VISVESVARAYA TECHNOLOGICAL UNIVERSITY, BELAGAVI
Scheme of Teaching and Examination – 2018-19
M.Tech in Signal Processing (ESP)
Choice Based Credit System (CBCS)

I SEMESTER

Sl. No	Course	Course Code	Course Title	Teaching Hours /Week		Examination				Credits
				Theory	Practical/ Field work/ Assignment	Duration in hours	CIE Marks	SEE Marks	Total Marks	
1	PCC	18ELD11	Advanced Engineering Mathematics	04	--	03	40	60	100	4
2	PCC	18ECS12	Advanced Digital Signal Processing	04	--	03	40	60	100	4
3	PCC	18EVE13	Advanced Embedded Systems	04	--	03	40	60	100	4
4	PCC	18ESP14	Multirate Systems and Filter Banks	04	--	03	40	60	100	4
5	PEC	18ESP15	Digital Compression	04	--	03	40	60	100	4
6	PCC	18ESPL16	Advanced Digital Signal Processing Lab	-	04	03	40	60	100	2
7	PCC	18RMI17	Research Methodology and IPR	02	--	03	40	60	100	2
			TOTAL	**22**	**04**	**21**	**280**	**420**	**700**	**24**

Note: PCC: Professional core, PEC: Professional Elective.

Internship: All the students shall have to undergo mandatory internship of 6 weeks during the vacation of I and II semesters and /or II and III semesters. A University examination will be conducted during III semester and prescribed credit shall be included in the III semester. Internship shall be considered as a head of passing and shall be considered for the award of degree. Those, who do not take-up/complete the internship shall be declared as failed and have to complete during subsequent University examination after satisfying the internship requirements.

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II SEMESTER

Sl. No	Course	Course Code	Course Title	Teaching Hours /Week		Examination				Credits
				Theory	Practical/ Field work/ Assignment	Duration in hours	CIE Marks	SEE Marks	Total Marks	
1	PCC	18ESP21	Image Processing and Machine Vision	04	--	03	40	60	100	4
2	PCC	18ESP22	DSP System Design	04	--	03	40	60	100	4
3	PCC	18ESP23	Biomedical Signal Processing	04	--	03	40	60	100	4
4	PEC	18XXX24X	Professional elective 1	04	--	03	40	60	100	4
5	PEC	18XXX25X	Professional elective 2	04	--	03	40	60	100	4
6	PCC	18ESPL26	Image Processing Lab	--	04	03	40	60	100	2
7	PCC	18ESP27	Technical Seminar	--	02	--	100	--	100	2
TOTAL				**20**	**06**	**18**	**340**	**360**	**700**	**24**

Note: PCC: Professional core, PEC: Professional Elective

Professional Elective 1		**Professional Elective 2**	
Course Code Under : 18xxx24x	**Course Title**	**Course Code Under : 18xxx25x**	**Course Title**
18ECS241	Wireless Sensor Networks	18ESP251	Channel Coding
18ELD242	Reconfigurable Computing	18ESP252	Statistical Signal Processing
18ESP243	Detection and Estimation	18ELD253	Micro Electro Mechanical Systems

Note:

1.Technical Seminar: CIE marks shall be awarded by a committee comprising of HoD as Chairman, Guide/co-guide in any and a senior faculty of the department. Participation in seminar by all postgraduate students of the same and other semesters of the programme shall be mandatory.

The CIE marks awarded for Technical Seminar, shall be based on the evaluation of Seminar Report, Presentation skill and Question and Answer session in the ratio 50:25:25.

2. Internship: All the students shall have to undergo mandatory internship of 6 weeks during the vacation of I and II semesters and /or II and III semesters. A University examination will be conducted during III semester and prescribed credit shall be included in the III semester. Internship shall be considered as a head of passing and shall be considered for the award of degree. Those, who do not take-up/complete the internship shall be declared as failed and have to complete during subsequent University examination after satisfying the internship requirements.

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III SEMESTER

Sl. No	Course	Course Code	Course Title	Teaching Hours /Week		Examination				Credits
				Theory	Practical/ Field work/ Assignment	Duration in hours	CIE Marks	SEE Marks	Total Marks	
1	PCC	18ESP31	Adaptive Signal Processing	04	--	03	40	60	100	4
2	PEC	18XXX32X	Professional elective -3	04	--	03	40	60	100	4
3	PEC	18XXX33X	Professional elective -4	04	--	03	40	60	100	4
4	Proj	18ESP34	Evaluation of Project phase -1	--	02	--	100	--	100	2
5	INT	18ESP35	Internship	(Completed during the intervening vacation of I and II semesters and /or II and III semesters.)		03	40	60	100	6
TOTAL				12	02	12	**260**	**240**	**500**	**20**

Note: PCC: Professional core, PEC: Professional Elective, Proj: Project, INT: Internship,

Professional Elective 3		Professional Elective 4	
Course Code Under : 18xxx32x	**Course Title**	**Course Code Under : 18xxx33x**	**Course Title**
18ESP321	Speech and Audio Processing	18ESP331	VLSI Design for Signal Processing
18ESP322	Array Signal Processing	18ESP332	Pattern Recognition & Machine Learning
18ESP323	Communication System Design using DSP Algorithm	18ECS333	IoT

Note:

1. Project Phase-1: Students in consultation with the guide/co-guide if any, shall pursue literature survey and complete the preliminary requirements of selected Project work. Each student shall prepare relevant introductory project document, and present a seminar.

CIE marks shall be awarded by a committee comprising of HoD as Chairman, Guide and a senior faculty of the department. The CIE marks awarded for project work phase -1, shall be based on the evaluation of Project Report, Project Presentation skill and Question and Answer session in the ratio 50:25:25.

SEE (University examination) shall be as per the University norms.

2. Internship: Those, who have not pursued /completed the internship shall be declared as failed and have to complete during subsequent University examinations after satisfying the internship requirements.

Internship SEE (University examination) shall be as per the University norms.

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IV SEMESTER

Sl. No	Course	Course Code	Course Title	Teaching Hours /Week		Examination				Credits
				Theory	Practical/ Field work/ Assignment	Duration in hours	CIE Marks	SEE Marks Viva voce	Total Marks	
1	Proj	18ESP41	Project work phase -2	--	04	03	40	60	100	18
			TOTAL	--	**04**	**03**	**40**	**60**	**100**	**18**

Note: Proj: Project.

Note:

1. Project Phase-2:

CIE marks shall be awarded by a committee comprising of HoD as Chairman, Guide/co-guide, if any and a Senior faculty of the department. The CIE marks awarded for project work phase -2, shall be based on the evaluation of Project Report subjected to plagiarism check, Project Presentation skill and Question and Answer session in the ratio 50:25:25.

