

**DIGITAL SIGNAL PROCESSING & APPLICATIONS
(AEI3103)**

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) An LTI discrete time system is causal if and only if,
 (a) $h(n) \neq 0$ for $n < 0$ (b) $h(n) = 0$ for $n < 0$
 (c) $h(n) \neq \infty$ for $n < 0$ (d) $h(n) \neq 0$ for $n > 0$
- (ii) The sampling is the process of conversion of continuous time signal into
 (a) digital signal (b) unit impulse signal
 (c) unit step signal (d) discrete time signal
- (iii) The Z-transform is a,
 (a) finite series (b) infinite power series
 (c) geometric series (d) both (a) and (c)
- (iv) The ROC of the sequence $x(n) = u(-n)$ is,
 (a) $|z| > 1$ (b) $|z| < 1$
 (c) no ROC (d) $-1 < |z| < 1$
- (v) If the Z-transform of $x(n)$ is $X(z)$, then Z-transform of $(0.5)^n x(n)$ is,
 (a) $X(0.5z)$ (b) $X(0.5^{-1}z)$
 (c) $X(2^{-1}z)$ (d) $X(2z)$
- (vi) The DFT of product of two discrete time sequences $x_1(n)$ and $x_2(n)$ is equivalent to,
 (a) $\frac{1}{N} [X_1(k) \otimes X_2(k)]$ (b) $\frac{1}{N} [X_1(k) \otimes X_2^*(k)]$
 (c) $\frac{1}{N} [X_1(k)X_2(k)]$ (d) $X_1(k) \otimes X_2(k)$
- (vii) The number of complex additions and multiplication in FFT are, respectively
 (a) $\frac{N}{2} \log_2 N$ and $N \log_2 N$ (b) $N \log_2 N$ and $\frac{N}{2} \log_2 N$
 (c) $\frac{N}{2} \log_2 N$ and $\frac{N}{2} \log_2 N$ (d) $N \log_2 N$ and $N \log_2 N$
- (viii) The frequency response of a digital filter is periodic in the range
 (a) $0 < \omega < 2\pi$ (b) $-\pi < \omega < \pi$
 (c) $0 < \omega < \pi$ (d) $0 < \omega < 2\pi$ or $-\pi < \omega < \pi$

- (ix) The poles of Butterworth transfer function symmetrically lie on a circle in s-plane with angular spacing
 (a) $\frac{\pi}{N}$ (b) $\frac{\pi}{2N}$
 (c) $\frac{2\pi}{N}$ (d) $\frac{\pi}{N^2}$
- (x) The linear phase realization is used in FIR systems in order to minimize,
 (a) multipliers (b) memory
 (c) delays (d) adders

Fill in the blanks with the correct word

- (xi) In a discrete time signal $x(n)$, if $x(n) = x(-n)$ then it is called _____.
- (xii) When a system output at time n depends on past output values, it is called _____ system.
- (xiii) The smallest value of N for which $x(n + N) = x(n)$ is true is called _____.
- (xiv) The tolerance in the passband and stop band are called _____.
- (xv) In linear phase filters when impulse response is antisymmetric and N is even, the magnitude function is _____.

Group - B

2. (a) What is Nyquist rate? [[CO1](Remember/LOCQ)]
 (b) Consider the analog signals, $x(t) = 4\cos 2\pi(30t)$ and $x(t) = 4\cos 2\pi(5t)$. Find a sampling frequency so that 30 Hz signal is an alias of 5 Hz signal? [[CO1](Apply/IOCQ)]
 (c) Determine the even and odd parts of the signal $x(n) = 3e^{j\frac{\pi}{5}n}$. [[CO1](Analyze /IOCQ)]
 (d) Determine if the system $y(n) = x(n) + \frac{1}{x(n-1)}$ described by the following input-output equations is linear or non-linear. [[CO2](Analyze /IOCQ)]
2 + 3 + 3 + 4 = 12

