Question Paper

Exam Date & Time: 06-Jan-2024 (02:30 PM - 05:30 PM)

MANIPAL ACADEMY OF HIGHER EDUCATION

V SEMESTER B.TECH. (BME) DEGREE END SEMESTER MAKEUP EXAMINATIONS, JAN 2024

DIGITAL SIGNAL PROCESSING [BME 3153]

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

Descriptive

Answer all the questions.

1A) Determine the Nyquist rates for the analog signals given by (4)

i. $x(t) = 2cos\,(50\pi t) + 5\,sin(300\,\pi\,t) - 4\,\cos\,(100\,\pi t)$

ii. $x(t) = 5\,cos\,2000\pi t + 3\,sin\,6000\pi t + 2\,cos\,12{,}000\pi t$

Plot the frequency spectrum of the given signals.

1B) Determine whether each of the following signals is periodic. If the signal is periodic, state its period. (3)

i. $e^{\frac{j\pi n}{2}}$

ii. $x(n) = \frac{\sin \pi n}{\pi n}$

iii. $nu(n)$

Sketch the periodic signals.

1C) Determine the discrete linear cross correlation $R_{xy}(n)$ and $R_{yx}(n)$ of the periodic sequences whose first period is given by (3)

$$x(n) = \left\{\underset{\uparrow}{1}, 3, 0, 4\right\} \quad \text{and} \quad y(n) = \left\{\underset{\uparrow}{2}, 1, -2, 1\right\}$$

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

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

ii. Determine the sequence that has a DFT $Y(k) = e^{j5k\frac{2\pi}{10}} X(k)$ where $X(k)$ is the 10-point DFT of $x(n)$

2B) Two finite-length sequences $x_1(n)$ and $x_2(n)$ are given. Determine and sketch their six-point circular convolution. (3)

$x_1(n) = [1\ 2\ 3\ 3\ 4\ \ 5]$ and $x_2(n) = [0\ 1\ 2]$ (assume both the sequences start at index $n = 0$)

2C) Using final value theorem, determine $x(\infty)$, if $X(z)$ is given by $\frac{z+2}{4(z-1)(z+0.7)}$ (3)

3A) An LTI system has impulse response given by the following plot Figure 3a.1 and the input sequence is shown in Figure 3a.2: (4)

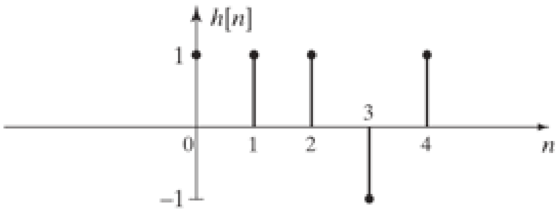

Figure 3a.1: Impulse response $h(n)$

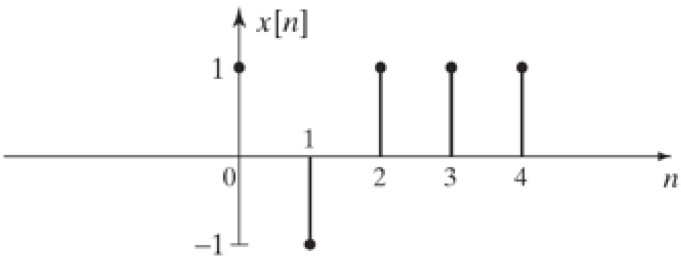

Figure 3a.2: Input sequence $x(n)$

Use discrete convolution to determine the output of the system $y(n)$. Give your answer as a carefully labelled sketch of $y(n)$.

3B) Determine the inverse Z-transform using Long division method (4)

$X(z) = \frac{z^2+z+2}{z^3-2z^2+3z+4}$, ROC: $|z| < 1$

3C) Design a digital filter from the analog filter function $H(s) = \frac{4}{s^2+16}$ using Bilinear Transformation (2)

4A) Given the following digital system with a sampling rate of 10000 Hz, (4)

$y(n) = x(n) - x(n-2)$

a. Determine the frequency response.

b. Determine and plot the magnitude-frequency response for frequencies f =1kHz to 5kHz.

Determine the filter type based on the magnitude frequency response.

4B) Design an IIR system: (3)

$y(n) + 2y(n-1) + 3y(n-2) = 4x(n) + 5x(n-1) + 6x(n-2)$

i. Draw the signal flow graph for the direct form 2 implementation of this system.

ii. Draw the signal flow graph for the transposed direct form 2 implementation of the system.

4C) Design an ideal highpass filter with a frequency response. (3)

$$H_d(e^{j\omega}) = \begin{cases} 1, & \frac{\pi}{4} \leq \omega < \pi \\ 0, & |\omega| \leq \frac{\pi}{4} \end{cases}$$

Determine $h(n)$ and $H(z)$ for M=11 and plot the magnitude frequency response.

5A) Consider the causal LTI system has a system function (4)

$$H(z) = \frac{1z^2}{z^2 - 1.04z + 0.98}$$

i. Plot the zeros and poles and determine whether this system is stable in Z-plane?

Infer about the resulting system's stability if the coefficients are rounded to the nearest tenth.

5B) Explain with expressions to design a low pass Finite Impulse Response (FIR) filter using window method. Illustrate with a neat sketch the effect of Gibb's phenomenon during the design. (3)

5C) Using the bilinear transformation, design a highpass filter, monotonic in passband with cut-off frequency of 1000Hz and down 10dB at 350Hz. The sampling frequency is 5000 Hz. (3)

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