Code No: RR320402

Set No. 1

III B.Tech II Semester Regular Examinations, Apr/May 2006
DIGITAL SIGNAL PROCESSING
(Common to Electronics & Communication Engineering, Electronics & Instrumentation Engineering, Electronics & Control Engineering, Electronics & Telematics and Instrumentation & Control Engineering)

Time: 3 hours **Max Marks: 80**

Answer any FIVE Questions
All Questions carry equal marks

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1. (a) The unit-sample response of a linear-shift-invariant system is known to be zero. Except in the interval $N_0 \leq n \leq N_1$. The input x(n) is known to be zero except in the interval $N_2 \leq n \leq N_3$. As a result, the output is constrained to be zero except in some interval $N_4 \leq n \leq N_5$. Determine $N_4 and N_5$ in terms of $N_0, N_1, N_2 and N_3$.
   (b) By direct evaluation of the convolution sum, determine the step response of a Linear shift-invariant system whose unit-sample response h(n) is given by $h(n) = a^{-n}u(-n)$, 0 < a < 1. [8+8]

2. (a) Let x(n) and $X(e^{jw})$ denote a sequence and its Fourier transform. Show that $\sum_{n=-\infty}^{\infty} x(n)\ x*(n) = {}^{1}\!/_{(2\pi)} \int_{-\pi}^{\pi} X(e^{j\omega})\, d\omega$
   This is one form of Parseval's theorem
   (b) For a real sequence show that magnitude spectrum is even and phase spectrum is odd. [8+8]

3. (a) Distinguish between DFT and DTFT .
   (b) Consider a sequence x(n) of length L. Consider its DTFT $X_d(w)$ is sampled and N is the number of frequency samples. Discuss the relation between L and N for inverse DTFT = inverse DFT comment on the aliasing problem.
   (c) Compute the DFT of $x(n) = \{1, 0, 0, 0\}$ and compare with $X_d(w)$. [4+6+6]

4. An 8 point sequence is given by x(n) = {2,2,2,2,1,1,1,1}. Compute 8 point DFT of x(n) by
   (a) radix - 2 D I T F F T
   (b) radix - 2 D I F FF T
   Also sketch magnitude and phase spectrum. [16]

5. (a) An LTI system is described by the equation y(n)=x(n)+0.81x(n-1)-0.81x(n-2)-0.45y(n-2). Determine the transfer function of the system. Sketch the poles and zeroes on the Z-plane.
   (b) Define stable and unstable system test the condition for stability of the first-order IIR filter governed by the equation y(n)=x(n)+bx(n-1). [8+8]

6. (a) What is an IIR digital filter?

(b) How are IIR digital filter realized?

(c) What are the various realizability constraints imposed on transfer function of an IIR digital filter. [4+4+6]

7. A low pass filter is to be designed with the following desired frequency response.
$H_d(e^{j\omega}) = \begin{cases} e^{-j2\omega}, & -\pi/4 \le \omega \le \pi/4 \\ 0, & \pi/4 \le |\omega| \le \pi \end{cases}$
Determine the filter coefficients $h_d(n)$ if the window function is defined as
$\omega(n) = \begin{cases} 1, & 0 \le n \le 4 \\ 0, & otherwise \end{cases}$
Also determine the frequency response $H(e^{j\omega})$ of the designed filter. And plot the magnitude and phase spectra. [16]

8. (a) Explain the parallel form realisation for IIR system and obtain the direct form I, direct form II realisation of the LTI systems governed by the equation.
$y(n) = -\frac{3}{8}y(n-1) + \frac{3}{32}y(n-2) + \frac{1}{64}y(n-3) + x(n) + 3x(n-1) + 2x(n-2)$

(b) Compare cascade and parallel form relations. [12+4]

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1. (a) Let e(n) be an exponential sequence, i.e., e(n)=x^n, for all n and let x(n) and y(n) denote two arbitrary sequences, Show that
   [e(n)x(n)]*[e(n)y(n)] = e(n)[x(n)*y(n)]
   (b) Consider a discrete-time linear shift-invariant system with unit-sample response h(n). If the input x(n) is a periodic sequence with period N. Show that the output y(n) is also a periodic sequence with period N. [8+8]

