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 step response of LTI system when the impulse response h(n) is unit step u(n) is
(a) n+1 (b) n-1 (c) n (d) n^2

(ii) If the z- transform of x(n) is X (z) with ROC |z| >R,then the z- transform of a^n x(n), a> 0 and its ROC are
(a) X (z/a), |z| > a R (b) X (z/a), |z| > R/a
(c) X (az), |z| <a R (d) X (az), |z| < R/a

(iii) Which of the following is true regarding the number of computations required to compute an N-point DFT?
(a) N^2 complex multiplications and N(N-1) complex additions
(b) N^2 complex additions and N(N-1) complex multiplications
(c) N^2 complex multiplications and N(N+1) complex additions
(d) N^2 complex additions and N(N+1) complex multiplications.

(iv) If x(n) is a real sequence and X(k) is its N-point DFT, then which of the following is true?
(a) X(N-k)=X(-k) (b) X(N-k)=X*(k)
(c) X(-k)=X*(k) (d) All of the mentioned.

(v) If g(n) is a real valued sequence of 2N points and $x_1(n)=g(2n)$ and $x_2(n)=g(2n+1)$, then what is the value of G(k), k=0,1,2…N-1?
(a) $X_1(k)-W_2^kNX_2(k)$ (b) $X_1(k)+W_2^kNX_2(k)$
(c) $X_1(k)+W_2^kX_2(k)$ (d) $X_1(k)-W_2^kX_2(k)$.

(vi) The main lobe width of length M rectangular window is
(a) $\frac{4\pi}{M}$ (b) $\frac{8\pi}{M}$ (c) $\frac{12\pi}{M}$ (d) variable.

(vii) The mapping in the bilinear transformation is
(a) one-to-one (b) one-to-many
(c) many-to-one (d) many-to-many.

(viii) The poles of a Butterworth filter lie on a/an
(a) Circle (b) Parabola (c) Ellipse (d) Helix.

(ix) What is the process of increasing the sampling rate by a factor D?
(a) Sampling (b) Interpolation
(c) Decimation (d) None of the mentioned.

(x) The TMS320 C4X is a _____ processor.
(a) fixed-point (b) floating-point
(c) multiprocessor (d) none of the above

Fill in the blanks with the correct word

(xi) The _____ of X(z) is the set of all value of z, for which X(z) attains a finite value.

(xii) For a sequence x(n) of length M, h(n) of length N , the length of the sequence resulting from circular convolution of x(n) and h(n) is _____ (given M>N)

(xiii) The FIR filters have _____ phase response.

(xiv) The length of the filter having transfer function, $H(z) = 2 + 1.z^{-1} + 3.z^{-3} + 2.z^{-10}$ is _____.

(xv) In sampling rate conversion by rational factor, _____ is performed first.

Group - B

2. (a) Two discrete time signal x(n) and h(n) are both nonzero only for n = 0,1,2 and are zero otherwise. It is given that x(0) =1 , x(1) = 2 , x(2) = 1 and h(0) =1.If y(n) be the linear convolution of x(n) and h(n) ,then find the value of expression 10 y(3) + y(4) where y(1) =3 and y(2)= 4. *[(CO2)(Analyse/HOCQ)]*

(b) Determine the convolution of the pair of signals by means of the z-transform x 1(n) = $(1/2)^n$ u(n) ; x2(n) = cos (nπ) u(n) for |z| > 1. *[(CO2)(Apply/LOCQ)]*

6 + 6 = 12

3. (a) Find the inverse z-transformation of X(z)= $= \frac{z(z+1)}{(z-1)(z-3)}$.For 1 < |z| < 3 using
(i) Partial fraction method. (ii) Convolution method. *[(CO2)(Apply/IOCQ)]*

(b) Find the difference equation satisfying the input and output of an LTI system with transfer function:
H(z) = $\frac{(1+z^{-1})^2}{(1-z^{-1})(1+\frac{3}{4}z^{-1})}$ *[(CO2)(Apply/IOCQ)]*

8 + 4 = 12

Group - C

4. (a) What is FFT? Explain that computational efficiency is high as compared to DFT *[(CO3)(Remember/LOCQ)]*

(b) What are the FFT algorithms? Mention the difference between them. *[(CO3)(Understand/LOCQ)]*

(c) Draw the butterfly diagram of DIF algorithm and find out 4 point DFT of $x(n) = \{\underset{\uparrow}{0},1,2,3\}$. *[(CO3)(Apply/IOCQ)]*

4 + 4 + 4 =12

5. (a) A length-8 sequence is given by $x(n) = \{\underset{\uparrow}{-4},5,2,-3,0,-2,3,4\}$, $0 \le n \le 7$, with an 8-point DFT given by X(k). Determine the sequence y(n) whose 8-point DFT is given by $Y(k) = e^{-\frac{j2\pi 3k}{4}} X(k)$. *[(CO3)(Analyse/IOCQ)]*

(b) Find x(n) whose 4 point DFT is $X(k) = \{\underset{\uparrow}{6},-2+2i,-2,-2-2i\}$. *[(CO3)(Analyse/IOCQ)]*

6 + 6 = 12

Group - D

6. (a) Compare between IIR Digital filter and FIR Digital filter. *[(CO4)(Analyse/IOCQ)]*

(b) A digital Butterworth filter has to be designed using bilinear transformation. The filter specifications are as follows:
$0.8 \le |H(e^{j\omega})| \le 1$ $0 \le \omega \le 0.2\pi$
$|H(e^{j\omega})| \le 0.2$ $0.6\pi \le \omega \le \pi$
Find the filter order N and cut-off frequency. *[(CO4)(Apply/IOCQ)]*

(c) State the disadvantage of impulse invariant technique. *[(CO4)(Understand/LOCQ)]*

(d) Evaluate the digital transfer function H(z) by using impulse invariant method for the analog transfer function H(S) = 1/ (s+2).Assume T=0.5sec. *[(CO4)(Apply/IOCQ)]*

3 + 4 + 2 + 3 = 12

7. (a) Compare Butterworth and Chebyshev filters. *[(CO4)(Analyse/IOCQ)]*

(b) For the transfer function
$H(s) = \frac{1}{s^2+\sqrt{2}s+1}$
find the corresponding system function H(z) using bilinear transform. *[(CO4)(Analyse/IOCQ)]*

(c) Derive the relationship between analog and digital frequency using bilinear transformation. *[(CO2)(Remember/LOCQ)]*

3 + 5 + 4 = 12

Group - E

8. Obtain the Direct Form-I and Direct Form-II realization for the system described by difference equation
$y(n) = -0.1y(n-1)+0.2y(n-2)+3x(n)+3.6x(n-1)+0.6x(n-2)$ *[(CO6)(Apply/IOCQ)]*

(6 + 6) = 12

9. (a) Discuss the role of anti-aliasing filters in decimation and anti-imaging filters in interpolation. Why are these filters important, and how do they impact the overall signal quality? *[(CO5)(Analyse/HOCQ)]*

(b) Illustrate the concept of multistage decimation and interpolation. *[(CO5)(Remember/LOCQ)]*

8 + 4 = 12

Cognition Level	LOCQ	IOCQ	HOCQ
Percentage distribution	25	60.42	14.58