3. (a) Consider the analog signal $x(t) = 2 \sin 80\pi t$. If the sampling frequency is 60 Hz, Find the sampled version of discrete time signal $x(n)$. Also find an alias frequency corresponding to $F_s = 60$ Hz. [[CO1](Apply/IOCQ)]
 (b) Determine whether the signal $x(n) = \sin\left(\frac{\pi}{4}n\right)$ is energy or power signal [[CO1](Analyze /IOCQ)]
 (c) Test the stability of the system whose impulse response is $h(n) = 0.2^n u(n) + 4^n u(-n)$ [[CO2](Analyze/IOCQ)]
5 + 4 + 3 = 12

Group - C

4. (a) Determine the Z-transform and their ROC of the discrete time signal $x(n) = (0.6)^n u(n) + (0.7)^n u(-n - 1)$. [[CO3](Apply/IOCQ)]

- (b) Determine the impulse response $h(n)$ for the system described by the second-order difference equation, $y(n) + 4y(n - 1) + 3y(n - 2) = x(n - 1)$. [[CO3](Apply/IOCQ)]
- (c) If $Z\{x_1(n)\} = X_1(z)$ and $Z\{x_2(n)\} = X_2(z)$, then prove that $Z\{x_1(n)x_2(n)\} = \frac{1}{2\pi j} \oint_c X_1(V)X_2\left(\frac{z}{v}\right)v^{-1}dv$. [[CO3](Analyze/IOCQ)]
- 4 + 4 + 4 = 12**
5. (a) Find the Z-transform and its ROC of the discrete time signal $x(n) = (n + 0.5)\left(\frac{1}{3}\right)^n u(n)$. [[CO3](Apply/IOCQ)]
- (b) If $X(z) = Z\{x(n)\}$ and the initial conditions for $x(n)$ are zero, then prove that $Z\{x(n - m)\} = z^{-m}X(z)$. [[CO4](Analyze/IOCQ)]
- (c) Determine the transfer function and impulse response for the systems described by the equation $y(n) - \frac{7}{4}y(n - 1) + \frac{5}{8}y(n - 2) = 2x(n)$. [[CO2](Apply/IOCQ)]
- 5 + 2 + 5 = 12**

Group - D

6. (a) Find the circular convolution of two finite duration sequences $x_1(n) = \{1, -1, -2, 3, -1\}$ and $x_2(n) = \{1, 2, 3\}$ using concentric circle method. [[CO4](Apply/IOCQ)]
- (b) Compute the N point DFT of $x(n) = \delta(n)$. [[CO4](Understand/LOCQ)]
- (c) Compare the DIT and DIF radix-2 FFT. [[CO4](Understand/LOCQ)]
- 6 + 2 + 4 = 12**
7. (a) Define Short Time Fourier Transform (STFT). Write down the advantage and disadvantage of STFT. [[CO4](Understand/LOCQ)]
- (b) Find the IDFT of the sequence $X(k) = \{10, -2 + j2, -2 - 2 - j2\}$ using FFT algorithm. [[CO4](Apply/IOCQ)]
- (2 + 2 + 2) + 6 = 12**

Group - E

8. (a) State some advantages of digital filters. [[CO5](Understand/LOCQ)]
- (b) What are the requirements for a digital filter to be stable and causal? [[CO5](Understand/LOCQ)]
- (c) The frequency response of a digital filter is, $H(e^{j\omega}) = (0.7 + 0.6 \cos \omega - 0.9 \cos 2\omega)e^{-j7.5\omega}$. Determine the phase delay and group delay. [[CO5](Apply/IOCQ)]
- (d) What are the possible types of impulse response for Linear phase FIR filters? [[CO5](Remember/LOCQ)]
- 2 + 3 + 4 + 3 = 12**
9. (a) What are the possible types of impulse response for linear phase FIR filters? [[CO5](Remember/LOCQ)]
- (b) What is the need for employing window technique for FIR filter design? [[CO5](Analyze/IOCQ)]

(c) What is Gibbs phenomenon?

[(CO5)(Apply/IOCQ)]

(d) Explain the characteristics of rectangular window with typical sketches.

[(CO5)(Analyze/IOCQ)]

2 + 3 + 2 + 5 = 12

Cognition Level	LOCQ	IOCQ	HOCQ
Percentage distribution	25	75	0