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15EC52

Fifth Semester B.E. Degree Examination, July/August 2021
Digital Signal Processing

Time: 3 hrs. Max. Marks: 80

Note: ***Answer any FIVE full questions.***

1 a. Compute the N-point DFT of the sequence, $x(n) = a.n \quad 0 \le n \le N-1$. **(08 Marks)**

b. Obtain the relationship between DFT and Z-transform. **(04 Marks)**

c. Find the Inverse DFT of the sequence $X(K) = (2, 1+j, 0, 1-j)$. **(04 Marks)**

2 a. Compute the 8-point DFT of the sequence x(n) given below:
x(n) = (1, 1, 1, 1, 0, 0, 0, 0). **(06 Marks)**

b. Compute the N-point DFT of the sequence,
$x(n) = a^n, \; 0 \le n \le N-1$. **(04 Marks)**

c. Find the IDFT of 4-point sequence,
$X(K) = (4, -j2, 0, j2)$ using the DFT. **(06 Marks)**

3 a. In many signal processing applications, we often multifly an infinite length sequence by a window of length N. The time-domain expression for this window is,

$$w(n) = \frac{1}{2} + \frac{1}{2}\cos\left[\frac{2\pi}{N}\left(n - \frac{N}{2}\right)\right]$$

What is the DFT of the windowed sequence, $y(n) = x(n)w(n)$? Keep the answer in terms of X(n). **(07 Marks)**

b. Let x(n) be a real sequence of length N and its N-point DFT is given by X(K). Show that :
(i) $X(N-K) = X^*(K)$. (ii) X(0) is real, and
(iii) If N is Even, $X\left(\frac{N}{2}\right)$ is real. **(09 Marks)**

4 a. Let x(n) = (1, 2, 0, 3, -2, 4, 7, 5). Evaluate the following :
(i) X(0) (ii) X(4) (iii) $\sum_{K=0}^{7} X(K)$ (iv) $\sum_{K=0}^{7} |X(K)|^2$ **(08 Marks)**

b. Perform $x(n)*h(n), \; 0 \le n \le 11$ for the sequence x(n) and h(n) given below using overlap-add based fast convolution technique. Choose appropriately number of points of circular convolution.
h(n) = (1, 1, 1)
and x(n) = (1, 2, 0, -3, 4, 2, -1, 1, -2, 3, 2, 1, -3) **(08 Marks)**

5 a. Find the 4 point circular convolution of x(n) and h(n) given in Fig. Q5 (a) using radix-2 DIF-FFT algorithm. **(08 Marks)**

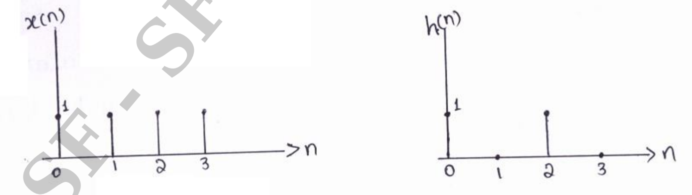

Fig. Q5 (a)

b. Find the 8-point DFT of sequence x(n), x(n) = (1, 1, 1, 1, 0, 0, 0, 0) using DIT-FFT radix-2 algorithm. Use the butterfly diagram. **(08 Marks)**

6 a. Derive the DIT-FFT algorithm. **(08 Marks)**

b. Find number of complex multiplications and complex additions in finding 512 point DFT. **(02 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. **(06 Marks)**

7 a. Draw the block diagrams of direct form-I and direct form-II realization for a digital IIR filter described by the system function.

$$H(z) = \frac{8z^3 - 4z^2 + 11z - 2}{\left(z - \frac{1}{4}\right)\left(z^2 - z + \frac{1}{2}\right)}.$$ **(08 Marks)**

b. Obtain a parallel realization for the system described by,

$$H(z) = \frac{(1+z^{-1})(1+2z^{-1})}{\left(1+\frac{1}{2}z^{-1}\right)\left(1-\frac{1}{4}z^{-1}\right)\left(1+\frac{1}{8}z^{-1}\right)}.$$ **(08 Marks)**

8 a. Design an analog bandpass filter to meet the following frequency domain specifications:

(i) a −3.0103 dB upper and lower cut-off frequency of 50 Hz and 20 kHz.
(ii) a stopband attenuation of atleast 20 dB at 20 Hz and 45 kHz and
(iii) a monotonic frequency response. **(08 Marks)**

b. Let $H_a(s) = \frac{s+a}{(s+a)^2 + b^2}$ be a casual second order transfer function. Show that the casual second order digital function H(z) is obtained from $H_a(s)$ through impulse invariance method is given by,

$$H(z) = \frac{1 - e^{-aT}\cos bTz^{-1}}{1 - 2\cos bTe^{-aT}z^{-1} + e^{-2aT}z^{-2}}.$$ **(08 Marks)**

9 a. The desired frequency response of a low pass filter is given by,

$$H_d(e^{jw}) = H_d(w) = \begin{cases} e^{-j3w}, & |w| < \frac{3\pi}{4} \\ 0, & \frac{3\pi}{4} < |w| < \pi \end{cases}.$$

Determine the frequency response of the FIR filter if Hamming window is used with N = 7. **(08 Marks)**

b. Determine the co-efficients K_m of the lattice filter corresponding to FIR filter described by the system function,

$$H(z) = 1 + 2z^{-1} + \frac{1}{3}z^{-2}$$

Also, draw the corresponding second order lattice structure. **(08 Marks)**

10 a. A low pass filter is to be designed with the following desired frequency response:

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

Determine the filter co-efficients $h_d(n)$ and $h(n)$ if $w(n)$ is a rectangular window defined as follows:

$$w_R(n) = \begin{cases} 1, & 0 \le n \le 4 \\ 0, & \text{otherwise} \end{cases}$$

Also find the frequency response, $H(w)$ of the resulting FIR filter. **(06 Marks)**

b. 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)**

c. Realize an FIR filter with impulse response $h(n)$ given by,

$$h(n) = \left(\frac{1}{2}\right)^n [u(n) - u(n-4)]$$

Using direct form – I. **(04 Marks)**

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