M.TECH-SP-2016-17 SCHEME OF TEACHING AND EXAMINATION

M.Tech in Signal Processing

I SEMESTER

Subject Code	Title	Teaching hours/week		Duration of Exam in Hours	Marks for		Total Marks	CREDITS
		Lecture	Practical / Field Work / Assignment/ Tutorials		I.A.	Exam		
16ELD11	Advanced Engineering Mathematics	4	--	3	20	80	100	4
16ESP12	Statistical Signal Processing	4	--	3	20	80	100	4
16EVE13	Advanced Embedded Systems	4	--	3	20	80	100	4
16ESP14	Modern DSP	4	--	3	20	80	100	4
16EXX15X	Elective – 1	3	--	3	20	80	100	3
16ESPL16	Signal Processing lab	--	3	3	20	80	100	2
16ESPL17	Seminar on advanced topics from refereed journals	--	3	--	100	--	100	1
Total		**19**	**6**	**18**	**220**	**480**	**700**	**22**

Elective-1:

16ECS151	Advanced Computers Networks	16ESP153	Modern Spectral Analysis & Estimation
16ESP152	Multirate Systems and Filter Banks	16ECS154	Simulation, Modeling and Analysis

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II SEMESTER

Subject Code	Title	Teaching hours/week		Duration of Exam in Hours	Marks for		Total Marks	CREDITS
		Lecture	Practical / Field Work / Assignment/ Tutorials		I.A.	Exam		
16ESP21	Image Processing and Machine Vision	4	--	3	20	80	100	4
16ESP22	DSP System Design	4	--	3	20	80	100	4
16ESP23	Digital Signal Compression	4	--	3	20	80	100	4
16ESP24	Biomedical Signal Processing	4	--	3	20	80	100	4
16EXX25X	Elective-2	3	--	3	20	80	100	3
16ESPL26	Image Processing Lab	--	3	3	20	80	100	2
16ESP27	Seminar on Advanced topics from refereed Journals	--	3	--	100	--	100	1
Total		**19**	**6**	**18**	**220**	**480**	**700**	**22**

Elective - 2:

16ESP251	Detection & Estimation	16ESP253	Pattern Recognition
16EVE252	VLSI Design for Signal Processing	16ESP254	Channel Coding

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III SEMESTER: Internship

Subject Code	Title	Teaching hours/week		Duration of the Exam in Hours	Marks for		Total Marks	CREDITS
		Lecture	Practical / Field Work		I.A.	Exam		
16ESP31	Seminar / Presentation on Internship (After 8 weeks from the date of commencement)	--	--	--	25	--	25	20
16ESP32	Report on Internship	--	--	--	25		25	
16ESP33	Evaluation and Viva-voce on Internship	--	--	--	–	50	50	
16ESP34	Evaluation of Project Phase-I	--	--	--	50	--	50	1
	Total	**--**	**--**	**--**	**100**	**50**	**150**	**21**

M.Tech in Signal Processing

IV SEMESTER

Subject Code	Subject	Teaching hours/week		Duration of Exam in Hours	Marks for		Total Marks	CREDITS
		Lecture	Practical / Field Work / Assignment/ Tutorials		I.A.	Exam		
16ESP41	Adaptive Signal processing	4	--	3	20	80	100	4
16EXX42X	Elective-3	3	--	3	20	80	100	3
16ESP43	Evaluation of Project Phase-II	--	--	--	50	-	50	3
16ESP44	Evaluation of Project Work and Viva-Voce	--	--	--	--	100+100	200	10
	Total	**7**	**--**	**06**	**90**	**360**	**450**	**20**

Elective-3:

16ESP421	Array Signal Processing	16ECS423	Communication System Design using DSP Algorithms
16ESP422	Speech and Audio processing	16ELD424	Reconfigurable Computing

Note:

1. Project Phase-1: 6-week duration shall be carried out between 2nd and 3rd Semester vacation. Candidates in consultation with the guide shall carry out literature survey/ visit industries to finalize the topic of Project.

2. Project Phase-2: 16-week duration during 4th semester. Evaluation shall be done by the committee constituted comprising of HoD as Chairman, Guide and Senior faculty of the department.

3. Project Evaluation: Evaluation shall be taken up at the end of 4th semester. Project work evaluation and Viva-Voce examination shall be conducted

a. Internal Examiner shall carry out the evaluation for 100 marks.

b. External Examiner shall carry out the evaluation for 100 marks.

c .The average of marks allotted by the internal and external examiner shall be the final marks of the project evaluation.

d. Viva-Voce examination of Project work shall be conducted jointly by Internal and External examiner for 100 marks.

M.Tech-SP-2016-FIRST SEMESTER SYALLABUS

ADVANCED ENGINEERING MATHEMATICS [As per Choice Based Credit System (CBCS) scheme] SEMESTER – I			
Subject Code	16ELD11	IA Marks	20
Number of Lecture Hours/Week	04	Exam Marks	80
Total Number of Lecture Hours	50 (10 Hours per Module)	Exam Hours	03
CREDITS – 04			

Course objectives: This course will enable students to:

- Acquaint with principles of linear algebra, calculus of variations, probability theory and random process.
- Apply the knowledge of linear algebra, calculus of variations, probability theory and random process in the applications of electronics and communication engineering sciences.

Modules	**Revised Bloom's Taxonomy (RBT) Level**
Module -1	
Linear Algebra-I Introduction to vector spaces and sub-spaces, definitions, illustrative examples and simple problems. Linearly independent and dependent vectors-definition and problems. Basis vectors, dimension of a vector space. Linear transformations- definition, properties and problems. Rank-Nullity theorem(without proof). Matrix form of linear transformations-Illustrative examples.**(Text 1 & Ref. 1)**	**L1,L2**
Module -2	
Linear Algebra-II Computation of Eigen values and Eigen vectors of real symmetric matrices-Given's method. Orthogonal vectors and orthogonal bases. Gram-Schmidt orthogonalization process. QR decomposition, singular value decomposition, least square approximations.**(Text 1 & Ref. 1)**	**L1,L2**
Module -3	
Calculus of Variations Concept of functional-Eulers equation. functional dependent on first and higher order derivatives, functional on several dependent variables. Isoperimetric problems-variation problems with moving boundaries.**(Text 2 & Ref. 2)**	**L1,L2**
Module -4	

Probability Theory Review of basic probability theory. Definitions of random variables and probability distributions, probability mass and density functions, expectation, moments, central moments, characteristic functions, probability generating and moment generating functions-illustrations. Binomial, Poisson, Exponential, Gaussian and Rayleigh distributions-examples.**(Text 3 & Ref. 3)**	**L1,L2**
Module -5	
Joint probability distributions Definition and properties of CDF, PDF, PMF, conditional distributions. Expectation, covariance and correlation. Independent random variables. Statement of central limit theorem-Illustrative examples. Random process- Classification, stationary and ergodic random process. Auto correlation function-properties, Gaussian random process.**(Text 3 & Ref. 3)**	**L1,L2**

Course Outcomes: After studying this course, students will be able to:

- Understand vector spaces, basis, linear transformations and the process of obtaining matrix of linear transformations arising in magnification and rotation of images.
- Apply the techniques of QR and singular value decomposition for data compression, least square approximation in solving inconsistent linear systems.
- Utilize the concepts of functionals and their variations in the applications of communication systems, decision theory, synthesis and optimization of digital circuits.
- Learn the idea of random variables (discrete/continuous) and probability distributions in analyzing the probability models arising in control systems and system communications.
- Apply the idea of joint probability distributions and the role of parameter-dependent random variables in random process.

Question paper pattern:

- The question paper will have 10 full questions carrying equal marks.
- Each full question consists of 16 marks with a maximum of four sub questions.
- There will be 2 full questions from each module covering all the topics of the module
- The students will have to answer 5 full questions, selecting one full question from each module.

Text Books:

1. David C.Lay, Steven R.Lay and J.J.McDonald: Linear Algebra and its Applications, 5th Edition, Pearson Education Ltd., 2015.
2. E. Kreyszig, “Advanced Engineering Mathematics”, 10th edition, Wiley, 2015.
3. Scott L.Miller, Donald G.Childers: “Probability and Random Process with application to Signal Processing”, Elsevier Academic Press, 2ndEdition, 2013.

Reference books:

1. Richard Bronson: “Schaum’s Outlines of Theory and Problems of MatrixOperations”, McGraw-Hill, 1988.
2. Elsgolts. L: ”Differential Equations and Calculus of Variations”, MIR Publications, 3rd Edition, 1977.
3. T.Veerarajan: “Probability, Statistics and Random Process“, 3rd Edition, Tata McGraw Hill Co., 2008.

Web links:

1. http://nptel.ac.in/courses.php?disciplineId=111
2. http://www.class-central.com/subject/math(MOOCs)
3. http://ocw.mit.edu/courses/mathematics/
4. www.wolfram.com

STATISTICAL SIGNAL PROCESSING [As per Choice Based Credit System (CBCS) scheme] SEMESTER – I			
Subject Code	16ESP12	IA Marks	20
Number of Lecture Hours/Week	04	Exam Marks	80
Total Number of Lecture Hours	50 (10 Hours per Module)	Exam Hours	03
CREDITS – 04			

Course objectives: This course will enable students to:

- Understand random processes and its properties
- Understand the basic theory of signal detection and estimation
- Identify the engineering problems that can be put into the frame of statistical signal processing
- Solve the identified problems using the standard techniques learned through this course,
- Make contributions to the theory and the practice of statistical signal processing.

Modules	**Revised Bloom's Taxonomy (RBT) Level**
Module -1	
Random Processes: Random variables, random processes, white noise, filtering random processes, spectral factorization, ARMA, AR and MA processes (Text 1).	**L1, L2**
Module -2	
Signal Modeling: Least squares method, Padé approximation, Prony's method, finite data records, stochastic models, Levinson-Durbin recursion; Schur recursion; Levinson recursion(Text 1).	**L2, L3**
Module -3	

Spectrum Estimation: Nonparametric methods, minimum-variance spectrum estimation, maximum entropy method, parametric methods, frequency estimation, principal components spectrum estimation(Text 1).	**L1, L2**
Module -4	
Optimal and Adaptive Filtering: FIR and IIR Wiener filters, Discrete Kalman filter, FIR Adaptive filters: Steepest descent, LMS, LMS-based algorithms, adaptive recursive filters, RLS algorithm (Text 1).	**L2, L3**
Module -5	
Array Processing: Array fundamentals, beam-forming, optimum array processing, performance considerations, adaptive beam-forming, linearly constrained minimum-variance beam-formers, side-lobe cancellers, space-time adaptive processing (Text 2).	**L2, L3**

Course outcomes: After studying this course, students will be able to:

- Characterize an estimator.
- Design statistical DSP algorithms to meet desired needs
- Apply vector space methods to statistical signal processing problems
- Understand Wiener filter theory and design discrete and continuous Wiener filters
- Understand Kalman Filter theory and design discrete Kalman filters
- Use computer tools (such as Matlab) in developing and testing stochastic DSP algorithms

Question paper pattern:

- The question paper will have ten full questions carrying equal marks.
- Each full question consists of 16 marks with a maximum of four sub questions.
- There will be 2 full questions from each module covering all the topics of the module
- The students will have to answer 5 full questions, selecting one full question from each module.

