

ECE 351 DSP: Assignment 3

Instructor: Manuj Mukherjee

Total: 30 points

Submission deadline: 11:59PM 20.11.2023

A word on the notation: I shall represent finite duration causal signals as arrays. For example, $x[n] = [1, 2, 3]$ means $x[0] = 1$, $x[1] = 2$, and $x[2] = 3$, and $x[n] = 0$ for all other n .

All coding is to be done in Python. MATLAB codes will not be awarded any points.

- 1) Design a Kaiser window filter with pass band edges $f_p = \frac{1}{8}, \frac{1}{4}, \frac{1}{3}$ sample⁻¹ and stop band edges $f_s = \frac{1}{6}, \frac{1}{5}, \frac{5}{12}$ sample⁻¹.

The pass band ripples are at -32 dB and the stop band ripples are at -40 dB.

- Write a python code that designs the above filter, and plot its magnitude response in dB. You might get one ripple slightly higher than the stop band ripple while designing with `signal.kaiserord`. That design is still acceptable as long as everything else is correct.
- Now, assume that you have to implement this filter using a 128 point DFT and overlap-and-add method. Suppose your incoming signal $x[n]$ is length 250. What should be the length L of each of the segments of $x[n]$?

[**Hint:** Be careful to note that the supplied frequencies are in sample⁻¹ and not Hz.]

[8+2=10 points]

- 2) Consider the system given by the difference equation $y[n] = \frac{7}{12}y[n-1] - y[n-2] + x[n] - \frac{13}{6}x[n-1] + \frac{1}{3}x[n-2]$.

- Find its transfer function.
- Show that this is a mixed-phase system.
- Decompose the system into a min-phase system and an all pass filter.

[2+3+5=10 points]

- 3) Design an equiripple notch filter with pass band edges being 20 Hz and 60 Hz, and stop edges being 30 Hz and 50 Hz. The sampling frequency is 200 Hz. The pass band ripple is -30 dB, and the stop band ripple is -20 dB.

- Write a python code to design the said filter and plot its magnitude response in dB. The pass band of the desired filter might extend a bit while designing using `signal.remez`, but ensure you choose a high enough M to meet the stop band ripple.
- Now, assume that $x[n]$ is a 100-point sequence which is to be passed through this filter. The filter is to be implemented via DFT. What is the minimum N needed for the DFT?

[9+1=10 points]