ELIZADE UNIVERSITY

ELIZADE UNIVERSITY, ILARA-MOKIN, ONDO STATE

FACULTY OF ENGINEERING

DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING

FIRST SEMESTER EXAMINATION, 2020/2021 ACADEMIC SESSION

COURSE TITLE: Digital Signal Processing

COURSE CODE: EEE 519

EXAMINATION DATE: March 2, 2021

COURSE LECTURER: Prof Dr. M.J.E. Salami

HOD's SIGNATURE

TIME ALLOWED: 3 Hours

INSTRUCTIONS:

1. ANSWER **ANY FIVE QUESTIONS**
2. SEVERE PENALTIES APPLY FOR MISCONDUCT, CHEATING, POSSESSION OF UNAUTHORIZED MATERIALS DURING EXAM.
3. YOU ARE **NOT** ALLOWED TO BORROW CALCULATORS AND ANY OTHER WRITING MATERIALS DURING THE EXAMINATI

QUESTION 1 [12 Marks]

a) Use appropriate expressions/diagrams to explain the difference between
   (i) Nyquist frequency and folding frequency (2 marks)
   (ii) Uniform quantization and non-uniform quantization (2 marks)

b) A digital communication link carries binary-coded words representing samples of an input signal

$$x(t) = 5\cos(2{,}000\,\pi t) + 2\cos(6{,}000\,\pi t) + 4\sin(10{,}000\,\pi t)$$

which is sampled at a rate of 8 kHz. Each input sample is quantized into L different voltage levels to achieve a minimum signal-to-quantization noise ratio (SQNR) of 45 dB.

   i. Obtain an expression for the resulting discrete-time signal, $x(n)$ and determine the resulting analog signal after the sampled signal is reconstructed. (2 marks)
   ii. Determine L and **bit rate** at which the link operates, if *uniform* quantization is used. (3 marks)
   iii. Determine L and **bit rate** at which the link operates, if *non-uniform* quantization is used. (3 marks)

QUESTION 2 [12 Marks]

a) An analog signal is quantized and transmitted by using a pulse code modulation (PCM) system. Suppose each sample at the receiving end of the system must be known to within ±0.5 percent of the peak-to-peak full-scale value. Determine the number of binary digits which sample must contain. (4 marks)

b) The TI carrier system used in digital telephony multiplexes 24 voice channels based on 8-bit PCM. Each voice signal is usually put through a low-pass filter with the cut-off frequency of about 3.4 kHz. The filtered voice signal is sampled at 8 kHz. In addition, a single bit is added at the end of the frame for the purpose of synchronization. Determine the
   (i) Duration of each bit and resultant transmission rate (bits//s). (6 marks)
   (ii) Minimum required transmission bandwidth. (2 marks)

QUESTION 3 [12 Marks]

a) Consider the DT signals

$$x(n) = (0.5)^n u(n), \quad y(n) = \left(\frac{1}{3}\right)^n u(\mathrm{n}).$$

Determine
   i) $z(n) = x(n) * y(n)$. (2 marks)
   ii) $R_{xy}(l)$. (2 marks)

b) The input $x(n)$ and output $y(n)$ of a LTI system satisfies the difference equation

$$2\,y(n) - \frac{1}{2}\,y(n-1) - y(n-3) + \frac{1}{3}y(n-4) = x(n) + 2\,x(n-4) - 3\,x(n-6).$$

<u>**Draw the form II realization for the system**</u>. (2 marks)

c) Consider the DT system shown in Fig.Q3c, where $x(n)$ and $y(n)$ represent respectively the input signal and system response.
   i) Determine the difference equation that describes the system. (2 marks)
   ii) Use time-domain technique to compute $y(n), n \geq 0$ if $y(-1) = 0, y(-2) = 2$, and $x(n) = (0.25)^n \mathrm{u}(\mathrm{n})$. (4 marks)

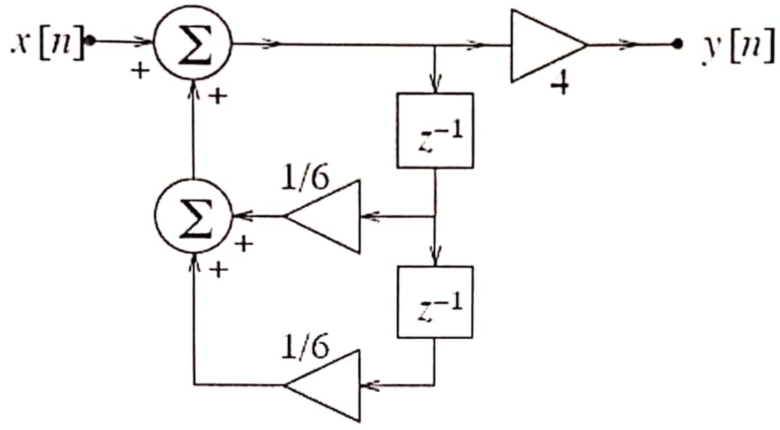

Fig. Q3c

QUESTION 4 [12 Marks]

a) Use appropriate expression to justify the use of the same algorithm for the computation of convolution and correlation sequences. (2 marks)

b) Suppose two discrete-time signals $x(n)$ *and* $y(n)$ are linearly combined to produce another discrete-time signal $g(n)$ so that

$$g(n) = x(n) + ay(n - l)$$

Show that

$|R_{xy}(l)| \leq \sqrt{R_{xx}(0)R_{yy}(0)}$. (2 marks)

c) Suppose an unknown sinusoidal signal $x(n)$, is buried in an independently generated noise (often termed white Gaussian noise), $w(n)$ so that

$$y(n) = x(n) + W(n),$$

where

$$x(n) = 2A\cos\left(\frac{\pi n}{10}\right),$$

and that $w(n)$ is independently selected from sample to sample, and unrelated to the sinusoidal signal and it has a variance of σ_w^2.