SEE shall be at the end of IV semester. Project work evaluation and Viva-Voce examination (SEE), after satisfying the plagiarism check, shall be as per the University norms.

M.Tech-SIGNAL PROCESSING-2018-FIRST SEMESTER SYLLABUS

ADVANCED ENGINEERING MATHEMATICS [As per Choice Based Credit System (CBCS) scheme] SEMESTER – I			
Subject	**18ELD11**	**CIE**	**40**
Number of Lecture Hours/Week	**04**	**SEE Marks**	**60**
Total Number of Lecture Hours	**50 (10 Hours per Module)**	**Exam Hours**	**03**
CREDITS – 04			

Course Learning Objectives: This course will enable the students

- To learn principles of advanced engineering mathematics through linear algebra and calculus of variations.
- To understand probability theory and random process that serve as an essential tool for applications of electronics and communication engineering sciences.

Modules	**RBT Levels**
Module -1	
I. **Linear Algebra-I:** Introduction to vector spaces and sub-spaces, definitions, illustrative example. Linearly independent and dependent vectors- Basis-definition and problems. Linear transformations-definitions. Matrix form of linear transformations-Illustrative examples (Text Book: 1).	**L1, L2**
Module -2	
II. **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 (Text. Book: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.Book: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. Poisson, Gaussian and Erlang distributions-examples. (Text Book: 3)	**L1, L2**
Module -5	
Engineering Applications on Random processes: Classification. Stationary, WSS and ergodic random process. Auto-correlation function-properties, Gaussian random process. (Text Book: 3)	**L2, L3, L4**

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 technique of singular value decomposition for data compression, least square approximation in solving inconsistent linear systems.
- Utilize the concepts of functional 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.
- Analyze random process through parameter-dependent variables in various random processes.

Question paper pattern:

- Examination will be conducted for 100 marks with question paper containing 10 full questions, each of 20 marks.
- Each full question can have a maximum of 4 sub questions.
- There will be 2 full questions from each module covering all the topics of the module.
- Students will have to answer 5 full questions, selecting one full question from each module.
- The total marks will be proportionally reduced to 60 marks as SEE marks is 60.

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. Elsgolts, L.:"Differential Equations and Calculus of Variations", MIR Publications 3rd Edition, 1977.
3. T.Veerarajan: "Probability, Statistics and Random Process", 3rd Edition, Tata Mc-Graw Hill Co., 2016.

Reference Book:

1. Gilbert Strang: Introduction to Linear Algebra, 5th Edition, Wellesley-Cambridge Press., 2016
2. Richard Bronson: "Schaum's Outlines of Theory and Problems of Matrix Operations", McGraw-Hill, 1988.
3. Scott L.Miller,Donald G.Childers: "Probability and Random Process with application to Signal Processing", Elsevier Academic Press, 2nd Edition,2013.
4. E. Kreyszig, "Advanced Engineering Mathematics", 10th edition, Wiley, 2015.

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

ADVANCED DIGITAL SIGNAL PROCESSING
[As per Choice Based Credit System (CBCS) Scheme]
SEMESTER – I

Course Code	**18ECS12**	**CIE Marks**	**40**
Number of Lecture Hours/Week	**04**	**SEE Marks**	**60**
Total Number of Lecture Hours	**50 (10 Hours per Module)**	**Exam Hours**	**03**

Credits – 04

Course objectives: This course will enable students to

- Understand Multirate digital signal processing principles and its applications.
- Estimate the various spectral components present in the received signal using different spectral estimation methods such as Parametric and Nonparametric.
- Design and implement an optimum adaptive filter using LMS and RLS algorithms.
- Understand the concepts and mathematical representations of Wavelet transforms.

Modules	**RBT Levels**
Module-1	
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, 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	
Linear prediction and Optimum Linear Filters: Random signals, Correlation Functions and Power Spectra, Innovations Representation of a Stationary Random Process. Forward and Backward Linear Prediction. Solution of the Normal Equations. The Levinson-Durbin Algorithm. Properties of the Linear Prediction-Error Filters. (Text 1)	L1, L2, L3
Module-3	
Adaptive filters: Applications of Adaptive Filters-Adaptive Channel Equalization, Adaptive noise cancellation, Linear Predictive coding of Speech Signals, Adaptive direct form FIR filters-The LMS algorithm, Properties of LMS algorithm. Adaptive direct form filters- RLS algorithm. (Text 1)	L1, L2, L3
Module-4	
Power Spectrum Estimation: Non parametric Methods for Power Spectrum Estimation - Bartlett Method, Welch Method, Blackman and Tukey Methods. **Parametric Methods for Power Spectrum Estimation:** Relationship between the auto correlation and the model	L1, L2, L3

parameters, Yule and Walker methods for the AR Model Parameters, Burg Method for the AR Model parameters, Unconstrained least-squares method for the AR Model parameters, Sequential estimation methods for the AR Model parameters, ARMA Model for Power Spectrum Estimation. (Text 1)	
Module-5	
WAVELET TRANSFORMS: The Age of Wavelets, The origin of Wavelets, Wavelets and other reality transforms, History of wavelets, Wavelets of the future. **Continuous Wavelet and Short Time Fourier Transform:** Wavelet Transform, Mathematical preliminaries, Properties of wavelets. Discrete Wavelet Transform: Haar scaling functions, Haar wavelet function, Daubechies Wavelets. (Chapters 1, 3 & 4 of Text 2)	L1, L2, L3
Course Outcomes: After studying this course, students will be able to: • Design adaptive filters for a given application • Design multirate DSP Systems • Implement adaptive signal processing algorithm • Design active networks • Understand advanced signal processing techniques, including multi-rate processing and time-frequency analysis techniques	
Question paper pattern: • Examination will be conducted for 100 marks with question paper containing 10 full questions, each of 20 marks. • Each full question can have a maximum of 4 sub questions. • There will be 2 full questions from each module covering all the topics of the module. • Students will have to answer 5 full questions, selecting one full question from each module. • The total marks will be proportionally reduced to 60 marks as SEE marks is 60.	
Text Books: 1. "Digital Signal Processing, Principles, Algorithms and Applications", JohnG. Proakis, Dimitris G.Manolakis, Fourth edition, Pearson-2007. 2. Insight into Wavelets- from Theory to Practice", K.P Soman, Ramachandran, Resmi- PHI Third Edition-2010.	

