INSTITUTE OF AERONAUTICAL ENGINEERING

(Autonomous)

Dundigal, Hyderabad -500 043

ELECTRONICS AND COMMUNICATION ANDENGINEERING

COURSE DESCRIPTOR

Course Title	**DIGITAL SIGNAL PROCESSING**					
Course Code	**AEC012**					
Programme	B.Tech					
Semester	**VI**	ECE				
Course Type	**CORE**					
Regulation	IARE - R16					
Course Structure	**Theory**			**Practical**		
	Lectures	**Tutorials**	**Credits**	**Laboratory**	**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					

I. COURSE OVERVIEW:

The present course covers the concepts and techniques of modern digital signal processing which are fundamental to all the signal/speech/image processing, applications. The course starts with a detailed overview of discrete-time signals and systems, representation of the systems by means of difference equations, and their analysis using Fourier and z-transforms. The notion of discrete Fourier transform is introduced, followed by an overview of fast algorithms for its computation. The methods for spectral analysis of discrete-time signals are discussed next, principal methods for design of FIR and IIR filters, followed by multi-rate signal processing and finite word length effects. While this course deals largely with the theory of DSP, we will use a powerful software package, MATLAB, to look at applications of this theory, particularly Fourier analysis and digital filter design.

II. COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
UG	AHS011	III	Mathematical Transform Techniques

III. MARKS DISTRIBUTION:

Subject	SEE Examination	CIA Examination	Total Marks
Digital Signal Processing	70 Marks	30 Marks	100

IV. DELIVERY / INSTRUCTIONAL METHODOLOGIES:

✘	Chalk & Talk	✔	Quiz	✔	Assignments	✘	MOOCs
✔	LCD / PPT	✔	Seminars	✘	Mini Project	✔	Videos
✘	Open Ended Experiments						

V. EVALUATION METHODOLOGY:

The course will be evaluated for a total of 100 marks, with 30 marks for Continuous Internal Assessment (CIA) and 70 marks for Semester End Examination (SEE). Out of 30 marks allotted for CIA during the semester, marks are awarded by taking average of two CIA examinations or the marks scored in the make-up examination.

Semester End Examination (SEE): The SEE is conducted for 70 marks of 3 hours duration. The syllabus for the theory courses is divided into FIVE units and each unit carries equal weightage in terms of marks distribution. The question paper pattern is as follows. Two full questions with "either‟ or ‟choice" will be drawn from each unit. Each question carries 14 marks. There could be a maximum of two sub divisions in a question.

The emphasis on the questions is broadly based on the following criteria:

50 %	To test the objectiveness of the concept.
50 %	To test the analytical skill of the concept OR to test the application skill of the concept.

Continuous Internal Assessment (CIA):
CIA is conducted for a total of 30 marks (Table 1), with 25 marks for Continuous Internal Examination (CIE), 05 marks for Quiz/ Alternative Assessment Tool (AAT).

Table 1: Assessment pattern for CIA

Component	Theory		Total Marks
Type of Assessment	CIE Exam	Quiz / AAT	
CIA Marks	25	05	30

Continuous Internal Examination (CIE):

Two CIE exams shall be conducted at the end of the 8th and 16th week of the semester respectively. The CIE exam is conducted for 25 marks of 2 hours duration consisting of two parts. Part–A shall have five compulsory questions of one mark each. In part–B, four out of five questions have to be answered where, each question carries 5 marks. Marks are awarded by taking average of marks scored in two CIE exams.

Quiz / Alternative Assessment Tool (AAT):

Two Quiz exams shall be online examination consisting of 25 multiple choice questions and are be answered by choosing the correct answer from a given set of choices (commonly four). Marks shall be awarded considering the average of two quizzes for every course. The AAT may include seminars, assignments, term paper, open ended experiments, five minutes video and MOOCs.

VI. HOW PROGRAM OUTCOMES ARE ASSESSED:

Program Outcomes (POs)		Strength	Proficiency assessed by
PO 1	**Engineering knowledge**: Apply the knowledge of mathematics, science, engineeringfundamentals, and an engineering specialization to the solution of complex engineering problems.	3	Lectures, Assignments, Exercises
PO 2	**Problem analysis**: Identify, formulate, review research literature, and analyze complexengineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences	2	Seminar
PO 5	**Modern tool usage**: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.	2	Design Exercises
PO 9	**Individual and team work:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary Settings.	1	Micro projects.
PO 10	**Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.	1	Seminars, Paper Presentations.

