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) Find the convolution of two sequences $x(n) = \alpha^n u(n)$ and $h(n) = \beta^n u(n)$ when $\alpha = \beta$.

(b) Consider a system described by the difference equation $y[n] = \frac{1}{9}[y(n+1) - x(n+1)]$ and $y(n) = 0$ for $n > 0$. Find the impulse response of the system.

(c) Consider a system whose output y(n) is related to the input x(n) by

$$y(n) = \sum_{k=-\infty}^{\infty} x(k)x(n+k)$$

Determine whether or not the system is (i) linear,(ii) shift-invariant .

(d) Determine the z-transform of the signal $x(n) = 2^n u(n) + 3(\frac{1}{2})^n u(n)$.

(e) Compute the N point DFT of the signal $x(n) = u(n) - u(n - n_0)$, $0 < n_0 < N$.

(f) Let $x(n)$ be a left-sided sequence that is equal to zero for $n > 0$. If

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

find $x(0)$.

(g) Perform the circular convolution of the following two sequences :

$x_1(n) = \delta(n) + 3\delta(n-2) + \delta(n-3)$
$x_2(n) = 0.5\delta(n) + \delta(n-1) + \delta(n-3) + 6\delta(n-4)$

(7×4)

2. (a) Consider the sequence $x(n) = \delta(n) + 2\delta(n-2) + \delta(n-3)$

(i) Find the four point DFT of $x(n)$.

(ii) If $y(n)$ is the four point circular convolution of $x(n)$ with itself, find $y(n)$ and the four point DFT $Y(k)$.

(b) A causal discrete-time LTI system is described by

$$y(n) - \frac{3}{4}y(n-1) + \frac{1}{8}y(n-2) = x(n)$$

where $x(n)$ and $y(n)$ are the input and output of the system, respectively.

(i) Determine the system function H(z) for causal system function.

(ii) Find the impulse response h(n) of the system.

(iii) Find the step response of the system.

(8+10)

3. (a) Derive the filter coefficient updating equation using recursive least square (RLS) adaptivealgorithm.

(b) Design an IIR low-pass Chebyshev filter using impulse-invariant method for the following specifications:

Passband: $0.75 \leq |H(e^{j\omega})| \leq 1 \quad 0 \leq \omega \leq 0.25\pi$

Stopband: $|H(e^{j\omega})| \leq 0.230.63\pi$ s$\leq |\omega| \leq \pi$

and sampling frequency is 8kHz.

(10+8)

4. (a) Design a fourth order high-pass linear phase FIR filter using Hanning window for cut-off frequency =1.5 rad/sample.

(b) Suppose that a digital image is subjected to histogram equalization. Show that a second pass of histogram equalization will produce exactly the same result as the first pass.

(10+8)

5. (a) Explain the address generation unit in DSP processor with the help of block diagram.

(b) Compute the 8-point DFT of the sequence

$x(n) = \delta(n) + 2\delta(n-1) + \delta(n-2) + 2\delta(n-3) + \delta(n-4) + 2\delta(n-5) + \delta(n-6) + 2\delta(n-7)$

using the radix-2 DIF-FFT algorithm. Show all intermediate results.

(c) What are the architectural features of Digital signal processor thatdistinguishes from a microprocessor?

(6+8+4)

6. (a) Derive the expression of magnitude and phase response of symmetrical liner phase FIR filter with even value of filter length.

(b) The transfer function of an IIR filter is given by $H(z) = \dfrac{0.3(1-0.25z^{-2})}{1+0.1z^{-1}-0.72z^{-2}}$.

Draw the realization diagram for each of the following cases:

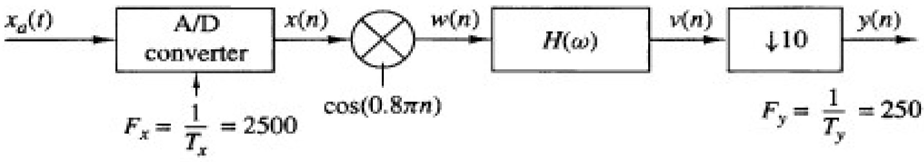
(i) Cascade form

(ii) Direct form I and II

(9+9)

7. (a) Determine the system function H(z) and the difference equation for the system that uses the Goertzel algorithm to compute the DFT value X(N-k).

(b) An analog signal $x_a(t)$ is band limited to the range $900 \leq F \leq 1100$ Hz. It is used as an input to the system shown in the figure given below. In this system, $H(\omega)$ is an ideal low pass filter with cutoff frequency $F_c = 125$ Hz.



(i) Determine and sketch the spectra for the signals $x(n), w(n), v(n)$, and $y(n)$.

(ii) Show that it is possible to obtain $y(n)$ by sampling $x_a(t)$ with period $T = 4$ Milliseconds.

(8+10)