ADVANCED EMBEDDED SYSTEM
[As per Choice Based Credit System (CBCS) scheme]
SEMESTER – I

Subject	18EVE13	CIE	40
Number of Lecture Hours/Week	04	SEE Marks	60
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	RBT Levels
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:

- Examination will be conducted for 100 marks with question paper containing 10 full questions, each of 20 marks.
- Each full question can have a maximum of 4 sub questions.
- There will be 2 full questions from each module covering all the topics of the module.
- Students will have to answer 5 full questions, selecting one full question from each module.
- The total marks will be proportionally reduced to 60 marks as SEE marks is 60.

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”, 2nd edn, Newnes, (Elsevier), 2010.

Reference Book:

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

MULTIRATE SYSTEMS and FILTER BANKS **[As per Choice Based Credit System (CBCS) scheme]** **SEMESTER – I**			
Course Code	**18ESP14**	**CIE Marks**	**40**
Number of Lecture Hours/Week	**04**	**SEE Marks**	**60**
Total Number of Lecture Hours	**50 (10 Hours per Module)**	**Exam Hours**	**03**
Credits – 04			

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	**RBT Levels**
Module-1	
Fundamentals of Multirate 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:

- Examination will be conducted for 100 marks with question paper containing 10 full questions, each of 20 marks.
- Each full question can have a maximum of 4 sub questions.
- There will be 2 full questions from each module covering all the topics of the module.
- Students will have to answer 5 full questions, selecting one full question from each module.
- The total marks will be proportionally reduced to 60 marks as SEE marks is 60.

Text Books:

6. P.P.Vaidyanathan, “Multirate Systems and Filter Banks", Pearson Education (Asia) Pte.Ltd, 2004.
7. Gilbert Strang and Truong Nguyen, "Wavelets and Filter Banks", Wellesley-Cambridge Press,1996.

Reference Book:

1. N. J. Fliege, "Multirate Digital Signal Processing‖, John Wiley & Sons, USA,2000.
2. Vikram Gadre & Aditya Abhyankar “Multiresolution and Multirate Signal Processing: Introduction, Principles and Applications” McGraw Hill Education, First edition(2017).
3. Steven M. Kay “Modern Spectral Estimation” Pearson Education, First edition (2017)

DIGITAL COMPRESSION **[As per Choice Based Credit System (CBCS) scheme]** **SEMESTER – I**			
Course Code	**18ESP15**	**CIE Marks**	**40**
Number of Lecture Hours/Week	**04**	**SEE Marks**	**60**
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	**RBT Levels**
Module-1	
Introduction: Compression techniques, Modelling& coding, Distortion criteria, Differential Entropy, Rate Distortion Theory, Vector Spaces, Information theory, Models for sources, Codinguniquely 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.	**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, Application to audio compression	**L1, L2**
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 & scalingfunction, Implementation using filters, Image compression–EZW, SPIHT, JPEG 2000. **Analysis/Synthesis Schemes:** Speech compression–LPC-10,CELP, MELP. **Video Compression:** Motion compensation, Video signal representation, Algorithms for video conferencing & video phones–H.261, H.263, Asymmetric applications–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.	**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 areavailable.

Question paper pattern:

- Examination will be conducted for 100 marks with question paper containing 10 full questions, each of 20 marks.
- Each full question can have a maximum of 4 sub questions.
- There will be 2 full questions from each module covering all the topics of the module.
- Students will have to answer 5 full questions, selecting one full question from each module.
- The total marks will be proportionally reduced to 60 marks as SEE marks is 60.

Text Book:

1. K.Sayood, “Introduction to Data Compression”, Harcourt India Pvt. Ltd. & Morgan Kaufmann Publishers, 1996.

Reference Books:

1. N.JayantandP.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.LiandM.S.Drew, “Fundamentals of Multimedia”, Pearson Education (Asia) Pvt.Ltd., 2004.

Advanced Digital Signal Processing Lab
[As per Choice Based Credit System (CBCS) scheme]
SEMESTER – I

Course Code	**18ESPL16**	**CIE Marks**	**40**
Number of Lecture Hours/Week	**01Hr Tutorial (Instructions) + 03 Hours Laboratory**	**SEE Marks**	**60**
Total Number of Lecture Hours		**Exam Hours**	**03**

Credits – 02

Course objectives: This laboratory courseenables students to get practical Experience in Digital Signal processing ,analysis and realization of LTI systems .

Laboratory Experiments:	**RBT Levels**
01. Generate various fundamental discrete time signals.	L1, L2,L3
02. Basic operations on signals (Multiplication, Folding, Scaling).	
03. Find out the DFT & IDFT of a given sequence without using inbuilt instructions.	
04. Interpolation & decimation of a given sequence.	
05. Generation of DTMF (Dual Tone Multiple Frequency) signals.	
06. Estimate the PSD of a noisy signal using periodogram and modified periodogram.	
07. Estimation Of PSD using different methods (Bartlett, Welch, Blackman-Tukey).	
08. Design of Chebychev Type I,II Filters.	
09. Cascade Digital IIR Filter Realization.	
10. Parallel Realization of IIR filter.	
11. Estimation of power spectrum using parametric methods (yule-walker & burg).	
12. Design of LPC filter using Levinson-Durbin algorithm.	
13. Time-Frequency Analysis with the Continuous Wavelet Transform.	
14. Signal Reconstruction from Continuous Wavelet Transform Coefficients.	

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

- Filter design.
- Filter Realization
- Signal Manipulations
- Wavelet Transforms
- Estimating PSD using various techniques

Conduct of Practical Examination:

- All laboratory experiments are to be included for practical examination.
- The experiments can be conducted in Matlab or using any other related tools.
- Strictlyfollowtheinstructionsasprintedonthecoverpageofanswerscriptforbr eakupofmarks.
- Change of experiment is allowed only once and Marks allotted to the Procedure part will be made zero.

RESEARCH METHODOLOGY AND IPR

[As per Choice Based Credit System (CBCS) scheme]
SEMESTER –I

Course Code	18RMI17	CIE Marks	40
Number of Lecture Hours/Week	02	Exam Hours	03
Total Number of Lecture Hours	25	SEE Marks	60
Credits - 02			

Course objectives:

- To give an overview of the research methodology and explain the technique of defining a research problem
- To explain the functions of the literature review in research.
- To explain carrying out a literature search, its review, developing theoretical and conceptual frameworks and writing a review.
- To explain various research designs and their characteristics.
- To explain the details of sampling designs, and also different methods of data collections.
- To explain the art of interpretation and the art of writing research reports.
- To explain various forms of the intellectual property, its relevance and business impact in the changing global business environment.
- To discuss leading International Instruments concerning Intellectual Property Rights.■

Module-1	**Teaching Hours/ RBT Level**
Research Methodology: Introduction, Meaning of Research, Objectives of Research, Motivation in Research, Types of Research, Research Approaches, Significance of Research, Research Methods versus Methodology, Research and Scientific Method, Importance of Knowing How Research is Done, Research Process, Criteria of Good Research, and Problems Encountered by Researchers in India. ■	**05** **L1, L2**
Module-2	