i) Obtain $R_{xx}(l)$ in terms of A. (2 marks)

ii) Obtain an expression for $R_{yy}(l)$ in terms of $R_{xx}(l)$ *and* σ_w^2. (2 marks)

Use **Fig. Q4c** to determine the parameters of the

iii) Unknown sinusoid, that is its period, N, and amplitude, A. (2 marks)

iv) Noise variance, σ_w^2. (2 marks)

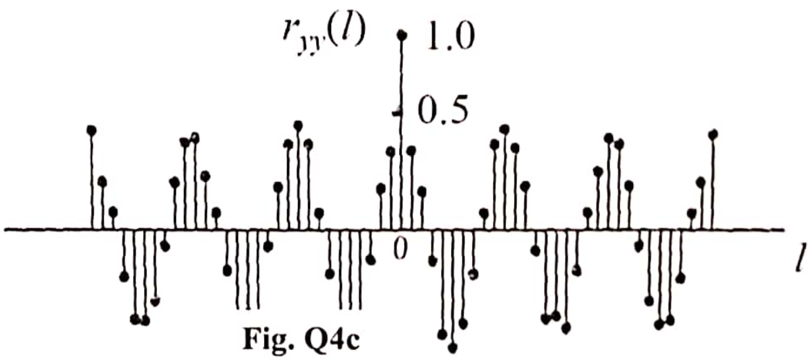

Fig. Q4c

QUESTION 5 [12 Marks]

a) Consider the following DT signals:

1) $x_1(n) = \left(\frac{1}{2}\right)^n \delta(n+2) + u(n+1) - u(n-4).$

2) $x_2(n) = \left(\frac{1}{3}\right)^n u(n) + \left(\frac{1}{2}\right)^n u(-n-1).$

i) Determine the two-sided z-transform, $X_1(z)$ *and* $X_2(z)$. Using illustrated diagrams, state the ROC of $X_1(z)$ *and* $X_2(z)$. (5 marks)

ii) Determine the one-sided z-transform, $X_1(z)$ *and* $X_2(z)$. Using illustrated diagrams, state the ROC of $X_1(z)$ *and* $X_2(z)$. (4 marks)

b) Use the appropriate properties of the z-transform to compute $x(n)$ if

$X(z) = \ln\{1 - 2z\},\ |z| < \frac{1}{2}.$ (3 marks)

QUESTION 6 [10 Marks]

a) Suppose the z-transform of a signal is given as

$$X(z) = \frac{1}{1 - 3.5z^{-1} + 1.5z^{-2}}$$

Determine $x(n)$ if region of convergence (ROC) is such that

i) $ROC: |z| > 3.$ (2 marks)

ii) $ROC: |z| < 0.5.$ (2 marks)

iii) $ROC: 0.5 < |z| < 3.$ (2 marks)

b) Design a digital resonator to meet the following specification

$F_0 = 200\ Hz, \Delta F = 6\ Hz$

The system sampling frequency is $1.2\ kHz$. (4 marks)

c) A digital notch filter is required to remove an undesirable 50 Hz hum associated with a power supply in an ECG recording application. The sampling frequency used is $F_S = 500\ samples/s$. Design a second-order FIR notch filter to satisfy this purpose. Choose the gain b_0 so that $|H(\omega)| = 1\ for\ \omega = 0$. (2 marks)

QUESTION 7 [12 Marks]

a) Use appropriate expressions to explain the similarity, differences and applications for the following:

i) Discrete-time Fourier series analysis and discrete-time Fourier transform. (2 marks)

ii) Discrete-time Fourier transform and discrete Fourier transform. (2 marks)

b) Suppose the DT signal

$$x(n) = 2 + 3\cos\left(\frac{\pi n}{2}\right) + 5\sin\left(\frac{\pi n}{3} - \frac{\pi}{4}\right) + 4exp\left\{j\frac{\pi n}{4}\right\};\ -\infty < n < \infty,$$

is used as an input to the digital filter shown in **Fig.Q7b,** where $\omega_0 = \frac{\pi}{3}$.

i) Determine the discrete-time Fourier series (DTFS) coefficients of $x(n)$. (3 marks)

ii) Verify the validity of Parseval's theorem for $x(n)$. (2 marks)

iii)) Compute the filter response, $y(n)$. (3 marks)

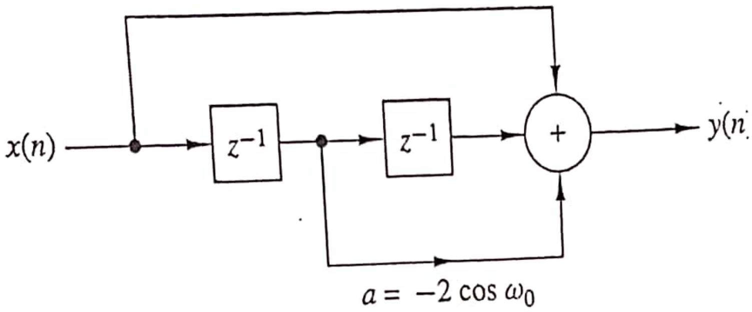

Fig. Q7b