OPERATIONAL AMPLIFIERS LAB

BEFORE YOU BEGIN

PREREQUISITE LABS

- Introduction to Matlab
- Introduction to Arbitrary/Function Generator
- Resistive Circuits

EXPECTED KNOWLEDGE

- Students should be familiar with the fundamentals of operational amplifiers.
- Students should be familiar with the circuits described in this lab and know how to analyze them for both ideal and non-ideal operational amplifiers.

EQUIPMENT

- Digital Multimeter
- Split or Dual Programmable Power Supply
- AFG3000 Series Arbitrary/Function Generator

MATERIALS

- Two µA741 Operational Amplifiers
- Two Banana to BNC Converters
- Banana Cables
- BNC to Banana Cables
- Speakers
- Speaker Control Box
- Complete Set of Resistors
- 250 Ω Potentiometer
- 20 kΩ High Resolution Potentiometer
- Solderless Breadboard

OBJECTIVES

After completing this lab you should know:

- How to build a circuit that uses 741 operational amplifiers.
- How to determine the practical limitations of operational amplifiers.
- The difference between ideal and non-ideal operational amplifiers.
- How to use operational amplifiers to amplify voltage signals.

INTRODUCTION

Operational amplifiers, or op amps for short, were first introduced in the 1940s. They were made using bulky vacuum tubes and consumed large amounts of power. When transistors were created, the size and power consumption of op amps was drastically reduced, making them cheaper and more efficient. In 1968, Fairchild Semiconductor introduced the μA741, which quickly became the industry standard and is still widely used today.

Op amps were first used to perform mathematical operations such as addition, subtraction, multiplication, division, integration, and differentiation. Today, operational amplifiers are used in signal filters, communications, audio mixing, control systems, remote controlled devices, and many other areas of electrical engineering.

PRELAB

OPERATIONAL AMPLIFIERS

Using an Internet web browser, download and print the data sheet for your particular operational amplifier.

Answer Questions 1 – 7.

FREQUENCY SWEEP

The AFG3000 Series Arbitrary/Function Generator can be set to sweep through a range of frequency values. This type of signal is called a chirp. The following steps outline the procedure for creating chirp signals:

1. Push the **Default** front panel button, and select **OK** using the display menu button. Select **OK** again to complete the operation.
2. If the AFG3000 is a dual channel instrument: Select the **CH1/CH2** front-panel button until **CH1** is displayed in the top left of the display.
3. Press the front-panel **Amplitude/High** button and set the amplitude of the waveform to the desired value.
4. In the **Run Mode** selection, press the **Sweep** button.
5. Press the **Start Frequency** menu button and set the desired starting frequency.
6. Press the **Stop Frequency** menu button and set the desired stopping frequency.
7. Press the **Sweep Time** menu button and set the desired time interval for the sweep to last.
8. Note that the sweep type is set to **Linear** as default.

CONNECTING THE OPERATIONAL AMPLIFIER RAILS

In order to build the circuits in this lab, you will have to configure the Programmable Power Supply in split mode where the ground point is electrically "centered" between +V and -V. Figure 1 shows how to connect the power supply and the schematic for the connection.

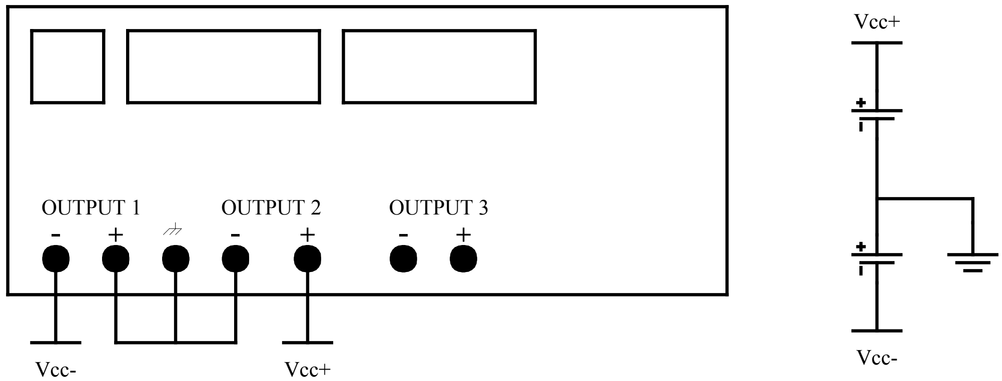

Figure 1. Op Amp Rails Connection.

