M.TECH/AEIE/1ST SEM/AEIE 5101/2021

ADVANCED DIGITAL SIGNALS AND SYSTEMS
(AEIE 5101)

Time Allotted : 3 hrs **Full Marks : 70**

Figures out of the right margin indicate full marks.

Candidates are required to answer Group A and any 5 (five) from Group B to E, taking at least one from each group.

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

Group – A
(Multiple Choice Type Questions)

1. Choose the correct alternative for the following: **10 × 1 = 10**

(i) The operation $x(n) * \delta(n - n_0)$ generates an output
(a) $x(n + n_0)$ (b) $x(n - n_0)$
(c) $x(-n + n_0)$ (d) $x(-n - n_0)$

(ii) Which of the following system is causal?
(a) $y(n) = x(-n) - x(2n - 1)$ (b) $y(n) = x^2(n) - x(n + 1)$
(c) $h(n) = n\left(\frac{1}{2}\right)^n u(n)$ (d) $h(n) = n\left(\frac{1}{2}\right)^n u(n + 1)$

(iii) The system with impulse response $h(n) = 2^n u(\mathrm{n} - 1)$ is
(a) stable (b) BIBO stable
(c) unstable (d) marginally stable

(iv) The impulse response of a LTI system is $h(n) = \{1,1,1\}$. What is the response of the signal to the input $x(n) = \{1,2,3\}$?
(a) {1,3,6,3,1} (b) {1,2,3,2,1}
(c) {1,3,6,5,3} (d) {1,1,1,0,0}

(v) Which operation is implemented by keeping every M-th sample of $x(n)$ and removing $M - 1$ in between samples to generate $y(n)$?
(a) Up-sampling (b) Down-sampling
(c) Both (a) and (b) (d) None of the above

(vi) If M and N are the orders of numerator and denominator of rational system function respectively, then how many additions are required in direct form-I realization of that IIR filter?
(a) M+N-1 (b) M+N
(c) M+N+1 (d) M+N+2

(vii) In an$N$ -point sequence, if $N = 16$, the total number of complex additions and multiplications using Radix-2 FFT are
(a) 64 and 80 (b) 64 and 32 (c) 80 and 64 (d) 24 and 12

(viii) How the sampling rate conversion is achieved by factor I/D?
(a) By increase in the sampling rate with I
(b) By filtering the sequence to remove unwanted images of spectra of original signal
(c) By decimation of filtered signal with factor D
(d) All of the above

(ix) Drawbacks FIR filters are:
(a) more computation than an IIR with similar effect
(b) prevent phase distortion
(c) less computation
(d) all of above

(x) Power spectral density function is a _____ .
(a) real and even function (b) non negative function
(c) periodic (d) all of the mentioned

Group - B

2. (a) A linear, time-invariant system can be completely characterized by its response to a unit impulse sequence. Why is this true? How do we obtain response to any arbitrary sequence?
[(CO1) (Understand/LOCQ)]

(b) Determine whether the following system is time variant or time invariant:
$y(n) = \log_{10}(|x(n)|)$. [(CO1) (Analyze/IOCQ)]

(c) Test whether the signal $x(n) = \cos(\frac{\pi}{4}n^2)$ is periodic or not. If periodic find the fundamental period. [(CO1) (Evaluate/HOCQ)]

4 + 4 + 4 = 12

3. (a) Compute the DFT of the following sequence and sketch the magnitude and phase spectrum: {1,2,2,1}. [(CO2) (Analyze/IOCQ)]

(b) What are the drawbacks of FFT? How it is overcome by short time Fourier transform? Write down expression of discrete wavelet transform and explain its significance. What are the applications of wavelet transform?
[(CO2) (Understand/LOCQ)]

6 + 6 = 12

Group – C

4. (a) Use backward difference derivative to convert the following analog filter transfer function$H(s) = \frac{1}{(s+0.1)^2+9}$ into digital filter transfer functions. Assume $T = 1$sec. [(CO3) (Analyze/IOCQ)]

(b) Design a 5-tap low pass FIR filter using rectangular window whose cut-off frequency is $\omega_c = \frac{\pi}{2}$ rad/s and desired frequency response is given by

$$H_d(e^{j\omega}) = \begin{cases} e^{-j\omega\tau} & for\ -\omega_c \le \omega \le \omega_c \\ 0 & for\ -\pi \le \omega \le -\omega_c. \\ 0 & for\ \omega_c \le \omega \le \pi \end{cases}$$

