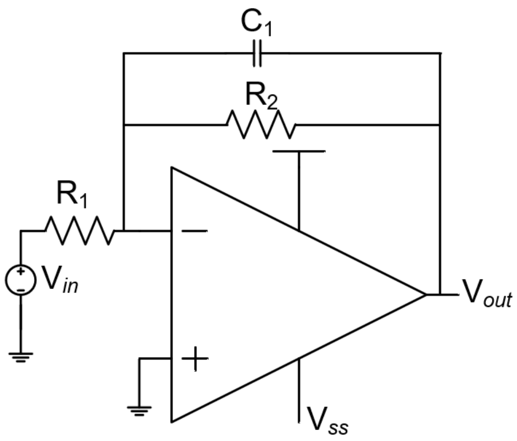

Figure 5-6 AMP Circuit No.4

a) When V_{in} is as shown below, draw the waveform of the output signal.

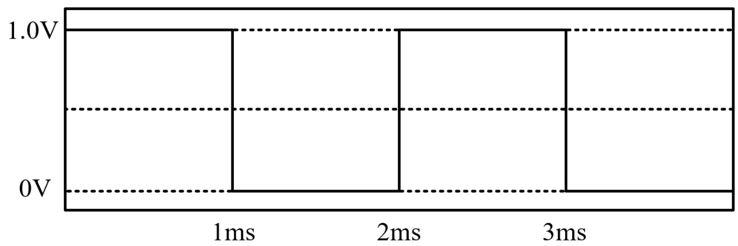

Figure 5-6 V_{in} setting

b) Now, remove R_2 and draw the waveform of the output signal again.

Make sure that you understand the difference between inverting and non-inverting configurations for an op-amp and how to calculate the gain in both cases.

Make sure that you fully understand point 7 of the experiment, where you had to increase the DC supply voltage to avoid distortion of the output. Talk to the GTAs or the teacher if you need more clarification.

You reached the end of Lab 5. Show your results to the GTAs to get your attendance signed off. If you finish early, you may start to look at the Lab Report Task.