DIGITAL SIGNAL PROCESSING
(ECEN 3102)

Time Allotted : 2½ hrs **Full Marks : 60**

Figures out of the right margin indicate full marks.

Candidates are required to answer Group A and any 4 (four) from Group B to E, taking one from each group.

Candidates are required to give answer in their own words as far as practicable.

Group – A

1. Answer any twelve: **12 × 1 = 12**

Choose the correct alternative for the following

(i) The N-point DFT of a finite length signal $x(n) = \delta(n)$ is
(a) 0 (b) 1 (c) z^{-1} (d) W_N.

(ii) The ROC of signal $x(n) = a^n$ for $-5<n<5$ is
(a) entire z plane (b) entire z plane except z=0 and z= ∞
(c) entire z plane except z=0 (d) entire z plane except z=∞.

(iii) Which type of filter has impulse response $h(n)= (1/2)^n u(n)$?
(a) LPF (b) BPF (c) HPF (d) APF.

(iv) Total number of complex multiplications required in radix-2 DIT-FFT algorithm is
(a) $N \log_2 N$ (b) $(N/2)\log_2 N$ (c) $\log_2 N$ (d) N(N-1).

(v) The poles of Chebyshev filter lies
(a) on the ellipse (b) on the circle
(c) on the hyperbola (d) none of the above.

(vi) If the input x(n)= [1,4,7] and the output y(n)=[-1,-4]?
(a) y(n) +4 y(n-1) +7 y(n-2)= x(n)+4x(n-1)
(b) y(n) +4 y(n-1) +7 y(n-2)= - x(n) - 4x(n-1)
(c) y(n) - 4 y(n-1) - 7 y(n-2)= x(n)+4x(n-1)
(d) y(n) - 4 y(n-1) +7 y(n-2)= x(n)- 4x(n-1).

(vii) Determine the number of complex additions required for 32 points direct computations of DFT.
(a) 240 (b) 56 (c) 854 (d) 992

(viii) If X(k) consists of N number of frequency samples, then its discrete frequency locations are given by
(a) F_s/N (b) N (c) kF_s/N (d) N/F_s.

(ix) IIR filters are designed by considering all the
(a) infinite sample of frequency response
(b) finite sample of impulse response
(c) infinite sample of impulse response
(d) all of above.

(x) The zeros of Butterworth filters exists at
(a) infinity (b) origin
(c) left half of s plane (d) right half of s plane.

Fill in the blanks with the correct word

(xi) The length of a sequence x(n) is M and length of sequence h(n) is N. Circular convolution of the sequences x(n) and h(n) being y(n), length of y(n) is _____ (given M>N).

(xii) The poles of an FIR filter always lie at _____.

(xiii) The distortion in frequency axis due to nonlinear relationship between analog and digital frequency is called _____.

(xiv) The rectangular window has a relative side-lobe level of _____.

(xv) To avoid aliasing of output spectrum of decimator for decimation by D, the input spectrum is _____ to π/D.

Group - B

2. (a) Given a discrete system having zero at z=0.5, poles at z=2 and z=-3. Determine the (i) transfer function H(z) of the system (ii) impulse response of the system. (iii) Comment on the causality and stability of the system. *[(CO1)(Analyze/IOCQ)]*

(b) Given impulse response of a system given as
$h(n)=\delta(n+2)+ 2.\delta(n+1)-\delta(n-1)+ 3\delta(n-2)+ 2\delta(n-3)$
(i) Represent the impulse response of the system graphically. (ii) Determine the z-transform of h(n). *[(CO1)(Evaluate/HOCQ)]*

(3 + 3 + 2) + (2 + 2) = 12

3. (a) State the relation between input, x(n) and output, y(n) of a system with impulse response, h(n). *[(CO2)(Understand/LOCQ)]*

(b) Given a system with impulse response h(n)=u(n). The input fed to the system, x(n)=u(n). Determine the output of the system. *[(CO2)(Evaluate/HOCQ)]*

(c) For a given system with impulse response h(n), (i) state the condition of h(n) for which the system would be stable. (ii) if $h(n)= \left(\frac{1}{5}\right)^n u(n)$, determine whether the system is causal and/or stable. *[(CO2)(Analyze/IOCQ)]*

2 + 4 + (2 + 4) = 12

Group - C

4. (a) State and explain the sampling interval on the frequency axis for an 8-point DFT and 16-point DFT. *[(CO3)(Understand/LOCQ)]*

