Electrical & Electronic Engineering, University of Galway

EE445 DIGITAL SIGNAL PROCESSING

Octave Assignment DSP-1

FREQUENCY RESPONSE OF DISCRETE-TIME SYSTEMS

Objective

The objective of this laboratory exercise is to use Octave to investigate the frequency response and impulse response of several discrete-time systems.

Report

Reports must be prepared in **electronic** form, and should be submitted preferably in Microsoft Word or PDF format. The report should consist of the following elements:

- Listings of the Octave code you develop during this assignment. Code listings should be copied into your report as text, and not as "screenshots" taken from e.g. the Octave editor. Code included as a screenshot cannot be properly tested and graded.
- Additional plots that are generated by your code (where required), and the answers to any additional questions that may be asked in each part of the assignment.

Note that it is not expected that Reports will be of excessive length – a shorter report is actually better, as long as it contains the required information. Furthermore, please include all of your code etc. in the main report itself, rather than submitting a number of separate Octave files (or including everything in a Zip file). This is to facilitate keeping everything in the one place.

Your report should be named according to the convention "DSP1_FirstnameSurname_StudentID" e.g. "DSP1_JohnDoe_12345678". An assignment will be created on the EE445 Canvas page for you to upload your report (accessible under the "Assignment" menu on the left hand side). Details of the submission deadline will be communicated by means of a Canvas announcement.

NOTE

1. ***Please make use of appropriate comments in your code, for clarity. Marks will be lost if the code cannot be easily followed.***
2. ***Please ensure that your Report clearly indicates your name and which class you belong to. Submissions that do not include this information cannot be marked.***
3. ***Axes on plots should be labeled appropriately (including units, if applicable). Also, make sure that you include a caption with each figure. Marks will be lost if plots are not properly annotated.***
4. ***Remember that Octave is simply a software tool, and is just a means to an end – as with any programming environment, it's easy to make logical (not just syntax) errors that will give you the wrong result. So, you should always try to have some idea of what the answer should be, so that you can identify the presence of logical errors in the code that you've written.***

Plagiarism and Academic Integrity

You will no doubt be aware that the University treats academic integrity and plagiarism very seriously. Students are expected to work independently and to submit their own original report, without copying material from another person, or from another source (or from e.g. ChatGPT). Submissions will be processed to detect plagiarism. Further information relating to academic integrity may be found at: https://www.universityofgalway.ie/centre-excellence-learning-teaching/teachinglearning/academicintegrity/

Background Material

DSP Course Notes, Sections 2, 3 and 4

Examples

Before attempting the exercises below, you should refer to the examples covered in the lectures, the code for which is located on the EE445 subject page on Canvas. Also, remember that to obtain help on any Octave function or code construct, you can use the online Help menu in the Octave application itself, or the documentation in Adobe Acrobat format. Alternatively, you can simply type "help <function name>" at the Octave prompt ">>".

Exercises

1. Using the Octave `freqz` function, calculate and plot the magnitude response (in dB) of the following discrete-time system that contains a pair of complex conjugate poles:

   $$H(z) = \frac{1 + 0.5z^{-1}}{1 - 1.8\cos(\frac{\pi}{16})z^{-1} + 0.81z^{-2}}$$

   Use 1024 points evenly spaced between 0 and half the sampling frequency. For the plot, the x-axis should be in units of Hz (or kHz); you may assume a sampling rate of 16 kHz.

   Determine the locations of the poles (in polar form), and calculate the centre frequency of the filter in Hz, assuming a sampling frequency of 16 kHz.

2. Determine the transfer function, and hence calculate and plot the magnitude response and impulse response, of a second-order filter that has a complex conjugate pole pair with a pole frequency of 3.5 kHz, and pole radius of 0.95. The filter also has a double zero at $z = 0$ in the z-plane. The sampling frequency is 20 kHz. For the magnitude response, use 2048 points equally spaced between DC and half the sampling frequency. You should ensure that your plots have proper axes.

3. For each of the following difference equations, calculate and plot the magnitude response and the impulse response, and state what type of filter the difference equation represents (i.e. low-pass, band-pass, notch or band-stop etc. – this is not too "exact" so choose the categorization that most suits).

(i) $$y(n)+0.13y(n-1)+0.52y(n-2)+0.3y(n-3)=0.16x(n)-0.48x(n-1)$$
$$+0.48x(n-2)-0.16x(n-3)$$

(ii) $$y(n)=0.634x(n)-0.634x(n-2)+0.268y(n-2)$$

(iii) $$y(n)+0.268y(n-2)=0.634x(n)+0.634x(n-2)$$

(iv) $$10y(n)-5y(n-1)+y(n-2)=0.634x(n)-5x(n-1)+10x(n-2)$$