Integrative Case Study Draft

ESE 351

In the previous two assignments, you experimented with two simple RC circuits. You explored multiple ways to simulate the output of a system and saw that by passing signals of varying frequency through a system, you could construct a magnitude plot that displays how each circuit attenuates different frequencies. You also noted linear properties of the RC circuit system.

In the final assignment in this series, you will use your work from the previous sections to design your own RC circuits to satisfy various design requirements, and then test those circuits’ response to various inputs.

This case study will require you to complete a writeup using the IEEE journal format. You can find a detailed word template for this format [here](http://ieeeauthorcenter.ieee.org/wp-content/uploads/Transactions-template-and-instructions-on-how-to-create-your-article.doc). You might also consider completing your writeup using LaTeX, a typesetting system that is particularly useful for academic publications, though this is not required. An introduction to LaTeX can be found [here](https://www.overleaf.com/learn/latex/Free_online_introduction_to_LaTeX_(part_1)), and some IEEE templates for LaTeX can be found [here](https://www.overleaf.com/org/ieee).

Your final case study submission will include:

* A writeup in IEEE style which includes all of the following sections, as well as any other sections you decide to include. (Each section can be as long or as brief as it needs to be)
  + An Abstract describing your findings in brief
  + A Background describing the context of your work
  + A Methods section describing how you created your results, including how you decided to design your circuits
  + A Results section including your beautiful plots and other output
  + A Conclusion section summarizing what you learned.
* Your MATLAB code and any dependent functions
* A published pdf of your MATLAB output

# Case Study

Choose **any two** of the following objectives to complete. For each objective, you can use any simulation method that we have covered in this class and any circuit you can think of. In addition, you can place as many circuits in series or in parallel as you would like and use any values of R and C for each. (That is to say, you can break your model up into several smaller models to make it easier to simulate)

You may also amplify or normalize your output signal (multiplying the entire signal by a constant), which may be necessary if your circuit attenuates the signal too much.

For each objective, do the following:

* Design a circuit to accomplish the described task. Be sure to include an explanation in the Methods section of your writeup on why you made the design choices you did.
* Using a method of your choice, plot the step response of your circuit.
* Using a method of your choice, plot the impulse response of your circuit.
* Generate a Bode magnitude plot for your circuit.
* Test your circuit to see if it completes the desired task and describe the results qualitatively.
* Describe qualitatively how well your circuit completed the task
* Taking the signal described by the objective, use the plotpowerspectrum() function included in module 3 on the canvas site to plot the power spectrum of the signal before and after passing through your circuit and compare the two

## Objective 1: Noise Removal

Included in the week 3 module is a sound file “noisy.wav.” When the audio was recorded, there was a fan running near the microphone, resulting in high-frequency white noise. In addition, a refrigerator nearby was humming, resulting in a low-frequency 60 Hz buzz.

For this objective, design a circuit that will filter out as much of the low and high frequency noise as possible while leaving the desired signal intact.

## Objective 2: Bass Boost

For this objective, record a short sample of your voice or someone else’s. Design a circuit that will “boost” the bass of the signal relative to the other components (the fundamental frequency of a human voice is usually between 80 and 300 Hz). In your observations, note: is it possible to construct an RC circuit with a gain of greater than 0 dB? If so, provide an example. If not, explain why not.

## Objective 3: Notch Filter

Included in the week 3 module is a sound file “notch.wav.” This signal contains white noise – noise that is evenly distributed across every single frequency. It also contains a single large spike at f = 500 Hz.

For this objective, design a circuit that will attenuate the 500 Hz frequency while leaving the surrounding frequencies mostly unattenuated. In your observations, note: is it possible to perfectly eliminate a specific frequency? If so, explain how. If not, explain why not.

## Objective 4: Damped Oscillator

Consider a new circuit design that includes an inductive component as shown. Using the relationship for the voltage across an inductor (), and the Kirchoff Voltage Law, construct a differential equation modeling the voltage across the capacitor. List any assumptions you had to make.

Test your circuit using the values R = 1kΩ, C = 2µF, L = 100 mH. Find the frequency at which the circuit has the largest gain and see if you can find a relationship between that frequency and your values of R, C, and L.

In your observations, note: how is the Bode plot for this circuit different from the others you’ve seen so far? Can you explain physically why this is the case?