Defining the Research Problem: Research Problem, Selecting the Problem, Necessity of Defining the Problem, Technique Involved in Defining a Problem, An Illustration. **Reviewing the literature:** Place of the literature review in research, Bringing clarity and focus to your research problem, Improving research methodology, Broadening knowledge base in research area, Enabling contextual findings, How to review the literature, searching the existing literature, reviewing the selected literature, Developing a theoretical framework, Developing a conceptual framework, Writing about the literature reviewed. ■	**05** **L1, L2**
Module-3	
Research Design: Meaning of Research Design, Need for Research Design, Features of a Good Design, Important Concepts Relating to Research Design, Different Research Designs, Basic Principles of Experimental Designs, Important Experimental Designs. **Design of Sample Surveys:** Introduction, Sample Design, Sampling and Non-sampling Errors, Sample Survey versus Census Survey, Types of Sampling Designs. ■	**05** **L1, L2**
Module-4	
Data Collection: Experimental and Surveys, Collection of Primary Data, Collection of Secondary Data, Selection of Appropriate Method for Data Collection, Case Study Method. **Interpretation and Report Writing:** Meaning of Interpretation, Technique of Interpretation, Precaution in Interpretation, Significance of Report Writing, Different Steps in Writing Report, Layout. **Interpretation and Report Writing (continued):** of the Research Report, Types of Reports, Oral Presentation, Mechanics of Writing a Research Report, Precautions for Writing Research Reports. ■	**05** **L1, L2, L3, L4**
Module-5	

Intellectual Property: The Concept, Intellectual Property System in India, Development of TRIPS Complied Regime in India, Patents Act, 1970, Trade Mark Act, 1999,The Designs Act, 2000, The Geographical Indications of Goods (Registration and Protection) Act1999, Copyright Act,1957,The Protection of Plant Varieties and Farmers' Rights Act, 2001,The Semi-Conductor Integrated Circuits Layout Design Act, 2000, Trade Secrets, Utility Models, IPR and Biodiversity, The Convention on Biological Diversity (CBD) 1992, Competing Rationales for Protection of IPRs, Leading International Instruments Concerning IPR, World Intellectual Property Organisation (WIPO),WIPO and WTO, Paris Convention for the Protection of Industrial Property, National Treatment, Right of Priority, Common Rules, Patents, Marks, Industrial Designs, Trade Names, Indications of Source, Unfair Competition, Patent Cooperation Treaty (PCT), Advantages of PCT Filing, Berne Convention for the Protection of Literary and Artistic Works, Basic Principles, Duration of Protection, Trade Related Aspects of Intellectual Property Rights(TRIPS) Agreement, Covered under TRIPS Agreement, Features of the Agreement, Protection of Intellectual Property under TRIPS, Copyright and Related Rights, Trademarks, Geographical indications, Industrial Designs, Patents, Patentable Subject Matter, Rights Conferred, Exceptions, Term of protection, Conditions on Patent Applicants, Process Patents, Other Use without Authorization of the Right Holder, Layout-Designs of Integrated Circuits, Protection of Undisclosed Information, Enforcement of Intellectual Property Rights, UNSECO.■	**05** **L1, L2, L3, L4**

Course outcomes:

At the end of the course the student will be able to:

- Discuss research methodology and the technique of defining a research problem
- Explain the functions of the literature review in research, carrying out a literature search, developing theoretical and conceptual frameworks and writing a review.
- Explain various research designs and their characteristics.
- Explain the art of interpretation and the art of writing research reports
- Discuss various forms of the intellectual property, its relevance and business impact in the changing global business environment and leading International Instruments concerning IPR.■

Question paper pattern:

- Examination will be conducted for 100 marks with question paper containing 10 full questions, each of 20 marks.
- Each full question can have a maximum of 4 sub questions.
- There will be 2 full questions from each module covering all the topics of the module.
- Students will have to answer 5 full questions, selecting one full question from each module.
- The total marks will be proportionally reduced to 60 marks as SEE marks is 60.

M.Tech-SIGNAL PROCESSING-2018-SECOND SEMESTER SYLLABUS

IMAGE PROCESSING AND MACHINE VISION [As per Choice Based Credit System (CBCS) scheme] SEMESTER – II			
Course Code	**18ESP21**	**CIE Marks**	**40**
Number of Lecture Hours/Week	**04**	**SEE Marks**	**60**
Total Number of Lecture Hours	**50 (10 Hours per Module)**	**Exam Hours**	**03**
Credits – 04			

Course Objectives: This course will enable students to:

- 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	RBT Levels
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, Images as stochastic processes	**L1,L2**
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	**L1,L2,L3**

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	
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: • Examination will be conducted for 100 marks with question paper containing 10 full questions, each of 20 marks. • Each full question can have a maximum of 4 sub questions. • There will be 2 full questions from each module covering all the topics of the module. • Students will have to answer 5 full questions, selecting one full question from each module. • The total marks will be proportionally reduced to 60 marks as SEE marks is 60.	
Text Book:	

1. 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, 2004K.Sayood, “Introduction to Data Compression”, Harcourt India Pvt. Ltd. & Morgan Kaufmann Publishers, 1996.

DSP SYSTEM DESIGN **[As per Choice Based Credit System (CBCS) scheme]** **SEMESTER – II**			
Course Code	**18ESP22**	**CIE Marks**	**40**
Number of Lecture Hours/Week	**04**	**SEE Marks**	**60**
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 mathematical package such as MATLAB to design and simulate a DSP system.
- Understand the architecture of a digital signal processor and some programming issues in fixed-point digital signal processor in real-time implementation.
- Learn to design a real-time signal processing algorithms using the latest fixed-point processor.

Modules	**RBT Levels**
Module-1	
Introduction to popular DSP CPU Architecture: CPU Data Paths and Control-Timers-Internal Data/Program Memory-External Memory Interface-Programming –Instructionset 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/ Black fin (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:

- Examination will be conducted for 100 marks with question paper containing 10 full questions, each of 20 marks.
- Each full question can have a maximum of 4 sub questions.
- There will be 2 full questions from each module covering all the topics of the module.
- Students will have to answer 5 full questions, selecting one full question from each module.
- The total marks will be proportionally reduced to 60 marks as SEE marks is 60.

Text Books:

1. Rulf Chassaing, "Digital Signal Processing and Application with C6713 and C6416 DSK", Wiley-Interscience Publication
2. T.J. Terreland Lik- Kwan Shark, "Digital Signal Processing- A Student Guide", 1st Edition; Macmillan Press Ltd.

