Fall 2024   EE 313 Linear Systems and Signals   Prof. Evans

Mini-Project #2 Averaging and Nulling FIR Filters

Assigned on Saturday, October 25, 2024, 10:00am
Due on Wednesday, November 6, 2024, by 11:59pm pm via Canvas submission

Late submission is subject to a penalty of two points per minute late.

Reading: McClellan, Schafer and Yoder, *Signal Processing First*, 2003, Chapter 3.
Companion Web site with demos and other supplemental information: http://dspfirst.gatech.edu/

E-mail address for Mr. Elyes Balti (TA) is ebalti@utexas.edu. Please consider posting questions on Ed Discussion, which can be answered by anyone in the class. You may post anonymously.

Office hours for Mr. Balti and Prof. Evans follow:

Time Slot	Monday	Tuesday	Wednesday	Thursday	Friday
11:00 am		Evans (ECJ 1.204)		Evans (ECJ 1.204)	
11:30 am		Evans (ECJ 1.204)		Evans (ECJ 1.204)	
12:00 pm		Evans (ECJ 1.204)		Evans (ECJ 1.204)	
12:30 pm					
1:00 pm			Balti (EER 5.652)		
1:30 pm			Balti (EER 5.652)		
2:00 pm	Evans (EER 6.882 or Zoom)		Balti (EER 5.652)		Balti (EER 4.650)
2:30 pm	Evans (EER 6.882 or Zoom)		Balti (EER 5.652)		Balti (EER 4.650)
3:00 pm	Evans (EER 6.882 or Zoom)				Balti (EER 4.650)
3:30 pm	Evans (EER 6.882 or Zoom)		Evans (EER 6.882 or Zoom)		Balti (EER 4.650)
4:00 pm	Evans (EER 6.882 or Zoom)		Evans (EER 6.882 or Zoom)		
4:30 pm	Evans (EER 6.882 or Zoom)		Evans (EER 6.882 or Zoom)		
5:00 pm				Balti (EER 4.702)	
5:30 pm				Balti (EER 4.702)	
6:00 pm				Balti (EER 4.702)	
6:30 pm				Balti (EER 4.702)	

You may work individually or in a group of two or three persons. If you work in a group, then create one report together. Each of you would submit the same report on Gradescope. Be sure that the mini-project report represents the independent work of the author(s) on the report.

This mini-project report is something that you could bring with you on interviews to show as an example of your work.

For mini-project #2, please complete the following assignment on discrete-time linear time-invariant graphical user interface and nulling filters from *Signal Processing First*:

Lab S-5: DLTI GUI and Nulling Filters

Please see the homework page for additional guidance on what to include in the mini-project report.

Here are hints on the mini-project #2 as of November 3, 2024:

- **Theme**: The assignment is to design, analyze, and simulate averaging and nulling FIR filters.

- **Takeaways**: There are three key ideas concerning linear time-invariant systems:

  o **Time domain**: Output signal is the convolution of the input signal and the filter's impulse response.

  o **Frequency domain**: Output signal is the product of the input signal and the filter's frequency response. The filter's frequency response is the Fourier transform of the impulse response.

  o **Filtering**: The magnitude of the frequency response can be designed to pass, attenuate, and amplify bands of frequencies as well as eliminate individual frequencies. The phase of the frequency response can be designed to delay all frequencies by the same amount in the time domain (linear phase) or assign a different delay to each frequency component. Practical filters have different frequency responses than ideal filters.

- **Scope and format** are described at the bottom of the homework hints page.

- **Download** the *Signal Processing First* dltidemo (Discrete-Time Linear Time-Invariant Demo)

  o Unzip it in your MATLAB folder.

  o In MATLAB, change directories to the dltidemo folder

  o Type in the MATLAB command dltidemo and click YES to add the folder to the path

- **Section 1.6**. In addition to lab assignment, compute and plot the poles and zeros for the three-coefficient nulling filter in terms of a null frequency at $0.75\,\pi$, plot the magnitude response and pole-zero diagram, and connect the values of the poles and zeros to the magnitude response of the nulling filter.

- **Section 1.7**. In Ideal Filters section, part (b) asks you to use as the input signal

  x[n] = 1.5 + 0.9 cos(0.55π n)

  What's the discrete-time frequency that corresponds to 1.5? It's 0 rad/sample because 1.5 does not oscillate. Mathematically, 1.5 cos(0 n) = 1.5. That is, 1.5 is a cosine with discrete-time frequency of 0 rad/sample, phase of 0 rad, and amplitude of 1.5.

  The Practical Filters section asks to "Right-click to get values from the frequency response plot". For me, I need to hold down the Control key while Right-Clicking.

- **Section 2.1(d)**. The input signal is

  $x[n] = 1.8 \cos(0.1\pi(n-2)) = 1.8 \cos(0.1\pi\, n - 0.2\pi))$

  which is a cosine with discrete-time frequency 0.1π, phase of 0.2π, and amplitude of 1.8.

  The output of the LTI system will be a cosine of the same frequency; however, the amplitude will be scaled by the magnitude response of the LTI system evaluated at the discrete-time frequency 0.1π and the phase will be shifted by the phase response of the LTI system evaluated at the discrete-time frequency 0.1π.

  The output is in the form

  $y[n] = A \cos(w_0 (n - n_7))$

  where n_7 is an integer.

- **Section 2.1(d)**. The discrete-time Fourier transform of a rectangular pulse can written using a Dirichlet function. Please see *Signal Processing First*, Section 6.7, pages 145-146.

- **Section 2.3**. This section relies on the Matlab file

  speechbad.zip

  Please download and extra the contents to create the file "speechbad.mat". This is a binary file format specific to Matlab that contains a copy of one of more Matlab variables. Load it into Matlab using

  ```
  load speechbad
  ```

  to define a corrupted speech segment in the Matlab variable xxbad. The sampling rate is 8000 Hz. You can use the sound command to play it:

  ```
  sound(xxbad, 8000)
  ```

- Please submit a narrative report whose sections follow the same sections as in the assigned lab exercise. The audience for your report is other students in the course. Here are several examples of narrative reports for previous mini-project #2 assignments for this course:

  o Fall 2018 Octave Band Filtering for Audio Signals: Assignment and Report

  o Fall 2021 Wireless Localization: Assignment and Report

  o Fall 2023 Image Filtering: Assignment and Report