Text Books:

1. Monson H.Hayes, “Statistical Digital Signal Processing and Modeling”, John Wiley & Sons (Asia) Pvt.Ltd., 2002.
2. Dimitris G. Manolakis, Vinay K. Ingle, and Stephen M. Kogon, "Statistical and Adaptive Signal Processing: Spectral Estimation, Signal Modeling, Adaptive Filtering and ArrayProcessing”, McGraw-HillInternationalEdition,2000.

Reference Books:

1. Bernard Widrowand Samuel D.Stearns, "Adaptive Signal Processing", Pearson Education (Asia) Pvt. Ltd., 2001.
2. Simon Haykin, "Adaptive Filters", Pearson Education (Asia) Pvt. Ltd, 4th edition, 2002.
3. J.G. Proakis, C.M. Rader, F. Ling, C.L. Nikias, M. Moonen and I.K. Proudler, "Algorithms for Statistical Signal Processing", Prentice Hall, 2001, ISBN-0130622192.

ADVANCED EMBEDDED SYSTEM [As per Choice Based Credit System (CBCS) scheme] SEMESTER – I			
Subject Code	16EVE13	IA Marks	20
Number of Lecture Hours/Week	04	Exam Marks	80
Total Number of Lecture Hours	50 (10 Hours per Module)	Exam Hours	03
CREDITS – 04			

Course objectives: This course will enable students to:

- Understand the basic hardware components and their selection method based on the characteristics and attributes of an embedded system.
- Describe the hardware software co-design and firmware design approaches
- Explain the architectural features of ARM CORTEX M3, a 32 bit microcontroller including memory map, interrupts and exceptions.
- Program ARM CORTEX M3 using the various instructions, for different applications.

Modules	**Revised Bloom's Taxonomy (RBT) Level**
Module -1	
Embedded System: Embedded vs General computing system, classification, application and purpose of ES. Core of an Embedded System, Memory, Sensors, Actuators, LED, Opto coupler, Communication Interface, Reset circuits, RTC, WDT, Characteristics and Quality Attributes of Embedded Systems (Text 1: Selected Topics from Ch -1, 2, 3).	**L1, L2, L3**
Module -2	
Hardware Software Co-Design, embedded firmware design approaches, computational models, embedded firmware development languages, Integration and testing of Embedded Hardware and firmware, Components in embedded system development environment (IDE), Files generated during compilation, simulators, emulators and debugging (Text 1: Selected Topics From Ch-7, 9, 12, 13).	**L1, L2, L3**
Module -3	

ARM-32 bit Microcontroller: Thumb-2 technology and applications of ARM, Architecture of ARM Cortex M3, Various Units in the architecture, General Purpose Registers, Special Registers, exceptions, interrupts, stack operation, reset sequence (Text 2: Ch 1, 2, 3)	**L1, L2, L3**
Module -4	
Instruction Sets: Assembly basics, Instruction list and description, useful instructions, Memory Systems, Memory maps, Cortex M3 implementation overview, pipeline and bus interface (Text 2: Ch-4, 5, 6)	**L1, L2, L3**
Module -5	
Exceptions, Nested Vector interrupt controller design, Systick Timer, Cortex-M3 Programming using assembly and C language, CMSIS (Text 2: Ch-7, 8, 10)	**L1, L2, L3**

Course Outcomes: After studying this course, students will be able to:

- Understand the basic hardware components and their selection method based on the characteristics and attributes of an embedded system.
- Explain the hardware software co-design and firmware design approaches.
- Acquire the knowledge of the architectural features of ARM CORTEX M3, a 32 bit microcontroller including memory map, interrupts and exceptions.
- Apply the knowledge gained for Programming ARM CORTEX M3 for different applications.

Question paper pattern:

- The question paper will have 10 full questions carrying equal marks.
- Each full question consists of 16 marks with a maximum of four sub questions.
- There will be 2 full questions from each module covering all the topics of the module
- The students will have to answer 5 full questions, selecting one full question from each module.

Text Books:

1. K. V. Shibu, "Introduction to embedded systems", TMH education Pvt. Ltd. 2009.
2. Joseph Yiu, “The Definitive Guide to the ARM Cortex-M3”, 2^{nd} edn, Newnes, (Elsevier), 2010.

Reference Book:

James K. Peckol, "Embedded systems- A contemporary design tool", John Wiley, 2008.

MODERN DSP [As per Choice Based Credit System (CBCS) scheme] SEMESTER – I			
Subject Code	16ESP14	IA Marks	20
Number of Lecture Hours/Week	04	Exam Marks	80
Total Number of Lecture Hours	50 (10 Hours per Module)	Exam Hours	03
CREDITS – 04			

Course objectives: This course will enable students to:

- Understand the Sampling rate conversion methods.
- Understand word length effects in DSP systems.
- Explore non-parametric methods for power spectrum estimation.
- Analyze power spectrum estimation using parametric methods.
- Pursue research in multiple areas of digital signal processing.

Modules	**Revised Bloom's Taxonomy (RBT) Level**
Module -1	
Introduction: **Multirate Digital Signal Processing:** Introduction, Decimation by a factor 'D', Interpolation by a factor 'I', Sampling rate Conversion by a factor 'I/D', implementation of Sampling rate conversion, Multistage implementation of Sampling rate conversion, Sampling rate conversion of Band Pass Signals, Sampling rate conversion by an arbitrary factor, Applications of Multirate Signal Processing, Digital Filter banks, Two Channel Quadrature Mirror Filter banks, M-Channel QMF bank (Text 1).	**L1, L2,L3**
Module -2	
Transform Analysis of LTI systems: The frequency response of LTI systems, System functions for systems characterized by linear constant coefficient difference equations, frequency response for rational system functions, Relationship between magnitude and phase, All pass systems, minimum phase systems, linear systems with generalized linear phase (Text 2).	**L1, L2**

Module -3	
Linear Prediction and Optimum Linear Filters: Representation of a random process, Forward and backward linear prediction, Solution of normal equations, Properties of the linear error-prediction filters, AR lattice and ARMA lattice-ladder filters, Wiener filters for filtering and prediction (Text 1).	**L1,L2, L3**
Module -4	
Time frequency transformation: The Fourier Transform: Its Power and Limitations, The short Time Fourier Transform, The Gabor transform, The wavelet transform, Perfect reconstruction Filter Banks and Wavelets, Recursive Multi resolution Decomposition, Haar Wavelet (Text 3).	**L1,L2**
Module -5	
Hardware and Software for Digital Signal Processors: Digital signal processor architecture, Digital signal processor hardware units, Fixed-point and floating-point formats (Text 4).	**L1,L2**

Course outcomes: After studying this course, students will be able to:

- Explain sampling and reconstruction processes.
- Generate different signals at different sample rates to determine the relevant parameters in specific applications.
- Apply correlation functions and power spectra for various signal classes, in particular for stochastic signals
- Construct simple multi-rate signal processing systems.
- Interpret the result of signal processing problems by use of Matlab.
- Design simple, specific signal processing systems based on analysis of signal characteristics, the objective of the processing system, and utility of methods presented in the course.

Question paper pattern:

- The question paper will have 10 full questions carrying equal marks.
- Each full question consists of 16 marks with a maximum of four sub questions.
- There will be 2 full questions from each module covering all the topics of the module
- The students will have to answer 5 full questions, selecting one full question from each module.

Text Books:

1. Proakis and Manolakis, “Digital Signal Processing”, Prentice Hall, 4th edition, 1996.
2. Alan V. Oppenheim and Ronald W.Schafer, “Discrete-Time signal Processing”, PHI Learning, 2003.
3. Roberto Cristi, “Modern Digital Signal Processing”, Cengage Publishers, India, Eerstwhile Thompson Publications, 2003.
4. Li Tan, “Digital Signal Processing – Fundamentals and Applications”, Elsevier, 2008.

Reference Book:

S.K.Mitra, “Digital Signal Processing: A Computer Based Approach”, 3rd edition, Tata McGraw Hill, India, 2007.

ADVANCED COMPUTER NETWORKS [As per Choice Based Credit System (CBCS) scheme] SEMESTER – I			
Subject Code	16ECS151	IA Marks	20
Number of Lecture Hours/Week	03	Exam Marks	80
Total Number of Lecture Hours	40 (08 Hours Per Module)	Exam Hours	03
CREDITS – 03			

Course objectives: This course will enable students to:

- Develop an awareness towards basic networking principles
- Learn various aspects involved in multiple access and multiplexing
- Develop an awareness regarding the LAN architectures and the various data switching techniques
- Learn the scheduling techniques of networks
- Learn protocols operating in at different layers of computer networks
- Develop an awareness towards the network control and traffic management

Modules	**Revised Bloom's Taxonomy (RBT) Level**
Module -1	
Introduction to networks: Computer network, Telephone networks, Networking principles (Text 1), Protocol layering (Text 2), Multiplexing- TDM, FDM, SM, WDM (Text 1). **Multiple Access:** Introduction, Choices and constraints, base technologies, centralized and distributed access schemes (Text 2).	**L1, L2, L3**
Module -2	
Local Area Networks: Ethernet - Physical layer, MAC, LLC, LAN interconnection, Token ring- Physical layer, MAC, LLC, FDDI (Text 1). Switching- introduction, circuit switching, packet switching, multicasting (Text 2). **Scheduling:** Introduction, requirements, choices, performance bounds, best- effort techniques. Naming and addressing (Text 2).	**L1, L2, L3**
Module -3	
SONET, SDH (Text 2), ATM Networks- features, signaling and routing, header and adaptation layers (Text 1), virtual circuits, SSCOP, Internet- addressing, routing, end point control (Text 2). **Internet protocols-** IP, TCP, UDP, ICMP, HTTP (Text 2).	**L1, L2, L3**
Module -4	

Traffic Management: Introduction, framework for traffic management, traffic models, traffic classes, traffic scheduling (Text 2). **Control of Networks:** Objectives and methods of control, routing optimization in circuit and datagram networks, Markov chains, Queuing models in circuit and datagram networks (Text 1).	**L1, L2, L3**
Module -5	
Congestion and flow control: Window congestion control, rate congestion control, control in ATM Networks (Text 1), flow control model, open loop flow control, closed loop flow control (Text 2).	**L1, L2, L3, L4**

Course outcomes: After studying this course, students will be able to:

- Choose appropriate multiple access and multiplexing techniques as per the requirement.
- Choose standards for establishing a computer network
- Identify switching techniques based on the applications of the network
- Identify IP configuration for the network with suitable routing, scheduling, error control and flow control
- Analyze and develop various network traffic management and control techniques

Question paper pattern:

- The question paper will have 10 full questions carrying equal marks.
- Each full question consists of 16 marks with a maximum of four sub questions.
- There will be 2 full questions from each module covering all the topics of the module
- The students will have to answer 5 full questions, selecting one full question from each module.