Reference Books:

1. David.J Defatta.J,Lucas Joseph.G &Hodkiss WilliamS, "Digital Signal Processing: A System Design Approach",1st Edition,JohnWiley.
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. AndrewBateman,WarrenYates,"Digital Signal Processing Design", 1st Edition
5. Naim Dahnoun, "Digital Signal Processing Implementation using the TMS320C6000 DSP Platform", 1st Edition.

BIOMEDICAL SIGNAL PROCESSING
[As per Choice Based Credit System (CBCS) scheme]
SEMESTER – II

Course Code	**18ESP23**	**CIE Marks**	**40**
Number of Lecture Hours/Week	**04**	**SEE Marks**	**60**
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	**RBT Levels**
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.	**L1,L2**
Module-3	
ECG-Pre-processing, Measurements of amplitude and time intervals, Classification, QRS detection, ST segment analysis, Base line wander removal, waveform recognition, morphological studies and rhythm analysis, automated diagnosis based on decision theory ECT compression, Evoked potential estimation.	**L1,L2**
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:

- Examination will be conducted for 100 marks with question paper containing 10 full questions, each of 20 marks.
- Each full question can have a maximum of 4 sub questions.
- There will be 2 full questions from each module covering all the topics of the module.
- Students will have to answer 5 full questions, selecting one full question from each module.
- The total marks will be proportionally reduced to 60 marks as SEE marks is 60.

TEXT Book:

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

Reference Books:

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

WIRELESS SENSOR NETWORKS **[As per Choice Based Credit System (CBCS) scheme]** **SEMESTER – II**			
Course Code	**18ECS241**	**CIE Marks**	**40**
Number of Lecture Hours/Week	**04**	**SEE Marks**	**60**
Total Number of Lecture Hours	**50 (10 Hours per Module)**	**Exam Hours**	**03**
Credits – 04			

Course Outcomes:

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

- Understand the hardware details of different types of sensors and select right type of sensor for various applications.
- Understand conversion of sensor information into digital data and packetize to a specific protocol for Transmission
- Understand radio standards and communication protocols to be used for wireless sensor.
- Understand the issues involved in synchronization and security.

Modules	**RBT Levels**
Module-1	
Motivation for a Network of Wireless Sensor Nodes Sensing and Sensors, Wireless Sensor Networks, Challenges and Constraints (till 1.2.7 of Text) **Applications:**Structural Health Monitoring (till 2.1.4 of Text), Traffic Control, Health Care, Pipeline Monitoring, Precision Agriculture (2.2 to 2.5 of Text)	L1, L2, L3
Module-2	
Sensing Node Architecture: The Sensing Subsystem, The Processor Subsystem (in brief only), Communication Interfaces, Prototypes (3.1 to 3.4 of Text). **Medium Access Control :**Overview - Contention-Free Medium Access, Contention-Based Medium Access, Wireless MAC Protocols – CSMA, MACA and MACAW, MACA By Invitation, IEEE 802.11, IEEE 802.15.4 and ZigBee, Characteristics of MAC Protocols in Sensor Networks, Contention-Free MAC Protocols, Contention-Based MAC Protocols, Hybrid MAC Protocols (6.1 to 6.6 of Text).	L1, L2, L3
Module-3	
Network Layer: Overview, Routing Metrics, Flooding and Gossiping, Data-Centric Routing, Proactive Routing, On-Demand Routing, Location-Based Routing, QoS-Based Routing Protocols (7.1 to 7.6, 7.8, 7.9 of Text).	L1, L2, L3
Module-4	
Power management: Local Power Management Aspects, Dynamic Power Management, Conceptual Architecture (8.1 to 8.3 of Text). **Time Synchronization:** Clocks and the Synchronization Problem, Time Synchronization in Wireless Sensor Networks, Basics of Time Synchronization, Time Synchronization Protocols (9.1 to 9.3, 9.4 till 9.4.5).	L1, L2, L3

Module-5	
Localization: Overview, Ranging Techniques, Range-Based Localization, Range-Free Localization, Event-Driven Localization (10.1 to 10.5 of Text). **Network Security**: Fundamentals of Network Security, Challenges of Security in Wireless Sensor Networks, Security Attacks in Sensor (11.1 to 11.3 of Text).	L1, L2, L3

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

- Explain the concepts of sensors and conversion to digitally formatted signal for transmission.
- Evaluate the capacity and degradation in performance of various wireless MAC protocols in a transmission environment.
- Analyze schemes to transport sensor data to a server in a power efficient and time efficient manner.
- Develop and evaluate the performance of a sensor network including localization of sensor faults.

Question paper pattern:

- Examination will be conducted for 100 marks with question paper containing 10 full questions, each of 20 marks.
- Each full question can have a maximum of 4 sub questions.
- There will be 2 full questions from each module covering all the topics of the module.
- Students will have to answer 5 full questions, selecting one full question from each module.
- The total marks will be proportionally reduced to 60 marks as see marks is 60.

Text Book:

Waltenegus Dargie and Christian Poellabauer, "Fundamentals of Wireless Sensor Networks Theory and Practice", John Wiley & Sons Ltd. ISBN 978-0-470-99765-9, 2010.

Reference Book:

Ian F. Akyildiz and **Mehmet Can Vuran** "Wireless Sensor Networks", John Wiley & Sons Ltd. ISBN 978-0-470-03601-3 (H/B), 2010.

RECONFIGURABLE COMPUTING
[As per Choice Based credit System (CBCS) Scheme
SEMESTER – II

Subject Code	18ELD242	CIE Marks	40
Number of Lecture Hours/Week	04	SEE marks	60
Total Number of Lecture Hours	50 (10 Hours per Module)	Exam Hours	03

CREDITS – 04

Course Objectives: The aim of this course is to enable the students to

- Acquire 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.

Modules	RBT Level
Module-1	
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)	**LI, L2**
Module-2	
Languages and Compilation: Design Cycle, Languages, HDL, High Level Compilation, Low level Design flow, Debugging Reconfigurable Computing Applications.(Text 1)	**L1,L2**
Module-3	
Implementation: Integration, FPGA Design flow, Logic Synthesis. **High Level Synthesis for Reconfigurable Devices:** Modelling, Temporal Partitioning Algorithms.(Text 2)	**L1, L2, L3**
Module-4	
Partial Reconfiguration Design: Partial Reconfiguration Design, 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)	**L1,L2**
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)	**L1, L2, L3**

System on a Programmable Chip: Introduction to SoPC, Adaptive Multiprocessing on Chip.(Text 2)	

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

- Simulate and 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:

- Examination will be conducted for 100 marks with question paper containing 10 full questions, each of 20 marks.
- Each full question can have a maximum of 4 sub questions.
- There will be 2 full questions from each module covering all the topics of the module.
- Students will have to answer 5 full questions, selecting one full question from each module.
- The total marks will be proportionally reduced to 60 marks as SEE marks is 60.

