GENERAL SIR JOHN KOTELAWALA DEFENCE UNIVERSITY

Faculty of Engineering

Department of Electrical, Electronic and Telecommunication Engineering

BSc Engineering Degree

5 ~~4~~th Semester Examination – May/June 2019

Intake ~~33~~ 34 (ET/MC)

Digital Signal Processing

(ET 3132)

Time allowed: 2 hours.

ADDITIONAL MATERIAL PROVIDED

Nil

INSTRUCTIONS TO CANDIDATES

This paper contains **4** questions on 5 pages.

Answer any **FOUR** questions.

THIS IS AN CLOSED BOOK EXAMINATION

This examination accounts for 80% 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 1

a Briefly describe the following terms. **(20 marks)**

i Discrete-time signal (2 marks)

ii Unit step function (2 marks)

iii Odd symmetric signal (2 marks)

iv Conjugate symmetric signal (2 marks)

v Scaling of the independent variable of a signal (2 marks)

b Write down what is known as signal decomposition. (3 marks)

c Briefly explain the two main properties of a linear shift-invariant (LSI) system. (4 marks)

d State three (3) methods of performing convolutions in a LSI system. (3 marks)

graphical, direct, euler

$h(n)e^{-j\omega n}$

Question 2 **(30 marks)**

a Clearly explain what is defined as the frequency response of a linear shift-invariant (LSI) system by deriving an equation for the frequency response of a LSI system. (4 marks)

b Consider the linear shift-invariant system with unit sample response $\boldsymbol{h(n) = \alpha^n u(n)}$ where $\boldsymbol{\alpha}$ is a real number with $\boldsymbol{|\alpha| < 1}$.

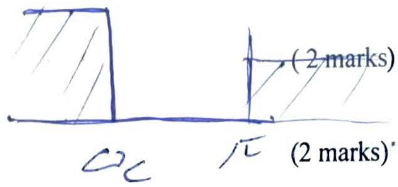
i What is the frequency response of the system? (4 marks)

ii What is the magnitude of the frequency response? (4 marks) iii What is the phase of the frequency response? (4 marks)

iv What is the group delay of the frequency response? (4 marks)

c Find the frequency response of the system $H(e^{j\omega}) = \begin{cases} 2 & |\omega| \le \omega_c \\ 0 & \omega_c \le |\omega| \le \pi \end{cases}$ (4 marks)

d Briefly explain the following terms.



i Linear phase filter (2 marks)

ii Frequency selective filter (2 marks)

iii Interconnection of systems (2 marks)

Question 3 **(26 marks)**

a Define what is known as the discrete-time Fourier transform (DTFT) of a linear shift-invariant system. (4 marks)

b Find the DTFT of the signal $x(n) = -\alpha^n u(-n-1)$ where $|\alpha| > 1$. (4 marks)

c Provide a brief description on the following properties of DTFT.

i Periodicity (2 marks)

ii Modulation (2 marks)

iii Convolution (2 marks)

iv Parseval's Theorem (2 marks)

d Write down three (2) ~~(3)~~ applications of DTFT. (2 marks) e i Draw a block diagram of the functionality of an analog to digital (A/D) converter. (6 marks)

ii Briefly explain the functionality of a zero-order hold in a digital to analog (D/A) converter. (2 marks)

Question 4 **(24 marks)**

a Define what is known as the z-transformation of a discrete-time signal. (4 marks)

b Write down one advantage of z-transformation over discrete-time Fourier transform (DTFT). (2 marks)

c i Find the z-transformation of the sequence $x(n) = \alpha^n u(n)$. (4 marks)

ii What is the requirement for the DTFT to exist for the sequence given in Question 4. c. i. (2 marks)

d Draw the signal flow graph for the system described using the constant coefficient difference equation $H(z) = \frac{b(0)+b(1)z^{-1}}{1+a(1)z^{-1}}$ (4 marks)

e Consider a FIR linear phase low-pass filter design where a Hanning windows is used. The side-lobe amplitude of a Hanning window is -31dB, the transition width is 3.1/N and the stopband attenuation is -44 dB. The impulse response the filter using Hanning window is given as $h_d(n) = \frac{\sin(n-\alpha)\omega_c}{\pi(n-\alpha)}$, where α is the delay and ω_c is the cut-off frequency. The filter specifications are,

$$0.99 \leq |H(e^{j\omega})| < 1.01 \quad 0 \leq |\omega| \leq 0.18\pi$$
$$|H(e^{j\omega})| \leq 0.01 \quad 0.2\pi \leq |\omega| \leq \pi$$

y(n) =

i Calculate the stop-band attenuation. (2 marks) ii Calculate the transition width. (2 marks)

iii Find the impulse response of the filter. (4 marks)

---- END OF QUESTION PAPER ----

$$X(z) = \sum_{n=-\infty}^{\infty} x(n)\, z^{-n}$$

$$= \sum_{n=-\infty}^{\infty} \alpha^{n} u(n)\, z^{-n}$$

$$= \sum_{n=0}^{\infty} (\alpha z^{-1})^{n}$$

$$= \frac{1}{1-\alpha z^{-1}}$$