Text Books:

1. J. Walrand and P. Varaya, "High performance communication networks", Harcourt Asia (Morgan Kaufmann), 2000.
2. S. Keshav, "An Engineering approach to Computer Networking", Pearson Education, 1997.

Reference Books:

1. Leon-Garcia, and I. Widjaja, "Communication network: Fundamental concepts and key architectures", TMH, 2000.
2. J. F. Kurose, and K. W. Ross, "Computer networking: A top down approach featuring the Internet", Pearson Education, 2001.

MULTIRATE SYSTEMS AND FILTER BANKS As per Choice Based Credit System (CBCS) scheme] SEMESTER – I			
Subject Code	16ESP152	IA Marks	20
Number of Lecture Hours/Week	03	Exam Marks	80
Total Number of Lecture Hours	40 (08 Hours per Week)	Exam Hours	03
CREDITS – 03			

Course objectives: This course will enable students to:

- Understand need of multi-rate systems and it applications.
- Understand theory of multi-rate DSP, solve numerical problems and write algorithms
- Understand theory of prediction and solution of normal equation

Modules	Revised Bloom's Taxonomy (RBT) Level
Module -1	
Fundamentals of Multi-rate Systems: Basic multi-rate operations, interconnection of building blocks, poly-phase representation, multistage implementation, applications of multi-rate systems, special filters and filter banks (Text 1).	**L1, L2**
Module -2	
Maximally decimated filter banks: Errors created in the QMF bank, alias-free QMF system, power symmetric QMF banks, M-channel filter banks, poly-phase representation, perfect reconstruction systems, alias-free filter banks, tree structured filter banks, trans-multiplexers (Text 1).	**L2, L3**
Module -3	
Para-unitary Perfect Reconstruction Filter Banks: Lossless transfer matrices, filter bank properties induced by para-unitariness, two channel Para-unitary lattices, M-channel FIR Para-unitary QMF banks, transform coding (Text 1).	**L2, L3**
Module -4	
Linear Phase Perfect Reconstruction QMF Banks: Necessary conditions, lattice structures for linear phase FIR PR QMF banks, formal synthesis of linear phase FIR PR QMF lattice (Text 1). **Cosine Modulated Filter Banks:** Pseudo-QMF bank and its design, efficient poly-phase structures, properties of cosine matrices, cosine modulated perfect reconstruction systems (Text 1).	**L2, L3**

Module -5	
Wavelet Transform: Short-time Fourier transform, Wavelet transform, discrete-time Ortho-normal wavelets, continuous time Ortho-normal wavelets (Text 2).	**L2, L3**

Course outcomes: After studying this course, students will be able to:

- Understand the fundamentals of multirate signal processing and its applications.
- Learn the theory of sampling rate conversion and develop methods for decimating, interpolating and changing the sampling rate of the signal and to develop efficient polyphaser implementations of sampling rate converters.
- Explain multirate filter banks, the theoretical and practical aspects of multirate signal processing and the applications of filter banks.
- Design perfect reconstruction and near perfect reconstruction filter bank system and to learn.
- Assess the computational efficiency of multirate systems.
- Analyze the quantization effects in filter banks.

Question paper pattern:

- The question paper will have 10 full questions carrying equal marks.
- Each full question consists of 16 marks with a maximum of four sub questions.
- There will be 2 full questions from each module covering all the topics of the module
- The students will have to answer 5 full questions, selecting one full question from each module.

Text Books:

1. P.P.Vaidyanathan,“MultirateSystemsandFilterBanks",PearsonEducation(Asia)Pte.Ltd,2004.
2. Gilbert Strang and Truong Nguyen, "Wavelets and Filter Banks", Wellesley-Cambridge Press, 1996.

Reference Book:

N. J. Fliege, "Multirate Digital Signal Processing”, John Wiley & Sons, USA,2000.

MODERN SPECTRAL ANALYSIS & ESTIMATION [As per Choice Based Credit System (CBCS) scheme] SEMESTER – I			
Subject Code	16ESP153	IA Marks	20
Number of Lecture Hours/Week	03	Exam Marks	80
Total Number of Lecture Hours	40 (08 Hours per Module)	Exam Hours	03
CREDITS – 03			

Course objectives: This course will enable students to:

- Understand Power spectral density and its estimation.
- Acquire knowledge of both Non-parametric &Parametric PSD estimation methods.
- Interpretthe filter bank methods in terms of PSD.

Modules	Revised Bloom's Taxonomy (RBT) Level
Module -1	
Basic Concepts: Introduction, Energy Spectral Density of deterministic signals, Power Spectral Density of random signals, properties of Power Spectral Densities, The Spectral Estimation problem, Coherence Spectrum (Text 1).	**L1, L2**
Module -2	
Spectrum Estimation: Introduction, Correlogram method, Periodogram Computation of FFT, properties of Periodogram method such as bias analysis, window design considerations. Signals with Rational spectra. ARMA state – space Equation, sub space Parameter Estimation (Text 1).	**L2, L3**
Module -3	
Parametric Methods for line Spectra: Models of sinusoidal Signals in Noise, Non-linear least squares method. High Order Yule Walker method, Min – Norm Method, ESPRIT Method, Forward – Backward Estimation (Text 1).	**L2, L3**
Module -4	

Filter Bank Method: Filter bank Interpretation of the period gram, Refined Filter bank Method, Capon Method, Filter Bank Reinterpretation of the periodogram (Text 1).	**L1, L2**
Module -5	
Optimum Linear Filter : Optimum Signal Estimation, Linear MSE Estimation, Solution of the normal equations optimum FIR and IIR filters. Inverse filtering and deconvolution (Text 2).	**L2, L3**

Course outcomes: After studying this course, students will be able to:

- Perform the spatial frequency analysis of signals.
- Use various methods and algorithm the estimation of PSD
- Analyze various signal characteristics for design of optimal systems

Question paper pattern:

- The question paper will have 10 full questions carrying equal marks.
- Each full question consists of 16 marks with a maximum of four sub questions.
- There will be 2 full questions from each module covering all the topics of the module
- The students will have to answer 5 full questions, selecting one full question from each module.

Text Books:

1. Stoica and Moses, “Introduction to Spectral Analysis”, PHI, 1997.
2. Monalakis,IngleandKogen,“StatisticalandAdaptiveSignalProcessing”, Tata McGraw Hill, 2000.

SIMULATION, MODELLING AND ANALYSIS [As per Choice Based Credit System (CBCS) scheme] SEMESTER – I			
Subject Code	16ECS154	IA Marks	20
Number of Lecture Hours/Week	03	Exam Marks	80
Total Number of Lecture Hours	40 (08 Hours per Module)	Exam Hours	03
CREDITS – 03			

Course objectives: This course will enable students to:

- Understand the process of simulation and modeling
- Learn simulation of deterministic and probabilistic models, with a focus of statistical data analysis and simulation data.

Modules	Revised Bloom's Taxonomy (RBT)
Module -1	
Basic Simulation Modeling: Nature of simulation, Systems, Models and Simulation, Discrete-Event Simulation, Simulation of Single Server Queuing System, Simulation of inventory system, Parallel and distributed simulation and the high level architecture, Steps in sound simulation study, and Other types of simulation, Advantages and disadvantages. (1.1, 1.2, 1.3, 1.4, 1.4.1, 1.4.2, 1.4.3, 1.5, 1.5.1, 1.5.2, 1.6, 1.7, 1.8, 1.9 of Text)	**L1,L2**
Module -2	
Review of Basic Probability and Statistics Random Variables and their properties, Simulation Output Data and Stochastic Processes, Estimation of Means, Variances and Correlations, Confidence Intervals and Hypothesis tests for the Mean **Building valid, credible and appropriately detailed simulation models**: Introduction and definitions, Guidelines for determining the level of models detail, Management's Role in the Simulation Process, Techniques for increasing model validity and credibility, Statistical procedure for comparing the real worldobservations and simulation output data. (4.2, 4.3, 4.4, 4.5, 5.1, 5.2, 5.4, 5.5, 5.6, 5.6.1, 5.6.2 of Text)	**L1,L2, L3**
Module -3	

Selecting Input Probability Distributions: Useful probability distributions, activity I, II and III. Shifted and truncated distributions; Specifying multivariate distribution, correlations, and stochastic processes; Selecting the distribution in the absence of data, Models of arrivalprocess (6.2, 6.4, 6.5, 6.6, 6.8, 6.10, 6.11, 6.12 of Text).	**L1,L2, l3**
Module -4	
Random Number Generators: Linear congruential Generators, Other kinds, Testing number generators, **Generating the Random Variates**: General approaches, Generating continuous random variates, Generating discrete random variates, Generating random vectors, and correlated random variates, Generating arrival processes (7.2, 7.3, 7.4, 8.2, 8.3, 8.4, 8.5, 8.6 of Text).	**L1,L2, L3**
Module -5	
Output data analysis for a single system: Transient and steady state behavior of a stochastic process; Types of simulations with regard to analysis; Statistical analysis for terminating simulation; Statistical analysis for steady state parameters; Statistical analysis for steady state cycle parameters; Multiple measures of performance, Time plots of important variables. (9.2, 9.3, 9.4, 9.4.1, 9.4.3, 9.5, 9.5.1, 9.5.2, 9.5.3, 9.6, 9.7, 9.8 of Text)	**L1,L2,L3**

Course Outcomes:

After studying this course, students will be able to:

- Define the need of simulation and modeling.
- Describe various simulation models.
- Discuss the process of selecting of probability distributions.
- Perform output data analysis.

Question paper pattern:

- The question paper will have 10 full questions carrying equal marks.
- Each full question consists of 16 marks with a maximum of four sub questions.
- There will be 2 full questions from each module covering all the topics of the module
- The students will have to answer 5 full questions, selecting one full question from each module.

Text Book:

Averill Law, "Simulation modeling and analysis", McGraw Hill 4th edition, 2007.

Reference Books:

1. Tayfur Altiok and Benjamin Melamed, “Simulation modeling and analysis with ARENA”, Elsevier, Academic press, 2007.
2. Jerry Banks, "Discrete event system Simulation", Pearson, 2009
3. Seila Ceric and Tadikamalla, "Applied simulation modeling", Cengage, 2009.
4. George. S. Fishman, "Discrete event simulation", Springer, 2001.
5. Frank L. Severance, "System modeling and simulation", Wiley, 2009.