(b) Consider a finite length sequence $x(n)=\delta(n)-3\delta(n-4)$, with a 10-point DFT X(k). Determine (i) the sequence that has a DFT, $Y_1(k)=X(k)\ e^{-j\frac{2\pi}{10}.3k}$ and (ii) the sequence that has a DFT, $Y_1(k)=X(k)\ e^{-j\frac{2\pi}{10}.7k}$ *[(CO3)(Apply/IOCQ)]*

(c) Explain the computational benefits of FFT algorithms in calculating DFTs. *[(CO3)(Remember/LOCQ)]*

3 + (3 + 3) + 3 = 12

5. (a) Compute the circular convolution of following sequence
$x_1(n) = \delta(n) + \delta(n-1) - \delta(n-2) - \delta(n-3)$
$x_2(n) = \delta(n) - \delta(n-2) + \delta(n-4)$
using matrix multiplication method. *[(CO3)(Apply/IOCQ)]*

(b) Compute the 8 point DFT of sequence $x(n) = \cos(n\pi/2)$ using radix 2 DIT-FFT algorithm. *[(CO3)(Apply/IOCQ)]*

6 + 6 = 12

Group - D

6. (a) What are the advantage of Chebyshev filter over Butterworth filter. *[(CO4)(Remember/LOCQ)]*

(b) Determine the poles of lowpass filter for N=3. Sketch the location of poles on s plane and hence determine the normalizied transfer function. *[(CO4)(Analyse/HOCQ)]*

(c) The normalized transfer function of an analog filter is given by $H(s_n) = 1/(s_n^2 +1.4142\ s_n +1)$. Convert the analog filter to digital filter with cutoff frequency of 0.4π, using bilinear transformation method. *[(CO4)(Apply/IOCQ)]*

4 + 6 + 2 = 12

7. (a) Differentiate between IIR filters and FIR filters. *[(CO4)(Analyze/IOCQ)]*

(b) A digital Butterworth filter has to be designed using bilinear transformation. The filter specifications are as follows:

$$0.9 \le \left|H(e^{i\omega})\right| \le 1 \qquad 0 \le \omega \le 0.5\pi$$

$$\left|H(e^{j\omega})\right| \le 0.2 \qquad 0.75\pi \le \omega \le \pi$$

Determine the filter order N and the cut-off frequency ω_c. *[(CO4)(Apply/IOCQ)]*

(c) Explain the concept of warping effect w.r.t. bilinear transformation. *[(CO4)(Remember/IOCQ)]*

4 + (3 + 3) + 2 = 12

Group - E

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

$$y(n) = 3y(n-1) + x(n) + 4x(n-1)$$

Realize it in direct form I structure. *[(CO5)(Analyze/IOCQ)]*

(b) Design the filter having transfer function given as

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

using Direct-Form II realization of filter. *[(CO5)(Analyze/IOCQ)]*

6 + 6 = 12

9. (a) Realize the system given by difference equation y(n) = (¾) y(n-1) – (1/8) y(n-2) + x(n) +(1/3) x(n-2) in cascaded form. *[(CO5,CO4)(Apply/IOCQ)]*

(b) Explain in detail the architecture of TMS 320C6713 DSP processor. *[(CO5,CO6)(Remembering/LOCQ)]*

(c) What do mean by interpolator and decimator? *[(CO5)(Understand/LOCQ)]*

4 + 6 + 2 = 12

Cognition Level	LOCQ	IOCQ	HOCQ
Percentage distribution	20.83	64.58	14.58

Course Outcome (CO):

After the completion of the course students will be able to

1. Recall the concepts of trigonometry, complex algebra, Fourier transform to analyze different signals and systems.
2. Apply the concept of z-transformation, convolution to determine the transfer function of a system and evaluate the output of the system.
3. Extend the knowledge of discrete-time Fourier transform to interpret DFT, FFT and apply the concept as a frequency transformation tool.
4. Design transfer functions of IIR/FIR filters applying transformation techniques/windowing methods.
5. Construct and model digital filters from their transfer function, develop concept of multirate signal processing and architecture of digital signal processor.
6. Develop a thorough understanding of the central elements of digital signal processing theory and apply this theory to real-world signal processing applications..

**LOCQ: Lower Order Cognitive Question; IOCQ: Intermediate Order Cognitive Question; HOCQ: Higher Order Cognitive Question.*