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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, $x(n) = a^n$, $0 \le n \le N-1$. **(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) $x_1(n) = \cos\left(\dfrac{2\pi n}{N}\right)$, $0 \le n \le N-1$ 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) $x_2(n) = \cos\left(\dfrac{\pi}{2}n\right)x(n)$ 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) $DFT\{x(n)W_N^{-\ell n}\} = X((K - \ell))_N$ ii) $\displaystyle\sum_{n=0}^{N-1} |x(n)|^2 = \frac{1}{N}\sum_{K=0}^{N-1} |x(k)|^2$. **(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; $H_a(s) = \dfrac{1}{s+2}$. 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.
    $$H(z) = \frac{8 - 4z^{-1} + 11z^{-2} - 2z^{-3}}{\left(1 - \dfrac{1}{4}z^{-1}\right)\left(1 - z^{-1} + \dfrac{1}{2}z^{-2}\right)}$$ (08 Marks)

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, $H(z) = 1 + \dfrac{1}{2}z^{-1} + \dfrac{1}{4}z^{-2} + \dfrac{1}{8}z^{-3}$. (04 Marks)

OR

10 a. Realize the linear-phase FIR filter having the following impulse response:
    $h(n) = \delta(n) + \dfrac{1}{4}\delta(n-1) - \dfrac{1}{8}\delta(n-2) + \dfrac{1}{4}\delta(n-3) + \delta(n-4)$. (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 $\delta(n)$ 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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