SIGNAL PROCESSING LAB [As per Choice Based Credit System (CBCS) scheme] SEMESTER – I			
Laboratory Code	16ESPL16	IA Marks	20
Number of Lecture Hours/Week	01Hr Tutorial (Instructions) + 02 Hours Laboratory	Exam Marks	80
		Exam Hours	03
CREDITS -02			

Course objectives: This laboratory course enables students to

- Implement (MATLAB) basic operations on signals
- Understand signal behavior in time domain and frequency domain
- Understand Sampling rate variation using decimation and interpolation
- Understand the concept of power spectrum
- Pursue research work in signal processing

Laboratory Experiments: **NOTE: Experiments 1-10 are to be carried using Matlab and 11-12 using a DSP kit.**	**Revised Bloom's Taxonomy (RBT) Level**
1. Generate various fundamental discrete time signals.	**L1, L2**
2. Basic operations on signals (Multiplication, Folding, Scaling).	**L1, L2**
3. Find out the DFT & IDFT of a given sequence without using inbuilt instructions.	**L2, L3**
4. Interpolation & decimation of a given sequence.	**L2, L3**
5. Generation of DTMF (Dual Tone Multiple Frequency) signals.	**L2, L3**
6. Estimate the PSD of a noisy signal using periodogram and modified periodogram.	**L2, L3, L4**
7. Estimation of power spectrum using Bartlett and Welch methods.	**L2, L3**
8. Estimation of power spectrum using Blackman-Bukey method.	**L2, L3, L4**
9. Estimation of power spectrum using parametric methods (Yule-Walker & Burg).	**L2, L3, L4**

10. Design of LPC filter using Levinson-Durbin algorithm.	**L3, L4**
11. Noise cancellation using LMS algorithm (Implementation should be done using DSP kit)	**L2, L3**
12. Power spectrum estimation (Implementation should be done using DSP kit)	**L2, L3**

Course outcomes: On the completion of this laboratory course, the students will be able to:

- Implement basic operation for signals using MATLAB
- Compute and visualize DFT and IDFT of any given signal
- Compute either decimated or interpolated signal
- Solve problems of power spectrum
- Can take up research work on signal processing

Conduct of Practical Examination:

- All laboratory experiments are to be included for practical examination.
- Students are allowed to pick one experiment from the lot.
- Strictly follow the instructions as printed on the cover page of answer script for breakup of marks.
- Change of experiment is allowed only once and Marks allotted to the procedure part to be made zero.

M.Tech-SP-2016-SECOND SEMESTER SYLLABUS

Image Processing and Machine Vision [As per Choice Based Credit System (CBCS) Scheme SEMESTER – II			
Subject Code	16ESP21	IA Marks	20
Number of Lecture Hours/Week	04	Exam marks	80
Total Number of Lecture Hours	50 (10 Hours per Module)	Exam Hours	03
CREDITS – 04			

Course Objectives:

- An introduction to image analysis and computer vision for undergraduates.
- An introduction to low-level vision (early processing) techniques such as binary image analysis, filtering, edge detection and texture analysis.
- An introduction to mid-level vision topics such as image segmentation and feature extraction.
- Application of Image processing techniques to image retrieval, image classification, and object recognition with emphasis on feature extraction and image representations for recognition.

Modules	**Revised Bloom's Taxonomy (RBT) Level**
Module 1	
The image mathematical and physical background: Linearity, The Dirac distribution and convolution, Linear integral transforms, Images as linear systems, **Introduction to linear integral transforms:** 2D Fourier transform, Sampling and the Shannon constraint, Discrete cosine transform, Wavelet transform, Eigen-analysis, Singular value decomposition Principal component analysis, Other orthogonal image transforms,	**L1,L2**

Images as stochastic processes	
Module 2	
Image pre-processing: Scale in image processing, Canny edge detection, Parametric edge models, Edges in multi-spectral images, Pre-processing in frequency domain, Line detection, Corner detection, Maximally stable extremal regions, **Image restoration**: Degradations that are easy to restore, Inverse filtration, Wiener filtration	**L1,L2,L3**
Module 3	
Image segmentation: Threshold detection methods, Optimal thresholding, Multi-spectral thresholding, Edge-based segmentation, Edge image thresholding, Edge relaxation, Border tracing, Border detection as graph searching, Border detection as dynamic programming, Hough transforms, Border detection using border location information, Region construction from borders, Region-based segmentation, Region merging, Region splitting, Splitting and merging, Watershed segmentation, Region growing post-processing. **Matching :** Matching criteria, Control strategies of matching **Evaluation issues in segmentation:** Supervised evaluation, Unsupervised evaluation	**L1,L2,L3**
Module 4	
Advanced segmentation: Mean Shift Segmentation, Active contour models-snakes, Traditional snakes and balloons, Extensions, Gradient vector flow snakes, Geometric deformable models-level sets and geodesic active contours, Fuzzy Connectivity, **Contour-based shape representation and description:** Chain codes, Simple geometric border representation, Fourier transforms of boundaries, Boundary description using segment sequences, B-spline representation, Other contour-based shape description approaches, Shape invariants.	**L1,L2,L3**
Module 5	

Knowledge representation: Statistical pattern recognition, Classification principles, Classifier setting, Classifier learning, Support Vector Machines, Cluster analysis **Neural nets:** Feed-forward networks, Unsupervised learning, Hopfield neural nets **Optimization techniques in recognition:** Genetic algorithms, Simulated annealing **Fuzzy systems:** Fuzzy sets and fuzzy membership functions, Fuzzy set operators, Fuzzy reasoning, Fuzzy system design and training	**L1,L2,L3**

Course outcomes: After studying this course, students will be able to:

- Apply techniques for image enhancement, segmentation and filtering.
- Analyze image data.
- Implement a complete image-processing package using standard concepts.
- Decide on a suitable learning/ recognition technique for a problem in hand using standard concepts.

Question paper pattern:

- The question paper will have 10 full questions carrying equal marks.
- Each full question consists of 16 marks with a maximum of four sub questions.
- There will be 2 full questions from each module covering all the topics of the module
- The students will have to answer 5 full questions, selecting one full question from each module.

Text Book:

Milan Sonka, Vaclav Hlavac , Roger Boyle **"Image Processing, Analysis, and Machine Vision",** Cengage Learning, 2014 or 3rd Edition, 2008ISBN:049508252X

Reference Books:

1) Scott.E.Umbaugh, **"Computer Vision and Image Processing"**, Prentice Hall, 1997.
2) A. K.Jain, **"Fundamentals of Digital Image Processing"**, Pearson, 2004.
3) S.Jayaraman, S.Esakkirajan, T. Veerakumar, **"Digital Image Processing"**, Tata McGraw Hill, 2004.

DSP System Design [As per Choice Based Credit System (CBCS) Scheme SEMESTER – II			
Subject Code	16ESP22	IA Marks	20
Number of Lecture Hours/Week	04	Exam marks	80
Total Number of Lecture Hours	50 (10 Hours per Module)	Exam Hours	03
CREDITS – 04			

Course Objectives: This course will enable students to:

- Understand the key theoretical principles underpinning DSP in a design procedure through design examples and case studies.
- Learn how to use a powerful general-purpose mathematicalpackage such as MATLAB to design and simulate a DSP system.
- Understand the architecture of a digital signal processor andsome programming issues in fixed-point digital signal processor inreal-time implementation.
- Learn to design a real-time signal processing algorithms using the latest fixed-point processor.

Modules	**Revised Bloom's Taxonomy (RBT) Level**
Module 1	
Introduction t o popular DSP CPU Architecture –CPU Data Paths and Control-Timers-Internal Data/Program Memory-External Memory Interface-Programming –Instruction set and Addressing Modes-Code Composer Studio-Code Generation Tools –Code Composer Studio Debugtools –Simulator (Text 1)	**L1,L2,L3**
Module 2	
Sharc Digital Signal Processor- A popular DSP from Analog Devices - Sharc/ Tiger Sharc/ Blackfin (one of them) - Architecture - IOP	

Registers - Peripherals - Synchronous Serial Port Interrupts - Internal/External/Multiprocessor Memory Space - Multiprocessing - Host Interface - Link Ports. (Text 2)	**L1,L2,L3**
Module 3	
Digital Signal Processing Applications-FIR and IIR Digital Filter Design, Filter Design Programs using MATLAB- Fourier Transform: DFT, FFT programs using MATLAB (Text 1)	**L1,L2,L3**
Module 4	
Real Time Implementation –Implementation of Real Time Digital Filters using DSP-Implementation of FFT Applications using DSP – DTMF Tone Generation and Detection (Text 1)	**L1,L2,L3**
Module 5	
Current trends- Current trend in Digital Signal Processor or DSP Controller- Architecture and their applications. (Text 1)	**L1,L2,L3**

Course Outcomes: After studying this course, students will be able to:

- Understand fundamental concepts of 'DSP Architecture' and 'Sharc Digital Signal Processor'
- Analyze the concept of IIR type digital filters, FIR type digital filters, DFT and FFT
- Apply a design technique of Real-Time Digital Filters, FFT.
- Use the "MATLAB" language and "signal processing toolboxes" for analyzing, designing and implementing digital signal processing (DSP) systems such as digital filters.

Question paper pattern:

- The question paper will have 10 full questions carrying equal marks.
- Each full question consists of 16 marks with a maximum of four sub questions.
- There will be 2 full questions from each module covering all the topics of the module
- The students will have to answer 5 full questions, selecting one full question from each module.

Text Books:

1) Rulf Chassaing, **"Digital Signal Processing and Application with C6713 and C6416 DSK"**, Wiley-Interscience Publication

2) T.J. TerrelandLik- Kwan Shark, **"Digital Signal Processing- A Student Guide"**, 1st Edition; Macmillan Press Ltd.

Reference Books:

1) David. J Defatta. J,Lucas Joseph.G & Hodkiss William S, **"Digital Signal Processing: A System Design Approach"**,1st Edition, John Wiley.
2) Steven K Smith, Newnes, **"Digital Signal Processing-A Practical Guide for Engineers and Scientists"**, Elsevier Science.
3) Rulph Chassaing, **"DSP Applications using 'C' and the TMS320C6X DSK"**, 1st Edition.
4) Andrew Bateman, Warren Yates, **"Digital Signal Processing Design"**, 1st Edition
5) Naim Dahnoun, **"Digital Signal Processing Implementation using the TMS320C6000 DSP Platform"**, 1st Edition.