Text Books:

1. M. Gokhale and P. Graham, "Reconfigurable Computing: Accelerating Computation with Field-Programmable Gate Arrays", Springer, 2005. ISBN: 978-0-387-26105-8
2. C. Bobda, "Introduction to Reconfigurable Computing: Architectures, Algorithms and Applications", Springer, 2007. ISBN: 978-1-4020-6088-5

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.

DETECTION and ESTIMATION
[As per Choice Based Credit System (CBCS) scheme]
SEMESTER – II

Course Code	**18ESP234**	**CIE Marks**	**40**
Number of Lecture Hours/Week	**04**	**SEE Marks**	**60**
Total Number of Lecture Hours	**50 (10 Hours per Module)**	**Exam Hours**	**03**

Credits – 04

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 Levels**
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-Bucyfilters, 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:

- Examination will be conducted for 100 marks with question paper containing 10 full questions, each of 20 marks.
- Each full question can have a maximum of 4 sub questions.
- There will be 2 full questions from each module covering all the topics of the module.
- Students will have to answer 5 full questions, selecting one full question from each module.
- The total marks will be proportionally reduced to 60 marks as SEE marks is 60.

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.

CHANNEL CODING **[As per Choice Based Credit System (CBCS) scheme]** **SEMESTER – II**			
Course Code	**18ESP251**	**CIE Marks**	**40**
Number of Lecture Hours/Week	**04**	**SEE Marks**	**60**
Total Number of Lecture Hours	**50 (10 Hours per Module)**	**Exam Hours**	**03**
Credits – 04			

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.

Modules	**RBT Levels**
Module-1	
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.	**L1,L2**
Module-2	
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.	**L1,L2**
Module-3	
BCH Codes: Binary primitive BCH codes, Decoding procedures, Implementation of Galois field Arithmetic, Implementation of Error correction. Non–binary BCH codes: q–aryLinear Block Codes, Primitive BCH codes over GF (q), Reed–Solomon Codes, Decoding of Non –Binary BCH and RS codes: The Berlekamp-Massey Algorithm.	**L1,L2**
Module-4	

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.	**L1,L2**
Module-5	
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.	**L1,L2**

Course Outcomes: After studying this course, students will 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.

Question paper pattern:

- Examination will be conducted for 100 marks with question paper containing 10 full questions, each of 20 marks.
- Each full question can have a maximum of 4 sub questions.
- There will be 2 full questions from each module covering all the topics of the module.
- Students will have to answer 5 full questions, selecting one full question from each module.
- The total marks will be proportionally reduced to 60 marks as SEE marks is 60.

Text Books:

1. Shu Lin &Daniel J. Costello, Jr. “Error Control Coding”, Pearson/ Prentice Hall, Second Edition,2004.

Reference Book:

1. Blahut, R.E. “Theory and Practice of Error Control Codes”, Addison Wesley, 1984.

STATISTICAL SIGNAL PROCESSING
[As per Choice Based Credit System (CBCS) scheme]
SEMESTER – II

Course Code	**18ESP252**	**CIE Marks**	**40**
Number of Lecture Hours/Week	**04**	**SEE Marks**	**60**
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	**RBT Levels**
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 (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. (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:

- Examination will be conducted for 100 marks with question paper containing 10 full questions, each of 20 marks.
- Each full question can have a maximum of 4 sub questions.
- There will be 2 full questions from each module covering all the topics of the module.
- Students will have to answer 5 full questions, selecting one full question from each module.
- The total marks will be proportionally reduced to 60 marks as SEE marks is 60.

Text Book:

2. Monson H.Hayes, "Statistical Digital Signal Processing and Modeling", John Wiley & Sons (Asia) Pvt.Ltd., 2002.

3. Dimitris G. Manolakis, Vinay K. Ingle, and Stephen M. Kogon, "Statistical and Adaptive Signal Processing: Spectral Estimation, Signal Modeling, Adaptive Filtering and Array Processing" ,McGraw-HillInternationalEdition,2000.

MICRO ELECTRO MECHANICAL SYSTEMS **[As per Choice Based credit System (CBCS) Scheme** **SEMESTER – II**			
Subject Code	**18ELD253**	**CIE Marks**	**40**
Number of Lecture Hours/Week	**04**	**SEE Marks**	**60**
Total Number of Lecture Hours	**50** **(10 Hours per Module)**	**Exam Hours**	**03**
CREDITS – 04			

Course Objectives: This course will enable students to:

- Know an overview of microsystems, their fabrication and application areas.
- Teach working principles of several MEMS devices.
- Develop mathematical and analytical models of MEMS devices
- Know methods to fabricate MEMS devices
- Expose the students to various application areas where MEMS devices can be used.

Modules	**RBT Level**
Module-1	
Overview of MEMS and Microsystems: MEMS and Microsystem, Typical MEMS and Microsystems Products, Evolution of Microfabrication, Microsystems and Microelectronics, Multidisciplinary Nature of Microsystems, Miniaturization. Applications and Markets.	**L1, L2**
Module-2	
Working Principles of Microsystems: Introduction, Microsensors, Microactuation, MEMS with Microactuators, Microaccelerometers, Microfluidics. **Engineering Science for Microsystems Design and Fabrication:** Introduction, Atomic Structure of Matters, Ions and Ionization, Molecular Theory of Matter and Inter-molecular Forces, Doping of Semiconductors, The Diffusion Process, Plasma Physics, Electrochemistry.	**L1, L2**
Module-3	
Engineering Mechanics for Microsystems Design: Introduction, Static Bending of Thin Plates, Mechanical Vibration, Thermomechanics, Fracture Mechanics, Thin Film Mechanics, Overview on Finite Element Stress Analysis.	**L1,L2,L3**
Module-4	

Scaling Laws in Miniaturization: Introduction, Scaling in Geometry, Scaling in Rigid-Body Dynamics, Scaling in Electrostatic Forces, Scaling of Electromagnetic Forces, Scaling in Electricity, Scaling in Fluid Mechanics, Scaling in Heat Transfer.	**L1,L2,L3**
Module-5	
Overview of Micro-manufacturing: Introduction, Bulk Micro-manufacturing, Surface Micromachining, The LIGA Process, Summary on Micro-manufacturing. **Microsystem Design:** Introduction, Design Considerations, Process Design, Mechanical Design, Using Finite Element Method.	**L1,L2,L3**

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

- Understand the technologies related to Micro Electro Mechanical Systems.
- Describe the design and fabrication processes involved with MEMS devices.
- Analyse the MEMS devices and develop suitable mathematical models
- Understand the various application areas for MEMS devices

Question paper pattern:

- Examination will be conducted for 100 marks with question paper containing 10 full questions, each of 20 marks.
- Each full question can have a maximum of 4 sub questions.
- There will be 2 full questions from each module covering all the topics of the module.
- Students will have to answer 5 full questions, selecting one full question from each module.
- The total marks will be proportionally reduced to 60 marks as SEE marks is 60.

