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Subject : Foundation of Signal Processing Class : TE Computer / IT SEM-VI

Assignment-1 Topic : Discrete Time Signal Date : 7-2-2023

NOTE : [1] All questions are Compulsory.

[2] Do not write answers for FAQs in your assignment. But you should be in a position to answer FAQs at the time of correction.

[3] Deadline for submission of corrected assignment is 28th February 2023.

[4] After deadline you will have to attempt all questions.

Module-1 : Discrete-Time Signal

1.1 Introduction: Signals, Systems, and Signal, Continuous Time signal, Discrete - Time signal and representation, Digital signal, The Sampling theorem, Some elementary discrete time signals, Classification of Discrete - Time Signals, Modifications of Discrete - Time Signals.

1.2 Operations on Discrete - Time Signals: Linear Convolution, Circular Convolution, Matrix Representation of Circular Convolution, Linear Convolution using Circular Convolution, Auto and Cross Correlation.

1.3 Discrete - Time systems: Static and dynamic, time variant and time invariant, linear and nonlinear, causal and non causal. Representation of system using impulse response, Finite Impulse Response (FIR) and Infinite Impulse Response (IIR) system, Response of the FIR system using convolution.

1.1 Introduction of Signals: [Solve at least 1 question on Sampling]

Q.(1) Consider the signal, $x(t) = 3 \cos(50\pi t) + 10 \sin(300\pi t) - \cos(100\pi t)$

- (a) If the signal is sampled with $F_s=200\text{Hz}$, What will be the DT signal obtained after sampling?
- (b) If ideal interpolation is used, what will be the reconstructed analog signal?

Q.(2) Let $x(t) = \sin(480\pi t) + 3 \sin(720\pi t)$ is sampled with $F_s = 600\text{ Hz}$.

- (a) Determine the Nyquist rate(i.e. Minimum Sampling Frequency) and folding Frequency.
 - (b) What are the Frequencies in radians in the resulting DT signal $x[n]$?
 - (c) If $x[n]$ is passed through an ideal LPF what is the reconstructed signal.?
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- **Classification of Discrete - Time Signals** [Solve all questions]

Q.(3) Determine whether the following DT signals are periodic or not. If periodic, find the period.

- | | |
|--|---|
| (a) $x[n] = \cos(0.3 \pi n) u[n]$ | (b) $x[n] = \cos(0.3 \pi n + 0.5 \pi) u[n]$ |
| (c) $x[n] = \cos(0.3 \pi n) + \cos(0.5 \pi n)$ | (d) $x[n] = \cos(0.3 \pi n) u[n]$ |

Q.(4) Determine whether the following DT signals are Energy signal, Power Signal or Neither Energy Nor Power Signal.

- | | |
|--|-----------------------------------|
| (a) $x[n] = (0.5)^n u[n] + (2)^n u[n-1]$ | (b) $x[n] = \cos(0.5 \pi n) u[n]$ |
|--|-----------------------------------|

Q.(5) Determine whether the following DT signals are Even, Odd or Neither Even Nor Odd Signal.

- | | |
|---|-----------------------------------|
| (a) $x[n] = (0.5)^n u[n] + \delta[n] + (2)^n u[-n-1]$ | (b) $x[n] = \cos(0.3 \pi n) u[n]$ |
|---|-----------------------------------|

- **Representations of DT Signals and Operations of DT Signals** [Solve all questions]

Q.(6) Sketch the following Discrete Time Signals :-

- | | |
|---|--|
| (a) $x[n] = 2 u[n-3] - 3 \delta[n+2]$ | (d) $x[n] = \delta[n] + 2 \delta[n-1] + 3 \delta[n-3]$ |
| (b) $x[n] = u[n] - u[n-5]$ | |
| (c) $x[n] = u[n] + u[n-5] - u[n-8] - u[n-10]$ | (e) $x[n] = \cos(0.3 \pi n) u[n]$ |

Q.(7) A discrete time signal is defined as,

$$x[n] = \begin{cases} 1 + n/3 & \text{for } -3 \leq n \leq 1 \\ 1 & \text{for } 2 \leq n \leq 3 \\ 0 & \text{Otherwise} \end{cases}$$

Plot the signal and calculate its even and odd part.

1.2 Operations on Discrete Time Signals :

- **Discrete Convolution** : [Solve at least 1 Question on LC and 1 Question on CC]

Q(3) Let $x(n) = \delta(n) + 2 \delta(n-1) + 3 \delta(n-2) + 4 \delta(n-3)$

$$h(n) = 5 \delta(n+1) + 6 \delta(n-1).$$

Find Convolution and Plot the output signal.

Q(4) Given $x(n) = u[n] + u(n-1) - u(n-3)$

$$h(n) = u(n-1) + u(n-2) - u(n-4) - u(n-5)$$

Find Linear Convolution of the given two sequences.

