Question Paper

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

MANIPAL ACADEMY OF HIGHER EDUCATION

FIFTH SEMESTER B.TECH MAKEUP EXAMINATIONS, DEC 2022

DIGITAL SIGNAL PROCESSING [BME 3153]

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

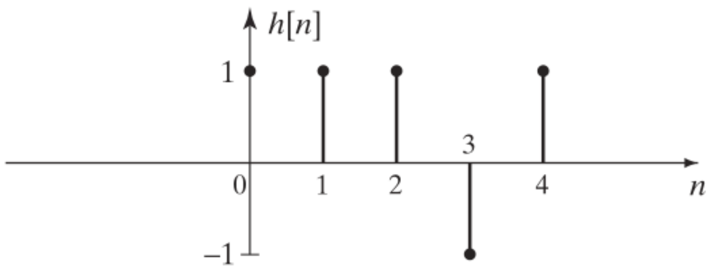
A

Answer all the questions.

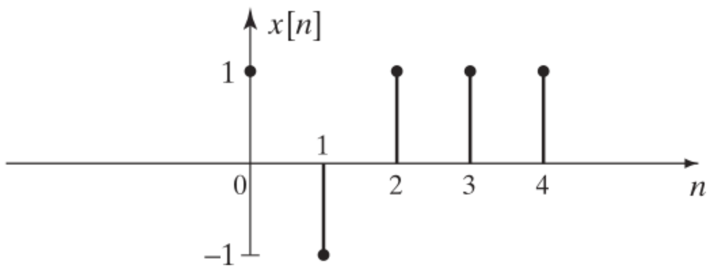
Instructions to Candidates: Answer ALL questions Missing data may be suitably assumed

1) An LTI system has impulse response given by the following plot: (4)

A)



The input to the system, x[n], is



Use discrete convolution to determine the output of the system y[n] Give your answer as a carefully labelled sketch of y[n]

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

its period. $e^{\frac{j\pi n}{6}}$, $\frac{\sin\frac{\pi n}{5}}{\pi n}$, $e^{\frac{j\pi n}{\sqrt{2}}}$

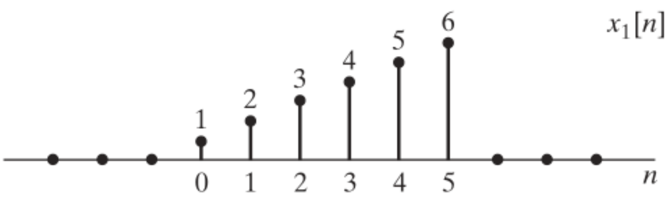
C) Determine the output of an LTI system if the impulse response $h(n)$ is $a^n u(-n-1)$ and $x(n)$ is $u(n)$ (3)

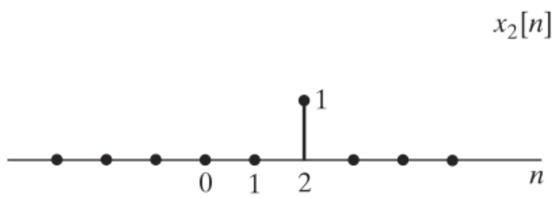
2) Consider the finite-length sequence x[n] in Figure. The five-point DFT of x[n] is denoted by X[k]. Plot the sequence y[n] whose DFT is Y[k]=W_5^(-2k) X[k] (using properties of DFT). (4)

A)

B) Determine the inverse z-transform using power series expansion $X(z)=\frac{1}{1+\frac{1}{2}z^{-1}}$ (3)

C) Two finite-length sequences x1[n] and x2[n] are given. Determine and sketch their six-point circular convolution. (3)





3) 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) If the $DFT\{x(n)\} = X(k) = \{4,-j2,0,j2\}$, using properties of DFT, find DFT of (4)

i. $x(n-2)$

ii. $x(-n)$

iii. $x^*(n)$

iv. $x^2(n)$

C) Convert the analog filter function $H(s) = \frac{4}{s^2+9}$ to a digital filter function using approximation of derivatives. (2)

4) Consider a stable LTI system with input x[n] and output y[n]. The input and output satisfy the difference equation $y[n-1] - \frac{10}{3}y[n] + y[n+1] = x[n]$. (4)

A) (i) Plot the poles and zeros of the system function in the z-plane.

(ii) Determine the impulse response h[n].

B) Consider the causal LTI system with system function $H(z) = 1 - \frac{1}{3}z^{-1} + \frac{1}{6}z^{-2} + z^{-3}$ (3)

i. Draw the signal flow graph for the direct form 1 implementation of this system.

ii. Draw the signal flow graph for the transposed direct form 1 implementation of the system

C) Determine the order of a Butterworth low-pass filter satisfying the following specifications: $f_p = 0.1Hz, f_s = 0.15Hz, A_p = 0.5dB, A_s = 15dB, f = 1Hz$ using Bilinear transformation. (3)

5) A causal LTI system has a system function $H(z) = \frac{1}{1-1.04z^{-1}+0.98z^{-2}}$ (3)

A) i. Plot the zeros and poles and determine whether this system is stable?

ii. If the coefficients are rounded to the nearest tenth, would the resulting system be stable?

B) An ideal discrete-time highpass filter with cut-off frequency $\omega_c = \frac{\pi}{2}$ was designed using the bilinear transformation with T = 1 ms. Determine the cut-off frequency Ω_c for the prototype continuous-time ideal highpass filter? (2)

C) Design a digital Butterworth filter satisfying the following constraints: (5)

$0.8 \le |H(\omega)| \le 1; 0 \le \omega \le 0.2\pi$

$|H(\omega)| \le 0.2; 0.32\pi \le \omega \le \pi$

with T = 1 s. Apply impulse invariant transformation.

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