INSTITUTE OF AERONAUTICAL ENGINEERING

(Autonomous)

Dundigal, Hyderabad - 500 043

ELECTRONICS AND COMMUNICATION ENGINEERING

TUTORIAL QUESTION BANK

Course Title	**DIGITAL SIGNAL PROCESSING**				
Course Code	AEC012				
Programme	B.Tech				
Semester	VI	ECE			
Course Type	Core				
Regulation	R16				
Course Structure	**Theory**			**Practical**	
	Lectures	**Tutorials**	**Credits**	**Practicals**	**Credits**
	3	1	4	-	-
Chief Coordinator	Dr. S China Venkateswarlu, Professor, ECE				
Course Faculty	Dr. G Manisha , Associate Professor, ECE Ms. S Sushma, Assistant Professor, ECE Mr. K Chaitanya, Assistant Professor, ECE				

COURSE OBJECTIVES:

The course should enable the students to:	
I	Provide background and fundamental material for the analysis and processing of digital signals and to familiarize the relationships between continuous-time and discrete-time signals and systems.
II	Study fundamentals of time, frequency and z-plane analysis and to discuss the inter-relationships of these analytic method and to study the designs and structures of digital (IIR and FIR) filters from analysis to synthesis for a given specifications.
III	Introduce a few real-world signal processing applications.
IV	Acquainting FFT algorithm, multi-rate signal processing techniques and finite word length effects.

COURSE OUTCOMES (COs):

Course Outcomes:	
CO 1	Interpret, represent and process discrete/digital signals and systems
CO 2	Understanding of time domain and frequency domain analysis of discrete time signals and systems
CO 3	Understand DFT for the analysis of digital signals & systems

CO 4	Demonstrate and analyze DSP systems like FIR and IIR Filter
CO 5	Understand multi rate signal processing of signals through systems

COURSE LEARNING OUTCOMES (CLOs):

CLO 1	Understand how digital to analog (D/A) and analog to digital (A/D) converters operate on a signal and be able to model these operations mathematically.
CLO 2	Describe simple non-periodic discrete-time sequences such as the impulse and unit step, and perform time shifting and time-reversal operations on such sequences.
CLO 3	Given the difference equation of a discrete-time system to demonstrate linearity, time-invariance, causality and stability, and hence show whether or not a given system belongs to the important class of causal, LTI systems.
CLO 4	Given the impulse response of a causal LTI system, show whether or not the system is bounded-input/bounded-output (BIBO) stable.
CLO 5	Perform time, frequency and Z-transform analysis on signals.
CLO 6	From a linear difference equation of a causal LTI system, draw the Direct Form I and Direct Form II filter realizations.
CLO 7	Knowing the poles and zeros of a transfer function, make a rough sketch of the gain response.
CLO 8	Define the Discrete Fourier Transform (DFT) and the inverse DFT (IDFT) of length N.
CLO 9	Understand the inter-relationship between DFT and various transforms.
CLO 10	Understand the significance of various filter structures and effects of round-off errors.
CLO 11	Understand the fast computation of DFT and appreciate the FFT Processing.
CLO 12	Design of infinite impulse response (IIR) filters for a given specification.
CLO 13	Design of finite impulse response (FIR) filters for a given specification.
CLO 14	Compare the characteristics of IIR and FIR filters.
CLO 15	Understand the tradeoffs between normal and multi rate DSP techniques and finite length word effects.
CLO 16	Understand the signal interpolation and decimation, and explain their operation
CLO 17	Explain the cause of limit cycles in the implementation of IIR filters.

TUTORIAL QUESTION BANK

S. No	QUESTION	Blooms Taxonomy Level	Course Outcomes	Course Learning Outcomes	Course learning Outcome Codes
	UNIT-I **REVIEW OF DISCRETE TIME SIGNALS AND SYSTEMS**				
	PART-A (SHORT ANSWER QUESTIONS)				
1	Compare symmetric and anti symmetric signals.	Remember	CO 1	CLO1	AEC012.01
2	Discuss about impulse response?	Understand	CO 1	CLO2	AEC012.02
3	Describe an Liner Time Invariant system?	Understand	CO 1	CLO3	AEC012.03
4	List out the operations performed on the signals.	Remember	CO 1	CLO1	AEC012.01
5	State the condition for causality and stability?	Understand	CO 1	CLO2	AEC012.02
6	State the Sampling Theorem	Remember	CO 1	CLO3	AEC012.03
7	Express and sketch the graphical representations of a unit impulse, step and ramp signals	Understand	CO 1	CLO1	AEC012.01
8	List out the Applications of Digital Signal Processing?	Understand	CO 1	CLO2	AEC012.02
9	Describe the causal system and the non- causal system	Understand	CO 1	CLO3	AEC012.03
10	Discuss the advantages of Digital Signal Processing?	Remember	CO 1	CLO1	AEC012.01
11	Explicit about energy and power signals?	Remember	CO 1	CLO2	AEC012.02
12	State the condition for BIBO stable?	Remember	CO 1	CLO3	AEC012.03
13	Describe about Time invariant system and Time variant system.	Understand	CO 1	CLO1	AEC012.01
14	Draw the block diagram of Digital Signal Processing	Remember	CO 1	CLO2	AEC012.02
15	Solve the impulse response of a system as $h(k)=a^k u(k)$ determine the range of 'a' for which the system is stable.	Understand	CO 1	CLO3	AEC012.03
16	Discuss about memory and memory less system?	Understand	CO 1	CLO1	AEC012.01
17	Sketch the discrete time signal x(n) =4 δ (n+4) + δ(n)+ 2 δ (n-1) + δ (n-2)	Understand	CO 1	CLO2	AEC012.02
18	Prove the following are linear or non linear: a) $y(n)=e^{x(n)}$ b) $y(n)=x^2(n)$ c) $y(n)=ax(n)+b$ d) $y(n)=x(n^2)$	Understand	CO 1	CLO1	AEC012.01
19	Identify a time-variant system. a) $y(n)=e^{x(n)}$ b) $y(n)=x(n^2)$	Understand	CO 1	CLO2	AEC012.02

