Audio Amplifier and Graphic Equalizer Design using Opamps

LAB 2

Introduction

In this lab you will design, construct, and test an opamp-based audio amplifier and 3-band graphic equalizer. Figure 1 shows the block diagram of the system that you will build. The graphic equalizer will span the audio frequency band (20Hz - 20kHz). If you are using your own Discman/Walkman, make sure that it delivers

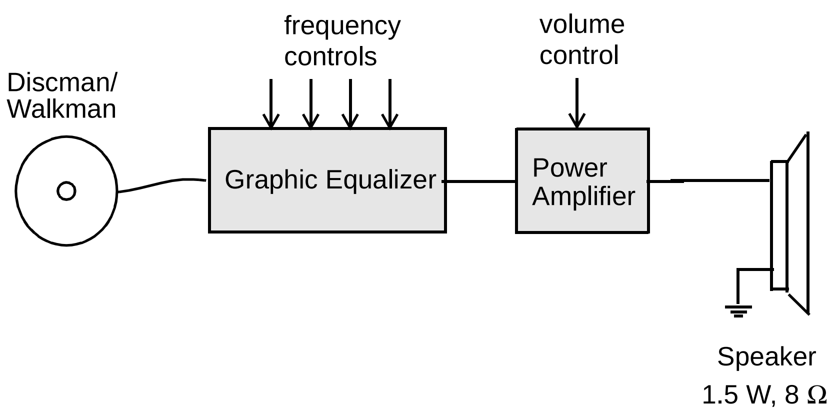

Figure 1 — 3-band audio graphic equalizer block diagram.

at least 1V peak-to-peak audio output. This is easily verified by measuring it with a meter or oscilloscope in the lab. We will have walkman radios available for testing, but you're welcome to use your own for this lab. Audio jacks will be supplied in your kit parts for use with your own walkman.

Week 1: Graphic Equalizer

A graphic equalizer circuit is shown in Figure 2. It is customary to arrange the values so that the part of the frequency spectrum on which the gain adjustments are made are divided into eight or nine octave segments covering the entire audio range (about 20Hz-20kHz.) You have enough circuit components to cover the entire audio spectrum in this manner; however, in the interest of saving time you are only *required* to select three frequencies. If you choose to build a circuit which

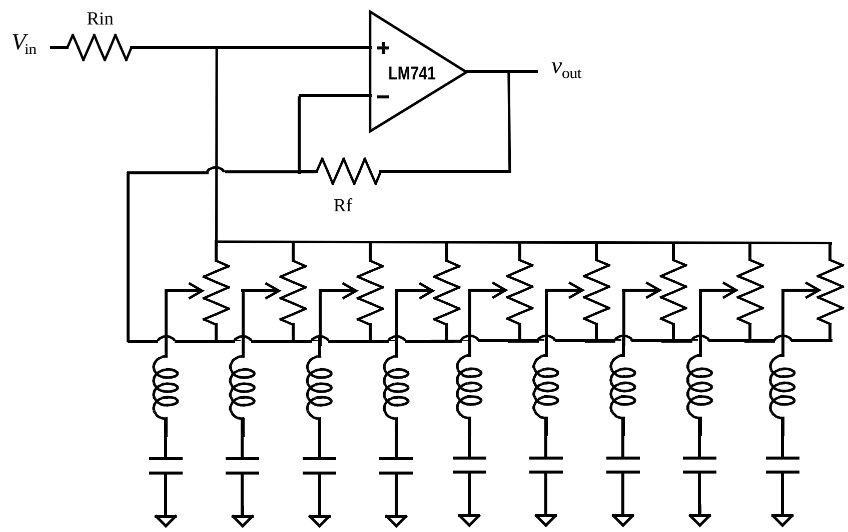

Figure 2 — Graphic equalizer circuit.

handles less than the nine frequency controls shown in Figure 2, then you must justify the frequencies that you choose. For example, if your favorite music is jazz, do some research and find out what frequency ranges you are most likely to want to amplify or attenuate based on your favorite musical instruments. For the chosen frequencies, the gain should meet the following specifications:

- maximum gain +15dB
- maximum attenuation -15 dB

Design Procedure

The series LC components form a resonance circuit which acts as a frequency dependent impedance. Each of the LC combinations specifies a resonance frequency for the graphic equalizer. When the audio signal has a frequency component that corresponds to one of the resonance frequencies, the impedance of that resonance circuit is at a minimum value for that component of the audio signal, and is then either amplified or attenuated, depending on the position of the potentiometer.