2. A LTI system is described by the difference equation y(n)=ay(n-1)+bx(n). Find the impulse response, magnitude function and phase function. Find the value of b if $|H(jw)| = 1$. Sketch the magnitude and phase response for a=0.9. [16]

3. (a) State and prove the circular time shifting and frequency shifting properties of the DFT.
   (b) Compute the circular convolution of the sequences
   $x_1(n) = \{1, 2, 0, 1\}$ and
   $x_2(n) = \{2, 2, 1, 1\}$ Using DFT approach. [8+8]

4. (a) Draw the butterfly line diagram for 8 - point FFT calculation and briefly explain. Use decimation -in-time algorithm.
   (b) What is FFT? Calculate the number of multiplications needed in the calculation of DFT using FFT algorithm with 32 point sequence. [8+8]

5. (a) Explain how the analysis of discrete time invariant system can be obtained using convolution properties of Z transform.
   (b) Determine the impulse response of the system described by the difference equation y(n)-3y(n-1)-4y(n-2)=x(n)+2x(n-1) using Z transform. [8+8]

6. Design a Digital IIR low pass filter with pass band edge at 1000 Hz and stop band edge at 1500 Hz for a sampling frequency of 5000 Hz. The filter is to have a pass band ripple of 0.5 db and stop band ripple below 30 db. Design Butter worth filler using both impulse invariant and Bilinear transformations. [16]

7. (a) Design a Finite Impulse Response low pass filter with a cut-off frequency of 1 kHz and sampling rate of 4 kHz with eleven samples using Fourier series method.
   (b) Show that an FIR filter is linear phase if h(n) = h(N-1-n). [8+8]

8. (a) Explain the structures for realisation of FIR system and draw the direct form structure of the FIR system described by the transfer function
$\mathrm{H(Z)} = 1 + \frac{1}{2}Z^{-1} + \frac{3}{4}Z^{-2} + \frac{1}{4}Z^{-3} + \frac{1}{2}Z^{-4} + \frac{1}{8}Z^{-5}$

   (b) Realize the following IIR system by cascade and parallel forms.
$y(n) + \frac{1}{4}y(n-1) - \frac{1}{8}y(n-2) = x(n) - 2x(n-1) + x(n-2)$ [8+8]

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1. (a) Write four advantages of Digital Signal Processing over Analog Signal Processing.
   (b) A signal y(n) is governed by the recursive equation $y(n) = 2y(n-1) + \delta(n) with y(0) = 4$. Find y(-2),y(3). Is the signal bounded or not?
   (c) Convolve the two signals $x(n) = (1/2)^n x(n) and \;\; h(n) = u(n) - u(n-10)$ where u(n) is unit step function. [6+4+6]

2. (a) Prove that the convolution in time domain leads to multiplication in frequency domain for discrete time signals
   (b) The out put y(n) for a linear shit invariant system, with the input x(n) is given by
   Y(n) = x(n)-2x(n-1)+x(n-2)
   Compute and sketch the magnitude and phase response of the system $|w| \leq \pi$ [8+8]

3. (a) What is " padding with Zeros " with an example, Explain the effect of padding a sequence of length N with L Zeros or frequency resolution.
   (b) Compute the DFT of the three point sequence $x(n) = \{2, 1, 2\}$. Using the same sequence, compute the 6 point DFT and compare the two DFTs. [8+8]

4. (a) Draw the butterfly line diagram for 8 - point FFT calculation and briefly explain. Use decimation -in-time algorithm.
   (b) What is FFT? Calculate the number of multiplications needed in the calculation of DFT using FFT algorithm with 32 point sequence. [8+8]

5. (a) Explain how the analysis of discrete time invariant system can be obtained using convolution properties of Z transform.
   (b) Determine the impulse response of the system described by the difference equation y(n)-3y(n-1)-4y(n-2)=x(n)+2x(n-1) using Z transform. [8+8]

6. (a) Using Bilinear transformation on an analog filter transfer function Ha(S), given the following 'S' plane points.
   S = 0.2++j0, -0.1+j0.3, -0.1+j0.6
   Find the corresponding 'Z' plane points. Also plot the resulting 'Z' plane points.