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	c) $y(n) = x(n) - x(n-1)$ d) $y(n) = nx(n)$				
20	List out the basic building blocks of realization structures?	Understand	CO 1	CLO3	AEC012.03
	PART-B (LONG ANSWER QUESTIONS)				
1	Obtain the impulse response and step response of the causal system given below and discuss on stability: y(n) + y(n–1) – 2y(n–2) = x(n–1)+2x(n–2)	Remember	CO 1	CLO1	AECB07.01
2	Test the following systems for linearity, time invariance, causality and stability. i. $y(n) = a^{\|x(n)\|}$ ii. y(n) = sin(2nfn/F) x(n)	Understand	CO 1	CLO2	AEC012.02
3	Evaluate the impulse response for the causal system y(n)-y(n-1) = x(n)+x(n-1)	Understand	CO 1	CLO3	AEC012.03
4	Analyze whether the following system is i. Linear ii. Causal iii. Stable iv. Time invariant $y(n) = \log_{10} \|x(n)\|$ Justify your answer.	Remember	CO 1	CLO1	AEC012.01
5	Express stable and unstable system test the condition for stability of the first- order system governed by the equation y(n)=x(n)+bx(n-1).	Understand	CO 1	CLO1	AEC012.01
6	A system is described by the difference equation y(n)-y(n-1)-y(n-2) = x(n-1). Assuming that the system is initially relaxed, determine it s unit sample response h(n).	Remember	CO 1	CLO2	AEC012.02
7	Calculate the impulse response and the unit step response of the systems described by the difference equation y(n) = 0.6y(n-1)-0.08 y(n-2) + x(n).	Understand	CO 1	CLO3	AEC012.03
8	The impulse response of LTI system is h(n)={1 2 1-1} Solve the response of the system if input is x(n)={1 2 31}	Understand	CO 1	CLO1	AEC012.01
9	Obtain the output y(n) of LTI system with impulse response $h(n)= a^n u(n)$. $\|a\|<1$ When the input is unit input sequence that is x(n)=u(n)	Understand	CO 1	CLO2	AEC012.02
10	Obtain impulse response for cascade of two LTI systems havimg Impulse responses of $H_1(n)=(1/2)^n u(n)$ and $H_2(n)=(1/4)^n u(n)$	Remember	CO 1	CLO1	AEC012.01

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11	Solve the Discrete convolution for the following sequences i) x(n)={ 1, 2, -1, 1}; h(n)={1, 0, 1,1} ii) u(n)*u(n-3)	Remember	CO 1	CLO2	AEC012.02
12	Obtain the stability of the system y(n)-(5/2)y(n-1)+y(n-2)=x(n)-x(n-1)	Remember	CO 1	CLO3	AEC012.03
13	Solve the response of the following difference equation y(n)-5y(n-1)+6y(n-2)=x(n) for x(n)=n	Understand	CO 1	CLO1	AEC012.01
14	Solve the inverse Z-transform of X(z)= $\frac{z(z+1)}{(z-2)(z-1)^3}$ roc |z| >2 using partial fraction method.	Understand	CO 1	CLO1	AEC012.01
15	Calculate the convolution of the pairs of signals by means of z-transform $X_1(n)=(1/2)^n$ u(n), $X_2(n)$= cosπn u(n)	Understand	CO 1	CLO2	AEC012.02
16	Obtain the cascade and parallel form realizations for the following systems Y (n) = -0.1y(n-1) + 0.2 y (n-2) + 3x (n) +3.6 x (n-1) +0.6 x (n-2)	Understand	CO 1	CLO3	AEC012.03
17	Obtain the Direct form II y (n) = -0.1 y(n-1) + 0.72 y(n-2) + 0.7x(n) -0.252 x(n-2)	Remember	CO 1	CLO1	AEC012.01
18	Evaluate the direct form- II realization of H (z) =8z-2+5z-1+1 / 7z-3+8z-2+1	Remember	CO 1	CLO2	AEC012.02
19	Obtain the i) Direct forms ii) cascade iii) parallel form realizations for the following systems y (n) = 3/4(n-1) – 1/8 y(n-2) + x(n) +1/3 x(n-1)	Understand	CO 1	CLO3	AEC012.02
20	Obtain the output y(n) of a filter whose impulse response is h(n) = {1 1 1} and input signal x(n) = {3 -1 0 1 3 2 0 1 2 1}. Using overlap save method	Understand	CO 1	CLO1	AEC012.01
PART-C (PROBLEM SOLVING AND CRITICAL THINKING QUESTIONS)					
1	Make a comparison between circular convolution and linear convolution. Given that $x_1(n) = \{1,-1,-2,3,-1\}$ *and* $x_2(n) = \{1,2,3\}$ Find circular convolution of $x_1(n) and x_2(n)$	Apply	CO 1	CLO3	AEC012.03
2	Obtain the transfer function and impulse response of the system $y(n) - \frac{3}{4}y(n-1) + \frac{1}{8}y(n-2) = x(n) + \frac{1}{3}x(n-1)$.	Apply	CO 1	CLO1	AEC012.01
3	Obtain the i) Direct forms ii) parallel form realizations for the following systems y (n) = x(n) +1/3 x(n-1)-1/5 x(n-2)	Apply	CO 1	CLO2	AEC012.02
4	Calculate the range of 'a' and 'b'for which the system is stable with impulse response $H(n) = \begin{cases} a^n & n \geq 0 \\ b^n & n < 0 \end{cases}$	Apply	CO 1	CLO3	AEC012.03

