Laboratory 5:
Amplifier Design Using Operational Amplifiers

In this lab, we will study two different op amp models (LM 741 and OPA 552) and design amplifier circuits for a sound card and speaker. We will also investigate an op amp amplifier circuit that is suitable for very large gains.

Preparation and Data Sheets

1. Please study the op amp section in the elements page developed by Prof. Mastascusa. Browse through the pages, and return to them later if you choose to do the exercises.
2. Please search for LM 741 and OPA 552 data sheets and compare the following attributes for the LM 741 and OPA 552 op amps (links are posted on the ELEC 225 labs page): open loop gain, input resistance, maximum output current.

Design 1: Sound Card Isolation Circuit

1. Please design a circuit using a 741 op amp to provide an output voltage equal to the voltage provided by a sound card.
2. Build the circuit and test the circuit using a function generator. Use the oscilloscope to observe the input and output as you vary the *amplitude* of a sine wave. Measure the voltage across a 33 Ω resistor (modeling headphones with 32 Ω input resistance).
3. Is there a limit to the input *voltage* so that the maximum *current* delivered by the 741 op amp is not exceeded? Explain your observations in item 2.
4. If you create a Thevenin model for your isolation amplifier, what is the Thevenin resistance, assuming ideal op amp behavior?
5. Now attach the sound card. Play your favorite music and observe the output of the amplifier on the oscilloscope. Listen to the music using the headphones. Also try adding an RC "filter" before the buffer and describe the effect on the music.

Analysis: Voltage Amplifier Circuits

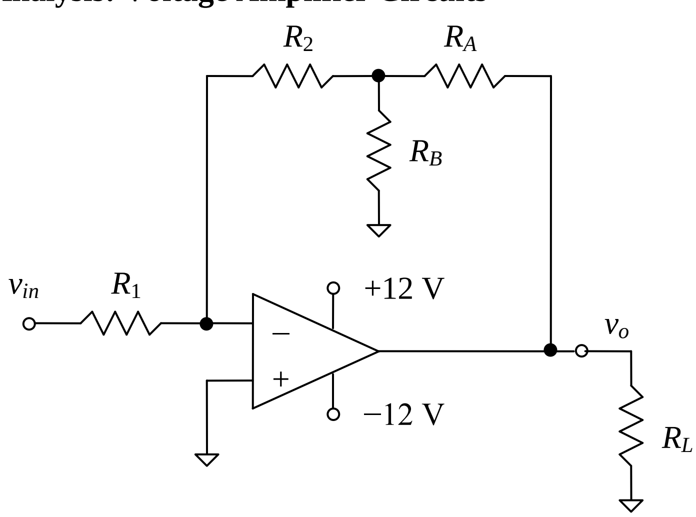

Figure 2: Inverting amplifier with T-bridge feedback network.

1. For the circuit in Figure 2, show that

$$\frac{v_o}{v_{in}} = -\left(\frac{R_A}{R_2} + \frac{R_A}{R_B} + 1\right)\frac{R_2}{R_1}$$

2. For the circuit in Figure 3, show that $\frac{v_o}{v_{in}} = -\frac{R_2}{R_1}$.

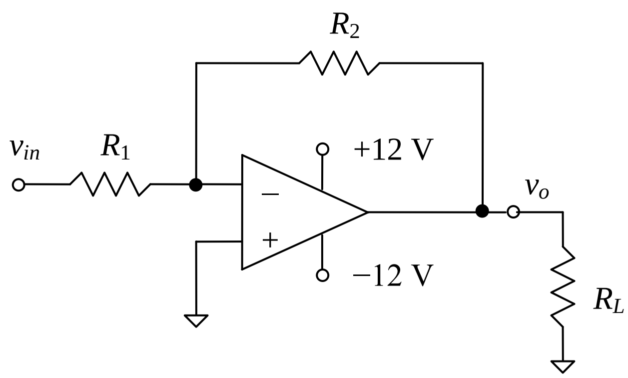

Figure 3: Inverting amplifier.

3. What is the advantage of the circuit in Figure 2 compared with Figure 3 for large gain? Design and demonstrate an amplifier with a gain of -1,000 using Figure 2.

4. Assuming ideal op amp behavior, what is the Thevenin model for the circuits in Figures 2 and 3 to the left of the node where the load resistor is attached? What is the *input resistance* at the input (ratio of v_{in} to the input current)?

Design 3: Amplifier Design for an 8 Ω Speaker

1. Design an amplifier to drive an 8 Ω speaker. Your amplifier should provided maximum power to the speaker while not exceeding the limitations of the op amps. Assume that your input signal has amplitude that is similar to the voltage provided by the sound card that you determined in Design 1 for the 741 op amp buffer.
2. What is the gain of your design? Why did you choose this gain? What current will be delivered to the speaker? Should you use an LM 741 or OPA 552 op amp?
3. What is the maximum power delivered to the speaker in your design?
4. Build and test your design using the function generator and oscilloscope. Test with an open-circuit load and an 8 Ω resistor load (which models the speaker).
5. Now connect the sound card through your isolation amplifier and inverting amplifier, and listen to music through an 8 Ω speaker.

Lab Report

Each pair of students should submit a brief report before leaving lab summarizing your answers to the questions and your amplifier designs. How does the load resistance (33 Ω versus 8 Ω) affect your choice of op amp and the power delivered to the load?