Digital Signal Compression [As per Choice Based Credit System (CBCS) Scheme SEMESTER – II			
Subject Code	16ESP23	IA Marks	20
Number of Lecture Hours/Week	04	Exam marks	80
Total Number of Lecture Hours	50 (10 Hours per Module)	Exam Hours	03
CREDITS – 04			

Course Objectives: This course will enable students to:

- Acquire contemporary knowledge in Data Compression and Coding.
- Equip with skills to analyze and evaluate different Data Compression and Coding methods

Modules	**Revised Bloom's Taxonomy (RBT) Level**
Module 1	
Introduction: Compression techniques, Modeling & coding, Distortion criteria, Differential Entropy, Rate Distortion Theory, Vector Spaces, Information theory, Models for sources, Coding–uniquely decodable codes, Prefix codes, Kraft McMillan Inequality. **Quantization:** Quantization problem, Uniform Quantizer, Adaptive Quantization, Non-uniform Quantization; Entropy coded Quantization, Vector Quantization, LBG algorithm, Tree structured VQ, Structured VQ, Variations of VQ–Gain shape VQ, Mean removed VQ, Classified VQ, Multistage VQ, Adaptive VQ, Trellis coded quantization.	**L1,L2**
Module 2	
Differential Encoding: Basic algorithm, Prediction in DPCM, Adaptive DPCM, Delta Modulation, Speech coding–G.726, Image coding. **Transform Coding:** Transforms–KLT, DCT, DST, DWHT; Quantization and coding of transform coefficients, Application to Image compression–JPEG,	**L1,L2**

Application to audio compression	
Module 3	
Sub-band Coding: Filters, Sub-band coding algorithm, Design of filter banks, Perfect reconstruction using two channel filter banks, M-band QMF filter banks, Poly-phase decomposition, Bit allocation, Speech coding– G.722, Audio coding–MPEG audio, Image compression.	**L1,L2**
Module 4	
Wavelet Based Compression: Wavelets, Multi resolution analysis & scaling function, Implementation using filters, Image compression–EZW, SPIHT, JPEG 2000. **Analysis/Synthesis Schemes:** Speech compression–LPC-10, CELP, MELP, Image Compression–Fractal compression**.** **Video Compression:** Motion compensation, Video signal representation, Algorithms for video conferencing & video phones–H.261, H.263, Asymmetric applications–MPEG 1, MPEG 2, MPEG 4, MPEG 7, Packet video.	**L1,L2**
Module 5	
Loss less Coding: Huffman coding, Adaptive Huffman coding, Golomb codes, Rice codes, Tunstall codes, Applications of Huffman coding, Arithmetic coding, Algorithm implementation, Applications of Arithmetic coding, Dictionary techniques–LZ77, LZ78, Applications of LZ78– JBIG, JBIG2, Predictive coding–Prediction with partial match, Burrows Wheeler Transform, Applications–CALIC, JPEG-LS, Facsimile coding– T.4, T.6.	**L1,L2**

Course outcomes: After studying this course, students will be able to:

- Explain the evolution and fundamental concepts of Data Compression and Coding techniques.
- Analyze the operation of a range of commonly used Coding and Compression techniques
- Identify the basic software and hardware tools used for data compression.
- Identify what new trends and what new possibilities of data compression are available.

Question paper pattern:

- The question paper will have 10 full questions carrying equal marks.
- Each full question consists of 16 marks with a maximum of four sub questions.
- There will be 2 full questions from each module covering all the topics of the

module

- The students will have to answer 5 full questions, selecting one full question from each module.

Text Book:

1) K.Sayood, **"Introduction to Data Compression"**, Harcourt India Pvt. Ltd. & Morgan Kaufmann Publishers, 1996.

Reference Books:

1) N.Jayantand P.Noll, **"Digital Coding of Waveforms: Principles and Applications to Speech and Video"**, Prentice Hall, USA, 1984.
2) D.Salomon, **"Data Compression: The Complete Reference"**, Springer, 2000.
3) Z.Liand M.S.Drew, **"Fundamentals of Multimedia"**, Pearson Education (Asia) Pvt. Ltd., 2004.

Biomedical Signal Processing [As per Choice Based credit System (CBCS) Scheme SEMESTER – II				
Subject Code	16ESP24	IA Marks		20
Number of Lecture Hours/Week	04	Exam marks		80
Total Number of Lecture Hours	50 (10 Hours per Module)	Exam Hours		03
CREDITS – 04				

Course Objectives: This course will enable students to:

- Understand the basic signals in the field of biomedical.
- Study origins and characteristics of some of the most commonly used biomedical signals, including ECG, EEG, evoked potentials, and EMG.
- Understand Sources and characteristics of noise and artifacts in bio- signals.
- Understand use of bio signals in diagnosis, patient monitoring and physiological investigation
- Explore research domain in biomedical signal processing.

Modules	**Revised Bloom's Taxonomy (RBT) Level**
Module 1	
Introduction-Genesis and significance of bio electric potentials, ECG, EOG, EMG and their monitoring and measurement, Spectral analysis,	**L1,L2**
Module 2	
Filtering- digital and analog filtering, correlation and estimation techniques, AR / ARMA models, Adaptive Filters.	**L1,L2**
Module 3	
ECG-Pre-processing, Measurements of amplitude and time intervals, Classification, QRS detection, ST segment analysis, Base line wander	**L1,L2**

removal, waveform recognition, morphological studies and rhythm analysis, automated diagnosis based on decision theory ECT compression, Evoked potential estimation.	
Module 4	
EEG: Evoked responses, Epilepsy detection, Spike detection, Hjorth parameters, averaging techniques, removal of Artifacts by averaging and adaptive algorithms, pattern recognition of alpha, beta, theta and delta waves in EEG waves, sleep stages,	**L1,L2**
Module 5	
EMG-Wave pattern studies, bio feedback, Zero crossings, Integrated EMG. Time frequency methods and Wavelets in Biomedical Signal Processing.	**L1,L2**

Course Outcomes: After studying this course, students will be able to:

- Model a biomedical system.
- Understand various methods of acquiring bio signals.
- Understand various sources of bio signal distortions and its remedial techniques.
- Analyze ECG and EEG signal with characteristic feature points.

Question paper pattern:

- The question paper will have 10 full questions carrying equal marks.
- Each full question consists of 16 marks with a maximum of four sub questions.
- There will be 2 full questions from each module covering all the topics of the module.
- The students will have to answer 5 full questions, selecting one full question from each module.

TEXT Book:

Willis J Tompkins, ED, **"Biomedical Digital Signal Processing"**, Prentice-Hall of India, 1996.

Reference Books:

1) R E Chellis and RI Kitney, **"Biomedical Signal Processing"**, in IV parts, Medical and Biological Engg. and current computing, 1990-91.
2) Special issue on **"Biological Signal Processing"**, Proc. IEEE 1972
3) Arnon Kohen, **"Biomedical Signal Processing"**, Volumes I &I I, CRC Press.
4) Metin Aray, **"Time frequency and Wavelets in Biomedical Signal Processing"**, IEEE Press, 1999.Current Published literature.

Detection & Estimation [As per Choice Based Credit System (CBCS) Scheme SEMESTER – II			
Subject Code	16ESP251	IA Marks	20
Number of Lecture Hours/Week	03	Exam marks	80
Total Number of Lecture Hours	40 (8 Hours per Module)	Exam Hours	03
CREDITS – 03			

Course Objectives: This course will enable students to:

- Acquire knowledge of estimation and detection background for engineering applications.
- Understand the main concepts and algorithms of detection and estimation theory.

Modules	**RBT Level**
Module 1	
Classical Detection and Estimation Theory: Introduction, simple binary hypothesis tests, M Hypotheses, estimation theory, composite hypotheses, general Gaussian problem, performance bounds and approximations. (Text 1)	**L1,L2**
Module 2	
Representations of Random Processes: Introduction, orthogonal representations, random process characterization, homogenous integral equations and eigen functions, periodic processes, spectral decomposition, vector random processes. (Text 2)	**L1,L2**
Module 3	
Detection of Signals – Estimation of Signal Parameters: Introduction, detection and estimation in white Gaussian noise, detection and estimation in nonwhite Gaussian noise, signals with unwanted parameters, multiple channels and multiple	

parameter estimation. (Text 1)	**L1,L2**
Module 4	
Estimation of Continuous Waveforms: Introduction, derivation of estimator equations, lower bound on the mean-square estimation error, multidimensional waveform estimation, non-random waveform estimation. . (Text 1)	**L1,L2**
Module 5	
Linear Estimation: Properties of optimum processors, realizable linear filters, Kalman-Bucy filters, fundamental role of optimum linear filters. (Text 1)	**L1,L2,L3**

Course outcomes: After studying this course, students will be able to:

- Acquire basics of statistical decision theory used for signal detection and estimation.
- Examine the detection of deterministic and random signals using statistical models.
- Comprehend the elements and structure of nonparametric detection.
- Examine the performance of signal parameters using optimal estimators.
- Analyze signal estimation in discrete-time domain using filters.

Question paper pattern:

- The question paper will have 10 full questions carrying equal marks.
- Each full question consists of 16 marks with a maximum of four sub questions.
- There will be 2 full questions from each module covering all the topics of the module
- The students will have to answer 5 full questions, selecting one full question from each module.

Text Books:

1) Harry L. Van Trees, "**Detection, Estimation, and Modulation Theory**", Part I, John Wiley & Sons, USA, 2001.
2) K Sam Shanmugam, Arthur M Breipohl, "**Random Signals: Detection, Estimation and Data Analysis"**, John Wiley & Sons, 1998.

Reference Books:

1) M.D. Srinath, P.K. Rajasekaran and R. Viswanathan, "**Introduction to Statistical Signal Processing with Applications**", Pearson Education (Asia) Pvt. Ltd. /Prentice Hall of India, 2003.
2) Steven M. Kay, "**Fundamentals of Statistical Signal Processing,**" **Volume I: "Estimation Theory**", Prentice Hall, USA, 1998.
3) Steven M. Kay, "**Fundamentals of Statistical Signal Processing", Volume II: "Detection Theory**," Prentice Hall, USA, 1998.