S. No	QUESTION	Blooms Taxonomy Level	Course Outcomes	Course Learning Outcomes	Course learning Outcome Codes
5	Use the one-sided Z-transform to solve y(n) $n \geq 0$ in the following cases. (a) $y(n) + y(n-1) - 0.25y(n-2) = 0$; $y(-1) = y(-2) = 1$ (b) $y(n) - 1.5y(n-1) + 0.5y(n-2) = 0$; $y(-1) = 1$; $y(-2) = 0$	Apply	CO 1	CLO1	AEC012.01
6	Obtain the i) Direct forms ii) cascade iii) parallel form realizations for the following systems $y(n) = 3/4(n-1) - 1/8\, y(n-2) + x(n) + 1/3\, x(n-1)$	Apply	CO 1	CLO2	AEC012.02
7	Evaluate the direct form –I cascade and parallel form for $y(n)+y(n-1)-4y(n-3)=x(n)+3x(n-2)$	Apply	CO 1	CLO3	AEC012.03
8	Given two sequences $x_1(n)\, and\, x_2(n)$ of length N obtain expression to compute circular convolution these sequences. List out changes required if circular convolution output same as linear convolution output with example.	Apply	CO 1	CLO1	AEC012.01
9	Obtain the transfer function and impulse response of the system $y(n) - \frac{33}{44} y(n-1) + \frac{11}{88} y(n-2) = x(n) + \frac{11}{33} x(n-1)$.	Apply	CO 1	CLO2	AEC012.02
10	Impulse response is h(n) = {1, 1, 1 } and input signal x(n) = {2, -1, 0,1,4 ,2,0,1,2,1} determine overlap add method.	Apply	CO 1	CLO3	AEC012.03
	UNIT-II **DISCRETE FOURIER TRANSFORM AND EFFICIENT COMPUTATION**				
	PART-A(SHORT ANSWER QUESTIONS)				
1	Describe about Discrete Fourier Transform (DFT) and Inverse Discrete Fourier Transform of a discrete time sequence	Remember	CO 2	CLO4	AEC012.04
2	List out symmetry, frequency shifting, time shifting and linearity properties of Discrete Fourier Transform.	Understand	CO 2	CLO5	AEC012.05
3	Elucidate on 1. Bit reversal order 2. In place computation	Remember	CO 2	CLO6	AEC012.06
4	Elucidate about zero padding and its uses in convolution	Understand	CO 2	CLO4	AEC012.04

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5	Draw Radix-2 DIT FFT and DIF FFT Butterfly diagrams	Remember	CO 2	CLO5	AEC012.05
6	List out the applications of FFT algorithm	Understand	CO 2	CLO6	AEC012.06
7	Distinguish between DTFT a nd DFT with examples	Remember	CO 2	CLO4	AEC012.04
8	Compare and contrast between Decimation in Frequency Transform (DIF) and Decimation in Time (DIT) algorithms	Understand	CO 2	CLO5	AEC012.05
9	State about the place computation in DIT and DIF FFT algorithm?	Remember	CO 2	CLO4	AEC012.04
10	Analyze the concept of zero padding where the result from linear convolution and circular convolution are same?	Understand	CO 2	CLO5	AEC012.05
11	Describe the disadvantage of direct computation of DFT	Understand	CO 2	CLO6	AEC012.06
12	Compare the DFT and FFT with examples	Remember	CO 2	CLO4	AEC012.04
13	List out the properties of twiddle factor?	Understand	CO 2	CLO4	AEC012.04
14	Justify the importance of butterfly computation for computing of DFT using FFT algorithm?	Remember	CO 2	CLO5	AEC012.05
15	Draw the basic butterfly diagram for DIT FFT and DIF FFT algorithm.	Understand	CO 2	CLO6	AEC012.06
16	State Discrete Fourier Transform and Inverse DFT of a discrete time sequence	Remember	CO 2	CLO4	AEC012.04
17	Compute the N-point DFT of $x(n) = a^n$	Understand	CO 2	CLO5	AEC012.05
18	Establish the relation between DFT and Z	Apply	CO 2	CLO6	AEC012.06

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	transform.				
19	Describe the effect of zero padding on convolution with examples?	Understand	CO 2	CLO4	AEC012.04
20	Describe radix-2 DIF FFT with examples	Understand	CO 2	CLO5	AEC012.05
	PART-B (LONG ANSWER QUESTIONS)				
1	List out FFT advantages? Obtain speed improvement factor for calculating the 64 DFT of sequence using direct computation and FFT algorithm?	Remember	CO 2	CLO4	AEC012.04
2	Appraise about overlap add method and overlap save method for filtering of long data Sequences using DFT.	Understand	CO 2	CLO5	AEC012.05
3	Find the DFT of a sequence x(n)={1,2,3,4,4,3,2,1} using DIT FFT algorithms	Understand	CO 2	CLO6	AEC012.06
4	Describe Radix-2 DIT-FFT algorithm. Compare it with DIF-FFT algorithms.	Remember	CO 2	CLO4	AEC012.04
5	Develop an 8 point DIT-FFT algorithm. Draw the signal flow graph.	Understand	CO 2	CLO4	AEC012.04
6	Compute 4-point-DFT of a sequence x(n)={0,1,2,3} using DIT FFT and DIF FFT algorithms	Remember	CO 2	CLO5	AEC012.05
7	Explore the complete DIF FFT for 8-point sequence and draw signal flow graph.	Remembering	CO 2	CLO6	AEC012.06
8	Compare the differences and similarities between DIT and DIF FFT algorithms?	Understanding	CO 2	CLO4	AEC012.04
9	Describe about the concept of frequency sampling for developing discrete Time Fourier Transform.	Understanding	CO 2	CLO5	AEC012.05

