Code No: RR311102 **Set No.1**

III B.Tech. I Semester Regular Examinations, November -2005
DIGITAL SIGNAL PROCESSING
(Common to Bio-Medical Engineering and Electronics & Computer Engineering)

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

Answer any FIVE Questions
All Questions carry equal marks

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1. (a) Consider a LSI system with unit sample response $h(n)n = \alpha^n u(n)$ where α is real and $0 < \alpha < 1$. If the input is $x(n) = \beta^n\, u(n), 0 < |\beta| < 1$,determine the the output f(n) in the form $y(n) = (k_1\alpha^n + k_2\beta^n u(n)$ by explicitly evaluating the convolution sum.
   (b) Define causality and stability of LSI system and state the conditions for stability.

   [12+4]

2. (a) Discuss the frequency-domain representation of discrete-time systems and signals. By deriving the necessary relation.
   (b) Draw the frequency response of LSI system with impulse response $h(n) = a^n u(-n)\ (|a| < 1)$

   [8+8]

3. (a) Compute Discrete Fourier transform of the following finite length sequence considered to be of length N.
      i. $x(n) = \delta(n + n_0)\ where\ 0 < n_0 < N$
      ii. $x(n) = \infty^n\ where\ 0 < \infty < 1.$
   (b) If x(n) denotes a finite length sequence of length N, show that $x((-n))_N = x((N - n))_N$. [8+8]

4. (a) Implement the Decimation in frequency FFT algorithm of N-point DFT where N-8. Also explain the steps involved in this algorithm.
   (b) Compute the FFT for the sequence x(n) = { 1, 1, 1, 1, 1, 1, 1, 1 } [8+8]

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) Compare Butter worth and Chebydhev approximations.
   (b) Determine the order and transfer function of the Chebyshev filter for following specifications:
      i. Maximum pass band ripple is 1 db for $\Omega \leq 4$ radius/sec.

ii. Stop band attenuation is 40 db for $\Omega \geq 4$ radius/sec. [8+8]

7. (a) Explain briefly the method of designing FIR filter using Fourier series method

   (b) Design a FIR filter approximating the ideal frequency response
   $$H_d(e^{j\Omega}) = \begin{cases} e^{-j\alpha\Omega}, & for \ |\Omega| \leq \pi/6 \\ 0 \quad , & for \, \pi/6 \ \leq |\Omega| \leq \pi \end{cases}$$
   Determine the filter coefficients for N=13. [6+10]

8. (a) A causal system is represented by the following difference equation.
   $y(n) + \frac{1}{4}y(n-1) = x(n) + \frac{1}{2}x(n-1)$
   Find the system transfer function H(Z), unit sample response and frequency response of the system

   (b) Realize $H(Z) = 1 + \frac{1}{2}Z^{-1} + \frac{1}{8}Z^{-2} + \frac{3}{4}Z^{-3} + \frac{1}{8}Z^{-4} + \frac{1}{2}Z^{-5} + Z^{-6}$ with minimum number of multipliers. [8+8]

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Code No: RR311102 **Set No.2**

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DIGITAL SIGNAL PROCESSING
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Time: 3 hours **Max Marks: 80**

Answer any FIVE Questions
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1. (a) A second order discrete time system is characterized by the difference equation. y(n)-0.1y(n-1)-0.02y(n-2)=2x(n)-x(n-1). Determine y(n) for $n \geq 0$ when $x(n) = u(n)$ and the initial conditions are y(-1) = -10 and y(-2) = 5.
   (b) State the conditions for a digital filter to be causal and stable.
   [12+4]

2. (a) State and prove time and frequency shifting properties of Fourier transform.
   (b) Find the Fourier transform of the following signals
      i. $x(n) = (\alpha^n sinw_o n)u(n)\ |\alpha| < 1$
      ii. $x(n) = (1/4)^n u(n+4)$

   [8+8]

3. (a) Compute Discrete Fourier transform of the following finite length sequence considered to be of length N.
      i. $x(n) = \delta(n + n_0)\ where\ 0 < n_0 < N$
      ii. $x(n) = \infty^n\ where\ 0 < \infty < 1.$
   (b) If x(n) denotes a finite length sequence of length N, show that $x((-n))_N = x((N-n))_N$. [8+8]

4. (a) Implement the Decimation in frequency FFT algorithm of N-point DFT where N-8. Also explain the steps involved in this algorithm.
   (b) Compute the FFT for the sequence x(n) = { 1, 1, 1, 1, 1, 1, 1, 1 } [8+8]

5. (a) Determine the frequency response , magnitude response and phase response for the system given by $y(n) - \frac{3}{4}y(n-1) + \frac{1}{8}y(n-2) = x(n) - x(n-1)$
   (b) A causal LTI system is described by the difference equation y(n)=y(n-1)+y(n-2)+x(n-1), where x(n) is the input and y(n) is the output. Find
      i. The system function H(Z)=Y(Z)/X(Z) for the system, plot the poles and zeroes of H(Z) and indicate the region of convergence.
      ii. The unit sample response of the system.
      iii. Is this system stable or not? [6+10]

6. (a) An analog integrator is described by a transfer function $H_A(S) = 1/S$.
      i. Obtain a digital integrator using bilinear transformation method.

ii. Obtain the difference equation for the digital integrator relating Input x(n) to the output y(n).

(b) Discuss magnitude characteristics of an analog Butterworth filter and given its pole locations.

i. Discuss about the pole locations for the digital Chebyshev filters.

ii. Compare the impulse invariance and bilinear transformation methods.

