

Building a Headphone Amplifier

Ph 261 Lab 09, Part I

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1 Purpose

Examine a practical application of the op amp: the CMoy headphone amplifier circuit.¹ This is the first of two labs using the CMoy. During the first week, you will build and test the circuit. *Don't disassemble your circuit at the end of the first session.* You will use this circuit again the following week.

2 Prelab

Study the CMoy headphone amplifier circuit (figures 1 and 3).

1. The light emitting diode (LED) has a diode drop of approximately 1.4 V. Calculate the current and the power dissipated in the LED. Which dissipates more power, the LED or the resistor in series with it?
2. Calculate the gain of the amplifier. Include the volume pot, which will give you a

range of gain values from minimum to maximum volume. Ignore the 100 k Ω resistor and 0.1 μ F capacitor (do you know why?).

3. Suppose you wanted to power this circuit from a AA battery (1.5V). Assuming that the potentiometer is set to maximum volume, and that the Op Amp can output from rail to rail, would the circuit function properly if the input is in the range

(a) $|V_{in}| \leq 40 \text{ mV} ?$

(b) $|V_{in}| \leq 200 \text{ mV} ?$

¹This lab is based on a popular do-it-yourself audio project originally designed by Chu Moy (http://headwize.com/projects/showfile.php?file=cmoy2_prj.htm). There are many variations on this amplifier: <http://tangentsoft.net/audio/cmoy-tutorial/>, <http://www.hegira.org/audio/>, http://www.guillermi2.net/archives/2004_06_01.html.

Does the volume setting matter? Why or why not?

3 Equipment Required

- 1 Digital Multimeter
- 1 DC Power Supply
- 2 Electrolytic Capacitor, $220\ \mu\text{F}$
- 2 Polypropylene Capacitor, $0.1\ \mu\text{F}$
- 1 Red LED
- 2 Resistor, $100\ \text{k}\Omega$, $1/4\ \text{W}$, 5%
- 2 Resistor, $10\ \text{k}\Omega$, $1/4\ \text{W}$, 5%
- 2 Resistor, $1\ \text{k}\Omega$, $1/4\ \text{W}$, 5%
- 3 Resistor, $4.7\ \text{k}\Omega$, $1/4\ \text{W}$, 5%
- 1 Dual Op Amp, TS922
- 1 Dual Audio Potentiometer, $10\ \text{k}\Omega$
- 1 Audio Cable (2.5 mm plug both ends)

The components for the optional kit are identical. The parts list for the kit (section ??) has a few more items like switch, jacks, battery clip and PCB.

Student Supplied Equipment

The following items are not absolutely required,² but the lab will be more interesting if you can use the circuit to listen to your own music. Bring any music you like, but please *keep it in the cans* (headphones).

- 1 Personal Music Device (MP3, CD, etc.)
- 1 Headphones or Earbuds

In addition to the above, students planning to purchase and build the kit amplifier should bring:

- 1 Candy Tin, $3'' \times 2'' \times \frac{3}{4}''$ or larger

Typical Altoids tins are slightly larger. Most builders will appreciate the extra room.

²Alternatively, your TA can help you generate an appropriate signal with the waveform generator.

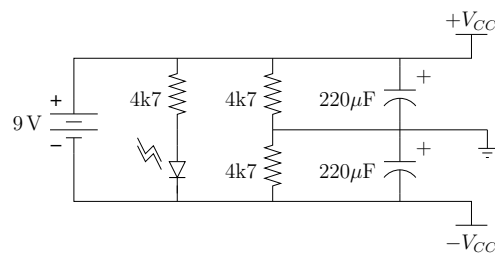


Figure 1: Schematic of the CMoy power circuit. Notice that you must make *three* connections to the amplifier circuit.

4 Procedure

Your instructor, TA, the Physics Department, and MSU are not responsible for damage to your personal audio equipment. Check any experimental circuit very carefully before you connect it to something you'd rather not destroy. We regret that we cannot put the magic black smoke back into your iPod.

