DEPARTMENT OF ELECTRONIC & ELECTRICAL ENGINEERING

Brunel University London

Pro-forma to accompany assignment/coursework 2023/2024

This pro-forma should be the first page to any set assignment/coursework. A full assignment brief should accompany this pro-forma.

Module Code: EE2624 Module Leader: Dr Mingliang Deng Assessor: Dr Mingliang Deng

Module Title: Digital Signal Processing

Assessment Title: Assignment **Weighting: 25%**

Main objectives of the assessment: To enable the students to demonstrate their understandings of the corresponding knowledge involving the digital signals and digital systems.	
Brief Description of the assessment: students are each required to work through the worksheet and complete all the questions independently.	
Learning outcomes for the assessment: • Knowledge and understanding of digital signal processing using time-domain and frequency domain analysis. • Knowledge and understanding of the mathematics of and an awareness of digital signal characterization and filtering. • The ability to design and implement digital filters.	**Assessment and marking criteria** The students will be required to answer all the questions, and the marking criteria is based on the solution sheet.
Assessment method by which a student can demonstrate learning outcomes: Written report	
Format for the assessment/coursework (Guidelines on the expected format and length of submission): The assessment should take the form of a word-processed document and to be submitted as a single .pdf document via WISEflow.	

Distribution date to students: 28th Nov. 2023	**Submission Deadline: 11th Dec. 2023**
Indicative Reading List: H.C.So, Digital Signal Processing: Foundations, Transforms and Filters, with Hands-on MATLAB Illustrations, McGraw-Hill, 2011	
Further information: Please reserve **ENOUGH time** to submit your report. **TWO HOURS** earlier submission attempt is highly recommended.	

Assignment

1 Introduction [5 marks]

1.1 Aim and Objective

Add your aims and objectives here.

1.2 Theory

Add your introductions and related theory here. Do not spend a lot of time on this section; keep it concise. It will be always necessary to introduce the theoretical background of the assignment.

2 Methods and Solutions [85 marks]

2.1 Question 1

For each of the following systems, determine whether the system is stable, causal, linear, and time invariant. [10 marks]

(a) $y[n]=x[n-n_0]$ [2 marks]

(b) $y[n]=e^{x[n]}$ [2 marks]

(c) $y[n]=ax[n]+b$ [3 marks]

(d) $y[n]=x[-n]$ [3 marks]

2.2 Question 2

Determine whether each of the following signals is periodic. If the signal is periodic, state its period. [10 marks]

(a) $x[n]=\cos(3n)$ [2 marks]

(b) $x[n]=e^{j(\frac{\pi n}{6}-\frac{\pi}{4})}$ [2 marks]

(c) $x[n]=\frac{\sin(\frac{\pi n}{5})}{\pi n}$ [3 marks]

(d) $x[n]=e^{j(\pi n/\sqrt{2})}$ [3 marks]

2.3 Question 3

For a given sequence x[n] with a length of FIVE: [10 marks]

$$x[n]=\begin{cases}1, & 0\le n\le 4\\ 0, & \text{otherwise}\end{cases}$$

(a) Calculate the DFT X[k] of x[n]. [2 marks]

(b) Give the Matlab codes for plotting both the magnitude response and phase response of X[k] and corresponding figures. (Note that the MATLAB command for DFT is *fft*) [5 marks]

(c) What are the differences between 10-point DFT of x[n] (append five zeros to x[n]) and the results obtained in (a)? [3 marks]

2.4 Question 4

Consider a 8-point sequence of x(0), x(1),..., x(7) [10 marks]

(a) List the sequence in bit-reversed order for FFT calculation. [3 marks]

(b) Draw the flow-graph for this 8-point decimation-in-time FFT algorithm utilizing the butterflies with the input in bit-reversed order, the output in normal order. [7 marks]

2.5 Question 5

For a LTI system with a transfer function H(z) of the form

$$H(z) = \frac{1 + 2z^{-1} + 3z^{-2}}{2 + 3z^{-1} + 4z^{-2}}$$

It is assumed that the ROC of H(z) includes the unit circle. [10 marks]

(a) Is it a FIR system or IIR system? Why? [2 marks]

(b) Use Matlab to plot the frequency response of this system. (Matlab codes and the figures should be provided.) [5 marks]

(c) Is it a low-pass filter? Why? [3 marks]

2.6 Question 6

For a LTI system with a transfer function of the form [15 marks]

$$H(z) = \frac{1 - 3z^{-1} + 2z^{-2}}{1 + 0.3z^{-1} - 0.1z^{-2}}$$

Draw a signal flow graph to implement this system in each of the following forms

(a) Direct form I. [2 marks]

(b) Direct form II. [3 marks]

(c) Cascade form with first order sections. [5 marks]

(d) Parallel form with second order sections. [5 marks]

2.7 Question 7

Design a causal FIR system of an ideal lowpass filter whose cut-off frequency is 0.5π.

[20 marks]

(a) The rectangular window and a filter length of seven are considered. Write down the design procedures and the detailed calculations. Show the Matlab codes for the filter implementation and use Matlab codes to plot the magnitude and phase responses of the designed filter. [6 marks]

(b) The Hanning window and a filter order of 20 are considered. Write down the design procedures and the detailed calculations. Show the Matlab codes for the filter implementation and use Matlab codes to plot the magnitude and phase responses of the designed filter. Mark both the transition width and tolerance on the filter magnitude response. [6 marks]

(c) If the maximum allowable transition width is 0.05π and the maximum allowable tolerance is 0.002, determine which window function can be used and explain why. Write down the design procedures and the detailed calculations. Show the Matlab codes for the filter implementation and use Matlab codes to plot the magnitude and phase responses of the designed filter. [8 marks]

3 Discussions and Conclusions [10 marks]

In this part of your report, you may also summarize what you have learnt by answering the following questions:

(a) What is the relationship between linear convolution and circular convolution? Express the circular convolution using the linear convolution.

(b) What is the relationship between DTFT, DFS, DFT and FFT? What are the basic ideas in derivation of the FFT algorithms?

(c) What are the differences between IIR and FIR systems? Explain the advantages and application scenarios of these two types of digital systems.

(d) What are the major factors that affect the choice of a specific realization for a digital filter?