Final Lab
December 5, 2016

DUE May 5, 2016 — 11:59 PM

INSTRUCTIONS:
All lab submissions include a written report and source code in the form of an m-file. The report contains all plots, images, and figures specified within the lab. All figures should be labeled appropriately. Answers to questions given in the lab document should be answered in the written report. ***The written report must be in PDF format***. Submissions are done electronically through **my.ECE**. NO LATE SUBMISSIONS ACCEPTED.

1 FFT Basics

(25 pts) Load *signal.mat*. This signal is sampled at $f_s = 100$ hz. Plot the magnitude and phase response of this signal. How many tones are there? What is the frequency of each tone?

2 Filter Design

(10 pts) Given a sample rate of $f_s = 10,000$ Hz, design a minimum-length, linear phase highpass filter with passband edge at 4 Khz and stopband edge at 3.6 Khz. The ripple in the passband should be no more than 1 dB and the stopband attenuation should be less than 50 dB. Plot the magnitude and phase response of the filter and add markers in your plot to prove that it meets the required specifications. What is the length of your filter?

(15 pts) Design a filter with the following characteristics shown in Figure 1 using any method. Plot the magnitude and phase spectrum, along with markers that prove that your filter is within spec.

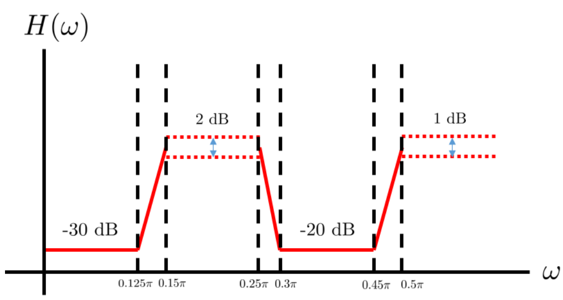

Figure 1

3 Sample Rate Conversion

Time domain must be in seconds. Frequency domain must be in hertz.

(5 pts) Load *samplerate.mat*. Assume that the analog sampling frequency f_s is 40 hz. Plot the magnitude spectrum and time domain plots of the original signal x using *plot* and *stem*, respectively.

(10 pts) Upsample the original signal by 3 by inserting zeros between samples. Plot the resulting magnitude spectrum and time domain plots for this new signal using *plot* and *stem*, respectively. What do you notice about the magnitude response compared with the magnitude response of the original signal? Why does this effect occur (*HINT:* think about your fourier transform properties)? If you cannot think of the fourier transform property, then you may present a math proof.

(10 pts) In the frequency domain, apply an ideal LPF to get rid of the extra spectral content introduced by zero insertion. Using *subplot*, plot both the magnitude spectrum after applying the LPF and the corresponding time-domain waveform.

(5 pts) Downsample the signal from section 4.3 by 2. Using *subplot*, plot both the time domain waveform and its associated magnitude response. What is the final sample rate of the waveform? What is the maximum value of D you can choose without aliasing?

4 Image Processing

(10 pts) Load the image *image1.jpg*. Display the image using **imshow**. Apply the filter given below:

$$\begin{bmatrix} -1 & -1 & -1 \\ -1 & 8 & -1 \\ -1 & -1 & -1 \end{bmatrix}$$

Plot the magnitude response (in dB) of the filtered image. What kind of filter is this? Invert the filtered image such that $255 \rightarrow 0$ and $0 \rightarrow 255$. In other words, white should become black and black should become white. Display the inverted image.

(10 pts) Load the image *image2.jpg*. Plot the magnitude response (in dB) of the image. Apply the filter given below:

$$\begin{bmatrix} 1/16 & 1/8 & 1/16 \\ 1/8 & 1/4 & 1/8 \\ 1/16 & 1/8 & 1/16 \end{bmatrix}$$

Plot the magnitude response (in dB) of the filtered image. What kind of filter is this?