1. Build the power supply portion of the circuit (fig. 1). For kit builders, more details are provided in section ?. The two electrolytic capacitors and the diode must be installed with the right polarity (fig. 2). The capacitors are particularly susceptible to damage if they are connected backwards. You may either build the circuit on the breadboard or solder components to the custom PCB in the kit, if you or your partner purchased one.
2. Apply 9V power using the variable DC lab supply. Test the circuit voltage. It should be approximately $\pm 4.5\ \text{V}$ with respect to ground. Record the values in your notebook.

3. Should the presence of the capacitors have any effect at this point? Predict first, and then test your hypothesis by pulling them both out. Replace when done, though. They do matter later on!
4. Turn off the power. Carefully build both channels of the amplifier (two identical circuits, one for the left ear and one for the right). Connect $\pm V_{CC}$ and ground to the power supply circuit. If you are using the kit, see section ??.
5. Test the circuit for serious errors before connecting to your personal music device or headphones.
 - (a) Turn the volume control to zero (counterclockwise). Set the power supply for 9V, connect to the amplifier, and turn on the power. Make sure that there are no voltages coming out the inputs, and that the input resistance is approx-

imately $10\text{ k}\Omega$. Record these values.

- (b) Make sure the volume control is at zero. Set the DMM to measure AC voltage. Ensure that both outputs have AC voltage less than 0.1 V with respect to ground. Zero is OK. Turn up the volume about halfway, and again make sure the output AC voltages are negligible.

Why do you think the above tests were chosen? Are there other tests you want to perform prior to connecting your personal equipment? If so, do it now.

6. With the volume control still at zero, connect the CMoy inputs to your personal music device, and the outputs to your headphones. Turn on the music player with volume approximately at half-maximum. Turn up the volume until you hear the music. If it doesn't work, turn the power off and check the circuit carefully. Once you have the circuit working, collect a hi-five and a signature from your TA.

Kit builders: If you have some time after completing the lab assignment, you may work on installing the amp into the candy tin.

5 Conclusion

At the beginning of the lab, you tested the power supply voltages relative to the artificial ground. Are component tolerances sufficient to account for any deviation from $\pm 4.5\text{ V}$? Explain why the capacitors can be ignored at this point.

Based on the circuit design, account as best you can for the input resistance you measured for the amplifier.

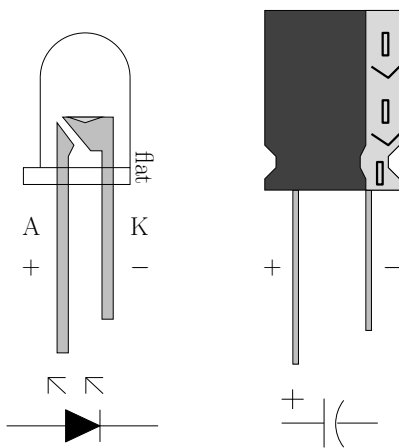


Figure 2: Polarities of the LED and electrolytic capacitors.

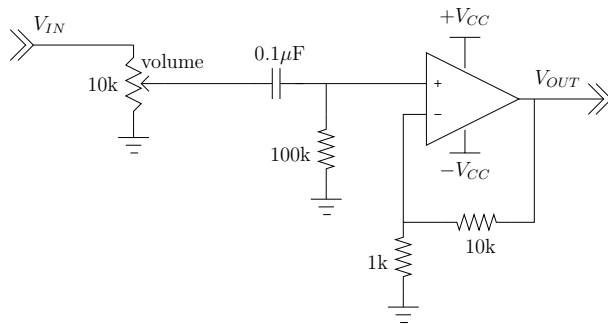


Figure 3: Schematic of the CMoy amplifier. Make two of these, one for each ear.

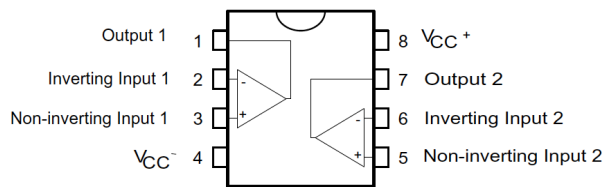


Figure 4: Pinout of TS922IN dual Op Amp.

Did your amplifier work? Please describe the subjective quality of the sound based on your recollection.