GENERAL SIR JOHN KOTELAWALA DEFENCE UNIVERSITY

Faculty of Engineering

Department of Electrical, Electronic and Telecommunication Engineering

BSc Engineering Degree

End Semester Examination – May 2022

Semester 5 - Intake 37 (ET/MC)

ET 3142– DIGITAL SIGNAL PROCESSING

Time allowed: 3 hours

9th May 2022

ADDITIONAL MATERIAL PROVIDED

Pages from 6 to 8 contain Useful Formulae

INSTRUCTIONS TO CANDIDATES

- This paper contains **5** questions on **8** pages
- **Answer ALL the questions.**
- This is a closed book examination
- This examination accounts for 70% of the module assessment. A total maximum mark obtainable is 100. The marks assigned for each question and parts thereof are indicated in square brackets
- If you have any doubt as to the interpretation of the wordings of a question, make your own decision, but clearly state it on the script
- Assume reasonable values for any data not given in or provided with the question paper, clearly make such assumptions made in the script
- All examinations are conducted under the rules and regulations of the KDU

Question 01

[20 marks]

a) Consider the sequence $x[n]$ in Figure Q1.1 and compute the followings.

(i) Compute the DTFT $X[e^{j\omega}]$ of $x[n]$. [05]

(ii) Compute the 4-point DFT $X[k]$ of $x[n]$. Simplify your answer for different k values. [10]

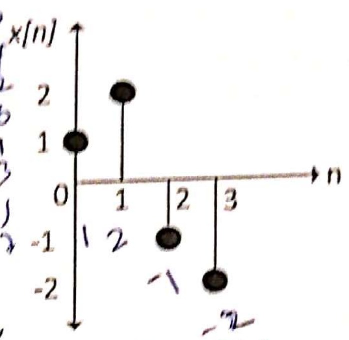


Figure Q1.1

b) The two sequences $x[n]$ and $h[n]$ are given by $x[n]=[1,3,0,1]$ and $h[n]=[1,-1,1,0]$. Without using DFT, calculate the circular convolution $x \otimes h$. [05]

Question 02

[20 marks]

The complex number $W_N = e^{-j\frac{2\pi}{N}}$ is an 8^{th} principal root of unity in the complex field.

a) Compute W_N^n for $n = 0,1,2,\ldots,7$. [04]

b) Plot the derived values in part a) in a complex domain with imaginary and real axis. [02]

c) Write the Fourier transform matrix F_8 with W_N^{kn} for $k,n = 0,1,2,\ldots,7$. [06]

d) An 8-point sequence is given by $x[n]=[1,0,1,-1,0,0,-1,1]$. Compute the 8-point DFT of $x[n]$ by DIT FFT algorithm. [08]

Question 03

[20 marks]

a) Explain Analog and Digital Filters by including two advantages and two disadvantages for each. [08]

b) Construct a digital band-pass filter for input $x[n]$ to derive output $y[n]$ using cascading and single stage methods. Use $h_1[n]$ and $h_2[n]$ as the impulse responses of low-pass and high-pass filters respectively. [04]

c) Brief explain the main functionality of the following filters. [04]

a. Recursive Filter
b. Moving average filter

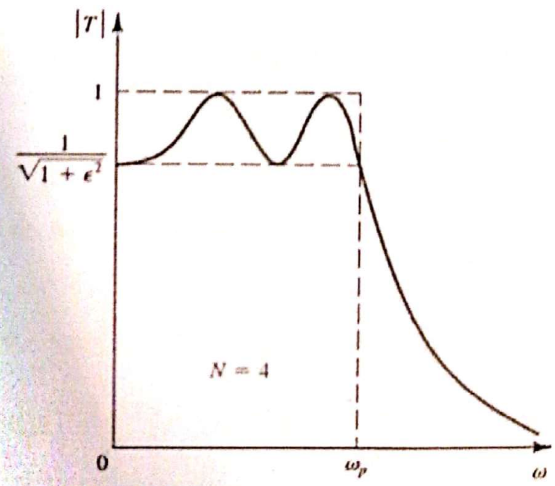
d) If you are designing a filter in order to filter the additive noise in a transferring signal, 'good performance in the time domain results in poor performance in the frequency domain, and vice versa'. Discuss this statement with two appropriate examples. [04]

Question 04

[20 marks]

a) "A Butterworth filter, is a monotonically decreasing low-pass filter. There are no ripples in the passbands". Based on this statement, mention a suitable signaling pattern that the Butterworth filter is suitable for. [01]

b) Magnitude response of an even-order Chebyshev filter is given in Figure Q4.1. State the importance of the cut off frequency and identify the importance of magnitude deviation at frequency of 0 Hz. [02]



$w_1 = 0.4\pi$
$w_2 = 0.6\pi$

Figure Q4.1

c) Design a **digital IIR low-pass filter** using the bilinear transformation with passband **edge at 1000Hz and stopband edge at 1500Hz** for a sampling frequency 5000Hz. The **filter is to have a passband ripple of 0.5dB** and a stopband ripple below 30dB. [17]

i) Give ω_1 and ω_2 in rad/s which are passband frequency and stopband frequency respectively.

ii) Specify k_1 and k_2 in dB which are gain at passband frequency ω_1 and gain at stopband frequency ω_2.

iii) Give the gain as A_1 and A_2 at the ω_1 and ω_2 respectively.

iv) Calculate the ratio of analog edge frequency.

v) Identify the order of the filter N. = 8

vi) Calculate the cutoff frequency Ω_c.

vii) Identify the analog filter transfer function $H_a(s)$.

viii) State the digital filter function $H(z)$ using the bilinear transformation.

Question 05 **[20 marks]**

Design an ideal low-pass filter with a frequency response

$$H_d\left(e^{j\omega}\right)=\begin{cases} e^{j2\omega}, -\dfrac{\pi}{4}\le\omega\le\dfrac{\pi}{4} \\ 0, \quad \dfrac{\pi}{4}\le|\omega|\le\pi \end{cases}$$

with the window fuction

$$W(n)=\begin{cases} 1, & 0\le n\le 4 \\ 0, & otherwise \end{cases}$$

-End of Question Paper-