2024

INFORMATION TECHNOLOGY

Paper : IT-502

(Digital Signal Processing)

Full Marks : 70

The figures in the margin indicate full marks.

*Candidates are required to give their answers in their own words
as far as practicable.*

Answer *any seven* questions.

1. Given the discrete-time sequence $x[n] = 2^n.u[n]$ (where $u[n]u[n]$ is the unit step function), apply the following operations and find the resulting sequences : 10

   (a) Time shift : $x[n-3]$

   (b) Time scale : $x[2n]$

   (c) Time shift and scale : $x[3n-2]$.

2. (a) Explain the convolution of the sum for two discrete sequences with proper mathematical equation(s).

   (b) Find the convolution of the following two discrete-time sequences using the convolution sum :

   - $x[n] = \{1, 2, 3\}$ for $n = 0, 1, 2$
   - $h[n] = \{2, 1, 0\}$ for $n = 0, 1, 2$ 5+5

3. (a) Define the forward DFT and IDFT as applied to discrete-time sequences.

   (b) Compute the Discrete Fourier Transform (DFT) of the following sequence :

   - $x[n] = \{1, 2, 3, 4\}$ for $n = 0, 1, 2, 3$ $n = 0, 1, 2, 3$

   Show all steps, including the DFT formula application, and compute both the magnitude and phase of the DFT coefficients.   5+5

4. (a) Define Z-transform for a discrete time sequence $x[n]$. Explain the role of Z-transform in analyzing systems.

   (b) Find the Z-transform of the following discrete-time sequence :

   - $x[n] = (0.5)^n.u[n]$

   Also, determine the Region of Convergence (ROC) of the Z-transform.   4+6

Please Turn Over

5. (a) What do you mean by a Digital FIR filter?

(b) Design a Linear Phase FIR filter with the following specifications :

- Sampling frequency : fs = 1000 Hz
- Cut-off frequency : fc = 200 Hz
- Filter type : Low-pass filter
- Desired impulse response length : N = 5.

3+7

6. (a) Explain the key characteristics of an IIR Filter.

(b) Design a second-order IIR filter to approximate a Butterworth filter with the following specifications :

- Sampling frequency : fs = 2000 Hz
- Cut-off frequency : fc = 300 Hz
- Filter type : Low-pass filter

Specify the transfer function of the filter.

3+7

7. (a) Explain the properties of Linear Time-Invariant systems.

(b) Given the LTI system with impulse response h[n] = {1, 2, 3, 2, 1}, determine the output of the system for the input x[n] = {1, 2, 3}.

4+6

8. (a) Explain the concept of Bounded Input Bounded Output (BIBO) stability for discrete-time systems.

(b) Given the system described by y[n] = x[n] + 0.5x[n – 1], determine if the system is BIBO stable.

5+5

9. Given the sequences x[n] = {1, 2, 3} and h[n] = {4, 5}, compute the convolution of x[n] and h[n] using the DFT method.

Show the steps involved in the computation using the DFT and inverse DFT.

10

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