S. No	QUESTION	Blooms Taxonomy Level	Course Outcomes	Course Learning Outcomes	Course learning Outcome Codes
10	Describe about radix-2 Fast Fourier transform (FFT)?	Understanding	CO 2	CLO6	AEC012.06
11	Design 8 point DFT Prove any five properties of DFT	Remembering	CO 2	CLO4	AEC012.04
12	Describe overlap add and overlap save methods.	Remember	CO 2	CLO4	AEC012.04
13	How to computing DFT and IDFT steps	Understand	CO 2	CLO5	AEC012.05
14	Distinguish between DFT and IDFT	Understand	CO 2	CLO6	AEC012.06
15	Describe 8 point DFT compare to 4 point DFT.	Remember	CO 2	CLO4	AEC012.04
16	Design Butter fly concept with example	Understand	CO 2	CLO4	AEC012.04
17	Find the DFT of a sequence x(n)={1,1,0,0} and find the IDFT of Y(k)={1,0,1,0}	Remember	CO 2	CLO5	AEC012.05
18	Describe DIT FFT Algorithm with example	Understand	CO 2	CLO6	AEC012.06
19	Describe DIF FFT Algorithm with example	Remember	CO 2	CLO4	AEC012.04
20	List out the merits and demerits of DFT compare to FFT algorithms	Understand	CO 2	CLO5	AEC012.05
	PART-C (PROBLEM SOLVING AND CRITICAL THINKING QUESTIONS)				
1	Obtain DFT of finite duration sequence $x(n) = \{1, 1, 1, 0, 0\}$ illustrate and explain the sampling of Fourier transform of the sequence.	Apply	CO 2	CLO4	AEC012.04
2	Calculate DFT of following sequence $x(n)$ for N=4 and N=8 and plot magnitude of DFT X(k) and comments on results obtained. $x(n) = \begin{cases} 1 & for\ 0 \le n \le 2 \\ 0 & for\ other\ wise \end{cases}$	Apply	CO 2	CLO5	AEC012.05

S. No	QUESTION	Blooms Taxonomy Level	Course Outcomes	Course Learning Outcomes	Course learning Outcome Codes
3	DFT $x(n)$ is X(k) show that $i)\ DFT\ of\ x((-n))_N = X((-k))_N$ $ii)\ DFT\ of \left\{x(n)e^{j\frac{2\pi ln}{N}}\right\} = X((k-l))_N$ $iii)\ DFT\ of\ x^*(n) = X^*(N-k)$	Apply	CO 2	CLO6	AEC012.06
4	An 8-point sequence is given by x(n)={2,2,2,2,1,1,1,1} compute 8-point DFT of x(n) by Radix-2 DIF Algorithm	Apply	CO 2	CLO4	AEC012.04
5	Find the IDFT of the sequence X(K)={7,-0.707-j0.707,-j,0.707-j0.707,1,0.707+j0.707,j,-0.707+j0.707} using DIT FFT Algorithm	Apply	CO 2	CLO5	AEC012.05
6	Evaluate the eight-point DFT of the following sequence by using DIT and DIF algorithm x (n) = 1 0≤ n ≤ 7 = o otherwise	Apply	CO 2	CLO4	AEC012.04
7	Obtain an 8 point DFT of the sequence x (n) = (1, 0, 1, -1, 1, -1, 0, 1).	Apply	CO 2	CLO5	AEC012.05
8	Find the output y(n) of a filter whose impulse response is h(n) = {1, 1, 1 } and input signal x(n) = {3, -1, 0,1,3,2,0,1,2,1} overlap save method.	Apply	CO 2	CLO6	AEC012.06
9	The 4-point DFT of 4-point sequence x(n) given by X(k) = { 10, -2+j2, -2, -2-j2} without computing DFT and IDFT determine DFT of following $x_1(n) = x(n)(-1)^n$ $ii)\ x_2(n) = x(4-n)$ $iii)\ x_3(n) = x((n-1))_4 + x((n-2))_4$	Apply	CO 2	CLO4	AEC012.04
10	Calculate the IDFT using DIF FFT algorithm given that X (k) = { 4, 1-j2.414, 0, 1-j0.410, 0, 1+jo.414,0, 1+j2.414}.	Apply	CO 2	CLO5	AEC012.05