(b) A signal $x(t) = 5Sin5\pi t$ is passed through a filter. If the signal is samples at T=1/50 seconds and number of sampling intervals equals 150 then sketch the input signal x(nT) and the output of the filter. [8+8]

7. (a) What is the principle of designing FIR filters using windows.

   (b) Using a rectangular window technique design a low pass filter with pass band gain of unity, cut-off frequency of 1kHz and working at a sampling frequency of 5 kHz. The length of the impulse response should be 7. [6+10]

8. (a) Obtain the cascade and parallel form realisation of the LTI system governed by the equation.

   (b) Compare cascade and performance of direct and canonic forms. [12+4]

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1. (a) Consider a discrete linear time invariant system described by the difference equation:
   Y(n)-(3/4)y(n-1)+(1/8)y(n-2)=x(n))+(1/3)x(n-1)
   Where y(n) is the output and x(n) is the input.
   Assuming that the system is relaxed initially obtain the unit sample response of the system.
   (b) Find the:
      i. impulse response
      ii. output response for a step input applied at n=0 of a discrete time linear time invariant system whose difference equation is given by y(n) = y(n-1)+0.5 y(n-2)+x(n)+x(n-1). [8+8]

2. (a) If $x(n) \rightarrow x(e^{j\omega})$ Constitute a Fourier transform pair. Prove the following:

Sequence	Fourier Transform
i. x*(-n)	$X*(e^{j\omega})$
ii. j Im[x(n)]	$X_0(e^{j\omega})$

   (b) Prove that the convolution in time domain leads to multiplication in frequency domain for discrete time signals.

   [8+8]

3. (a) If x(n) is a periodic sequence with a period N, also periodic with period 2N. $X_1(K)$ denotes the discrete Fourier series coefficient of x(n) with period N and $X_2(k)$ denote the discrete Fourier series coefficient of x(n) with period 2N. Determine $X_2(K)$ in terms of $X_1(K)$.
   (b) Prove the following properties.
      i. $W_N^n x(n) \rightarrow X\left((K+1)\right)_N R_N(K)$
      ii. $\mathrm{x}*(\mathrm{n}) \rightarrow \mathrm{X}*((-\mathrm{K}))_{\mathrm{N}}\mathrm{R}_{\mathrm{N}}(\mathrm{K})$ [8+8]

4. (a) Implement the decimation in time FFT algorithm for N=16.
   (b) In the above Question how many non - trivial multiplications are required. [10+6]

5. (a) Explain how the analysis of discrete time invariant system can be obtained using convolution properties of Z transform.

(b) Determine the impulse response of the system described by the difference equation y(n)-3y(n-1)-4y(n-2)=x(n)+2x(n-1) using Z transform. [8+8]

6. (a) Derive a relationship between complex variable S used in Laplace Transform (for analog filters) and complex variation Z used in Z-transform (for digital filters)

   (b) Discuss the various properties of Bilinear transformation method. [8+8]

7. (a) Design a low pass filter by the Fourier series method for a seven stage with cut-off frequency at 300 Hz if $t_s = 1msec$. Use hanning window.

   (b) Explain in detail, the linear phase response and frequency response properties of Finite Impulse Response filters. [8+8]

8. (a) Realize the following systems with minimum number of multipliers.
   H(Z) = $\frac{1}{4} + \frac{1}{2}Z^{-1} + \frac{3}{4}Z^{-2} + \frac{1}{2}Z^{-3} + \frac{1}{4}Z^{-4}$
   H(Z) = $\left[1 + \frac{1}{2}Z^{-1} + Z^{-2}\right]\left[1 + \frac{1}{4}Z^{-1} + Z^{-2}\right]$

   (b) Explain the principles of VOCODERS. [10+6]

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