No. of Printed Pages : **3**

Sl. No.

CE1.1-R4 : DIGITAL SIGNAL PROCESSING

NOTE :
1. **Answer question 1 and any FOUR from questions 2 to 7.**
2. **Parts of the same question should be answered together and in the same sequence.**

Time : 3 Hours **Total Marks : 100**

1. (a) A system is given as $y(n) = |x(n)|$. Determine whether it is stable, causal, linear or time-invariant.

(b) Evaluate the step response for the LTI system represented by the impulse response

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

(c) Compute the convolution $y(n) = h(n) * x(n)$ for the following signals, $x(n) = (0.8)^n u(n)$ and $h(n) = (0.4)^n u(n)$

(d) Determine the z-transform of the signal $x(n) = nu(n)$.

(e) Determine and sketch the magnitude and phase response of the following system $y(n) = x(n) - x(n-10)$

(f) If $x(n)$ has a N-point DFT $X(k)$, find the N point DFT of the signal

$$y(n) = \cos\left(\frac{2\pi n}{N}\right) x(n)$$

(g) Perform the circular convolution of the following two sequences.
$x_1(n) = \delta(n) + 2\delta(n-1) + 2\delta(n-2)$
$x_2(n) = \delta(n) + 2\delta(n-1) + 3\delta(n-2) + 4\delta(n-3)$

(7x4)

2. (a) A causal LTI system has a system function

$$H(z) = \frac{1}{1 - 1.04z^{-1} + 0.98z^{-2}}$$

(i) Is this system stable ?

(ii) If the coefficients are rounded to nearest tenth, then would the resulting system be stable ?

(b) Design a Chebyshev IIR digital low-pass filter to satisfy the following specifications :

$0.707 \le |H(\omega)| \le 1, \qquad 0 \le |\omega| \le 0.2\pi$

$|H(\omega)| \le 0.1, \qquad 0.5\pi \le |\omega| \le \pi$

Using bilinear transformation and assuming $T = 1s$

(c) Determine the variance of the noise generated by the analog-to-digital quantization noise at the output of a first-order stable digital filter with transfer function

$$H(z) = \frac{1}{1 - az^{-1}}$$

(5+8+5)

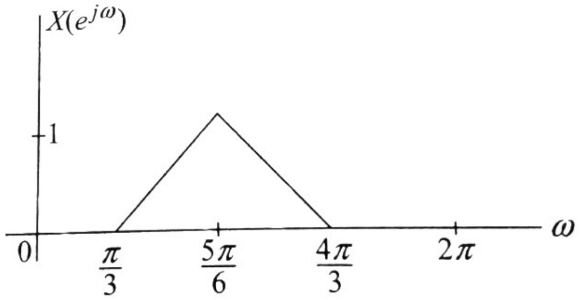
3. (a) Design a eighth order high-pass FIR filter using Hamming window, with a cutoff frequency of 1.2 rad/sec.

(b) Explain the various addressing modes used in DSP processors.

(c) Explain the Von Neumann and Harvard architectures in brief.

(8+5+5)

4. (a) Consider the sequence $x(n)$ with $X(e^{j\omega})$ as shown in the figure. Let $y(n) = x(2n)$ be the down sampled version of $x(n)$. Show how we can recover $x(n)$ from $y(n)$ using filters and multirate building blocks.



(b) A frequently used model for the generation of echo is $y(n) = \sum_{k=0}^{\infty} \alpha_k x[n-kT]$, where $x(n)$ is the digitized version of the original music signal, T is the interval between echoes and α_k is the gain for the k-th echo of the original signal. Show that the comb filter with system function $H(z) = \frac{1}{1-az^{-1}}$ can be used to generate artificial echoes. Also give a possible realization of the system.

(9+9)

5. (a) An LTI system is described by the difference equation.

$$y(n) - \frac{9}{4}y(n-1) + \frac{1}{2}y(n-2) = x(n) - 3x(n-1)$$

Specify the ROC of H(z) and determine $h(n)$ for the following conditions

(i) The system is stable

(ii) The system is causal.

(b) Consider a 4-point sequence $x(n) = \{\underset{\uparrow}{1}, 2, 3, 4\}$. Use Goertzel algorithm to compute DFT coefficient X(k) at frequency bin $k = 1$

(c) Using the signal flow graph method DIF-FFT, determine the 8-point DFT of the sequence $x(n) = \{1,1,1,1\}$. Show the intermittent values of the graph.

(6+6+6)

6. (a) A FIR digital filter is characterized by the following transfer function (filter length M = 11)

$$H(z) = \sum_{n=0}^{M-1} h(n) z^{-n}$$

Determine the amplitude response and show that phase and group delay of the causal filter are constant.

(b) Show how an inverse DFT can be obtained by using direct DFT method. Draw the signal flow graph for a 4-point DFT by DIT-FFT algorithm. Explain how the same signal flow graph can be used to compute inverse DFT.

(9+9)

7. (a) Show that with $x(n)$ as a N-point sequence and X(k) as its N-point DFT,

$$\sum_{n=0}^{N-1} |x(n)|^2 = \frac{1}{N} \sum_{k=0}^{N-1} |X(k)|^2$$

(b) Determine the lattice coefficients corresponding to the FIR system with the system function

$H(z) = 1 + \frac{7}{9} z^{-1} + \frac{3}{5} z^{-2}$, and realize it.

(c) Obtain the direct form-I and direct form-II realizations of the LTI system governed by the equation

$$y(n) = -\frac{13}{12} y(n-1) - \frac{9}{24} y(n-2) - \frac{1}{24} y(n-3) + x(n) + 4x(n-1) + 3x(n-2)$$

(5+6+7)

- o O o -