UNIT-III

STRUCUTRE OF IIR FILTERS

S. No	QUESTION	Blooms Taxonomy Level	Course Outcomes	Course Learning Outcomes	Course learning Outcome Codes
PART-A (SHORT ANSWER QUESTIONS)					
1	Illustrate the concept of IIR filter and categorize advantages of IIR filter?	Remember	CO 3	CLO7	AEC012.07
2	Distinguish between Analog filter and Digital filters	Remember	CO 3	CLO8	AEC012.08
3	State about IIR digital filter	Understand	CO 3	CLO9	AEC012.09
4	Elucidate LPF, HPF based on frequency response	Remember	CO 3	CLO10	AEC012.10
5	Elucidate BPF, BRF based on frequency response	Understand	CO 3	CLO11	AEC012.11
6	Comparison of LPF, HPF, BPF and BRP	Remember	CO 3	CLO12	AEC012.12
7	Analyze designing of IIR digital filters	Remember	CO 3	CLO7	AEC012.07
8	Describe Analog Low pass filter design	Remember	CO 3	CLO8	AEC012.08
9	Draw impulse response of an ideal lowpass filter.	Remember	CO 3	CLO9	AEC012.09
10	Mention any two procedures for digitizing the transfer function of an analog filter	Remember	CO 3	CLO10	AEC012.10
11	Describe Butterworth Filters	Remember	CO 3	CLO11	AEC012.11
12	Illustrate Chebyshev Filters-Type-1	Understand	CO 3	CLO12	AEC012.12
13	Describe Chebyshev Filters-Type-2	Remember	CO 3	CLO7	AEC012.07
14	Describe IIR Digital Filter Structures	Understand	CO 3	CLO8	AEC012.08
15	Illustrate Direct form IIR Digital filter structure	Remember	CO 3	CLO9	AEC012.09
16	Distinguish between Butterworth filters and Chebyshev-Type-1 Filter	Understand	CO 3	CLO7	AEC012.07
17	Distinguish between the frequency response of Chebyshev-Type-1 and Chebyshev-Type-II	Remember	CO 3	CLO8	AEC012.08
18	Elucidate Analog transformation of prototype LPF to HPF	Remember	CO 3	CLO9	AEC012.09
19	Demonstrate the transformation of analog filters into equivalent digital filters	Remember	CO 3	CLO10	AEC012.10
20	Comparison of IIR and FIR digital filters with real time examples	Remember	CO 3	CLO11	AEC012.11
PART-B (LONG ANSWER QUESTIONS)					
1	Describe the Transformation of Analog filters into equivalent digital filters using impulse invariant method	Remember	CO 3	CLO7	AEC012.07
2	Design an analog Butterwoth filter has a -2db passband attenuation at a frequency of 20 rad/sec. and at least -10db stop band attenuation at 30 rad/sec.	Remember	CO 3	CLO8	AEC012.08
3	Develop Analog Low pass Chebyshev Filters including type I and type -II	Understand	CO 3	CLO9	AEC012.09
4	Examine the impulse response and time index , a1 = 0.5 b0 = –3 b1 = 2 Impulse response Using MATLAB	Remember	CO 3	CLO10	AEC012.10
5	Describe Transformation of Analog filters into	Remember	CO 3	CLO11	AEC012.11

S. No	QUESTION	Blooms Taxonomy Level	Course Outcomes	Course Learning Outcomes	Course learning Outcome Codes
	equivalent digital filters using Bilinear transformation method				
6	Design a 4th order Butterworth-type IIR low-pass digital filter is needed with 3dB cut-off at one sixteenth of the sampling frequency fS.	Understand	CO 3	CLO12	AEC012.12
7	Calculate the impulse-response of the digital filter with $H(z) = \frac{1}{1 - 2 z - 1}$	Remember	CO 3	CLO7	AEC012.07
8	Consider a 1st order Anlog filter with a single pole at s=α .where α > 0, with system function Ha(s)= 1/ α=s	Remember	CO 3	CLO7	AEC012.07
9	Design a band stop Butterworth and chebyshev type-1 filter to meet the following specifications i) stop band 100 to 600Hz, ii) 20dB attenuation at 200 and 400hz the gain at ω =0 is unity iii) the pass band ripple for chebychev filter is 1.1dB iv) pass band attenuation for Butterworth filter is 3 dB.	Remember	CO 3	CLO8	AEC012.08
10	IIR discrete time filter design by bilinear transformation	Understand	CO 3	CLO9	AEC012.09
11	Design a second order Butterworth-type IIR lowpass filter with Ω c = π / 4.	Remember	CO 3	CLO10	AEC012.10
12	Design a Butterworth-type IIR low-pass digital filter is needed with 3dB cut-off at one sixteenth of the sampling frequency f s , and a stop-band attenuation of at least 24 dB for all frequencies above f s / 8	Remember	CO 3	CLO11	AEC012.11
13	Design a 4th order band-pass filter with Ω L = π / 2, Ω u = π / 4.	Remember	CO 3	CLO12	AEC012.12
14	Illustrate the IIR Filter Structures-Direct Form-I and Fixed Point Implementation	Remember	CO 3	CLO7	AEC012.07
15	Describe the Artifacts of IIR filters with suitable examples	Understand	CO 3	CLO8	AEC012.08
16	Design of a 2nd order IIR low-pass digital filter by the bilinear transform method	Remember	CO 3	CLO9	AEC012.09
17	IIR discrete time filter design by bilinear transformation	Understand	CO 3	CLO10	AEC012.10
18	Design a second order Butterworth-type IIR lowpass filter with Ω c = π / 4.	Remember	CO 3	CLO11	AEC012.11
19	A Butterworth-type IIR low-pass digital filter is needed with 3dB cut-off at one sixteenth of the sampling frequency f s , and a stop-band attenuation of at least 24 dB for all frequencies above f s / 8. (i) What order is needed? (b) Design it.	Remember	CO 3	CLO12	AEC012.12

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20	Design a 4th order band-pass filter with $\Omega_L = \pi / 4$, $\Omega_u = \pi / 2$.	Remember	CO 3	CLO7	AEC012.07
PART-C (PROBLEM SOLVING AND CRITICAL THINKING QUESTIONS)					
1	Using MATLAB, design a second order Butterworth-type IIR low-pass filter with $\Omega_c = \pi / 4$.	Apply	CO 3	CLO7	AEC012.07
2	Design a 4th order Butterworth-type IIR low-pass digital filter is needed with 3dB cut-off at one sixteenth of the sampling frequency fS.	Apply	CO 3	CLO8	AEC012.08
3	Design a 4th order band-pass IIR digital filter with lower & upper cut-off frequencies at 300 Hz & 3400 Hz when fS = 8 kHz.	Apply	CO 3	CLO9	AEC012.09
4	Design a 4th order band-pass IIR digital filter with lower & upper cut-off frequencies at 2000 Hz & 3000 Hz when fS = 8 kHz.	Apply	CO 3	CLO10	AEC012.10
5	Design of IIR filters from analog filters with help of properties	Apply	CO 3	CLO11	AEC012.11
6	Discuss and Explain Steps to design a digital filter using Impulse Invariance	Apply	CO 3	CLO12	AEC012.12
7	Design a 3rd order Butterworth digital filter using Impulse Invariant technique , assume sampling T is 1 sec. and for N is 3	Apply	CO 3	CLO7	AEC012.07
8	Discuss and Explain Bilinear Transformation method, wrapping effect and pre-wrapping ,draw the effect on magnitude response due to warping effect	Apply	CO 3	CLO8	AEC012.08
9	Apply bilinear transformation to H(s)=2/(s+1) (s+2) with T is 1 sec, find H(z).	Apply	CO 3	CLO9	AEC012.09
10	Compare Spectral transformations in Analog domain from a normalized LP analog filters, design filters with diff. frequency transformation in digital domain with Low pass, High pass and Band pass and Band stop	Apply	CO 3	CLO10	AEC012.10
UNIT-IV **SYMMETRIC AND ANTISYMMETRIC FIR FILTERS**					
PART-A(SHORT ANSWER QUESTIONS)					
1	Illustrate FIR filter? And categorize the advantages of FIR filter?	Remember	CO 4	CLO12	AEC012.12
2	State the necessary and sufficient condition for the linear phase characteristic of a FIR filter?	Understand	CO 4	CLO13	AEC012.13
3	List the well known design technique for linear phase FIR filter design?	Understand	CO 4	CLO14	AEC012.14