Program Outcomes (POs)		Strength	Proficiency assessed by
PO 12	**Life-long learning**: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.	2	Development of Mini Projects

3 = High; 2 = Medium; 1 = Low

VII. HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED:

Program Specific Outcomes (PSOs)		Strength	Proficiency assessed by
PSO 1	**Professional Skills:** An ability to understand the basic concepts in electronics & communication engineering and to apply them to various areas, like electronics, communications, signal processing, VLSI, embedded systems etc., in the design and implementation of complex systems.	3	Lectures and Assignments.
PSO 2	**Problem-Solving Skills:** An ability to solve complex Electronics and communication Engineering problems, using latest hardware and software tools, along with analytical skills to arrive cost effective and appropriate solutions.	-	-
PSO 3	**Successful Career and Entrepreneurship:** An understanding of social-awareness & environmental-wisdom along with ethical responsibility to have a successful career and to sustain passion and zeal for real-world applications using optimal resources as an Entrepreneur.	1	Guest lectures

3 = High; 2 = Medium; 1 = Low

VIII. COURSE OBJECTIVES (COs):

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	Acquaint in FFT algorithm, multi-rate signal processing techniques and finite word length effects.

IX. COURSE OUTCOMES (COs):

COs	Course Outcomes	CLO's	Course Learning Outcome
CO1	Interpret, represent and process discrete/digital signals and systems	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	Define simple non-periodic discrete-time sequences such as the impulse and unit step, and perform time shifting and time-reversal operations on such sequences.

COs	Course Outcomes	CLO's	Course Learning Outcome
		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.
CO2	Understanding of time domain and frequency domain analysis of discrete time signals and 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.
CO3	Understand DFT for the analysis of digital signals & systems	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.
CO4	Demonstrate and analyze DSP systems like FIR and IIR Filter	CLO 12	Design of finite impulse response (FIR) filters for a given specification.
		CLO 13	Compare the characteristics of IIR and FIR filters.
		CLO 14	Design of infinite impulse response (IIR) filters for a given specification.
CO5	Understand multi rate signal processing of signals through systems.	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.

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X. COURSE LEARNING OUTCOMES (CLOs):

CLO Code	CLOs	At the end of the course, the student will have the ability to:	POs Mapped	Strength of Mapping
AEC012.01	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.	PO 1, PO 2	3
AEC012.02	CLO 2	Define simple non-periodic discrete-time sequences such as the impulse and unit step, and perform time shifting and time-reversal operations on such sequences.	PO 1, PO 2	3

CLO Code	CLOs	At the end of the course, the student will have the ability to:	POs Mapped	Strength of Mapping
AEC012.03	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.	PO 1, PO 2 PO 9	3
AEC012.04	CLO 4	Given the impulse response of a causal LTI system, show whether or not the system is bounded-input/bounded-output (BIBO) stable.	PO 2, PO 5 PO 9, PO 12	3
AEC012.05	CLO 5	Perform time, frequency and Z-transform analysis on signals.	PO 5, PO 10	2
AEC012.06	CLO 6	From a linear difference equation of a causal LTI system, draw the Direct Form I and Direct Form II filter realizations.	PO 2, PO 12	3
AEC012.07	CLO 7	Knowing the poles and zeros of a transfer function, make a rough sketch of the gain response.	PO 1, PO 5 PO 9, PO 12	2
AEC012.08	CLO 8	Define the Discrete Fourier Transform (DFT) and the inverse DFT (IDFT) of length N.	PO 1, PO 2 PO 12	1
AEC012.09	CLO 9	Understand the inter-relationship between DFT and various transforms.	PO 2, PO 5, PO 9, PO 12	2
AEC012.10	CLO 10	Understand the significance of various filter structures and effects of round-off errors.	PO 1, PO 9 PO 10, PO 12	2
AEC012.11	CLO 11	Understand the fast computation of DFT and appreciate the FFT Processing.	PO 1 PO 2, PO 12	3
AEC012.12	CLO 12	Design of infinite impulse response (IIR) filters for a given specification.	PO 2, PO 9 PO 10, PO 12	2
AEC012.13	CLO 13	Design of finite impulse response (FIR) filters for a given specification.	PO 1, PO 5 PO 12	1
AEC012.14	CLO 14	Compare the characteristics of IIR and FIR filters.	PO 5 PO 12	1
AEC012.15	CLO 15	Understand the tradeoffs between normal and multi rate DSP techniques and finite length word effects.	PO 2, PO 9 PO 12	1
AEC012.16	CLO 16	Understand the signal interpolation and decimation, and explain their operation	PO 5	1
AEC012.17	CLO 17	Explain the cause of limit cycles in the implementation of IIR filters.	PO 5, PO 12	2

