Question Paper

Exam Date & Time: 01-Dec-2023 (02:30 PM - 05:30 PM)

MANIPAL ACADEMY OF HIGHER EDUCATION

FIFTH SEMESTER B.TECH END SEMESTER EXAMINATIONS, NOV 2023

DIGITAL SIGNAL PROCESSING [BME 3153]

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

Answer all the questions.

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

1) Given an analog signal (4)

A) $x(t) = 5\cos(2\pi \times 1500t),$ for $t \geq 0$ sampled at a rate of 8000Hz.

a. Sketch the spectrum of the original spectrum.

b. Sketch the spectrum of the sampled signal from 0 to 20kHz.

c. Determine the aliasing frequencies.

B) Determine the Discrete Time Fourier Transform of the following signals. (3)

i. $y(n) = 0.5^n u(n) + 2^n u(-n-1)$

ii. $x(n) = -a^n u(-n-1)$

C) Consider an ECG signal sampled as shown in the Figure 1C. Evaluate the response for the LTI system represented by the impulse response: $\delta(n) - \delta(n-1)$. Comment on the response with a carefully labelled sketch of y[n] (3)

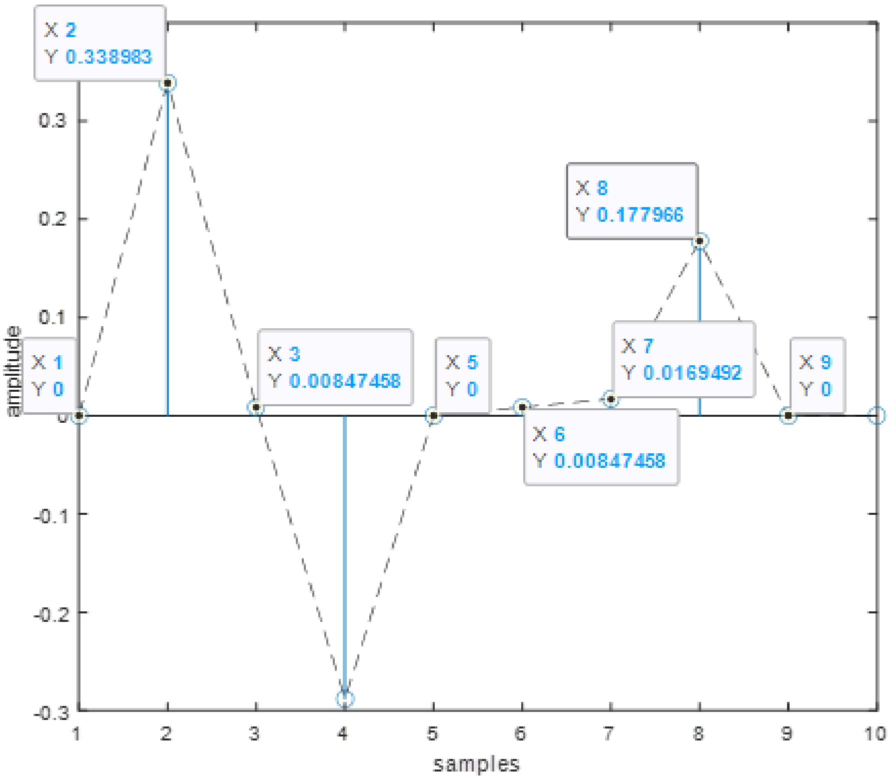

Figure 1 c

2) A) Given a sequence x(n) for $0 \leq n \leq 3$, where $x(0) = 0.8, x(1) = 0.6, x(2) = 0.4,$ and $x(3) = 0.2$, evaluate its Discrete Fourier Transform (DFT) $X(k)$ and plot the magnitude. (4)

B) Describe the four types of linear-phase discrete-time Finite Impulse Response (FIR) filters and the resulting impulse responses with their corresponding frequency responses. Infer and compare the filters that can be designed by placing possible zeros on the Z-plane. (3)

C) Determine the causal signal x(n) having Z-transform (3)

$$X(z) = \frac{z^2+z}{\left(z-\frac{1}{2}\right)^2\left(z-\frac{1}{4}\right)}$$

3) A) A filter is specified in terms of its pole-zero plot as follows: a zero at z = 1 and a zero at z = −1. (4)

(a) Determine the transfer function and difference equation of the filter

(b) Determine and plot the impulse response of the filter.

(c) Determine and plot the magnitude of the frequency response of the filter at $\omega = 0, \frac{\pi}{2}, \pi, \frac{3\pi}{2}, 2\pi$.

(d) Describe the nature of the filter.

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

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

C) Design the digital filter from the given analog filter (2)

$$H(s) = \frac{1000}{s + 1000}$$

And determine the difference equation using the Bilinear Transformation if the DSP system has a sampling period of T= 0.001s.

4) Given the following digital system with a sampling rate of 8000 Hz, (4)

A) $y(n) = 0.5x(n) + 0.5x(n-2)$

(a) Determine the frequency response.

(b) Determine and plot the magnitude-frequency response for frequencies f=1kHz, 2kHz, 3kHz, 4kHz and 5kHz.

(c) Determine the filter type based on the magnitude frequency response.

B) Determine the digital network in direct form-I, direct form-II and transposed form for the system (3)

$$y(n) = 2x(n) + 0.3x(n-1) + 0.5x(n-2) - 0.7y(n-1) - 0.9y(n-2)$$

C) Design a low-pass Butterworth digital filter to give response of 3 dB or less for frequencies upto 2 kHz and an attenuation of 20 dB or more beyond 4 kHz. Use the bilinear transformation technique. (3)

5) Design a first order high pass FIR filter by placing necessary zeros or poles in a particular location on Z-plane. (4)

A)

a. Determine the impulse response and transfer function of the system.
b. Sketch the magnitude frequency response of the same.

B) The desired frequency response of a filter is given: (3)

$$H_d(e^{j\omega}) = \begin{cases} 0 \ , -\frac{\pi}{2} \leq \omega \leq \frac{\pi}{2} \\ e^{-j\omega} , \frac{\pi}{2} < |\omega| \leq \pi \end{cases}$$

Sketch the magnitude-frequency response of the ideal filter.

If the window function is defined as

$$w(n) = \begin{cases} 1 \ , 0 \leq n \leq 4 \\ 0, \ otherwise \end{cases}$$

Determine the impulse response $h(n)$ and frequency response $H(e^{j\omega})$ of the designed filter.

C) A researcher uses the derivative operator (filter) specified as w(n) = x(n) – x(n – 1), where x(n) is the input and w(n) is the output. The result is then passed through the MA filter y(n) = 1/3[w(n) + w(n – 1) + w(n – 2)], where y(n) is the final output desired. (3)

a. Determine the transfer functions (in the z-domain) of the two filters individually as well as that of the combination.
b. Criticize the order placement of the two filters is placed first? Comment.
c. Determine the impulse response of each filter and that of the combination.

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