S. No	QUESTION	Blooms Taxonomy Level	Course Outcomes	Course Learning Outcomes	Course learning Outcome Codes
4	For What kind of Apply, the symmetrical impulse response can be used?	Understand	CO 4	CLO12	AEC012.12
5	State conditions a finite duration sequence h(n) will yield constant group delay in its frequency response characteristics and not the phase delay?	Understand	CO 4	CLO13	AEC012.13
6	Express Gibbs phenomenon?	Remember	CO 4	CLO14	AEC012.14
7	List out the desirable characteristics of the windows?	Remember	CO 4	CLO12	AEC0127.12
8	Compare Hamming window with Kaiser window.	Remember	CO 4	CLO13	AEC012.13
9	Draw impulse response of an ideal lowpass filter.	Remember	CO 4	CLO14	AEC012.14
10	Illustrate the principle of designing FIR filter using frequency sampling method?	Remember	CO 4	CLO12	AEC012.12
11	Analyze which type of filter is suitable for frequency same?	Understand	CO 4	CLO13	AEC012.13
12	State the effect of truncating an infinite Fourier series into a finite series	Remember	CO 4	CLO14	AEC012.14
13	Justify FIR filters are always stable?	Remember	CO 4	CLO12	AEC012.12
14	Demonstrate the procedure for designing FIR filters using windows.	Remember	CO 4	CLO13	AEC012.13
15	List out disadvantage of Fourier series method ?	Understand	CO 4	CLO14	AEC012.14
16	Draw the frequency response of N point Bartlett window	Remember	CO 4	CLO12	AEC012.12
17	Draw the frequency response of N point Blackman window	Understand	CO 4	CLO13	AEC012.13
18	Draw the frequency response of N point Hanning window	Remember	CO 4	CLO14	AEC012.14
19	What is the necessary and sufficient condition for linear phase characteristics in FIR filter	Remember	CO 4	CLO12	AEC012.12
20	Give the equation specifying Kaiser window.	Understand	CO 4	CLO13	AEC012.13
PART-B (LONG ANSWER QUESTIONS)					
1	Describe about optimized design of FIR filter using Parks-McClellan remez algorithm and its limitations.	Understand	CO 4	CLO12	AEC012.12
2	Compare IIR and FIR filters	Remember	CO 4	CLO13	AEC012.13
3	Design an ideal high pass filter with a frequency respose Hd(ejw)=1 for $\frac{\pi}{4} \leq \mid \omega \mid \leq \pi$ 0 for $\mid \omega \mid \leq \frac{\pi}{4}$ Find the values of h(n) for N=11.Find H(z).plot magnitude response.	Understand	CO 4	CLO14	AEC012.14
4	Design an ideal band reject filter with a frequency respose Hd(ejw)=1 for $\mid \omega \mid \leq \frac{\pi}{3}$ and $\mid \omega \mid \geq \frac{2\pi}{3}$ 0 for otherwise Find the values of h(n) for N=11.Find H(z).plot	Understand	CO 4	CLO12	AEC012.12

S. No	QUESTION	Blooms Taxonomy Level	Course Outcomes	Course Learning Outcomes	Course learning Outcome Codes
	magnitude response.				
5	Design an ideal differentiator H(ejw)=j ω $-\pi \leq \omega \leq \pi$ Using a) rectangular window b)Hamming window with N=8.plot frequency response in both cases.	Remember	CO 4	CLO13	AEC012.13
6	List out important features of FIR filter and explain advantages and disadvantages of FIR filters over IIR flters	Understand	CO 4	CLO12	AEC012.12
7	Calculate the frequency response of FIR filter defined by y(n)=0.25x(n)+x(n-1)+.25x(n-2) Calculate the phase delay and group delay.	Understand	CO 4	CLO13	AEC012.13
8	Illustrate for the use of window sequences in the design of FIR filter. Describe the window sequences generally used and compare their properties.	Remember	CO 4	CLO14	AEC012.14
9	Design an ideal high pass filter with a frequency respose Hd(ejw)=1 for $\frac{\pi}{4} \leq \vert\omega\vert \leq \pi$ 0 for $\vert\omega\vert \leq \frac{\pi}{4}$ Find the values of h(n) for N=11.Find H(z).plot magnitude response.	Remember	CO 4	CLO12	AEC012.12
10	Prove that an FIR filter has linear phase if the unit sample response satisfies the condition h(n)= ±h(M-1-n), n=0,1,….M-1. Also discuss symmetric and antisymmetric cases of FIR filter	Remember	CO 4	CLO13	AEC012.13
11	Design a HPF of length 7 with cut off frequency of 2 rad/sec using Hamming window. Plot the magnitude and phase response.	Remember	CO 4	CLO12	AEC012.12
12	Describe the principle and procedure for designing FIR filter using rectangular window	Remember	CO 4	CLO13	AEC012.13
13	Design a high pass filter using hamming window with a cut-off frequency of 1.2radians/second and N=9	Remember	CO 4	CLO12	AEC012.12
14	Analyze optimized design of FIR filter using Parks-McClellan remez algorithm and its limitations.	Remember	CO 4	CLO13	AEC012.13
15	Describe about optimized design of FIR filter using least mean square error method.	Understand	CO 4	CLO14	AEC012.14
16	Design a tenth order FIR band pass digital filter with lower and upper cut-off frequencies at π/8 and π/3 respectively.	Understand	CO 4	CLO12	AEC012.12
17	Design a HPF of length 7 with cut off frequency of 2 rad/sec using Hanning window. Plot the magnitude	Remember	CO 4	CLO13	AEC012.13

