

EGR 220: Engineering Circuit Theory Design Project:

I. Introduction

Passive filters are electrical circuits consisting of resistors, inductors and capacitors, that are designed to block certain frequencies and pass others. Filters are widely used in applications such as touch-tone phones, stereo equipment and communications equipment. For this project you will design a circuit that will filter selected frequencies from an audio signal (*a.k.a.* a music file).

II. Overview

Working in groups of 2 to 3 students, you will design a circuit to block (or pass) a specified frequency range from an audio signal. The range of frequencies to be blocked or passed will be defined by your group. You will build and test the circuit first using the function generator to generate the full range of audio frequencies and verify that your circuit is behaving according to your design criteria. You will then test your circuit with musical input.

Design is an iterative process and you should plan on reassessing your design criteria and rebuilding your circuit a number of times before you build the final circuit.

To verify your design, and know if you are achieving your design criteria, you will need to record significant experimental data and compare your data to expectations, based on theory. As part of the design process you will therefore create a Bode plot for your circuit based on theory, and also record sufficient data to compare this theoretical frequency response to the actual frequency response.

IIa. Design Criteria Possibilities

- Simulate what we would hear if we had low frequency hearing loss. For this example, your circuit should pass high frequencies unaffected from input to output and block low frequencies.
- Simulate high frequency hearing loss.
- Simulate how sound is perceived over the telephone, which transmits frequencies in the range of 300 to 3000 Hz.
- Simulate a unique hearing loss that blocks middle frequencies, while passing high and low frequencies.

IIb. The Design Process

You will begin by selecting R, L and C values based on your selected cutoff, bandpass, bandstop, and/or center frequency values. You will need to adjust these values based upon what is available in the lab. You will also need to adjust values in your circuit based upon the additional effects of resistance in the meters, amplifier and/or speakers.

Testing your design will involve viewing the input and output signals on the oscilloscope and quantifying these values at many input frequencies, generated by the function generator. You should take measurements of the output voltage and the input voltage at many frequencies to test your circuit (selecting the appropriate number of frequencies, and values of those frequencies, is part of the design process).

Once your circuit behaves as you expect (*i.e.*, meets the design requirements), you should listen to how music is affected by the specific circuit. You will use a music signal from a computer or iPod as the input to your circuit and the output of your circuit as the input to a stereo amplifier and speaker to listen to your filtered music. Be careful to account for how this system might “load” your circuit, making it behave differently when it is and is not connected to the amplifier/speaker system. ***What can you do to eliminate the problem of the stereo “loading” your filter?***

Note that design is an ***iterative process***. It is almost impossible that your circuit will work correctly the first time. Be careful and methodical. ***Draw a circuit diagram first***. You **must** have a clear circuit diagram **and** wiring diagram to receive help from me and/or other lab helpers. Build your circuit in stages. Know what you expect for output from each stage, and verify that each circuit stage works correctly alone, ***before*** you wire them together. Test and verify each circuit stage and the entire circuit with the **oscilloscope first**, before you test it with the speakers.

One note for wiring – you must have ***a common ground for everything*** – including all circuit components on the breadboard and every piece of lab equipment.

IV. Deliverables

- Project assigned November 22, with testing of *very simple, initial* designs in lab on November 22nd and during the following weeks as needed.
- Progress memos are due on December 6, one from each team.
 - The memo must be a professional document with text included, as needed, for such a document. To clarify your progress, you must also include a clear statement of your design criteria, a circuit diagram of your circuit design, a first set of experimental data, and a Bode (amplitude) plot comparing the theoretical frequency response of your circuit to the actual frequency response (based upon your experimental data).
- Final presentations (one per team) of the designs will be in lab on December 13.
 - Presentations should be no more than 10 minutes.
 - Your presentations must be professional (which means, *at a minimum*, you must have a title slide with team member names, an introduction, and a conclusion/summary).
 - You must include your design criteria, a circuit diagram, results and analysis that include a comparison of theoretical to experimental data, and a qualitative description of your circuit’s behavior at different frequencies.
 - The Bode plots must be created with Matlab
 - We will also observe and listen to the behavior of each circuit in lab on this day.
- Final reports (one per team) are due December 13

V. Extra Notes

- Debugging your circuit
 - Draw the circuit diagram both as a figure such as in text and as a wiring diagram
 - Confirm all connections in your circuit

- Test the input and output of individual stages of your circuit *without* the rest of the circuit connected, using the oscilloscope first (not the speakers)
- Rewire your circuit
 - Using a second breadboard if available
 - Take apart existing circuit if necessary
 - Test the input/output of the circuit at each stage as you wire it
- Ensure you have a common ground for *everything* including
 - the DC power supply if you are using op amps
 - all probes
- Team Presentations and Final Report – due Monday, Dec. 13, 2010
 - Presentation and report including, at a minimum
 - A title slide with team member names; A title for your report with all names
 - An introduction
 - Design criteria, that are specific to your circuit, **NOT** general criteria that apply to the entire class
 - Do **NOT** include any discussion of the design process
 - A circuit diagram (different from a photo of your circuit) – a circuit diagram is a figure of your circuit such as you see in the text book
 - Results and analysis that include a comparison of theoretical to experimental data (with a discussion comparing and contrasting and explaining)
 - Include a Bode plot that is created with Matlab, that includes both the theoretical *and* experimental data on the same plot
 - Be sure to label your plots/figures so that *anybody* would understand what you are presenting
 - A qualitative description of your circuit’s behavior at different frequencies. (For the presentation, this slide should not involve excessive text – remember this is presentation format. If the audience in a hypothetical conference room could not read the text on your slide then your slide is not useful and should not be included).
 - A conclusion/summary – that is distinct from the qualitative description from the bullet above.
 - (*hopefully an unnecessary comment*: a professional document does not include complaints or excuses)
 - To present to the class
 - A presentation that fits comfortably into no more than 10 minutes
 - Practice your presentation to ensure you do not go over time
 - Points will be deducted for presentations that are too long
 - You may not be able to include all the information from the slides you will hand, in your 10 minute presentation.
 - Decide what is most important to convey a complete story to your classmates, and skip slides as necessary.
 - You must allow time to demonstrate the functioning of your circuit within the 10 minute time period.

- FINAL TEAM REPORT
 - Hand in a final report that is similar in length to the Lab 6 report (*i.e.*, LONGER than the 1 page memos for other labs). Include all the standard elements you have been including, as well as an abstract. Make the report clear and concise. Excessively long or wordy reports will lose points. Reports that are so short so as to not present a complete story of what you did and what you found will also lose points. A major part of this assignment is for you to figure out how much material to include in your final report. Feel free to come talk with me about this.