Text Book:

1. Tai-Ran Hsu, MEMS and Micro systems: Design, Manufacture and Nanoscale Engineering, 2nd Ed, John Wiley & Sons, 2008. ISBN: 978-0-470-08301-7

Reference Books:

1. Hans H. Gatzen, Volker Saile, JurgLeuthold, Micro and Nano Fabrication: Tools and Processes, Springer, 2015.
2. Dilip Kumar Bhattacharya, Brajesh Kumar Kaushik, Micro electromechanical Systems (MEMS), Cenage Learning.

IMAGE PROCESSING LAB **[As per Choice Based Credit System (CBCS) scheme]** **SEMESTER – I**			
Course Code	**18ESPL26**	**CIE Marks**	**40**
Number of Lecture Hours/Week	**01Hr Tutorial (Instructions) + 03 Hours Laboratory**	**SEE Marks**	**60**
Total Number of Lecture Hours		**Exam Hours**	**03**
Credits – 02			

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.

Laboratory Experiments:	**RBT Levels**
1.Study the effects of a) Boolean operations on binary images b) Quantization of gray level images	**L2**
2. Study the effects of Contrast enhancement using a) Histogram equalization b) Histogram stretching.	**L2**
3**.** Using connected component labeling algorithms. Express pixelneighborhood relationships in terms of a graph	**L2**
4. Creates a binary image from image 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.
- The experiments can be conducted in Matlab or using any other related tools.
- Strictlyfollowtheinstructionsasprintedonthecoverpageofanswerscrip tforbreakupofmarks.
- Change of experiment is allowed only once and Marks allotted to the Procedure part will be made zero.

M.Tech-SIGNAL PROCESSING-2018-THIRD SEMESTER SYLLABUS

Adaptive Signal processing **[As per Choice Based Credit System (CBCS) scheme]** **SEMESTER – III**			
Course Code	**18ESP31**	**CIE Marks**	**40**
Number of Lecture Hours/Week	**04**	**SEE Marks**	**60**
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 - Wiener – Hopf 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 - radient estimation - performance penalty - variance - excess MSE and time constants – mis adjustments. (Text 1)	**L1,L2**
Module-3	
LMS algorithm convergence of weight vector: LMS/Newton algorithm - properties - sequential regression algorithm - adaptive recursive filters - random-search algorithms - lattice structure - adaptive filters with orthogonal signals (Text 1)	**L1, L2,L3**
Module-4	
Applications-adaptive modeling: Multipath communication channel, geophysical exploration, FIR digital filter synthesis. (Text 2)	**L1, L2,L3**

Module-5	
LMS algorithm convergence of weight vector: LMS/Newton algorithm - properties - sequential regression algorithm - adaptive recursive filters - random-search algorithms - lattice structure - adaptive filters with orthogonal signals (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-HallofIndia,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.

Speech and Audio Processing **[As per Choice Based Credit System (CBCS) scheme]** **SEMESTER – III**			
Course Code	**18ESP321**	**CIE Marks**	**40**
Number of Lecture Hours/Week	**04**	**SEE Marks**	**60**
Total Number of Lecture Hours	**50 (10 Hours per Module)**	**Exam Hours**	**03**
Credits – 04			

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, 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)	**L2,L3**
Module-3	
Homomorphic Speech Processing: Homomorphic systems for convolution, Complex cepstrum, Pitch detection, Formant estimation, Homomorphic vocoder. Linear Predictive Coding of	**L3,L4**

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)	
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 modelling
- 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:

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

Array Signal Processing **[As per Choice Based Credit System (CBCS) scheme]** **SEMESTER – III**			
Course Code	**18ESP322**	**CIE Marks**	**40**
Number of Lecture Hours/Week	**04**	**SEE Marks**	**60**
Total Number of Lecture Hours	**50 (10 Hours per Module)**	**Exam Hours**	**03**
Credits – 04			

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.	**L1,L2**
Module-3	
Sensor Arrays: Linear Arrays, Planar Arrays, Frequency – Wave number Response and Beam pattern, Array manifold vector, Conventional Beam former, Narrowband beam former.	**L1,L1**
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 First Null, Location of side lobes and Rate of Decrease, Grating Lobes, Array Steering.	**L1,L1**
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:

1. 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/

Communication System Design using DSP Algorithms
[As per Choice Based Credit System (CBCS) scheme]
SEMESTER – III

Course Code	**18ESP323**	**CIE Marks**	**40**	**Course Code**
Number of Lecture Hours/Week	**04**	**SEE Marks**	**60**	**Number of Lecture Hours/Week**
Total Number of Lecture Hours	**50 (10 Hours per Module)**	**Exam Hours**	**03**	**Total Number of Lecture Hours**

Credits – 04

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 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)	**L1,L2**
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:

1. 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.

VLSI Design for Signal Processing **[As per Choice Based credit System (CBCS) Scheme** **SEMESTER – III**			
Subject Code	**18EVE331**	**CIE Marks**	**40**
Number of Lecture Hours/Week	**04**	**SEE marks**	**60**
Total Number of Lecture Hours	**50 (10 Hours per Module)**	**Exam Hours**	**03**
CREDITS – 04			

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.

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. Algorithms for Computing Iteration Bound, Iteration Bound of multi rate data flow graphs.	**L1, L2**
Module-2	
Pipelining and Parallel Processing: pipelining of FIR Digital Filters, parallel processing, Pipelining and parallel processing for low power. **Retiming:** Definition and Properties, Solving Systems of Inequalities, Retiming Techniques.	**L1,L2,L3**
Module-3	
Unfolding: An Algorithm for Unfolding, Properties of Unfolding, Critical path, Unfolding and Retiming, Application of Unfolding. **Folding:** Folding Transformation, Register Minimization Techniques, Register Minimization in Folded Architectures, Folding of Multirate Systems.	**L1,L2,L3**
Module-4	
Systolic Architecture Design: systolic array design Methodology, FIR systolic array, 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 Pipelining 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:

1. 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 Tsividis, " 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.