INPUT RESISTANCE

For ideal op amps, we assume that the input resistance is infinite (open circuit). For practical op amps, the input resistance is usually in the range of 1 MΩ. Build the circuit shown in Figure 2.

Answer Questions 8 – 19.

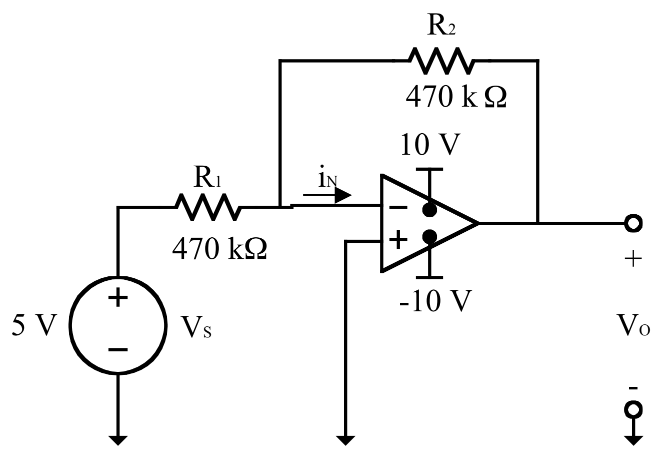

Figure 2. Inverting Amplifier Circuit for Input Resistance.

OUTPUT RESISTANCE

For ideal op amps we assume the output resistance is equal to zero. Practical op amps have an output resistance in the range of 10 Ω to 100 Ω. Build the circuit shown in Figure 3. Since this is a voltage follower, $V_O = V_S\left(\frac{R_L}{R_L + R_O}\right)$, where R_O is the output resistance of the op amp.

Answer Questions 20 – 23.

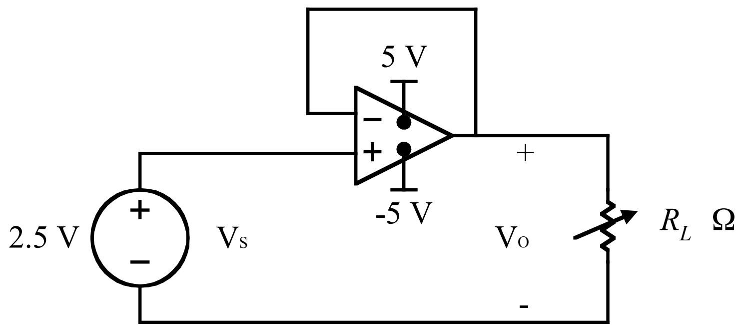

Figure 3. Voltage Follower Circuit for Output Resistance.

CLIPPING AND OUTPUT SATURATION

The voltage supplies that power the op amp limit the range of the output voltage. This means the output voltage, V_O, will not exceed the values of V_{CC+} and V_{CC-}. Build the circuit in Figure 4.

Answer Questions 24 - 26.

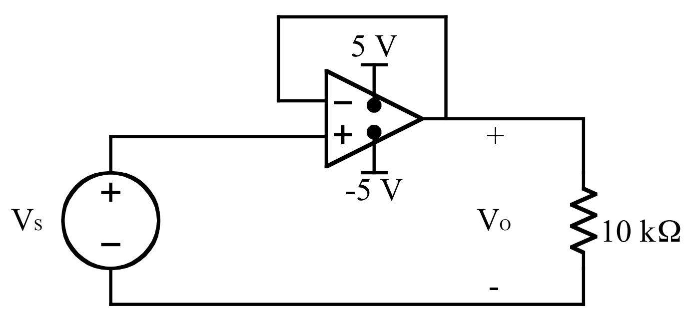

Figure 4. Voltage Follower with ±5 V Rails.

PROTECTION

Build the circuit shown in Figure 5.

Answer Question 27.

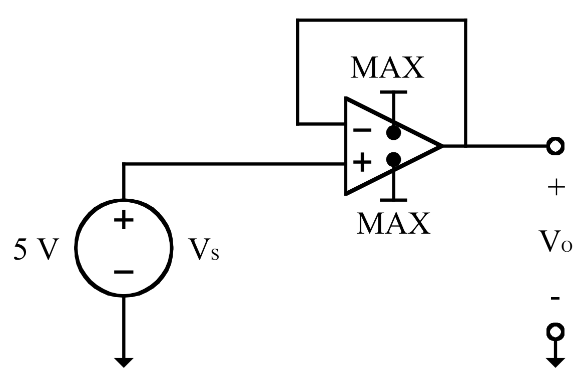

Figure 5. Voltage Follower.

