Question Paper

Exam Date & Time: 26-Nov-2022 (02:00 PM - 05:00 PM)

MANIPAL ACADEMY OF HIGHER EDUCATION

Vth SEMESTER B.TECH END SEMESTER EXAMINATIONS, NOV 2022, MANIPAL INSTITUTE OF TECHNOLOGY

DIGITAL SIGNAL PROCESSING [BME 3153]

Marks: 50 **Duration: 180 mins.**

A

Answer all the questions.

Instructions to Candidates: Answer ALL questions Missing data may be suitably assumed

1) Determine which of the following linear systems is time invariant. (3)

A)
i. $y(n) = -5x(n-10)$

i. $y(n) = 4x(n^2)$

ii. $y(n) = 2x(3n)$

B) Sketch and express the sequence $x(n) = \begin{cases} (-1)^n; & -2 \le n \le 2 \\ 0; & else \end{cases}$ as a sum of scaled and shifted unit steps (3)

C) The first nonzero value of a finite-length sequence x(n) occurs at index n = -6 and has a value x(-6) = 3, and the last nonzero value occurs at index n = 24 and has a value x(24) = -4. What is the index of the first nonzero value in the convolution (4)

$$y(n) = x(n) * x(n)$$

and what is its value? Also determine the last nonzero value

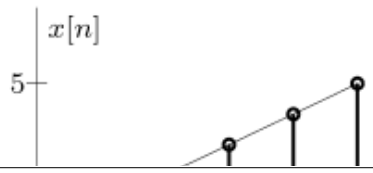
2) Consider the sequence $x(n) = \delta(n) + 2\delta(n-5)$ (4)

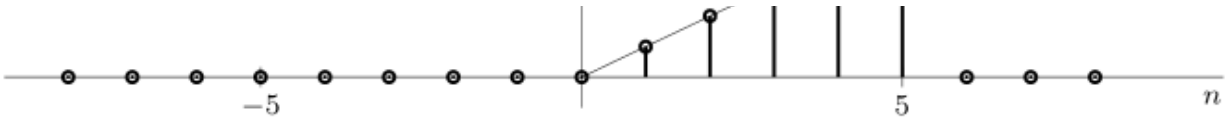
A)
i. Find the 10-point Discrete Fourier Transform of $x(n)$ using properties

ii. Find the sequence that has a DFT $Y(k) = e^{j2k\frac{2\pi}{10}}X(k)$ where $X(k)$ is the 10-point DFT of $x(n)$.

B) A system has an impulse response $h(n) = \{1,2,3\}$ and output response $y(n) = \{1,1,2,-1,3\}$. Determine the input sequence $x(n)$ using Z-transform (3)

C) Form an expression for the signal given and calculate the Z-transform using properties (3)





3) Consider the length-6 sequence defined for $0 \le n < 6$. $x(n) = \{1, -2, 3, 0, -1, 1\}$ with an 8-point DFT $X(k)$ (4)
. Evaluate the following functions of $X(k)$ without computing DFT:

A)

i. $X(0)$

i. $X(3)$

ii. $\sum_{k=0}^{5} X(k)$

iii. $\sum_{k=0}^{5} |X(k)|^2$

B) Compute and sketch the magnitude and angle of the DFT of the length-3 signal (4)
$x[n] = 3\delta[n] + 2\delta[n-1] + 3\delta[n-2]$

C) Determine the z-transform of the following sequence: $y(n) = 0.5^{n-5}.u(n-5)$ (2)

4) The FIR systems are given by (4)

A)

a. $H(z) = 1 + 1.61z^{-1} + 1.74z^{-2} + 1.61z^{-3} + z^{-4}$. Determine and draw the transposed of Direct form II structure

b. $H(z) = (1 - 3z^{-1} + z^{-2})^5$ Determine and draw the Cascade form structure.

B) An LTI system is described by the difference equation $y[n] = bx[n] - 0.81y[n-2]$. (3)

i. Determine the frequency response of the system in terms of b.

ii. Determine b so that $|H(e^{j\omega})|_{max} = 1$. Roughly plot the resulting magnitude response.

C) Determine the inverse Z-transform of (3)

a. $X(z) = z^2(1 - 13z^{-1})(1 - z^{-1})(1 + 2z^{-2})$

b. $X(z) = \frac{1 - z^{-1}}{1 - \frac{1}{4}z^{-1}}$

5) A digital low-pass filter is required to meet the following specifications. (3)

A) Passband attenuation $\le$ 1 dB

Passband edge = 4 kHz

Stopband attenuation $\ge$ 40 dB

Stopband edge = 8 kHz

Sampling rate = 24 kHz. Design the poles and cut-off frequency of Butterworth filter.

B) A Prototype low-pass filter has the system function $H_p(s) = \frac{1}{s^2 + 3s + 2}$. Obtain a band pass filter with (2)

$\Omega_0 = 3\,rad/s$ and $Q = 12$

C) A researcher uses a combination of the following 2 digital filters in cascade (series): (5)

Filter 1: The output is the first derivative or difference of the input.

Filter 2: The output is the average of the current input sample and the preceding

input sample.

i.

a. Give the input-output relationship in the time domain (difference equation) for each filter.

b. Derive the transfer function H(z) for each filter.

c. Derive the impulse response of the complete system.

d. Derive the transfer function H(z) of the complete system.

e. Does it matter which filter is placed first? Explain.

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