PATTERN RECOGNITION and MACHINE LEARNING [As per Choice Based Credit System (CBCS) scheme] SEMESTER – III			
Course Code	**18ESP332**	**CIE Marks**	**40**
Number of Lecture Hours/Week	**04**	**SEE Marks**	**60**
Total Number of Lecture Hours	**50 (10 Hours per Module)**	**Exam Hours**	**03**
Credits – 04			

Course objectives: The objective of the course is to discusses main and modern concepts for model selection and parameter estimation in recognition, decision making and statistical learning problems. Special emphasis will be given to regression, classification, regularization, feature selection and density estimation in supervised mode of learning.

Modules	RBT Levels
Module-1	
Introduction: Probability Theory, Model Selection, The Curse of Dimensionality, Decision Theory, Information Theory **Distributions:** Binary and Multinomial Variables, The Gaussian Distribution, The Exponential Family, Nonparametric Methods.**(Ch.: 1,2)**	**L1,L2**
Module-2	
Supervised Learning **Linear Regression Models:** Linear Basis Function Models, The Bias-Variance Decomposition, Bayesian Linear Regression, Bayesian Model Comparison **Classification & Linear Discriminant Analysis:** Discriminant Functions, Probabilistic Generative Models, Probabilistic Discriminative Mode**(Ch. :3,4)**	**L1,L2,L3**
Module-3	
Supervised Learning **Kernels:** Dual Representations, Constructing Kernels, Radial Basis Function Network, Gaussian Processes **Support Vector Machines:** Maximum Margin Classifiers, Relevance Vector Machines **Neural Networks:** Feed-forward Network, Network Training, Error Backpropagation**(Ch:5,6,7)**	**L1,L2,L3**
Module-4	
Unsupervised Learning: **Mixture Models:** K-means Clustering, Mixtures of Gaussians, Maximum likelihood, EM for Gaussian mixtures, Alternative View of EM. **Dimensionality Reduction:** Principal Component Analysis, Factor/Component Analysis, Probabilistic PCA, Kernel PCA,	**L1,L2,L3**

Nonlinear Latent Variable Models **(Ch.: 9,12)**	
Module-5	
Probabilistic Graphical Models: Bayesian Networks, Conditional Independence, Markov Random Fields, Inference in Graphical Models, Markov Model, Hidden Markov Models **(Ch.:8,13)**	**L1,L2,L3**

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

- Identify areas where Pattern Recognition and Machine Learning can offer a solution.
- Describe the strength and limitations of some techniques used in computational Machine Learning for classification, regression and density estimation problems.
- Describe and model data.
- Solve problems in Regression and Classification.

Question paper pattern:

- Examination will be conducted for 100 marks with question paper containing 10 full questions, each of 20 marks.
- Each full question can have a maximum of 4 sub questions.
- There will be 2 full questions from each module covering all the topics of the module.
- Students will have to answer 5 full questions, selecting one full question from each module.
- The total marks will be proportionally reduced to 60 marks as SEE marks is 60.

Text Book:

1. Pattern Recognition and Machine Learning. Christopher Bishop. Springer, 2006

IoT [As per Choice Based Credit System (CBCS) scheme] SEMESTER – III			
Course Code	**18ECS333**	**CIE Marks**	**40**
Number of Lecture Hours/Week	**04**	**SEE Marks**	**60**
Total Number of Lecture Hours	**50 (10 Hours per Module)**	**Exam Hours**	**03**
Credits – 04			

Course objectives: This course will enable students to:

- Introduce concept of IOT and its applications in today's scenario.
- Understand IOT content generation and transport through networks
- Understand the devices employed for IOT data acquisition and communication access technologies
- Introduce some use cases of IOT

Module-1	RBT
What is IOT Genesis, Digitization, Impact, Connected Roadways, Buildings, Challenges **IOT Network Architecture and Design** Drivers behind new network Architectures, Comparing IOT Architectures, M2M architecture, IOT world forum standard, IOT Reference Model, Simplified IOT Architecture.	**L1, L2**
Module-2	
IOT Network Architecture and Design Core IOT Functional Stack, Layer1(Sensors and Actuators) , Layer 2(Communications Sublayer), Access network sublayer, Gateways and backhaul sublayer, Network transport sublayer, IOT Network management. Layer 3(Applications and Analytics) – Analytics vs Control, Data vs Network Analytics IOT Data Management and Compute Stack	**L2,L3**
Module-3	
Engineering IOT Networks Things in IOT – Sensors, Actuators, MEMS and smart objects. Sensor networks, WSN, Communication protocols for WSN Communications Criteria, Range Frequency bands, power consumption, Topology, Constrained Devices, Constrained Node Networks IOT Access Technologies, IEEE 802.15.4 Competitive Technologies – Overview only of IEEE 802.15.4g, 4e, IEEE 1901.2a Standard Alliances – LTE Cat0, Cat-M, NB-IOT	**L2,L3**
Module-4	

Engineering IOT Networks IP as IOT network layer, Key Advantages, Adoption, Optimization, Constrained Nodes, Constrained Networks, IP versions, Optimizing IP for IOT. Application Protocols for IOT – Transport Layer, Application Transport layer, Background only of SCADA, Generic web based protocols, IOT Application Layer Data and Analytics for IOT – Introduction, Structured and Unstructured data, IOT Data Analytics overview and Challenges.	**L3,L4**
Module-5	
IOT in Industry (Three Use cases) • IOT Strategy for Connected manufacturing, Architecture for Connected Factory • Utilities – Power utility, IT/OT divide, Grid blocks reference model, Reference Architecture, Primary substation grid block and automation. • Smart and Connected cities –Strategy, Smart city network Architecture, Street layer, city layer, Data center layer, services layer, Smart city security architecture, Smart street lighting.	**L3,L4**

Question paper pattern:

- Examination will be conducted for 100 marks with question paper containing 10 full questions, each of 20 marks.
- Each full question can have a maximum of 4 sub questions.
- There will be 2 full questions from each module covering all the topics of the module.
- Students will have to answer 5 full questions, selecting one full question from each module.
- The total marks will be proportionally reduced to 60 marks as SEE marks is 60.

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

- Understand the basic concepts IOT Architecture and devices employed.
- Analyze the sensor data generated and map it to IOT protocol stack for transport.
- Apply communications knowledge to facilitate transport of IOT data over various available communications media.
- Design a use case for a typical application in real life ranging from sensing devices to analyzing the data available on a server to perform tasks on the device.

Text Book:

Cisco, IOT Fundamentals – Networking Technologies, Protocols, Use Cases for IOT, Pearson Education; First edition (16 August 2017). ISBN-10: 9386873745, ISBN-13: 978-9386873743

Reference Books:

Arshdeep Bahga and Vijay Madisetti, 'Internet of Things – A Hands on Approach', Orient Blackswan Private Limited - New Delhi; First edition (2015), ISBN-10: 8173719543, ISBN-13: 978-8173719547