<table>
<tr><td colspan="4" align="center"><u>VLSI Design for Signal Processing</u>
[As per Choice Based Credit System (CBCS) Scheme
SEMESTER – II</td></tr>
<tr><td>Subject Code</td><td>16EVE252</td><td>IA Marks</td><td>20</td></tr>
<tr><td>Number of Lecture Hours/Week</td><td>03</td><td>Exam marks</td><td>80</td></tr>
<tr><td>Total Number of Lecture Hours</td><td>40
(8 Hours per Module)</td><td>Exam Hours</td><td>03</td></tr>
<tr><td colspan="4" align="center">CREDITS – 03</td></tr>
<tr><td colspan="4">Course Objectives: This course will enable students to:
Learn several high-level architectural transformations that can be used to design families of architectures for a given algorithm.
Deal with high-level algorithm transformations such as strength reduction, look-ahead and relaxed look-ahead.</td></tr>
</table>

Modules	**RBT Level**
Module 1	
Introduction to DSP systems: Typical DSP Algorithms, DSP Application Demands and Scaled CMOS Technologies, Representations of DSP Algorithms. **Iteration Bounds:** Data flow graph Representations, loop bound and Iteration bound.	**L1, L2**
Module 2	
Iteration Bounds: Algorithms for Computing Iteration Bound, Iteration Bound of multi rate data flow graphs. **Pipelining and parallel processing:** pipelining of FIR Digital Filters, parallel processing, Pipelining and parallel processing for low power.	**L1,L2,L3**
Module 3	
Retiming: Definition and Properties, Solving Systems of Inequalities, Retiming Techniques, **Unfolding**: An Algorithm for Unfolding, Properties of Unfolding, Critical path, Unfolding and Retiming, Application of Unfolding. **Systolic architecture design:** systolic array design Methodology,	**L1,L2,L3**

FIR systolic array.	
Module 4	
Systolic architecture design: Selection of Scheduling Vector, Matrix-Matrix Multiplication and 2D systolic Array Design, Systolic Design for space representation containing Delays. **Fast convolution**: Cook-Toom Algorithm, Winograd Algorithm, Iterated convolution, cyclic convolution Design of fast convolution Algorithm by Inspection.	**L1,L2,L3**
Module 5	
Pipelined and Parallel recursive and adaptive filter: Pipeline Interleaving in Digital Filter, first order IIR digital Filter, Higher order IIR digital Filter, parallel processing for IIR filter, Combined pipelining and parallel processing for IIR Filter, Low power IIR Filter Design Using Pipe lining and parallel processing, pipelined Adaptive digital filter.	**L1,L2,L3**

Course Outcomes: After studying this course, students will be able to:

- Illustrate the use of various DSP algorithms and addresses their representation using block diagrams, signal flow graphs and data-flow graphs
- Use pipelining and parallel processing in design of high-speed /low-power applications
- Apply unfolding in the design of parallel architecture
- Evaluate the use of look-ahead techniques in parallel and pipelined IIR Digital filters.
- Develop an algorithm or architecture or circuit design for DSP applications

Question paper pattern:

- The question paper will have 10 full questions carrying equal marks.
- Each full question consists of 16 marks with a maximum of four sub questions.
- There will be 2 full questions from each module covering all the topics of the module
- The students will have to answer 5 full questions, selecting one full question from each module.

Text Book:
Keshab K.Parthi, "**VLSI Digital Signal Processing systems, Design and implementation** ", Wiley 1999.

Reference Books:

1) Mohammed Isamail and Terri Fiez, "**Analog VLSI Signal and Information Processing** ", Mc Graw-Hill,1994.
2) S.Y. Kung, H.J. White House, T. Kailath, "**VLSI and Modern Signal Processing** ", Prentice Hall, 1985.
3) Jose E. France, Yannis T sividis, " **Design of Analog - Digital VLSI Circuits for Telecommunication and Signal Processing** ", Prentice Hall, 1994.
4) Lars Wanhammar, "**DSP Integrated Circuits**", Academic Press Series in Engineering, 1st Edition.

<table>
<tr><td colspan="4" align="center"><u>Pattern Recognition</u>
[As per Choice Based Credit System (CBCS) Scheme
SEMESTER – II</td></tr>
<tr><td>Subject Code</td><td>16ESP253</td><td>IA Marks</td><td>20</td></tr>
<tr><td>Number of Lecture Hours/Week</td><td>03</td><td>Exam marks</td><td>80</td></tr>
<tr><td>Total Number of Lecture Hours</td><td>40
(8 Hours per Module)</td><td>Exam marks</td><td>03</td></tr>
<tr><td colspan="4" align="center">CREDITS – 03</td></tr>
<tr><td colspan="4">Course Objectives: This course will enable students to:
Equip with the basic mathematical and statistical techniques commonly used in pattern recognition.
Understand variety of pattern recognition algorithms, along with pointers on which algorithms work best under what conditions
Acquire overview knowledge of advanced topics in pattern recognition</td></tr>
<tr><td colspan="3">Modules</td><td>Revised Bloom’s Taxonomy Level</td></tr>
<tr><td colspan="4">Module 1</td></tr>
<tr><td colspan="3">Introduction:
Applications of pattern recognition, statistical decision theory, image processing and analysis.
Probability: Introduction, probability of events, random variables, Joint distributions and densities, moments of random variables, estimation of parameters from samples, minimum risk estimators
Statistical Decision Making: Introduction, Baye’s Theorem, multiple features, conditionally independent features, decision boundaries, unequal costs of error, estimation of error rates, the leaving-one—out technique. Characteristic curves, estimating the composition of populations.</td><td>L1,L2</td></tr>
</table>

Module 2	
Nonparametric Decision Making: Introduction, histograms, Kernel and window estimators, nearest neighbor classification techniques, adaptive Decision boundaries, adaptive discriminate Functions, minimum squared error discriminate functions, choosing a decision making technique.	**L1,L2**
Module 3	
Unsupervised Classification: Clustering, Hierarchical Clustering, Graph Based Method, Sum of Squared Error Technique ,Iterative Optimization clustering.	**L1,L2**
Module 4	
Neural Network Classifier: Single and Multilayer Perceptron, Back Propagation Learning, Hopfield Network, Fuzzy Neural Network	**L1,L2**
Module 5	
Time Varying Pattern Recognition, First Order Hidden Markov Model Evaluation, Decoding, Learning.	**L1,L2**

Course outcomes: After completing the course, the student will know

- The basic structure of pattern recognition systems and the statistical bases of the classification theory (the Bayes classifier).
- Will be able to distinguish supervised learning methods from the unsupervised ones.
- Will be able to apply supervised learning methods (model-based maximum likelihood, k-nearest neighbors) to the classifier design.
- Apply pattern recognition techniques to real-world problems such as document analysis and recognition.
- Implement simple pattern classifiers, classifier combinations, clustering algorithms and structural pattern recognizers.

Question paper pattern:

- The question paper will have 10 full questions carrying equal marks.
- Each full question consists of 16 marks with a maximum of four sub questions.
- There will be 2 full questions from each module covering all the topics of the module
- The students will have to answer 5 full questions, selecting one full question from each module.

Text Book:
Richard O. Duda, Peter E. Hart, David G. Stork, “Pattern Classification”, Wiley, 2^{nd} edition, 2001.

Reference Books:

1. Eart Gose, Richard Johnsonburg and Steve Joust, “Pattern Recognition and Image Analysis”, Prentice-Hall ofIndia-2003.
2. Robert J Schalkoff, “Pattern recognition: Statistical, Structural and neural approaches”, John Wiley.

<table>
<tr><td colspan="5"><u>Channel Coding</u>
[As per Choice Based Credit System (CBCS) Scheme
SEMESTER – II</td></tr>
<tr><td>Subject Code</td><td>16ESP254</td><td colspan="2">IA Marks</td><td>20</td></tr>
<tr><td>Number of Lecture Hours/Week</td><td>03</td><td colspan="2">Exam marks</td><td>80</td></tr>
<tr><td>Total Number of Lecture Hours</td><td>40
(8 Hours per Module)</td><td colspan="2">Exam marks</td><td>03</td></tr>
<tr><td colspan="5">CREDITS – 03</td></tr>
<tr><td colspan="5">Course Objectives: This course will enable students to:
Concepts and complexity of error-control codes and their practical applications.
Historical development behind synthesis of Channel coding techniques.
Classical channel codes including the classes of Cyclic codes, BCH codes, RS codes and various Convolutional codes.
Modern capacity approaching codes like Turbo codes
Burst Error Correcting Codes, their encoding and decoding strategies and performance evaluation.</td></tr>
<tr><td colspan="3">Modules</td><td colspan="2">Revised Bloom's Taxonomy (RBT) Level</td></tr>
<tr><td colspan="5">Module 1</td></tr>
<tr><td colspan="4">Introduction to Algebra: Groups, Fields, Binary Field Arithmetic, Construction of Galois Field GF (2^m) and its basic properties, Computation using Galois Field GF (2^m) Arithmetic, Vector spaces and Matrices.
Linear Block Codes: Generator and Parity check Matrices, Encoding circuits, Syndrome and Error Detection, Minimum Distance Considerations, Error detecting and Error correcting capabilities, Standard array and Syndrome decoding, Decoding circuits, Reed–Muller codes, Product codes and Inter leaved codes.</td><td>L1,L2</td></tr>
</table>

<table>
<tr><td colspan="2">Module 2</td></tr>
<tr><td>Cyclic Codes:Introduction, Generator and Parity check Polynomials, Encoding of cyclic codes, Generator matrix for Cyclic codes, Syndrome computation and Error detection, Meggitt decoder, Error trapping decoding, Cyclic Hamming codes, The (23, 12) Golay code, Shortened cyclic codes.</td><td>L1,L2</td></tr>
<tr><td colspan="2">Module 3</td></tr>
<tr><td>BCH Codes:
Binary primitive BCH codes, Decoding procedures, Implementation of Galois field Arithmetic, Implementation of Error correction. Non–binary BCH codes: q–ary Linear Block Codes, Primitive BCH codes over GF (q), Reed–Solomon Codes, Decoding of Non –Binary BCH and RS codes: The Berlekamp-Massey Algorithm.</td><td>L1,L2</td></tr>
<tr><td colspan="2">Module 4</td></tr>
<tr><td>Majority Logic Decodable Codes: One–Step Majority logic decoding, one–step Majority logic decodable Codes, Multiple–step Majority logic decoding.
Convolutional Codes: Encoding of Convolutional codes, Structural properties, Distance properties, Viterbi Decoding Algorithm for decoding, Soft – output Viterbi Algorithm, Stack and Fano sequential decoding Algorithms, Majority logic decoding.</td><td>L1,L2</td></tr>
<tr><td colspan="2">Module 5</td></tr>
<tr><td>Concatenated Codes & Turbo Codes: Single level Concatenated codes, Multi-level Concatenated codes, Soft decision Multi stage decoding, Concatenated coding schemes with Convolutional Inner codes, Introduction to Turbo coding and their distance properties, Design of Turbo codes. Burst–Error–Correcting Codes: Burst and Random error correcting codes, Concept of Inter–leaving, cyclic codes for Burst Error correction–Fire codes, Convolutional codes for Burst Error correction.</td><td>L1,L2</td></tr>
<tr><td colspan="2">Course outcomes: After completion of this course, students should be able to
• Get a clear concept of different error correcting and convolution codes.
• Work as designers of channel codes in physical layer design and storage system design.
• Work on synthesizing channel codes for new applications in Wireless/Wired communication systems and Storage systems.</td></tr>
</table>

Question paper pattern:

- The question paper will have 10 full questions carrying equal marks.
- Each full question consists of 16 marks with a maximum of four sub questions.
- There will be 2 full questions from each module covering all the topics of the module
- The students will have to answer 5 full questions, selecting one full question from each module.

Text Book:

Shu Lin &Daniel J. Costello, Jr. **"Error Control Coding"**, Pearson/ Prentice Hall, Second Edition, 2004.

Reference Book:

Blahut, R.E. **"Theory and Practice of Error Control Codes"**, Addison Wesley, 1984.

