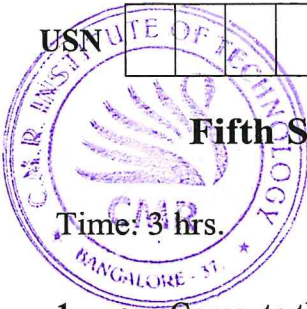


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Fifth Semester B.E. Degree Examination, July/August 2021

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, $x(n) = a^n$ $0 \leq n \leq N-1$. (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,
 $x(n) = a^n$, $0 \leq n \leq N-1$. (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 multiply 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) $X(N-K) = X^*(K)$. (04 Marks)
 - (ii) $X(0)$ is real, and (04 Marks)
 - (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) $X(0)$ (04 Marks)
 - (ii) $X(4)$ (04 Marks)
 - (iii) $\sum_{K=0}^7 X(K)$ (04 Marks)
 - (iv) $\sum_{K=0}^7 |X(K)|^2$ (08 Marks)
 - b. Perform $x(n)*h(n)$, $0 \leq n \leq 11$ 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)

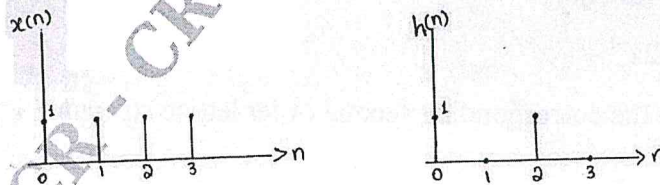


Fig. Q5 (a)

- 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)

Important Note : 1. On completing your answers, compulsorily draw diagonal cross lines on the remaining blank pages.
2. Any revealing of identification, appeal to evaluator and /or equations written eg, 42+8 = 50, will be treated as malpractice.

- 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.

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

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

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

- 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,

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

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

$$H_d(e^{j\omega}) = H_d(\omega) = \begin{cases} e^{-j3\omega}, & |\omega| < \frac{3\pi}{4} \\ 0, & \frac{3\pi}{4} < |\omega| < \pi \end{cases}$$

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:

$$H_d(e^{j\omega}) = H_d(\omega) = \begin{cases} e^{-j2\omega}, & |\omega| < \frac{\pi}{4} \\ 0, & \frac{\pi}{4} < |\omega| < \pi \end{cases}$$

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

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

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

- b. Realize the linear-phase FIR filter having the following impulse response. (06 Marks)

$$h(n) = \delta(n) + \frac{1}{4}\delta(n-1) - \frac{1}{8}\delta(n-2) + \frac{1}{4}\delta(n-3) + \delta(n-4).$$

- 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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