

Characterizing a Headphone Amplifier

Ph 261 Lab 09, Part II

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1 Purpose

This week you will characterize the CMoy headphone amplifier circuit that you built last week. Your methods will be a combination of subjective listening and rigorous, quantitative measurement.

2 Prelab

3 Equipment Required

- 1 CMoy Amplifier (built last week)
- 1 Digital Multimeter
- 1 DC Power Supply
- 1 Function Generator
- 1 Oscilloscope
- 1 Scope Probe

Student Supplied Equipment

The following items are not absolutely required, 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
- 1 Audio Cable (2.5 mm plug both ends)

The audio cable is to connect your personal music device to the amplifier.

4 Procedure

You will perform several subjective listening tests to determine noise levels. Always begin with the amplifier at minimum volume, and turn it up cautiously to avoid hearing damage. *It will be helpful if all of us are as quiet as possible.* You may find it most interesting to test using a low-end music source such as an iPod Shuffle.

1. Carefully check the CMoy circuit that you built last time, ensuring that it will be safe to connect to your personal music device and headphones. Make any necessary repairs and test it.
2. Disconnect the circuit from your personal music device. Now short the inputs to ground. This reduces the vulnerability of your circuit to external noise. Increase the volume to maximum. Try to determine if there is any noise (hiss) in the headphones. Turning the amp off and on repeatedly may help you to identify the noise, if any. Note your observations.

3. Now connect the music device. Turn it on, but pause the music. First turn the amplifier volume to maximum, and then maximize the volume of the music device. How does the result differ from what was observed without the music device?
4. When you listen to music, there is a trade-off between gain in the music device and in the amplifier. Listen with the following two set-ups. Try to make the volume in your headphones the same for both tests. *In each case, describe the sound quality. Can you hear noise—particularly in relatively quiet parts of the music?*
 - (a) Amplifier volume at maximum, music device volume set to a comfortable level.
 - (b) Music device volume at maximum, amplifier volume set to a comfortable level.

If you can't hear a difference, it may help to use a lower quality music player. Describe the sound quality in each instance. In particular, can you detect noise, and is one setting less noisy than the other?

5. If you have been using a battery, remove it and connect the DC power supply. Set the supply initially at 9 V. Listen to any sort of signal with the CMoy set at low volume (audible but quiet). Decrease the supply voltage until the signal becomes distorted. This is called “clipping”. Record the power supply voltage in your lab notebook, and explain what is happening. Repeat at higher volume (but not hurtful to your ears).
6. Increase the voltage again (but avoid damaging the Op Amp: *do not* exceed 12V).

Does the perceived volume change as you increase the supply voltage?

7. Connect the input (one side or “ear”) of your device to a signal generator and the corresponding output to the oscilloscope. Begin with a sine wave at about 1 kHz. Adjust the input signal amplitude and/or the amplifier volume so that the output signal is about 8 V peak-to-valley. Record the value. Now, without adjusting the input signal amplitude or the amplifier volume, examine the output amplitude over a wide range of frequencies, collecting data to answer the following questions:
 - (a) What is the maximum output amplitude? To characterize the frequency response of your amplifier you will use the relative response, which is a fraction of this maximum.
 - (b) Over what range of frequencies is the relative response 90% or greater?
 - (c) Find low frequency for which the relative response falls to $1/\sqrt{2} = 0.707$. This is called the 3dB point, and corresponds to 50% output power (for a load of fixed resistance, power goes like the square of amplitude).
 - (d) As you go to very high (ultrasonic) frequencies, the output waveform will be distorted. Describe and sketch the distorted waveform in your logbook. At what frequency do you first begin to notice this effect?
 - (e) Looking at a very high frequency, highly distorted signal on the scope, determine the maximum slope (in V/ μ s) of the output waveform. This is called the slew rate of the amplifier.

Kit builders: If there is time remaining in the lab period, you may finish the installation of your amplifier into the mint tin. are small but noticeable.

5 Conclusion

Based on listening to the amplifier without music, with and without the music device connected, which is the greater source of noise—the music device or the amplifier?

Based on your tests with either the amp or the music device set to maximum volume, how would you set up your system for optimal listening? Can you explain the results?

Discuss what happened when you varied the power supply voltage. Does the voltage affect the perceived volume? Does the volume setting affect the voltage at which clipping appears? Provide explanations to make sense of your observations.

The low-frequency response of the amp is determined by the high-pass filter. Compare the frequency you determined for the 3 dB point to $1/(2\pi RC)$, where $R = 100\text{ k}\Omega$ and $C = 0.1\text{ }\mu\text{F}$.

Look up the data sheet for the TS922 Op Amp. What is given for the typical slew rate? Compare to your measurements. Use the specified typical maximum slew rate to predict the frequency at which the slew rate limitation will begin to distort the waveform. Compare to your observations.

Interpret your quantitative measurements and your subjective listening tests—comment on the audio quality of your amplifier. Here are some basic facts to keep in mind about human hearing: People with good hearing can detect sounds ranging in frequency from 20 Hz, to 20 kHz. Variations of about 12% in amplitude (25% in power, which goes as the square of amplitude)