<table>
<tr><td colspan="4"><u>Image Processing Lab</u>
[As per Choice Based Credit System (CBCS) Scheme
SEMESTER – II</td></tr>
<tr><td>Subject Code</td><td>16ESPL26</td><td>IA Marks</td><td>20</td></tr>
<tr><td>Number of Lecture Hours/Week</td><td>03</td><td>Exam marks</td><td>80</td></tr>
<tr><td>Total Number of Lecture Hours</td><td>01Hr Tutorial (Instructions)
+ 02 Hours Laboratory</td><td>Exam Hours</td><td>03</td></tr>
<tr><td colspan="4">CREDITS – 02</td></tr>
<tr><td colspan="4">Course Objectives: This course will enable students to:
• Apply principles and techniques of digital image processing in applications machine vision and image analysis.
• Analyze and implement image processing algorithms to be suited for machine vision.
• Gain hands-on experience in using software tools for processing digital images.</td></tr>
<tr><td colspan="3">Modules</td><td>Revised Bloom’s Taxonomy (RBT) Level</td></tr>
<tr><td colspan="4">Experiments</td></tr>
<tr><td colspan="3">1.Study the effects of
a) Boolean operations on binary images
b) Quantization of gray level images</td><td>L2</td></tr>
<tr><td colspan="3">2. Study the effects of Contrast enhancement using
a) Histogram equalization
b) Histogram stretching.</td><td>L2</td></tr>
<tr><td colspan="3">3. Using connected component labeling algorithms. Express pixel neighborhood relationships in terms of a graph</td><td>L2</td></tr>
</table>

4. Creates a binary image from image I by replacing all values above a determined threshold level using a) global thresholding b) adaptive thresholding technique	**L3**
5. Transform an image given using Spatial Transformation	**L3**
6. Study how to compute forward 2D FFT and a) Find the log magnitude & phase and the inverse 2D FFT if an image. b) Compute the forward 2D FFT of the filter kernel. c) Design a laplacian high pass filter d) Study the Two Dimensional Filter Design using filter design functions	**L3**
7. Determine the suitability of homomorphic filtering using a low pass filter for image enhancement to fix non- uniform of illumination.	**L3**
8. Implement inverse, Wiener, Regular, and Lucy-Richardson for image restoration. And formulate how noise information in an image can be used to restore a degraded image.	**L3**
9. Study different methods of edge detection for use on noisy images, specifically, a) Motion blurb) Gaussian noise c) Filtered Gaussian noise via averaging.	**L3**
10. Write an algorithm for recognizing of circles and triangles.	**L3**

Course outcomes: After studying this course, students will be able to:

- Perform basic transformations for Image enhancement
- Apply histogram equalization for image enhancement
- Model the image restoration problem in both time and frequency domains
- Describe spatial transformations using images
- Implement different recognition tasks using image processing.

Conduct of Practical Examination:

- All laboratory experiments are to be included for practical examination.

- Students are allowed to pick one experiment from the lot.
- Strictly follow the instructions as printed on the cover page of answer script for breakup of marks.
- Change of experiment is allowed only once and Marks allotted to the procedure will be made zero.

M.Tech-SP-2016-FOURTH SEMESTER SYLLABUS

Adaptive Signal processing [As per Choice Based credit System (CBCS) Scheme SEMESTER – IV			
Subject Code	16ESP41	IA Marks	20
Number of Lecture Hours/Week	04	Exam marks	80
Total Number of Lecture Hours	50 (10 Hours per Module)	Exam Hours	03
CREDITS – 04			

Course Objectives: This course will enable students to:

- Understand meaning of "adaption" in terms of signal processing and geometrical terms.
- Analyze basic non-recursive adaptive filter, that is, the adaptive linear combiner.
- Understand performance or error surface under stationary and non-stationary conditions.
- Understand LMS algorithms and other types of adaptive algorithms.
- Understand adaptive modelling and system identification; inverse adaptive modelling, de-convolution and equalization.

Modules	RBT Level
Module 1	
Adaptive systems : Definitions and characteristics - applications - properties-examples - adaptive linear combiner input signal and weight vectors - performance function-gradient and minimum mean square error - introduction to filtering-smoothing and prediction - linear optimum filtering-orthogonality – WienerHopf equation- Performance Surface. (Text 1)	**L1,L2**
Module 2	
Searching performance surface-stability and rate of convergence: learning curve-gradient search - Newton's method - method of steepest descent - comparison - gradient estimation - performance penalty - variance - excess MSE and time constants – misadjustments. (Text 1)	**L1,L2**
Module 3	
LMS algorithm convergence of weight vector: LMS/Newton algorithm - properties - sequential regression algorithm - adaptive	**L1**

recursive filters - random-search algorithms - lattice structure - adaptive filters with orthogonal signals. (Text 1)	**L2,L3**
Module 4	
Applications-adaptive modeling: Multipath communication channel, geophysical exploration, FIR digital filter synthesis. (Text 2)	**L1, L2,L3**
Module 5	
System identification-adaptive modeling: Inverse adaptive modeling, equalization, and deconvolution adaptive equalization of telephone channels-adapting poles and zeros for IIR digital filter synthesis. (Text 2)	**L1,L2, L3**

Course outcomes:

After studying this course, students will be able to:

- Design optimal minimum mean square estimators and in particular linear estimators.
- Implement adaptive filters (FIR, IIR, non-causal, causal) and evaluate their performance.
- Identify applications in which it would be possible to use the different adaptive filtering approaches.

Question paper pattern:

- The question paper will have 10 full questions carrying equal marks.
- Each full question consists of 16 marks with a maximum of four sub questions.
- There will be 2 full questions from each module covering all the topics of the module
- The students will have to answer 5 full questions, selecting one full question from each module.

Text Books:

1. Simon Haykin, **"Adaptive Filter Theory"**, Pearson Education, 2003.
2. Bernard Widrow and Samuel D. Stearns, **"Adaptive Signal Processing"**, Person Education, 2005.

Reference Books:

1. John R.Treichler, C.Richard Johnson, Michael G.Larimore, **"Theory and Design of Adaptive Filters"**, Prentice-Hall of India,2002
2. S.Thomas Alexander, **"Adaptive Signal Processing-Theory and Application"**, Springer-Verlag.
3. D. G. Manolokis, V. K. Ingle and S. M. Kogar, **"Statistical and Adaptive Signal Processing"**, McGraw Hill International Edition, 2000.

Array Signal Processing [As per Choice Based credit System (CBCS) Scheme] SEMESTER – IV			
Subject Code	16ESP421	IA Marks	20
Number of Lecture Hours/Week	03	Exam marks	80
Total Number of Lecture Hours	40 (8 Hours per Module)	Exam Hours	03
CREDITS – 03			

Course Objectives: This course will enable students to:

- Understand various aspects of array signal processing.
- Explain the Concepts of Spatial Frequency along with the Spatial Samplings
- Describe array design methods and direction of arrival estimation techniques.

Modules	**RBT Level**
Module 1	
Spatial Signals: Signals in space and time, Spatial Frequency Vs Temporal Frequency, Review of Co-ordinate Systems, Maxwell's Equation, Wave Equation. Solution to Wave equation in Cartesian Co-ordinate system –Wave number vector, Slowness vector.	L1, L2
Module 2	
Wave number-Frequency Space Spatial Sampling: Spatial Sampling Theorem-Nyquist Criteria, Aliasing in Spatial frequency domain, Spatial sampling of multidimensional signals.	L2, L3
Module 3	
Sensor Arrays: Linear Arrays, Planar Arrays, Frequency – Wave number Response and Beam pattern, Array manifold vector, Conventional Beam former, Narrowband beam former.	L2, L3
Module 4	
Uniform Linear Arrays: Beam pattern in θ, u and ψ -space, Uniformly Weighted Linear Arrays. **Beam Pattern Parameters:** Half Power Beam Width, Distance to	L2, L3

First Null, Location of side lobes and Rate of Decrease, Grating Lobes, Array Steering.	
Module 5	
Array Design Methods: Visible region, Duality between Time - Domain and Space -Domain Signal Processing, Schelkunoff's Zero Placement Method, Fourier Series Method with windowing, Woodward -Lawson Frequency-Sampling Design. Non parametric method -Beam forming, Delay and sum Method, Capons Method.	L2, L3

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

- Understand the important concepts of array signal processing
- Understand the various array design techniques
- Understand the basic principle of direction of arrival estimation techniques

Question paper pattern:

- The question paper will have 10 full questions carrying equal marks.
- Each full question consists of 16 marks with a maximum of four sub questions.
- There will be 2 full questions from each module covering all the topics of the module
- The students will have to answer 5 full questions, selecting one full question from each module.

Text Book:

Harry L. Van Trees "**Optimum Array Processing Part IV of Detection, Estimation, and Modulation Theory**" John Wiley & Sons, 2002, ISBN: 9780471093909.

Reference Books:

1. Don H. Johnson Dan E. Dugeon, "**Array Signal Processing: Concepts and Techniques**", Prentice Hall Signal Processing Series, 1st Edition ,ISBN-13: 978-0130485137.
2. Petre Stoica and Randolph L. Moses "**Spectral Analysis of Signals**" Prentice Hall, 2005, ISBN: 0-13-113956-8.
3. Sophocles J. Orfanidis, "**Electromagnetic Waves and Antennas**", ECE Department Rutgers University, 94 Brett Road Piscataway, NJ 08854-8058. http://www.ece.rutgers.edu/~orfanidi/ewa/

<u>Speech and Audio Processing</u>

[As per Choice Based Credit System (CBCS) Scheme

SEMESTER – IV

Subject Code	16ESP422	IA Marks	20
Number of Lecture Hours/Week	03	Exam marks	80
Total Number of Lecture Hours	40 (8 Hours per Module)	Exam Hours	03

CREDITS – 03

Course Objectives: This course will enable students to:

- Familiarize the basic mechanism of speech production and get an overview of articulatory and acoustic Phonetics.
- Learn the basic concepts of methods for speech analysis and parametric representation of speech.
- Acquire knowledge about various methods used for speech and audio coding.
- Get an overall picture about various applications of speech and audio processing.