Find the values of the filter coefficients $h(n)$ and filter transfer function $H(z)$. [(CO3) (Evaluate/HOCQ)]

(c) What is Gibb's phenomenon? Explain the basic philosophy behind FIR filter design by windowing. [(CO3)(Understand/LOCQ)]

3 + 6 + 3 = 12

5. (a) What are the advantages of representing digital filters in block diagram form? [(CO4) (Understand/LOCQ)]

(b) State the main disadvantage of direct form realization of digital filters. Point out the main advantage of direct form-II realization over direct form-I realization. [(CO4) (Understand/LOCQ)]

(c) Construct the direct form-I and direct form-II structures of the following LTI system governed by the equation: $y(n) = -\frac{3}{8}y(n-1) + \frac{3}{32}y(n-2) + \frac{1}{64}y(n-3) + x(n) + 3x(n-1) + 2x(n-2)$. [(CO4)(Evaluate/HOCQ)]

2 + (2 + 1) + 7 = 12

Group - D

6. (a) With the help of block diagram explain the sampling rate conversion by a rational factor 'I/D'. Obtain necessary expressions. [(CO5) (Remember/LOCQ)]

(b) Given the sequence $x(n) = \{\ldots\ldots, 4, 3, \underline{2}, 6, 3, 5, 9, 4, \ldots\ldots\}$, find out the output $y(n)$ and $Y(z)$ of a down-sampler with down sampling factor 2. [(CO5) (Analyze/IOCQ)]

(c) What is poly phase decomposition of filter? Develop a two band poly-phase decomposition of the IIR filter having transfer function $H(z) = \frac{2+3.1z^{-1}+1.5z^{-2}}{1+0.9z^{-1}+0.8z^{-2}}$. [(CO5) (Evaluate/HOCQ)]

4 + 4 + 4 = 12

7. (a) What is adaptive filtering? Show a block diagram of basic adaptive filer structure. [(CO5) (Remember/LOCQ)]

(b) Illustrate, with a practical example, how adaptive filter may be used for noise cancellation. [(CO5) (Analyze/IOCQ)]

(c) Formulate weight updating rule using LMS algorithm of adaptive filter. [(CO5) (Evaluate/HOCQ)]

4 + 4 + 4 = 12

Group - E

8. (a) What is periodogram? [(CO6) (Remember/LOCQ)]
   (b) What are the non-parametric methods of power spectrum estimation? State the limitations of non-parametric methods of power spectrum estimation. [(CO6) (Remember /LOCQ)]
   (c) Determine the frequency resolution of the Bartlett, Welch and Blackman-Tukey methods of power spectrum estimation for quality factor $Q = 10$. Assume that overlap in Welch's method is 50%. Given the length of the sample sequence is 1000. [(CO6)(Analyse/IOCQ)]

2 + 4 + 6 = 12

9. (a) What is linear prediction? Give all pole linear prediction filter model expression and state its advantages on signal processing application. [(CO6) (Remember/LOCQ)]
   (b) Illustrate general Wiener filtering problem with a block diagram. Hence deduce the Wiener-Hopf equations for the FIR Wiener filter and the minimum mean square error. [(CO6) (Analyze/IOCQ)]

(2 + 2 + 2) + 6 = 12

Cognition Level	LOCQ	IOCQ	HOCQ
Percentage distribution	38%	34%	26%

Course Outcome (CO):

After the completion of the course students will be able to:

1. Characterize and analyze the properties of discrete time signals and systems.
2. Perform DFT, FFT and IDFT of a given discrete signal and learn STFT and DWT of discrete signal.
3. Design digital FIR and IIR filters according to the given specification.
4. Realize a digital filter structure from it's transfer function.
5. Understand theory of multirate DSP and adaptive filtering techniques, solve numerical problems.
6. Understand theory of prediction, solution of normal equations and methods of spectral estimation.

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

Department & Section	Submission Link
AEIE	https://classroom.google.com/c/NDA1NjY3NzE3NjI1/a/NDYzODcyNTAxOTQ4/details