INSTITUTE OF AERONAUTICAL ENGINEERING

(Autonomous)

Dundigal, Hyderabad - 500 043

DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING

COURSE DESCRIPTION FORM

Course Title	**DIGITAL SIGNAL PROCESSING**			
Course Code	**A70421**			
Regulation	**R15 – JNTUH**			
Course Structure	Lectures	Tutorials	Practicals	Credits
	4	-	-	4
Course Coordinator	Mr. A Naresh Kumar, Assistant Professor, EEE			
Team of Instructors	Mr. A Naresh Kumar, Assistant Professor, EEE			

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 differential equations, and their analysis using Fourier and z-transforms. The sampling theory of continuous - time signals is explained next, followed by exploring the transform-based analysis of linear time-invariant (LTI) systems and their structures. Subsequently, 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. PREREQUISITE(S):

Level	Credits	Periods / Week	Prerequisites
UG	4	4	Signals and Systems, Fundamentals of Fourier series and Fourier transforms

III. MARKS DISTRIBUTION:

Sessional Marks	University End Exam Marks	Total Marks
Mid Semester Test There shall be 2 midterm examinations. Each midterm examination consists of subjective type and Objective type tests. The subjective test is for 10 marks, with duration of 1 hour. Subjective test of each midterm exam shall contain 4 questions. The student has to answer 2 questions, each carrying 5 marks. The objective type test is for 10 marks with duration of 20minutes. It consists of 10 Multiple choice and 10 objective type questions. The student has to answer all the questions and each carries half mark. First midterm examination shall be conducted for the first 2 ½ units of syllabus and second midterm examination shall be conducted for the remaining 2 ½ units.	75	100

Seasonal Marks	University End Exam Marks	Total Marks
Five marks are earmarked for assignments. There shall be two assignments in every theory course. Marks shall be awarded considering the average of two assignments in each course reason whatsoever, will get zero marks(s).		

IV. EVALUATION SCHEME:

S. No	Component	Duration	Marks
1	I Mid Examination	90 minutes	20
2	I Assignment	-	5
3	II Mid Examination	90 minutes	20
4	II Assignment	-	5
5	External Examination	3 hours	75

V. COURSE OBJECTIVES:

At the end of the course, the students will be able to:

I. Discuss background and fundamental material for the analysis and processing of digital signals.
II. Understand the relationships between continuous-time and discrete-time signals and systems.
III. Understand fundamentals of time, frequency and z-plane analysis and to discuss the inter-relationships of this analytic method.
IV. Understand the designs and structures of digital (IIR and FIR) filters from analysis to synthesis for a given specifications.
V. Understand a few real-world signal processing applications.
VI. Demonstrate FFT algorithm, multi-rate signal processing techniques and finite word length effects.

VI. COURSE OUTCOMES:

After completing this course the student must demonstrate the knowledge and ability to:

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.
2. Understand discrete time signal processing and characterization of random signals, filter design techniques, and imperfections caused by finite word length.
3. Understand how to estimate the spectra of random signals that are to be processed by a discrete time filter, and to appreciate the performance of a variety of modern and classical spectrum estimation techniques.
4. Learn the theory of modern digital signal processing and digital filter design, including hands-on experience with important techniques involving digital filter design and digital simulation experiments
5. Introduce the fundamental principles and techniques of digital signal processing for understanding and designing new digital signal processing systems and for continued learning.
6. Perform time, frequency and Z-transform analysis on signals and LTI systems
7. Understand the properties like stability, causality, time-invariance and etc.
8. Understand the inter-relationship between DFT and various transforms.
9. Understand the significance of various filter structures and effects of round-off errors.
10. Design of infinite impulse response filters for a given specification.
11. Understand the fast computation of DFT and appreciate the FFT Processing.
12. Understand the tradeoffs between normal and multi rate DSP techniques and finite length word effects.
13. Design of finite impulse response filters for a given specification.
14. Understand identify, formulate, analyze and solve technical and engineering problems.
15. Understand use the techniques, skills and modern technical tools necessary for technical or engineering practice.