AUDIO AMPLIFIERS

INVERTING AUDIO AMPLIFIER

Build the circuit shown in Figure 6. Set V_S equal to a sinusoidal signal with amplitude of 1 V_{PP} and a frequency of 80 Hz.

Answer Questions 28 - 29.

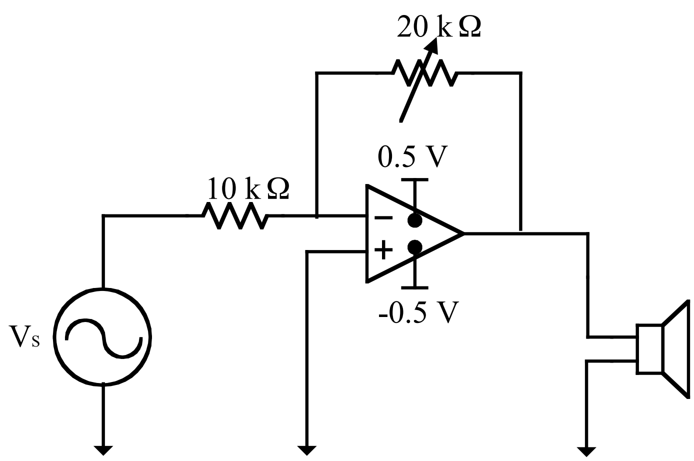

Figure 6. Inverting Audio Amplifier.

Increase the frequency until you can no longer hear the signal.

Answer Question 30.

Using a frequency of 1 kHz, change the signal to a square waveform, a saw tooth waveform and a triangle waveform.

Set the signal to chirp from 10 Hz to 10 kHz in 1 second.

Set V_S equal to a 1 V DC signal.

Answer Question 31.

Change V_S back to a sinusoid with a peak-to-peak amplitude of 100 mV. Increase the DC offset from 0 V in steps of 50 mV until you hear distortion.

Answer Questions 32 - 33.

SUMMING AUDIO AMPLIFIER

Build the circuit shown in Figure 7.

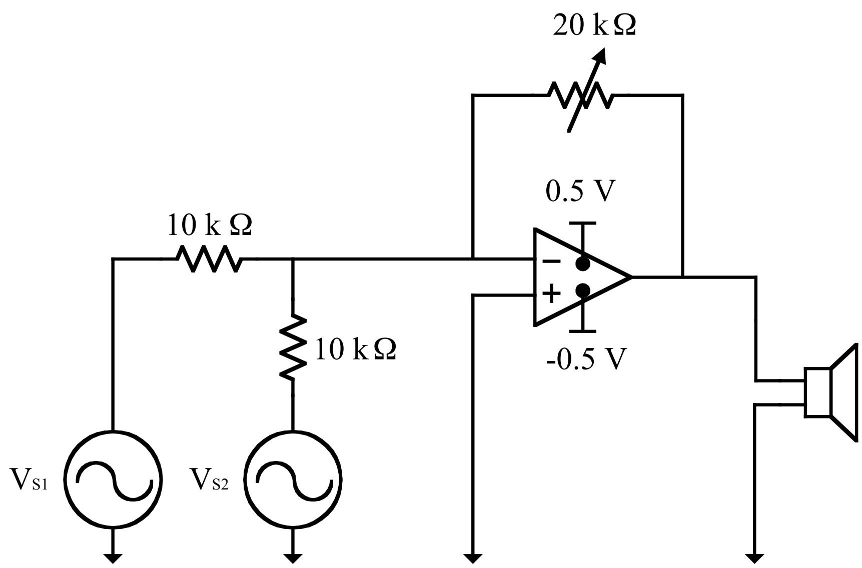

Figure 7. Summing Audio Amplifier.

Experiment using different waveforms, frequencies and chirp values for V_{S1} and V_{S2}.

Set V_{S1} equal to a sinusoidal signal with amplitude of 1 V and a frequency of 100 Hz. Set V_{S2} equal to a sinusoidal signal with amplitude of 1 V and a frequency of 101 Hz.

Answer Question 34.