S. No	QUESTION	Blooms Taxonomy Level	Course Outcomes	Course Learning Outcomes	Course learning Outcome Codes
	and phase response.				
18	Illustrate the principle and procedure for designing FIR filter using Hamming window	Remember	CO 4	CLO12	AEC012.12
19	Design a high pass filter using hanning window with a cut-off frequency of 1.2radians/second and N=9	Remember	CO 4	CLO13	AEC012.13
20	Illustrate about optimized design of FIR filter using Parks-McClellan remez algorithm and its limitations.	Remember	CO 4	CLO14	AEC012.14
PART-C (PROBLEM SOLVING AND CRITICAL THINKING QUESTIONS)					
1	a) Prove that an FIR filter has linear phase if the unit sample response satisfies the condition h(n)= ± h(M-1-n), n =0,1,….. M-Also discuss symmetric and anti symmetric cases of FIR filter. b) Analyze the need for the use of window sequence in the design of FIR filter. Describe the window sequence generally used and compare the properties.	Understand	CO 4	CLO12	AEC012.12
2	Given that for a linear phase filter, its impulse-response must be symmetric about n=N for some N, (i.e. h[N + n] = h[N-n] for all n), why cannot an IIR filter be linear phase?	Understand	CO 4	CLO13	AEC012.13
3	Design an ideal Hilbert transformer having frequency response H (e jώ) = j -π ≤ ω ≤ 0 -j 0 ≤ ω ≤ π for N=11 using rectangular window	Remember	CO 4	CLO14	AEC012.14
4	Using frequency sampling method design a band pass filter with following specifications Sampling frequency F=8000Hz , Cut off frequency fc1=1000Hz fc2=3000Hz. Determine the filter coefficients for N=7	Remember	CO 4	CLO12	AEC012.12
5	Design an FIR low pass digital filter using the frequency sampling method for the following specifications (16) Cut off frequency = 1500Hz Sampling frequency = 15000Hz Order of the filter N = 10 Filter Length require d L = N+1 = 11	Remember	CO 4	CLO12	AEC012.12
6	Design the first 15 coefficients of FIR filters of magnitude specification is given below H(ejw) =1, -π/2≤ ω≤π/2 0, otherwise	Understand	CO 4	CLO13	AEC012.13
7	Design a FIR linear phase digital filter approximating the ideal frequency response	Remember	CO 4	CLO14	AEC012.14

S. No	QUESTION	Blooms Taxonomy Level	Course Outcomes	Course Learning Outcomes	Course learning Outcome Codes
	hd(w)=1; |w|< π/6 = π/6<|w|< π With T=1 Sec using bilinear transformation .Realize the same in Direct form II				
8	Using a rectangular window technique design a lowpass filter with pass band gain of unity, cutoff frequency of 1000 Hz and working at a sampling frequency of 5 kHz. The length of the impulse response should be 7	Understand	CO 4	CLO12	AEC012.12
9	Design a filter with Hd(ejώ) = e- 3 jώ, π/4 ≤ ω ≤ π/4 =0 for π/4 ≤ ω ≤ π using a Hamming window with N=7.	Remember	CO 4	CLO12	AEC012.12
10	Illustrate optimized design of FIR filter using Parks-McClellan remez algorithm, least mean square error methods and limitations.	Remember	CO 4	CLO13	AEC012.13
UNIT-V **APPLICATIONS OF DSP**					
PART-A(SHORT ANSWER QUESTIONS)					
1	Describe about decimation by factor D	Remember	CO 5	CLO15	AEC012.15
2	Elucidate interpolation by factor I	Understand	CO 5	CLO16	AEC012.16
3	Analyze the spectrum of exponential signal	Understand	CO 5	CLO17	AEC012.17
4	Analyze the spectrum of exponential signal decimated by factor 2.	Remember	CO 5	CLO15	AEC01215
5	Analyze the spectrum of exponential signal interpolated by factor 2	Understand	CO 5	CLO16	AEC012.16
6	Describe about term up sampling and down sampling	Remember	CO 5	CLO17	AEC012.17
7	List out the Applications of multi rate DSP	Understand	CO 5	CLO15	AEC012.15
8	Elucidate does multirate mean?	Understand	CO 5	CLO16	AEC012.16
9	State the use of multirate DSP?	Understand	CO 5	CLO17	AEC012.17
10	List out the categories of multirate?	Remember	CO 5	CLO15	AEC01215
11	Illustrate “decimation" and "down sampling"?	Remember	CO 5	CLO16	AEC012.16
12	State is the "decimation factor"?	Remember	CO 5	CLO17	AEC012.17
13	Justify decimate?	Understand	CO 5	CLO15	AEC012.15
14	Is there a restriction on decimation factors I can use?	Remember	CO 5	CLO16	AEC012.16
15	List out signals can be down sampled?	Understand	CO 5	CLO17	AEC012.17
16	Analyze the reason if I violate the Nyquist criteria in down sampling or decimating?	Understand	CO 5	CLO15	AEC012.15