[8+8]

7. (a) Compare the performances of rectangular window, hamming window and Keiser window

(b) The desired response of a low pass filter is

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

Determine $H(e^{j\omega})$ for M=7 using a Hamming window. [6+10]

8. (a) Explain the different structures for realisation of IIR system. and explain how conversion can be made from direct form I structure to direct form II structure.

(b) Realize the given system in cascade and parallel form

$$\text{H(Z)} = \frac{1+\frac{1}{2}Z^{-1}}{\left[1-Z^{-1}+\frac{1}{4}Z^{-2}\right]\left[1-Z^{-1}+\frac{1}{2}Z^{-2}\right]}$$ [8+8]

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Code No: RR311102 **Set No.3**

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

Answer any FIVE Questions
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1. (a) Prove that a discrete LTI system is stable if and only if $\sum_{n=-\infty}^{\infty} |h(n)| < \infty$ where h(n) is the unit sample response of the system.
   (b) Check the following systems for linearity, causality, time invariance and stability using appropriate tests.
      i. $y(n) = n\, e^{|x(n)|}$
      ii. $y(n) = a^n cos(2\pi n/N)$ [8+8]
2. (a) Prove the modulation and time shifting properties of distribute time Fourier transform.
   (b) A discrete system is given by following difference equation
   y(n)-5y(n-1) = x(n) + 4x(n-1)
   where x(n) is the input and y(n) is the out put. Determine its magnitude and phase response as a function of frequency.
   [8+8]
3. (a) Define DFT of a sequence. Compute the N - point DFT of the sequence.
   $X(n) = Cos(2\pi rn/N), 0 \leq n \leq N-1$ and $0 \leq r \leq N-1$
   (b) Explain how DFT can be obtained by sampling DFS for a given sequence. [8+8]
4. (a) Let x(n) be a real valued sequence with N-points and Let X(K) represent its DFT , with real and imaginary parts denoted by $X_R(K)$ and $X_1(K)$ respectively. So that X(K) = $X_R(K) + JX_1(K)$. Now show that if x(n) is real, $X_R(K)$ is even and $X_1(K)$ is odd.
   (b) Compute the FFT of the sequence x(n) = { 1, 0, 0, 0, 0, 0, 0, 0 } [8+8]
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. Use the Bilinear transformation to convert the analog filter with system function $H(S) = S+0.1/(S+0.1)^2+9$ into a digital IIR filters. Select T = 0.1 and compare the location of the zeros in H(Z) with the locations of the zeros obtained by applying the impulse invariance method in the conversion of H(S). [16]

7. (a) Design a low pass filter using rectangular window by taking samples of $\omega(n)$ and with a cut-off frequency of 1.2 radians/sec.

   (b) Compare the various window functions. [8+8]

8. (a) A causal system is represented by the following difference equation.
   $\mathrm{y(n)} + \frac{1}{4}\mathrm{y(n-1)} = \mathrm{x(n)} + \frac{1}{2}\mathrm{x(n-1)}$
   Find the system transfer function H(Z), unit sample response and frequency response of the system

   (b) Realize $H(Z) = 1 + \frac{1}{2}Z^{-1} + \frac{1}{8}Z^{-2} + \frac{3}{4}Z^{-3} + \frac{1}{8}Z^{-4} + \frac{1}{2}Z^{-5} + Z^{-6}$ with minimum number of multipliers. [8+8]

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

Answer any FIVE Questions
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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) If $x(n) \rightarrow x(e^{j\omega})$ Constitute a Fourier transform pair. Prove the following:
   Sequence Fourier Transform
      i. Re[x(n)] $X * (e^{j\omega})$
      ii. $x_e(n)$ $Re[X(e^{j\omega})$
   (b) i. Discuss the frequency-domain representation of discrete-time systems and and signals.
      ii. Comment on the importance and significance of difference equations to specify a system.

   [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) Let x(n) be a real valued sequence with N-points and Let X(K) represent its DFT , with real and imaginary parts denoted by $X_R(K)$ and $X_1(K)$ respectively. So that X(K) = $X_R(K) + JX_1(K)$. Now show that if x(n) is real, $X_R(K)$ is even and $X_1(K)$ is odd.
   (b) Compute the FFT of the sequence x(n) = { 1, 0, 0, 0, 0, 0, 0, 0 } [8+8]

5. (a) With reference to Z-transform, state the initial and final value theorem.
   (b) Determine the causal signal x(n) having the Z-transform $X(Z) = \frac{Z^2+Z}{\left(Z-\frac{1}{2}\right)^2\left(Z-\frac{1}{4}\right)}$.
   [6+10]

6. Determine the system function H(Z) of the lowest order Chebyshev digital filter that meets the following specifications.

   (a) 1 db ripple in the passband $0 \le |W| \le 0.3\pi$

(b) At least 60 db attenuation in the stopband $0.35\pi \leq |W| \leq \pi$. Use the bilinear transformation. [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) Realize an FIR filter with impulse response h(n) given by $h\left(n\right) = \left(\frac{1}{2}\right)^{n}\left[u\left(n\right) - u\left(n-5\right)\right]$

   (b) A system is described by it's transfer function H(Z) given by $H\left(Z\right) = 4 + \frac{3Z}{Z-\frac{1}{2}} - \frac{1}{Z-\frac{1}{4}}]$ [8+8]

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