To understand the basic operation of this circuit, it is suggested that you first experiment with designing the gain for the circuit in Figure 3. Use a value of *r* that is sufficiently small compared to the resistance of the potentiometer, *R*. Analyze the circuit, build it, and confirm your analyses. Then replace the small resistor *r* with a series LC impedance. Now test the circuit's frequency response by connecting it to you function generator, sweeping the frequency throughout the audio range, and taking measurements of the response. After you have one band of your equalizer working, add the other two potentiometers and LC impedances and then again sweep the frequency and take measurements. Be sure to check the potentiometers and make sure that they either attenuate or amplify the signal at the LC resonant frequencies you chose. **It is strongly recommended that you use SPICE as part of your analysis, and run several circuit simulations *before* coming to lab.** When you have completed your circuit and verified its functionality, demonstrate it to the lab TA. **Please *DO NOT* disassemble your circuit after lab is over because you will need it for the following week.**

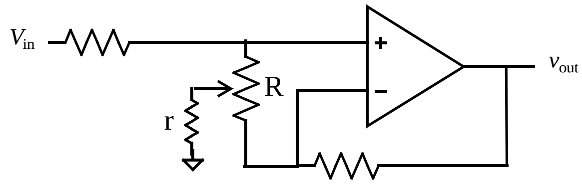

Figure 3 — Simplified Graphic equalizer circuit.

Week 2: Power Amplifier

Design a power amplifier circuit using the LM1875 power opamp (data sheets are appended to this lab). Provide the following features:

- Volume control based on a variable 1-5 volts/volt control for the output from the graphic equalizer. Be sure to read your datasheet for the 1875 as there must be a ‘trick’ implemented to get an ‘effective’ 1-5V/V gain from the output of the EQ circuit.
- The ability to drive an 8 ohm speaker load.
- The entire circuit, when assembled with the graphic equalizer, maintains input signal polarity.

It is extremely important that you use a heat sink with the LM1875 power amp. Why do you think it is necessary? Test your amplifier circuit first by applying a 1kHz sinusoidal input signal. Remember to keep the amplitude small enough so that you don’t saturate the op-amp, and verify that your dialable gain specifications are met. Next, attach your walkman to the input of the amplifier, and again verify its operation. Finally, attach your graphic equalizer circuit to the power amplifier, plug in your walkman, and check to make sure your entire circuit is functioning properly. What is the maximum allowable gain for this circuit when covering the entire audio frequency range? When everything is completed and working properly, demonstrate your circuit to the Lab TA.

Lab Notebook

In your lab notebook, it is expected that you will show all of your work, all of your designs, all of your ideas, all of your calculations, all of your assumptions, and all of your results. It is important that you show designs that did not work, and then explain why this is the case. Explain all of your mistakes, and your entire procedure. You will find that a very complete lab notebook makes it easier for you to write a good lab report, and it is also useful for reference later on. To sum it all up, *everything you do must go into the lab notebook, no matter what.* Remember that your lab notebook should be bound. Spiral and loose leaf binders are not acceptable. In addition, remember that every lab bench is to have two (2) lab notebooks. Your lab notebook will be submitted with your lab report, and will be a part of your grade for that lab. The lab TA's will also be spot checking your lab notebooks, at random times during the lab. In order to receive full credit for the spot checks, be sure that you are following these suggestions and the guidelines in your lab syllabus.

Protoboards and Good Analog Design Techniques

In order to have an analog circuit that functions predictably and reliably, good analog design techniques are necessary. Since most of the designs you will be doing in lab will be done on your protoboards, here are some suggestions for making your lab experience less frustrating and more productive:

- If you have an old protoboard, (one that has at one point caught fire, melted, or one that has been corrupted by plugging in digital IC's from 18-240 lab) chances are you will need a new protoboard. Beneath all those little sockets are metal clips, which spread out every time you plug something into them. By the time you have done this several times, they no longer make good contact with wires or IC pins. As a result, you will see strange, noisy waveforms on your oscilloscope, get unpredictable results, or get no results at all. While your protoboard may be ok for the 1's and 0's of digital IC's, analog components are much more sensitive. Protoboards are available at Tech Electronics.

- Try to keep all signal lines away from power lines, and in general keep all lines a short as possible. Noise can and will find its way into your circuit wherever possible. Long signal paths and power supply lines kept near signal paths are susceptible to noise pickup and coupling.

- Try to keep all your component leads as short as possible. Having wires and components going an inch up into the air and then back into your protoboard will result in noisy and unpredictable performance, especially as you get up into higher frequencies. Clip component leads and wires, and try to get those components flush with the surface of your protoboard. Think about a real circuit board... you don't see components with bent leads an inch up in the air wiggling around!

- Make sure you have a solid ground reference. Without one, your circuit will be 'floating' and will perform miserably or not at all.

- It is unrealistic to put the whole circuit together and expect it to work. Instead, try to build your design in stages, and test it at every step along the way.

Following these general guidelines will not only result in a circuit that works better, but will also make the debugging process much simpler. The extra time spent carefully cutting wires and leads and placing components will save you much more time in debugging later on.

Lab Report

In your lab report, show your final design and explain any problems, issues, and assumptions. Report your results for any and all experimental tests that you have made. Graphs and charts of your results (both theoretical and actual) are desirable. Be sure to comment on any differences between the theoretical or expected results and your actual results. Your report should include a brief (1-2 paragraph) introduction and conclusion. **The reports *must* be typed, handwritten reports are unacceptable.**

Parts List

(2) LM741 Operational Amplifiers

(1) LM1875 Power Operational Amplifier

(1) 1.5W Audio Speaker

(1) Walkman radio or CD player

(4) potentiometers (1k or 10k)

audio jacks/plugs

Resistors (assorted values)

Capacitors (standard values)

Inductors (standard values)