Modules	**RBT Level**
Module 1	
Digital Models For The Speech Signal: Process of speech production, Acoustic theory of speech production, Lossless tube models, and Digital models for speech signals. (Text 1) **Time Domain Models for Speech Processing:** Time dependent processing of speech, Short time energy and average magnitude, Short time average zero crossing rate, Speech vs silence discrimination using energy & zero crossings, Pitch period estimation, Short time autocorrelation function, Short time average magnitude difference function, Pitch period estimation using autocorrelation function, Median smoothing. (Text 1)	**L1,L2**
Module 2	
Digital Representations of the Speech Waveform: Sampling speech signals, Instantaneous quantization, Adaptive quantization,	**L2,L3**

Differential quantization, Delta Modulation, Differential PCM, Comparison of systems, direct digital code conversion.(Text 1) **Short Time Fourier Analysis:** Linear Filtering interpretation, Filter bank summation method, Overlap addition method, Design of digital filter banks, Implementation using FFT, Spectrographic displays, Pitch detection, Analysis by synthesis, Analysis synthesis systems. (Text 1)	
Module 3	
Homomorphic Speech Processing: Homomorphic systems for convolution, Complex cepstrum, Pitch detection, Formant estimation, Homomorphic vocoder. Linear Predictive Coding of Speech: Basic principles of linear predictive analysis, Solution of LPC equations, Prediction error signal, Frequency domain interpretation, Relation between the various speech parameters, Synthesis of speech from linear predictive parameters, Applications. (Text 1)	**L3,L4**
Module 4	
Speech Enhancement: Spectral subtraction & filtering, Harmonic filtering, parametric re-synthesis, Adaptive noise cancellation. Speech Synthesis: Principles of speech synthesis, Synthesizer methods, Synthesis of intonation, Speech synthesis for different speakers, Speech synthesis in other languages, Evaluation, Practical speech synthesis. (Text 1)	**L2,L3**
Module 5	
Automatic Speech Recognition: Introduction, Speech recognition vs. Speaker recognition, Signal processing and analysis methods, Pattern comparison techniques, Hidden Markov Models, Artificial Neural Networks. (Text 2) **Audio Processing:** Auditory perception and psychoacoustics - Masking, frequency and loudness perception, spatial perception, Digital Audio, Audio Coding - High quality, low-bit-rate audio coding standards, MPEG, AC- 3, Multichannel audio - Stereo, 3D binaural and Multichannel surround sound. (Text 3)	**L2,L3**
Course outcomes: After studying this course, students will be able to: • Understand basic concepts of speech production, speech analysis and	

synthesis

- Analyze Speech coding techniques
- Speech and speaker recognition systems.
- Concepts of Audio Processing and learn modeling
- Implement Applications-New audiogram matching techniques
- Develop systems for various applications of speech processing.

Question paper pattern:

- The question paper will have 10 full questions carrying equal marks.
- Each full question consists of 16 marks with a maximum of four sub questions.
- There will be 2 full questions from each module covering all the topics of the module
- The students will have to answer 5 full questions, selecting one full question from each module.

Text Books:

1. L. R. Rabiner and R. W. Schafer, **“Digital Processing of Speech Signals**", Pearson Education (Asia) Pvt. Ltd., 2004.
2. L. R. Rabiner and B. Juang, **“Fundamentals of Speech Recognition”**, Pearson Education (Asia) Pvt. Ltd., 2004.
3. Z. Li and M.S. Drew, “**Fundamentals of Multimedia**”, Pearson Education (Asia) Pvt. Ltd., 2004.

Reference Book:

D. O’Shaughnessy, **“Speech Communications: Human and Machine”**, Universities Press, 2001.

Communication System Design using DSP Algorithms [As per Choice Based credit System (CBCS) Scheme SEMESTER – IV				
Subject Code	16ECS423	IA Marks		20
Number of Lecture Hours/Week	03	Exam marks		80
Total Number of Lecture Hours	40 (8 Hours per Module)	Exam Hours		03
	CREDITS – 03			

Course Objectives: This course will enable students to:

- Understand communication systems, including algorithms that are particularly suited to DSP implementation.
- Understand Software and hardware tools, as well as FIR and IIR digital filters and the FFT.
- Discuss modulators and demodulators for classical analog modulation methods such as amplitude modulation (AM), double-sideband suppressed-carrier amplitude modulation (DSBSC-AM), single sideband modulation (SSB), and frequency modulation (FM).
- Explore digital communication methods leading to the implementation of a telephone-line modem.

Modules	**RBT Level**
Module 1	
Introduction to the course: Digital filters, Discrete time convolution and frequency responses, FIR filters - Using circular buffers to implement FIR filters in C and using DSP hardware, Interfacing C and assembly functions, Linear assembly code and the assembly optimizer. IIR filters - realization and implementation, FFT and power spectrum estimation: DTFT window function, DFT and IDFT, FFT, Using FFT to implement power spectrum.	**L1,L2**
Module 2	
Analog modulation scheme: Amplitude Modulation - Theory, generation and demodulation of AM, Spectrum of AM signal. Envelope detection and square law detection. Hilbert transform and	**L1,L2**

complex envelope, DSP implementation of amplitude modulation and demodulation. **DSBSC:** Theory generation of DSBSC, Demodulation, and demodulation using coherent detection and Costas loop. Implementation of DSBSC using DSP hardware. **SSB:** Theory, SSB modulators, Coherent demodulator, Frequency translation, Implementation using DSP hardware. (Text 1, 2)	
Module 3	
Frequency modulation: Theory, Single tone FM, Narrow band FM, FM bandwidth, FM demodulation, Discrimination and PLL methods, Implementation using DSP hardware. **Digital Modulation scheme:** PRBS, and data scramblers: Generation of PRBS, Self -synchronizing data scramblers, Implementation of PRBS and data scramblers. RS-232C protocol and BER tester: The protocol, error rate for binary signaling on the Gaussian noise channels, Three bit error rate tester and implementation.	**L1,L2**
Module 4	
PAM and QAM: PAM theory, baseband pulse shaping and ISI, Implementation of transmit filter and interpolation filter bank. Simulation and theoretical exercises for PAM, Hardware exercises for PAM. **QAM fundamentals:** Basic QAM transmitter, 2 constellation examples, QAM structures using passband shaping filters, Ideal QAM demodulation, QAM experiment. QAM receivers-Clock recovery and other frontend sub-systems. Equalizers and carrier recovery systems.	**L2,L3**
Module 5	
Experiment for QAM receiver frontend. Adaptive equalizer, Phase splitting, Fractionally spaced equalizer. Decision directed carrier tracking, Blind equalization, Complex cross coupled equalizer and carrier tracking experiment. Echo cancellation for full duplex modems: Multicarrier modulation, ADSL architecture, Components of simplified ADSL transmitter, A simplified ADSL receiver, Implementing simple ADSL Transmitter and Receiver.	**L2,L3**

Course outcomes: After studying this course, students will be able to:

- Implement DSP algorithms on TI DSP processors
- Implement FIR, IIR digital filtering and FFT methods
- Implement modulators and demodulators for AM,DSBSC-AM,SSB and FM
- Design digital communication methods leading to the implementation of a line communication system.

Question paper pattern:

- The question paper will have 10 full questions carrying equal marks.
- Each full question consists of 16 marks with a maximum of four sub questions.
- There will be 2 full questions from each module covering all the topics of the module
- The students will have to answer 5 full questions, selecting one full question from each module.

Text Book:

Tretter, Steven A., "**Communication System Design Using DSP Algorithms With Laboratory Experiments for the TMS320C6713™ DSK",** Springer USA, *2008.*

Reference Books:

1. Robert. O. Cristi, "**Modern Digital signal processing", ** Cengage Publishers, India, 2003.
2. S. K. Mitra, "**Digital signal processing: A computer based approach",** 3rd edition, TMH, India, 2007.
3. E.C. Ifeachor, and B. W. Jarvis, "**Digital signal processing: A Practitioner's approach",** Second Edition, Pearson Education, India, 2002,
4. Proakis, and Manolakis, "**Digital signal processing**", 3rd edition, Prentice Hall, 1996.

<table>
<tr><td colspan="5"><u>Reconfigurable Computing</u>
[As per Choice Based credit System (CBCS) Scheme
SEMESTER – IV</td></tr>
<tr><td>Subject Code</td><td>16ELD424</td><td>IA Marks</td><td colspan="2">20</td></tr>
<tr><td>Number of Lecture Hours/Week</td><td>03</td><td>Exam marks</td><td colspan="2">80</td></tr>
<tr><td>Total Number of Lecture Hours</td><td>40
(8 Hours per Module)</td><td>Exam Hours</td><td colspan="2">03</td></tr>
<tr><td colspan="5">CREDITS – 03</td></tr>
<tr><td colspan="5">Course Objectives: The aim of this course is to enable the students to
• Gain fundamental knowledge and understanding of principles and practice in reconfigurable architecture.
• Understand the FPGA design principles, and logic synthesis.
• Integrate hardware and software technologies for reconfiguration computing focusing on partial reconfiguration design.
• Focus on different domains of applications on reconfigurable computing.</td></tr>
<tr><td colspan="4">Modules</td><td>RBT Level</td></tr>
<tr><td colspan="5">Module 1</td></tr>
<tr><td colspan="4">Introduction: History, Reconfigurable Vs Processor based system, RC Architecture. Reconfigurable Logic Devices: Field Programmable Gate Array, Coarse Grained Reconfigurable Arrays. Reconfigurable Computing System: Parallel Processing on Reconfigurable Computers, A survey of Reconfigurable Computing System. (Text 1)</td><td>LI, L2</td></tr>
<tr><td colspan="5">Module 2</td></tr>
<tr><td colspan="4">Languages and Compilation: Design Cycle, Languages, HDL, High Level Compilation, Low level Design flow, Debugging Reconfigurable Computing Applications. (Text 1)</td><td>L1,L2</td></tr>
<tr><td colspan="5">Module 3</td></tr>
<tr><td colspan="4">Implementation: Integration, FPGA Design flow, Logic Synthesis. High Level Synthesis for Reconfigurable Devices: Modelling, Temporal Partitioning Algorithms. (Text 2)</td><td>L1, L2, L3</td></tr>
<tr><td colspan="5">Module 4</td></tr>
<tr><td colspan="4">Partial Reconfiguration Design: Partial Reconfiguration Design,</td><td>L1,L2</td></tr>
</table>

Bitstream Manipulation with JBits, The modular Design flow, The Early Access Design Flow, Creating Partially Reconfigurable Designs, Partial Reconfiguration using Hansel-C Designs, Platform Design. (Text 2)	
Module 5	
Signal Processing Applications: Reconfigurable computing for DSP, DSP application building blocks, Examples: Beamforming, Software Radio, Image and video processing, Local Neighbourhood functions, Convolution. (Text 1) **System on a Programmable Chip:** Introduction to SoPC, Adaptive Multiprocessing on Chip. (Text 2)	L1, L2,L3

Course Outcomes:: After studying this course, students will be able to:

- Synthesize the reconfigurable computing architectures.
- Use the reconfigurable architectures for the design of a digital system.
- Design of digital systems for a variety of applications on signal processing and system on chip configurations.

Question paper pattern:

- The question paper will have 10 full questions carrying equal marks.
- Each full question consists of 16 marks with a maximum of four sub questions.
- There will be 2 full questions from each module covering all the topics of the module
- The students will have to answer 5 full questions, selecting one full question from each module.

Text Books:

1. M. Gokhale and P. Graham, “Reconfigurable Computing: Accelerating Computation with Field-Programmable Gate Arrays”, Springer, 2005.
2. C. Bobda, “Introduction to Reconfigurable Computing: Architectures, Algorithms and Applications”, Springer, 2007.

Reference Books:

1. D. Pellerin and S. Thibault, “Practical FPGA Programming in C”, Prentice-Hall, 2005.

2. W. Wolf, “FPGA Based System Design”, Prentice-Hall, 2004.
3. R. Cofer and B. Harding, “Rapid System Prototyping with FPGAs: Accelerating the Design Process”, Newnes, 2005.