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XI. MAPPING COURSE OUTCOMES LEADING TO THE ACHIEVEMENT OF PROGRAM OUTCOMES

Course Outcomes (COs)	Program Outcomes (POs)						
	PO 1	PO 2	PO 5	PO 9	PO 10	PO 12	PSO 1
CO 1	3	2	2	1	1	3	1
CO 2		2					1
CO 3	3	2	2	2	1	3	1

Course Outcomes (COs)	Program Outcomes (POs)						
	PO 1	PO 2	PO 5	PO 9	PO 10	PO 12	PSO 1
CO 4	2		1	2	1	2	
CO 5	2			2		3	

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XII. MAPPING COURSE LEARNING OUTCOMES LEADING TO THE ACHIEVEMENT OF PROGRAM OUTCOMES AND PROGRAM SPECIFIC OUTCOMES:

CLO	Program Outcomes (POs)												Program Specific Outcomes (PSOs)		
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CLO 1	3	3											1		
CLO 2	3	3													
CLO 3	3	3							3						
CLO 4		3			3				3			3			
CLO 5					2					2					
CLO 6		3										3			
CLO 7	2				2				2			2			
CLO 8	1	1										1	1		
CLO 9		2			2				2			2	1		
CLO 10	2								2	2		2			
CLO 11	3	3													
CLO 12	2								2	2		2			
CLO 13	1				1							1	1		
CLO 14					1							1			
CLO 15		1							1			1			
CLO 16					1				1						
CLO 17					2							2			

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XIII. ASSESSMENT METHODOLOGIES–DIRECT

CIE Exams	PO 1, PO 2 PO 4 PO 12,PSO1	SEE Exams	PO 1, PO 2 PO 4 PO 12, PSO1	Assignments	PO 1	Seminars	PO1,PO2, PO4,PO12, PSO1
Laboratory Practices	-	Student Viva	-	Mini Project	-	Certification	-
Term Paper	-						

XIV. ASSESSMENT METHODOLOGIES-INDIRECT

✔	Early Semester Feedback	✔	End Semester OBE Feedback
✘	Assessment of Mini Projects by Experts		

XV. SYLLABUS

Unit-I	**REVIEW OF DISCRETE TIME SIGNALS AND SYSTEMS:**
Discrete time signal definition; Signal classification; Elementary signals; Transformation of elementary signals; Concept of digital frequency; Discrete time system definition; System classification; Linear time invariant (LTI) system; Properties of the LTI system; Time domain analysis of discrete time systems; Impulse response; The convolution sum; Methods of evaluating the convolution sum; Filtering using overlap-save and overlap-add method; Realization of digital filters: Concept of IIR and FIR filters; Realization structures for IIR and FIR filters using direct form-I and direct form-II, cascade, lattice and parallel.	
Unit -II	**DISCRETE FOURIER TRANSFORM AND EFFICIENT COMPUTATION:**
Introduction to discrete time Fourier transform (DTFT); Discrete Fourier transform (DFT) definition; Properties of DFT; Linear and circular convolution using DFT; Fast-Fourier-transform (FFT): Direct computation of DFT; Need for efficient computation of the DFT (FFT algorithms); Radix-2 FFT algorithm for the computation of DFT and IDFT using decimation-in-time and decimation-in-frequency algorithms; General Radix-N FFT.	
Unit- III	**STRUCUTRE OF IIR FILTERS:**
Analog filters: Butterworth filters; Chebyshev type-1 & type-2 filters; Analog transformation of prototype LPF to HPF/BPF/BSF. Transformation of analog filters into equivalent digital filters using impulse invariant method and bilinear transform method; Matlab programs of IIR filters.	
Unit -IV	**SYMMETRIC AND ANTISYMMETRIC FIR FILTERS:**
Design of linear phase FIR filters windowing and frequency sampling methods; Equiripple linear phase FIR filters; Parks-McClellan algorithm and remez algorithm; Least-mean-square error filter design; Design of FIR differentiators; Matlab programs of FIR filters; Comparison of FIR & IIR.	
Unit -V	**APPLICATIONS OF DSP:**
Multirate signal processing; Decimation; Interpolation; Polyphase structures for decimation and interpolation filters; Structures for rational sampling rate conversion; Applications of multirate signal processing for design of phase shifters, interfacing of digital systems with different sampling rates, sub band coding of speech signals. Analysis of finite word length effects: Representation of numbers; ADC quantization noise, coefficient quantization error, product quantization error, truncation & rounding errors; Limit cycle due to product round-off error; Round-off noise power; Limit cycle oscillations due to overflow in digital filters; Principle of scaling; Dead band effects.	