Q.(8) Determine the circular convolution of the following signals

$$x[n] = \{1, 4, 6, 3\} \text{ and } h[n] = \{7, 5, 8, 9\}.$$

Q.(9) Determine Linear convolution by Circular Convolution of the following signals,

$$x(n) = u[n] + u(n-1) - u(n-3) \quad \text{and}$$

$$h(n) = u(n-1) + u(n-2) - u(n-4) - u(n-5)$$

• **Discrete Correlation:** [Solve at least 1 Question on Correlation]

Q(3) Let $x(n) = \delta(n) + 2\delta(n-1) + 3\delta(n-2) + 4\delta(n-3)$

$$h(n) = 5\delta(n+1) + 6\delta(n-1).$$

Find Correlation and Plot the signal.

Q(4) Given $x(n) = u[n] + u(n-1) - u(n-3)$

$$h(n) = u(n-1) + u(n-2) - u(n-4) - u(n-5)$$

Find Correlation of the given two sequences.

Q.(10) Determine the Cross Correlation of the following signals

$$x[n] = \{1, 4, 6, 3\} \text{ and } h[n] = \{7, 5, 8, 9\}.$$

1.3 Discrete Time System [Solve at least 1 question]

Q.(11) Determine if the following systems are Linear/Non Linear and Time Variant/Time Invariant.

(a) $y[n] - 2y[n-1] = 4x[n]$

(b) $y[n] - 2ny[n-1] = 4x[n]$

(c) $y[n] + 2y^2[n] = 2x[n] - x[n-1]$

(d) $x[n] = x[2n] + 10$

Q.(12) Check for the following system is: i) Static or Dynamic, ii) Causal or Non-Causal,

iii) Linear or Non-Linear, iv) Time Variant or Time Invariant, v) Stable or Unstable

a) $y(n) = 2x[n-1] + x[2n]$ b) $y(n) = [x(n)]^2 + x[n]$

• **Additional Practice Problems:**

[1] Analog and Digital Signal Processing by Ashok Ambardar, Thomson Learning Second Edition

Q 3.1, 3.2 and 3.3 Page 59 :

Q 5.2 Page 121 :

[2] Digital Signal Processing by John G. Proakis, Pearson Education

Q 2.2 Page 129

Q 2.4 Page 130

Q 2.7 Page

Frequently Asked Questions

- (1) What is DSP?
 - (2) What do you mean by real time signal? Give example.
 - (3) How Discrete Time signal is obtained?
 - (4) What do you know about Analog Signal, Digital Signal, CT signal, DT Signal?
 - (5) What is antialiasing filter? Can it be Digital filter? justify.
 - (6) Let $x(t) = 10 \cos(100t) + 20 \cos(120t) - 5 \sin(50t)$. If $x(t)$ is sampled with sampling frequency $F_s = 200$ Hz. What will be Discrete Time Signal $x[n]$ at $n=0$?
 - (7) What do you mean by Causal signal, Anti-causal Signal and Both-sided signal?
 - (8) What are the classification of signals?
 - (9) Give one example of Causal, Anticausal and Both-sided signal.
 - (10) What is an energy and Power signal? Give example.
 - (11) Consider $x_1[n]$ is periodic with period = 4 and $x_2[n]$ is periodic with period = 6.
Let $x[n] = x_1[n] + x_2[n]$. What will be the period of $x[n]$?
 - (12) What is symmetric signal? Give example.
 - (13) What is Anti-symmetric signal? Give example.
 - (14) What is an Even signal? Give example.
 - (15) What is an odd signal? Give example.
 - (16) What is the sum of odd signal values?
 - (17) How to check whether the given signal is periodic or not?
 - (18) What is the concept of digital frequency f ?
 - (19) What is the unit of digital frequency ω and f ?
 - (20) Classify the following signal: Finite Length or Infinite Length :-
 $x[n] = u[n] + 2u[n-1] - 3u[n-5]$
 - (21) What is correlation?
 - (22) What are the applications of Correlation?
 - (23) What is the application of Convolution?
 - (24) What are the properties of Convolution?
 - (25) Consider $x_1[n]$ is periodic with period = 4 and $x_2[n]$ is periodic with period = 6.
Let $x[n] = x_1[n] + x_2[n]$. What will be the period of $x[n]$?
 - (26) Let $x[n] = u[n] + 2u[n] - 2u[n-4]$.
Determine which of the following classification is true for $x[n]$.
 - (a) Periodic, Finite length
 - (b) Periodic, Infinite length
 - (c) Non periodic, Finite length
 - (d) Non-periodic, Infinite length
 - 27) What is FIR and IIR System?
 - 28) State Sampling Theorem
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