FIJI NATIONAL UNIVERSITY

COLLEGE OF ENGINEERING, SCIENCE AND TECHNOLOGY

School of Electrical & Electronics Engineering

Bachelor of Engineering (Honours) (Electrical & Electronics Engineering)

EEB831 – Digital Signal Processing

FINAL EXAMINATION

Semester 1, 2019

Date: As per Exam Time Table

Time: As per Exam Time Table (3 hours)

Venue: As per Exam Timetable

Instructions to Students

1. You are allowed an extra ten (10) minutes of reading time during which you are NOT allowed to write.
2. Attempt ALL questions in this examination booklet
3. Write your answers in the answer booklet provided.
4. Write your Student ID number on each page used.
5. Begin each Section on a fresh page and use both sides of the answer sheet.
6. You may use calculators provided they are non-programmable.
7. Clearly number the questions in your answer paper in their correct sequence and write legibly. Show all working.
8. Attach any extra sheets used to your answer booklet securely with the string provided.

****

Question 1 **[25 marks]**

a) With the help of block diagram, explain the processes involved in acquiring an analog signal and converting it to a digital signal. [8 marks]

b) A digital communication link carries binary-coded words representing samples of an input signal $x_a(t) = 3\sin 300\pi t + 5\cos 950\pi t$. The link is operated at 6, 000 bits/s and each input sample is quantized into 4096 different voltage levels.

(i) Determine the sampling frequency. [2 marks]

(ii) What is the highest frequency that can be represented uniquely at this sampling rate? [1 mark]

(iii) Determine the resulting discrete-time signal and the resulting frequencies? [3 marks]

c) Given the signal $x(n) = \begin{cases} (-2)^n - 1, & -2 \le n < 2 \\ 0, & otherwise \end{cases}$

(i) Represent $x(n)$ using sequence representation. [2 marks]

(ii) Determine $y(n) = \sum_{k=-2}^{+\infty} x(n+2k)$ [5 marks]

(iii) Determine the autocorrelation sequence $r_{xx}(l)$. [4 marks]

Question 2 **[25 marks]**

a) Compute the signal energy and power for the discrete-time signal $x(n) = \left(\frac{1}{3}\right)^{2n} u(n)$. [5 marks]

b) Determine the spectra of the signal $x(n) = \{0, \underset{\uparrow}{1}, 0, 1\}$ given $x(n)$ is periodic with period N = 4. [10 marks]

c) A linear time-invariant system is characterized by the system function $H(z) = \frac{2.4}{1-0.83z^{-1}} + \frac{1.2}{1-0.97z^{-1}} - \frac{1.5}{0.72+z^{-1}}$. Specify the ROC of $H(z)$ and determine $h(n)$ so that the system is stable. Is the resulting system causal, anti-causal or non-causal? [4 marks]

Please Turn Over

d) Determine the impulse response of the system $y(n) = y(n-1) + 2.15y(n) - 3.89x(n)$ when the initial condition is y(-1) = 2. [6 marks]

Question 3 **[25 marks]**

a) Determine the transient and steady state response of the FIR filter $y(n) = 0.75y(n-1) + 0.5x(n)$ when the input signal is $x(n) = \sin(3\pi n/4)\,u(n)$. [13 marks]

b) Design a two-pole bandpass filter that has the center of its passband at $w = \pi/2$, zero in its frequency response characteristic at $w = 0$ and $w = \pi$, and a magnitude response of $\frac{1}{\sqrt{3}}$ at $w = 2\pi/5$. [12 marks]

Question 4 **[25 marks]**

a) Using the Kaiser window, design a highpass digital filter with the following specifications:
f_s = 20 kHz, f_{pass} = 5 kHz, f_{stop} = 4 kHz, A_{pass} = 0.15 dB, A_{stop} = 46 dB. [10 marks]

b) Design a lowpass digital filter operating at a rate of 10 kHz having an attenuation of $G_c^2 = 0.8$ at 1.5 kHz. (Hint: Use bilinear transformation) [10 marks]

c) Draw the canonical form realization of the filter $H(z) = \dfrac{-1.4 - 2.2z^{-1} + 3.1z^{-4}}{1 + 0.3z^{-1} + 0.5z^{-2} - 0.7z^{-4}}$. [5 marks]

Please find attached the z-transform table and some relevant equations on the next page.

Please Turn Over

Given below is the z-transform table.

Signal, $x(n)$	z-Transform, $X(z)$	ROC
$\delta(n)$	1	All z
$u(n)$	$\frac{1}{1-z^{-1}}$	$\lvert z \rvert > 1$
$-a^n u(-n-1)$	$\frac{1}{1-az^{-1}}$	$\lvert z \rvert < \lvert a \rvert$
$(\cos w_0 n)\, u(n)$	$\frac{1-z^{-1}\cos w_0}{1-2z^{-1}\cos w_0 + z^{-2}}$	$\lvert z \rvert > 1$
$(\sin w_0 n)\, u(n)$	$\frac{z^{-1}\sin w_0}{1-2z^{-1}\cos w_0 + z^{-2}}$	$\lvert z \rvert > 1$

Equations:

$$Z^{+}\{x(n-k)\} = z^{-k}\left[X^{+}(z) + \sum_{n=1}^{k} x(-n) z^{n}\right]$$

Analog lowpass filter: $H_a(s) = \dfrac{\alpha}{s+\alpha}$

highpass filter: $d(k) = \delta(k) - \dfrac{\sin(w_c k)}{\pi k}$

Kaiser Window: $w(n) = \dfrac{I_0(\alpha\sqrt{n(2M-n)}/M)}{I_0(\alpha)}$

$$\text{Shape parameter } \alpha = \begin{cases} 0.1102(A-8.7), & \text{if } A \ge 50 \\ 0.5842(A-21)^{0.4} + 0.07886(A-21), & \text{if } 21 < A < 50 \\ 0, & \text{if } A \le 21 \end{cases}$$

$$\text{Factor } D = \begin{cases} \dfrac{A-7.95}{14.36}, & \text{if } A > 21 \\ 0.922, & \text{if } A \le 21 \end{cases}$$

THE END

ALL THE BEST FOR THE EXAMINATION