GENERAL SIR JOHN KOTELAWALA DEFENCE UNIVERSITY
Faculty of Engineering
Department of Electrical, Electronic and Telecommunication Engineering

BSc Eng Hons Degree
Semester 5 Examination – May 2024
(Intake 39 – ET, MC)

ET 3142 – DIGITAL SIGNAL PROCESSING

Time allowed: 2 Hours | 15 May 2024

ADDITIONAL MATERIAL PROVIDED

None

INSTRUCTIONS TO CANDIDATES

This paper contains 4 questions on 4 pages

Answer ALL questions

This is a closed book examination

This examination accounts for 70% of the module assessment. 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

DETAILS OF ASSESSMENT

Learning Outcome (LO)	Questions that assess LO	Marks allocated (Total 70)
LO1	Q1	05
LO2	Q2	26
LO3	Q3	26
LO4	Q4	13

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Question 1

(a) Inverse of the discrete time Fourier transform is given by

$$x[n] = \frac{1}{2\pi}\int_{-\pi}^{\pi} X(\omega)e^{j\omega n}\,d\omega$$

Discuss how the integral on the right-side results in obtaining the sequence $x[n]$. [03]

(b) Discuss the reason as to why the sequence $x[n] = 2^n u[n]$ does not possess a discrete time Fourier transform. [02]

Question 2

Square of the Butterworth frequency response is given by

$$|H(j\Omega)|^2 = \frac{1}{1+\left(\frac{\Omega}{\Omega_c}\right)^{2N}}$$

An IIR filter is to be designed with a 3 dB cutoff frequency of 1.5 kHz and an attenuation of 40 dB at 3 kHz.

(a) Determine the square of Butterworth frequency response for this filter. [04]

(b) Compute the order of the filter. [06]

(c) Determine the general expression for the pole angles. [04]

(d) Plot the poles on the complex plane. [04]

(e) Hence give the design i.e. the system function, of this of the Butterworth filter. [04]

(f) Give the digital design of this Butterworth filter. [04]

Question 3

(a) Determine the time domain representation of the frequency response of an ideal low pass filter. [04]

(b) A linear phase FIR filter of order $N = 24$ is to be designed to approximate the ideal frequency response magnitude

$$|H_d(e^{j\omega})| = \begin{cases} 1; & |\omega| \le 0.2\pi \\ 0 & ; 0.2\pi < |\omega| \le \pi \end{cases}$$

(i) Express the frequency response of this filter using its impulse response. [04]

(ii) Compute the required delay to design the filter. [02]

(iii) Determine the ideal unit sample response of the filter. [04]

The following details are given for two (02) common window types.

Rectangular window: transition width $\Delta f = \frac{0.9}{N}$, stopband attenuation $-21\ dB$

Hamming window: transition width $\Delta f = \frac{3.3}{N}$, stopband attenuation $-53\ dB$

(iv) Give the expression for the filter when a rectangular window is used. [04]

(v) Give the expression for the filter when a Hamming window is used, given that the window function is

$$w[n] = 0.54 - 0.46\cos\left(\frac{2\pi n}{N}\right) \quad 0 \le n \le N$$

[04]

(vi) Compare the two (02) filters according to the details given. [02]

(vii) Discuss the effect of using a Kaiser window for this design. [02]

Question 4

Consider the filter depicted by the impulse response

$$h[n] = \begin{cases} \dfrac{\sin\left(\frac{n\pi}{2}\right)}{n\pi} & ; n \neq 0 \\ 0.5 & ; n = 0 \end{cases}$$

(a) Is this filter causal or at least can be made causal? [04]

(b) Is it stable? [04]

(c) Analyze the realizability of this filter by commenting on its rationality. [05]

End of question paper