# EECE 2150 - Circuits and Signals: Biomedical Applications

## Lab 12, Frequency Content of Signals

## Section 3

Prelab for DiMarzio Section: Be familiar with fft, fftshift, fftaxis, fftaxisshift from the fft project we did in class.

## Introduction

In this lab you will use Matlab to measure the frequency content of signals and you will try to connect what you hear in certain signals with your understanding of frequency

## Part I – Frequency Content of Recorded Sounds

1.1 **Record yourself speaking on your computer** for about 3 seconds. For this, you can use the **Sound Recorder** utility on your computer (usually in the Accessories / Entertainment menu). Save this file to the desktop in **".wmv" or ".wav" format.**

1.2 Note that some versions of Windows do not allow you to save in **.wmv** format, only in Windows Media **.wma** format. This is annoying, but you can convert to a .wmv file using a number of utilities, e.g. http://audio.online-convert.com/convert-to-wav
***You must convert to .wav since Matlab cannot read .wma files***

1.3 Read in the sound using the audioread function in Matlab. If you do not know how to use the audioread function type **"help audioread"** or **"doc audioread"** for instructions. Note from the help that audioread returns the sampling rate as well as the sounds signal. You will need to use the sampling rate so be sure to specify an output variable to save it. Helpful hints: Note that the desktop (or wherever you saved your .wmv file) must be in the Matlab path. Also note that the file name must be in single quotes when you use the audioread function (… audioread('myfile.wav')).

1.4 Now, analyze the frequency spectrum of your file using the functions we learned in the project. **Q1: Describe the frequency content of your spoken audio signal. For example, what frequency has the largest amplitude? Where is most of the signal located in the frequency spectrum, qualitatively?**

1.5 Next, use the stft_sound_plot function provided to examine the frequency content of shorter intervals of your sound, to find out how the frequencies shift as you go from one part of the sound sample to another. (This is also provided by us not Mathworks, and again you should run "help" on the function to learn how it works. You probably want to make the FFT length parameter a power of 2 that is somewhat longer than the window length, but this is not critical.) You may need to play around with the window size parameter to get the best results. Note that this parameter is in number of samples, so look at the total number of samples and adjust the window for an appropriate subset. To start, you may want to divide your signal into about 10 parts, so make the number of samples in the window about 1/10 of the number of total samples. Note that stft_sound_plot expects a 1-D array, whereas the sound file reading functions often generate a 2-D array. The function will note this and fix it but give you a warning message, or if you prefer you can fix it before calling the function. (You can do this in Matlab using **x(:, 1)** if **x** is the 2-D array and it has many rows but 2 columns). **Q2: How much does the frequency content change from one part of your sample to another? Record plots of at least two very different sub-intervals.**

1.6 Try this with a number of different sounds:
i) Try generating a vowel or a constant pitch tone. See if you can achieve a tall spike in your frequency spectrum by keeping the pitch constant, and see if the harmonics change depending on the vowel! Hint: You will almost certainly need to expand the scale of the x-axis to see the fundamental frequency and harmonics of the constant pitch sound. **Q3: Did you get a tall spike in frequency? Were there other harmonically-related spikes (as we might expect for a periodic signal?**
ii) Try generating a "noise-like" sound like "sh" or "ffff". **Q4: How is the spectrum of this sound different from the constant pitch sound? Does this sound have more high frequencies, low frequencies, all frequencies, or spikes, or something else?**
iii) Compare similar sounds made by lab partners, such as two vowel sounds. **Q5: Can you see differences between the frequency spectra?**

## Part II – Frequency Content of an ECG Signal

2.1 Load the example ECG data "**ecg_waveforms.mat**" into Matlab. This contains two ECG traces: i) **ECG1** - a noisy ecg file and ii) **ECG2** - a longer ECG trace. **Plot these in Matlab** to be sure they have loaded correctly.

2.2 Use the plot_frequency_content function to examine the frequency content of both signals. Note that the sampling rate was **Fs = 1000 Hz** for both signals. Again, after seeing the big picture (frequencies up to 500 Hz), it is important to expand the scale of the x-axis so that you can see the details of the low frequencies.
i) <u>For both signals:</u> **Q6: What is the overall frequency <u>range</u> that has the dominant frequency content of the signal?**

ii) For ECG1: **Q7: What is the frequency of the major noise content in the signal? Does this match what you observed with this same signal in a previous lab?**
iii) For ECG2: **Q8: What is the person's heart rate in beats per minute?** If you are not sure what to expect, check your own pulse to see what kind of frequency range you should expect, and then use that to guide your effort to answer this question. Again – you will have to expand the low-frequency part of the signal spectrum!
iii) **Q9: Do you see any other noticeable noise in both signals?** In particular look at frequencies that are integer multiples of the noise you found in in ii).

2.3 **Q10: If you were building an amplifier for ECG, what frequencies would you want to amplify? What frequencies would you want to reject?**

2.4 **Q11: What would be the minimum sampling rate you would want to record (digitize) someone's ECG?**

No Reflections for this lab.

## IMPORTANT: BEFORE YOU LEAVE THE LAB:

**(a) Place all of the components that your removed from the red tool box back in that box and return it to the cabinet that houses them**

**(b) Collect all used components and wires from your bench and place them in your group's reusable plastic container. If you are not going to use these components or wires again please discard them in the trash bin located in your lab room.**

**(c) Turn off all of the equipment you have used on your workbench.**

**(d) Make sure you return your protoboard, the equipment wires and your reusable container to the front window.**

**(e) Make sure to have your notebook signed by an instructor before you leave the lab.**

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