ECE 351 DSP: Assignment 3

Instructor: Manuj Mukherjee

Total: 30 points

Submission deadline: 10:00 AM 9.12.2022

Instruction: This assignment consists of coding questions only. However, you also need to provide some on-paper calculations on the choice of frequencies, and other inputs that you will be providing to the built-in functions like kaiserord, remez, etc. Coding can be done in both MATLAB and python, though python is preferred. However, built-in functions such as 'designfilt' of MATLAB, which automatically performs the filter design without you having to do any internal calculations, cannot be used. Using such built-in modules will lead to penalties. To be on the safe side, hence, I would encourage you to work with Python, and the built-in functions used in the codes I am using in class.

1) Consider the two sequences $x[n] = \binom{2n}{n}(\frac{1}{4})^n$,[1] $0 \leq n \leq 49$, and $h[n] = [-1, 0, 1]$. Write a code to compute $x[n] * h[n]$ using the overlap-and-add method with 16-point DFTs. To implement the 16-point DFTs, you can use built-in functions, such as fft, ifft, and fftconvolve from scipy.fft and scipy.signal. However, built in functions which perform the overlap-and-add method, such as oaconvolve, cannot be used. Plot the output sequence.

   You do not need to show on-paper calculations for this question.

   [6 points]

2) Consider the bandstop filter with the following specifications: Pass band edges at 30 Hz and 90 Hz, stop band edges at 50 Hz and 80 Hz, and a sampling frequency of 240 Hz, pass band ripple $\delta_1 = -30dB$, stop band ripple $\delta_2 = -50dB$. Design a Kaiser window FIR filter meeting these specifications. Plot the filter magnitude response (in dB).

   Note: You need to show rough on-paper calculations to show how you obtained the inputs to the different Python/MATLAB modules used.

   [**Hint**: This filter needs an odd M (Why? Think). Ensure your code handles this scenario. Else, the filter will not work.]

   [7 points]

[1] Take $\binom{0}{0} = 1$.

3) Consider a filter with the following pass and stop bands: Pass bands from 0-20 Hz, 140-160 Hz, and stop bands from 60-100 Hz, 180-200Hz, with the sampling frequency being 400 Hz. Let the stop band ripple be -30 dB and pass band ripple be -20 dB. Design an equiripple filter to meet these criteria. Plot the filter magnitude response (in dB).

   Note: You need to show rough on-paper calculations to show how you obtained the inputs to the different Python/MATLAB modules used.

   [7 points]

4) Design an IIR band-stop filter with pass bands from 0-100 rad/s, 200-400 rad/s, and stop bands from 110-190 rad/s. The sampling angular frequency is 800 rad/s. The pass band and stop band ripples are respectively at -30 dB and -40 dB. Plot the filter magnitude response (in dB), as well as the magnitude responses (in dB) of the basic analog-low pass filter, and the analog-notch filter obtained through frequency transformation.

   Note: You need to show rough on-paper calculations regarding what analog low-pass you are using, and details of the frequency transformation operation.

   [10 points]