Text Books:
1. John G. Proakis, Dimitris G. Manolakis, Digital signal processing, Principles, Algorithms and Applications, Prentice Hall, 4th Edition, 2007 2. Sanjit K Mitra, Digital signal processing, A computer base approach, Mc Graw-Hill Higher Education, 4th Edition, 2011. 3. Emmanuel C, Ifeacher, Barrie. W. Jervis, DSP-A Practical Approach, Pearson Education, 2nd Edition, 2002. 4. A.V. Oppenheim, R.W. Schaffer, Discrete Time Signal Processing, PHI, 2nd Edition, 2006.
Reference Books:
1. Li tan, Digital signal processing: fundamentals and applications, Elsevier Science &. Technology Books, 2nd Edition, 2008. 2. Robert J.schilling, Sandra. L.harris, Fundamentals of Digital signal processing using Matlab, Thomson Engineering, 2nd Edition, 2005. 3. Salivahanan, Vallavaraj, Gnanapriya, Digital signal processing‖, McGraw-Hill Higher Education, 2nd Edition, 2009.

XVI. COURSE PLAN:

The course plan is meant as a guideline. Probably there may be changes.

Lecture No	Topics to be covered	Course Learning Outcomes (CLOs)	Reference
1-5	List out the basic steps in DSP, Classify the Signals, Systems.	CLO 1 CLO 2	T1:2.1-2.3
6-8	Concept of Linear Convolution	CLO 3	T1:2.3,7.3
9-11	Time domain analysis of discrete time systems, Impulse response	CLO 4	T1:2.4
11-13	Describe the methods of Convolution Sum	CLO3	T1:2.3,7.3
14-15	Illustrate Structures for IIR and FIR systems	CLO 6	T1:2.5
16-21	Describe the signal analysis using DTFT, and Illustrate the DFT and its properties	CLO 8	T1:4.2 R1:3.1-3.2
21-25	Apply DFT for convolution of the signal	CLO 8	T1:7.2
26-30	Apply the DFT algorithm to Compute FFT in time domain, frequency domain and Compute the FFT using radix-N	CLO 10	T1:8.1.2 R2:4.5
31-35	Analyze the IIR filter design Approximations, Express Digital filters from analog filters	CLO 12	T1:10.3-10.4
36-40	Demonstration of the IIR filter design methods	CLO 12	T1:10.3-10.4
41-44	Demonstrate linear phase FIR Digital Filters using Windows, Discuss FIR Digital Filters using sampling method	CLO 13	T1:10.2.1-10.2.3
45-49	Express FIR filter design techniques., Distinguish between FIR and IIR filters	CLO 13	T1:10.2.4 R2:7.6
50-51	Explain Multirate Digital Signal processing, Express Decimation, interpolation	CLO 15	T1:11.1-11.5
52-53	Discuss Sampling rate conversion	CLO 15	T1:11.4
54-55	Demonstrate the applications of Multirate Digital Signal processing.	CLO 15	T1:11.9
56-57	Describe the quantization noise and Round-off noise	CLO 16	T1:9.4-9.6
58-60	Describe the Limit cycle oscillations and Dead band effects	CLO 17	T1:9.4-9.6

XVII. GAPS IN THE SYLLABUS - TO MEET INDUSTRY / PROFESSION REQUIREMENTS:

S NO	Description	Proposed Actions	Relevance with POs	Relevance with PSOs
1	Digital Filter Design.	Seminars / NPTEL	PO 2, PO 9 PO 10, PO 12	PSO 1
2	Introductions to DSP Processors	Seminars / Guest Lectures / NPTEL	PO1, PO5, PO 9 PO10, PO12	PSO 1

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