CBCS SCHEME

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17EC52

Fifth Semester B.E. Degree Examination, June/July 2023
Digital Signal Processing

Time: 3 hrs. Max. Marks: 100

Note: Answer any FIVE full questions, choosing ONE full question from each module.

Module-1

1 a. Compute the N-point DFT of the sequence, $x(n) = an$, $0 \le n \le N-1$. **(06 Marks)**

b. Obtain the relationship between DFT and discrete-time Fourier transform of aperiodic signals. **(06 Marks)**

c. State and prove the following properties related to N-point DFT:
i) Linearity ii) Multiplication of two DFTs. **(08 Marks)**

OR

2 a. Compute the 8-point DFT of the sequence, $x[n] = \{1, 1, 1, 1, 0, 0, 0, 0\}$. **(08 Marks)**

b. Compute the N-point DFT of the following:

i) $x_1(n) = \cos\left(\frac{2\pi n}{N}\right)$, $0 \le n \le N-1$ ii) $x_2(n) = 1$, $0 \le n \le N-1$. **(12 Marks)**

Module-2

3 a. The 8-point DFT of a length – 8 complex sequence:
$V(n) = x(n) + jh(n)$ is given by;
$V(0) = -2 + j3$, $V(1) = 1 + j5$, $V(2) = -4 + j7$
$V(3) = 2 + j6$, $V(4) = -1-j3$, $V(5) = 4-j$
$V(6) = 3 + j8$, $V(7) = j6$
Without computing IDFT of V(K) determine the 8-point DFTs of the sequences x(n) and h(n). **(08 Marks)**

b. Discuss the filtering of long data sequences using overlap-save method. **(06 Marks)**

c. Let x(n) be a finite length sequence with $X(k) = (0, 1 + j, 1, 1 - j)$. Using the properties of DFT, find DFTs of the following sequences:

i) $x_1(n) = e^{j\pi/2n}\, x(n)$ ii) $x_2(n) = \cos\left(\frac{\pi}{2}n\right)x(n)$ iii) $x_3(n) = x((n-1))_4$. **(06 Marks)**

OR

4 a. Why do we adopt FFT algorithms for the computation of N-point DFT. **(04 Marks)**

b. Perform $x(n) * h(n)$, for the sequences x(n) and h(n) given below using overlap-add method:
$h(n) = (1, 1, 1)$
$x(n) = (1, 2, 0, -3, 4, 2, -1, 1, -2, 3, 2, 1, -3)$.
Consider the initial data blocks size to be 6. **(08 Marks)**

c. Prove the following :

i) $\text{DFT}\{x(n)W_N^{-\ell n}\} = X((K-\ell))_N$ ii) $\sum_{n=0}^{N-1}|x(n)|^2 = \frac{1}{N}\sum_{K=0}^{N-1}|x(k)|^2$. **(08 Marks)**

Module-3

5 a. Compute the 8-point DFT of the sequence,
$x(n) = \{1, 1, 1, 1, -1, -1, -1, -1\}$, using DIT-FFT algorithm. **(08 Marks)**

b. Derive the second order Goertzel filter which can be used for computation of DFT samples. **(08 Marks)**

c. In the computation of N-point DFT using FFT algorithms, how many
   i) Complex multiplications are involved?
   ii) Complex additions are involved?
   iii) Real registers are used?
   iv) Butterflies (basic building blocks) are used? **(04 Marks)**

OR

6 a. Develop DIF-FFT algorithm for the computation of 8-point DFT. **(08 Marks)**
b. Write an explanatory note on Chirp-z transform. **(07 Marks)**
c. Find the 4-point real sequence x(n), if its 4-point DFT samples are X(0) = 6, X(1) = -2 + j2, X(2) = -2. Use DIF-FFT algorithm. **(05 Marks)**

Module-4

7 a. An LTI system is characterized by the difference equation:
$y(n) - 0.5y(n-2) - 2y(n-3) = 1.5\,x(n-2)$.
Realize the system in i) Direct form – I ii) Direct form – II structures. **(08 Marks)**
b. Derive the expressions for order and cut-off frequency related to analog low-pass Butterworth filter. **(08 Marks)**
c. An analog filter has the transfer function; $H_a(s) = \frac{1}{s+2}$. Transform $H_a(s)$ to a digital filter, H(z), using impulse invariance technique. Consider the sampling rate to be 2Hz. **(04 Marks)**

OR

8 a. A digital lowpass filter is required to meet the following specifications:
Monotonic passband and stopband.
-3.01dB cutoff frequency of 0.5π rad. And, stopband attenuation of atleast 15dB at 0.75π rad. Find the system function H(z) using Bilinear transformation. **(12 Marks)**
b. Obtain a parallel realization for the transfer function H(z) given below. **(08 Marks)**

$$H(z) = \frac{8 - 4z^{-1} + 11z^{-2} - 2z^{-3}}{\left(1 - \frac{1}{4}z^{-1}\right)\left(1 - z^{-1} + \frac{1}{2}z^{-2}\right)}$$

Module-5

9 a. A filter is to be designed with the following desired frequency response:

$$H_d(w) = \begin{cases} 0, & -\pi/4 < w < \pi/4 \\ e^{-j2w}, & \pi/4 < |w| < \pi \end{cases}$$

Use a rectangular window to design the related FIR filter and find its frequency response. **(10 Marks)**
b. Write the relevant equations and stop band attenuations obtained from following windows:
i) Rectangular ii) Hanning iii) Hamming. **(06 Marks)**
c. Realize on FIR filter with system function, $H(z) = 1 + \frac{1}{2}z^{-1} + \frac{1}{4}z^{-2} + \frac{1}{8}z^{-3}$. **(04 Marks)**

OR

10 a. Realize the linear-phase FIR filter having the following impulse response:
$h(n) = \delta(n) + \frac{1}{4}\delta(n-1) - \frac{1}{8}\delta(n-2) + \frac{1}{4}\delta(n-3) + \delta(n-4)$. **(06 Marks)**
b. A three-stage FIR lattice structure has the following coefficients: $K_1 = 0.65$, $K_2 = -0.34$ and $K_3 = 0.8$. Evaluate its impulse response by tracing a unit impulse δ(n) at its input through the lattice structure. Also, draw its direct form-I structure. **(10 Marks)**
c. The frequency response of an FIR filter is given by $H(w) = e^{-j2w}(1 + 1.8\cos 2w + 1.2\cos w)$. Determine impulse response coefficients of FIR filter. **(04 Marks)**

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