VII. HOW PROGRAM OUTCOMES ARE ASSESSED:

Program Outcomes		Level	Proficiency Assessed by
PO1	**Engineering Knowledge**: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems	H	Assignments, Tutorials
PO2	**Problem Analysis**: Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences	H	Assignments
PO3	**Design / Development of Solutions**: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations **(**	S	Mini Projects
PO4	**Conduct Investigations of Complex Problems**: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions	H	Projects
PO5	**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	S	Projects
PO6	**The Engineer and Society**: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice	N	--
PO7	**Environment and Sustainability**: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development	N	--
PO8	**Ethics**: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice	S	Oral Discussions
PO9	**Individual and Team Work**: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings	N	--
PO10	**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	S	Presentations
PO11	**Project Management and Finance:** Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments	H	Development of Prototype, Projects
PO12	**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	S	Seminars, Discussions

N - None **S - Supportive** **H - Highly Related**

VIII. HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED:

Program Specific Outcomes		Level	Proficiency Assessed by
PSO1	**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.	H	Lectures, Assignments
PSO2	**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.	S	Tutorials
PSO3	**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.	S	Seminars and Projects

N - None **S - Supportive** **H - Highly Related**

IX. SYLLABUS:

UNIT - I

INTRODUCTION

Introduction to digital signal processing: Discrete time signals and sequences, linear shift invariant systems, stability and causality, linear constant coefficient difference equations, Frequency domain representation of discrete time signals and systems.

REALIZATION OF DIGITAL FILTERS

Applications of Z-Transforms, solution of difference equations of digital filters, system function, stability criterion, frequency response of stable systems, realization of digital filters-direct, canonic, cascade and parallel forms.

UNIT - II

DISCRETE FOURIER SERIES

DFS representation of periodic sequences, Properties of discrete Fourier series, Discrete Fourier transforms: properties of DFT, linear convolution of sequences using DFT, computation of DFT: Over-lap add method, over-lap save method, Relation between DTFT, DFS, DFT, Z-Transform.

FAST FOURIER TRANSFORMS

Fast Fourier transforms (FFT)-Radix2 decimation in time and decimation in frequency FFT algorithms, inverse FFT and FFT with general radix- N.

UNIT - III

IIR DIGITAL FILTERS

Analog filter approximations - Butterworth and chebyshev, design of IIR digital filters from analog filters, step and impulse invariant techniques, bilinear transformation method, spectral transformations.

UNIT - IV

FIR DIGITAL FILTERS

Characteristics of FIR digital filters, frequency response, Design of FIR digital filters: Fourier method, digital filters using window techniques, frequency sampling technique, comparison of IIR and FIR filters.

UNIT - V

MULTIRATE DIGITAL SIGNAL PROCESSING:

Introduction, down sampling, decimation, up sampling, interpolation, sampling rate Conversion.

FINITE WORD LENGTH EFFECTS:

Limit cycles, Overflow oscillations, round-off noise in iir digital filters, computational output round off noise, methods to prevent overflow, trade off b / w round off and overflow noise, dead band effects.

X. TEXT BOOKS:

1. Digital signal processing, principles, Algorithms and applications: John G. Proakis, Dimitris G. Manolakis, Pearson Education/PHI, 4th ed., 2007.
2. V. Oppenheim, R. W. Schaffer, Discrete Time Signal Processing, Prentice Hall of India, New Delhi.
3. Fundamentals of Digital signal processing - Loney Ludeman, John wiley, 2009.

XI. REFERENCE BOOKS:

1. Digital signal processing: fundamentals and applications- li tan Elsevier, 2008.
2. Fundamentals of Digital signal processing using Matlab-Robert J. schilling, Sandra. L. Harris, Thomson.
3. Digital signal processing- salivahanan, vallavaraj and gnanapriya TMH, 2009
4. Discerte systems and Digital signal processing with Matlab - Taan S. EIali, CRC press, 2009.
5. Digital signal processing- a practical approach, E. C. I feachor and Barrie W Jervis, 2nd Pearson 2009.

XII. COURSE PLAN:

At the end of the course, the students are able to achieve the following course learning outcomes:

Lecture No.	Unit No	Course Learning Objective	Topics Covered	Text Book / Reference
1-5	I	**List** out the basic steps in DSP, **Classify** the Signals, Systems	Introduction to DSP, Advantages, Applications, Limitations, Continuous and Discrete time signals and sequences, Static, linear shift invariant systems, Stability and Causality	T1-1.1, 1.4,2.1, 2.3
6-10		**Solve** the difference equations, and **Locate & Sketch** the Spectral analysis of the discrete time system	Linear Constant coefficient difference solutions (Natural Response, Forced Response, Step and Impulse Response) and Frequency domain representation of discrete time signals and systems	T1-2.4,4.2
11-13		**Describe** the applications of z-transform, **Illustrate** the characteristics of the system, **Sketch** Spectral Analysis	Applications of Z-Transforms, Solution of difference equations of digital filters, System function, stability criterion, Frequency response of stable systems	T1-3.1, 3.2,3.3,3.4 3.5, 3.6.2
14-15		**Illustrate** Structures for IIR and FIR systems	Realization of digital IIR and FIR filters- using direct form-I, II, Canonic, cascade and parallel	T1-2.5
16-21	II	**Describe** the Periodic signal analysis using DFS, **List** the properties of DFS, and **Illustrate** the DFT and its properties	Discrete Fourier Series representation of periodic sequences, Properties of Discrete Fourier series, Discrete Fourier transform and properties of DFT	T1-4.1, 7.1,7.2
12-25		**Apply** DFT for convolution of the signal, **Apply & Compute** DFT using overlap add, save methods, **Relate** all transforms	Linear convolution of sequences using DFT, Computation of DFT: Over-lap add method and over-lap save method, Relation between DTFT, DFS, DFT, Z-transform	T1-7.3.1, 7.3.2,7.1.4
26-30		**Apply** the DFT algorithm to **Compute** FFT in time domain, frequency domain and **Compute** the FFT using radix-N	Fast Fourier transforms (FFT) using Radix-2 Decimation in time (DIT) algorithm, Decimation in frequency(DIF) algorithm, Inverse FFT, FFT with general radix- N	T1-8.1.2, 8.1.3,8.1.48.1.5

31-35	III	**Analyze** the IIR filter design Approximations, **Express** Digital filters from analog filters	IIR Filter-Analog filter approximations-Butterworth and Chebyshev, Express the Digital filters from analog filters	T1-10.3.1, 10.3.2, 10.3.3
36-40		**Demonstration** of the IIR filter design methods	IIR filter design using Step and Impulse invariant techniques, Bilinear transformation technique, Spectral transformations	T1-10.3.1, 10.3.2, 10.3.3
41-44	IV	**Demonstrate** the FIR digital filters, **Analyze** Frequency Response of FIR filters, **Express** FIR filter design techniques	FIR Filter: Characteristics (linear phase) of FIR digital filters, Frequency response, Design of FIR digital filters, FIR filter design using Fourier method	T1-10.2.1, 10.2.2,10.2.3, 10.2.7
45-49		**Demonstrate** linear phase FIR Digital Filters using Windows, **Discuss** FIR Digital Filters using sampling method, **Distinguish** between FIR and IIR filters	Digital FIR filters design using window techniques, Filter design using Frequency sampling technique, Comparison of IIR and FIR filters	T1-10.2.1, 10.2.2,10.2.3, 10.2.7
50-53	V	**Explain** Multirate Digital Signal processing, **Express** Decimation, interpolation	Introduction to Down and Up Sampling, Decimation, Interpolation	T1-11.1, 11.2, 11.3
54-58		**Discuss** Sampling rate conversion	Sampling rate Conversion by factor I/D,	T1-11.4, 11.7, 11.8, 11.1,11.2
59-61		**Describe** Overflow and Round-off noise, **Compute** round-off noise	Overflow oscillations, round-off noise in iir digital filters, Computational output round off noise	T1-9.4.3, T1-9.6.1, R5
62-65		**Examine** to prevent overflow and trade off, **Describe** Dead band effects	Methods to prevent overflow, trade off b/w round off and overflow noise, Dead band effects	T1-9.6.2, 9.5, 9.6.1, R5

XIII. MAPPING COURSE OBJECTIVES LEADING TO THE ACHIEVEMENT OF PROGRAM OUTCOMES AND PROGRAM SPECIFIC OUTCOMES:

Course Objectives	Program Outcomes												Program Specific Outcomes		
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
I	H							S			H			S	S
II		H								S			H	S	
III				H				S				S	H	S	
IV			S		S						H		H	S	
V	H			H										S	
VI		H			S					S			H	S	

S – Supportive **H - Highly Related**

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

Course Outcomes	Program Outcomes												Program Specific Outcomes		
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
1		H	S	H				S						S	S
2	H			H	S					S			H	S	
3		H						S					H	S	
4	H			H	S					S				S	
5		H	S		S			S			H		H	S	
6	H	H	S							S			H	S	
7			S	H				S			H	S		S	S
8		H	S	H				S						S	S
9	H			H	S					S			H	S	
10		H						S					H	S	
11	H			H	S					S				S	
12		H	S		S			S			H		H	S	
13	H	H	S							S			H	S	
14			S	H				S			H	S		S	S
15	H		S					S			H	S	H	S	

S – Supportive **H - Highly Related**

Prepared by: Mr. A Naresh Kumar, Assistant Professor, EEE

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