S. No	QUESTION	Blooms Taxonomy Level	Course Outcomes	Course Learning Outcomes	Course learning Outcome Codes
17	Compare Fixed and Binary floating point number representation?	Understand	CO 5	CLO16	AEC012.16
18	Evaluate How the multiplication & addition are carried out in floating point arithmetic?	Understand	CO 5	CLO17	AEC012.17
19	List out the effects of finite word length in digital filters?	Understand	CO 5	CLO15	AEC012.15
20	List the errors which arise due to quantization process.	Remember	CO 5	CLO16	AEC012.16
PART-B (LONG ANSWER QUESTIONS)					
1	Describethe applications of Multirate Digital Signal Processing	Remember	CO 5	CLO15	AEC012.15
2	Consider a signal x(n) = u(n) 1. Obtain a signal with a decimation factor '3' 2. Obtain a signal with a interpolation factor '3'.	Understand	CO 5	CLO16	AEC012.16
3	solve the expression for decimation by factor D	Understand	CO 5	CLO17	AEC012.17
4	Obtain the expression for interpolation by factor I	Remember	CO 5	CLO15	AEC012.15
5	Elucidate the sampling rate conversion by a factor of I/O and obtain necessary expressions with neat block diagram.	Understand	CO 5	CLO16	AEC012.16
6	Summarize notes on filter design and implementation for sampling rate conversion	Remember	CO 5	CLO17	AEC0127.17
7	Illustrate the output noise due to A/D conversion of the input x (n).	Understand	CO 5	CLO15	AEC012.15
8	Describe about (a) Truncation and rounding (b) Coefficient Quantization.	Understand	CO 5	CLO15	AEC012.15
9	List out the errors introduced by quantization with necessary expression	Understand	CO 5	CLO16	AEC012.16
10	i. State the various common methods of quantization. ii. Describe the finite word length effects in FIR digital filters.	Remember	CO 5	CLO17	AEC012.17
11	Describe the quantization in floating point realization of IIR digital filters. i. Explain the characteristics of limit cycle oscillation with respect to the system described by the difference equation: y(n) = 0.95y(n – 1) + x(n); x(n) = 0 and y(-1) = 13. Determine the dead band range of the system. ii. Explain the effects of coefficient quantization in FIR filters	Remember	CO 5	CLO15	AEC012.15
12	Describe the applications of Multirate Digital Signal Processing	Remember	CO 5	CLO15	AEC012.15
13	Illustrate the concept of coefficient quantization in IIR filter.	Understand	CO 5	CLO16	AEC012.16
14	Evaluate conditions prevent limit cycle oscillations? Explain.	Understand	CO 5	CLO17	AEC012.17

S. No	QUESTION	Blooms Taxonomy Level	Course Outcomes	Course Learning Outcomes	Course learning Outcome Codes
15	Discuss in detail the errors resulting from rounding and truncation.	Understand	CO 5	CLO15	AEC012.15
16	Describe about the limit cycle oscillations due to product round off and overflow errors.	Understand	CO 5	CLO16	AEC012.16
17	Describe the characteristics of a limit cycle oscillation with respect to the system described by the equation y(n) = 0.45y(n – 1) + x(n) when the product is quantized to 5 – bits by rounding. The system is excited by an input x(n) = 0.75 for n = 0 and x(n) = 0 for n ≠ 0. Also determine the dead band of the filter.	Understand	CO 5	CLO17	AEC012.17
18	Elucidate about quantization of analog signals? Derive the expression for the quantization error.	Understand	CO 5	CLO15	AEC012.15
19	Compare cycle oscillations and signal scaling.	Understand	CO 5	CLO16	AEC012.16
20	Illustrate meant by signal scaling? Explain.	Understand	CO 5	CLO17	AEC012.17
PART-C (PROBLEM SOLVING AND CRITICAL THINKING QUESTIONS)					
1.	Describe the decimation process with a neat block diagram.	Remember	CO 5	CLO15	AEC012.15
2.	List out the advantages and drawbacks of multirate digital signal processing	Remember	CO 5	CLO16	AEC012.16
3.	The output of an A/D is fed through a digital system whose system function is $H(z)=1/(1-0.8z^{-1})$.Calculate the output noise power of the digital system.	Understand	CO 5	CLO17	AEC012.17
4.	The output of an A/D is fed through a digital system whose system function is H(Z)=0.6z/z-0.6. Calculate the output noise power of the digital system=8 bits	Remember	CO 5	CLO15	AEC012.15
5.	Explore about quantization effect in ADC of signals. Derive the expression for Pe(n) and SNR.	Remember	CO 5	CLO16	AEC012.16
6.	A digital system is characterized by the difference equation y(n)=0.95y(n-1)+x(n).determine the dead band of the system when x(n)=0 and y(-1)=13.	Understand	CO 5	CLO17	AEC012.17
7.	Two first order filters are connected in cascaded whose system functions of the individual sections are $H1(z)=1/(1-0.8z^{-1})$ and $H2(z)=1/(1-0.9z^{1})$. Determine the overall output noise power.	Remember	CO 5	CLO15	AEC012.15
8.	Consider a signal x(n)=sin(π n)U(n). Obtain a signal with an interpolation factor of ‘2’	Understand	CO 5	CLO15	AEC012.15
9.	Design a decimator with the following specification D = 5, δp=, 0.025 δs=0.0035, ωs= 0.2π Assume	Understand	CO 5	CLO16	AEC012.16

S. No	QUESTION	Blooms Taxonomy Level	Course Outcomes	Course Learning Outcomes	Course learning Outcome Codes
	any other required data.				
10.	Illustrate quantization effect in ADC of signals with examples	Remember	CO 5	CLO17	AEC012.17

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