

UNIVERSITY OF MUMBAI



Syllabus for the
M. E. (Signal Processing)
Program: M.E.

Course: Signal Processing

(As per Credit Based Semester and Grading System with
effect from the academic year 2014–2015)

From Dean's Desk:

To meet the challenge of ensuring excellence in engineering education, the issue of quality needs to be addressed, debated and taken forward in a systematic manner. Accreditation is the principal means of quality assurance in higher education. The major emphasis of accreditation process is to measure the outcomes of the program that is being accredited. In line with this Faculty of Technology of University of Mumbai has taken a lead in incorporating philosophy of outcome based education in the process of curriculum development.

Faculty of Technology, University of Mumbai, in one of its meeting unanimously resolved that, each Board of Studies shall prepare some Program Educational Objectives (PEO's) and give freedom to affiliated Institutes to add few (PEO's) and course objectives and course outcomes to be clearly defined for each course, so that all faculty members in affiliated institutes understand the depth and approach of course to be taught, which will enhance learner's learning process. It was also resolved that, maximum senior faculty from colleges and experts from industry to be involved while revising the curriculum. I am happy to state that, each Board of studies has adhered to the resolutions passed by Faculty of Technology, and developed curriculum accordingly. In addition to outcome based education, semester based credit and grading system is also introduced to ensure quality of engineering education.

Semester based Credit and Grading system enables a much-required shift in focus from teacher-centric to learner-centric education since the workload estimated is based on the investment of time in learning and not in teaching. It also focuses on continuous evaluation which will enhance the quality of education. University of Mumbai has taken a lead in implementing the system through its affiliated Institutes and Faculty of Technology has devised a transparent credit assignment policy and adopted ten points scale to grade learner's performance. Credit assignment for courses is based on 15 weeks teaching learning process, however content of courses is to be taught in 12-13 weeks and remaining 3-2 weeks to be utilized for revision, guest lectures, coverage of content beyond syllabus etc.

Dr. S. K. Ukarande
Dean,
Faculty of Technology,
Member - Management Council, Senate, Academic Council
University of Mumbai, Mumbai

From the Chairman's Desk:

The engineering education in India in general is expanding in manifolds. Now, the challenge is to ensure its quality to the stakeholders along with the expansion. To meet this challenge, the issue of quality needs to be addressed, debated and taken forward in a systematic manner. Accreditation is the principal means of quality assurance in higher education and reflects the fact that in achieving recognition, the institution or program of study is committed and open to external review to meet certain minimum specified standards. The major emphasis of this accreditation process is to measure the outcomes of the program that is being accredited. Program outcomes are essentially a range of skills and knowledge that a student will have at the time of post graduation from the program. An engineering program must ensure that its post graduates understand the basic concepts of science and mathematics, have gone through one engineering field in dept of appreciate and use its methodologies of analyses and design, and have acquired skills for life-long learning.

An engineering program must therefore have a mission statement which is in conformity with program objectives and program outcomes that are expected of the educational process. The outcomes of a program must be measurable and must be assessed regularly through proper feedback for improvement of the programme. There must be a quality assurance process in place within the Institute to make use of the feedback for improvement of the programme. The curriculum must be constantly refined and updated to ensure that the defined objectives and outcomes are achieved. Students must be encouraged to comment on the objectives and outcomes and the role played by the individual courses in achieving them. In line with this Faculty of Technology of University of Mumbai has taken a lead in incorporating philosophy of outcome based education in the process of curriculum development.

I, as Chairman, Board of Studies in Electronics and Telecommunication Engineering University of Mumbai, happy to state here that, Program Educational Objectives were finalized in a meeting where more than 20 members from different Institutes were attended, who were either Heads or their representatives of Electronics and Telecommunication Engineering Department. The Program Educational Objectives finalized for post graduate program in Electronics and Telecommunication Engineering.

In addition to Program Educational Objectives, for each course of undergraduate program, objectives and expected outcomes from learner's point of view are also included in the curriculum to support the philosophy of outcome based education. I believe strongly that small step taken in right direction will definitely help in providing quality education to the stake holders.

Dr. Udhav Bhosle

Chairman, Board of Studies in Electronics and Telecommunication Engineering

University of Mumbai
Program Structure for ME Signal Processing
(w.e.f. A.Y. 2014-2015)

Semester I

Subject Code	Subject Name	Teaching Scheme (Contact Hours/week)			Credits Assigned				
		Theory	Pract.	Tut.	Theory	Practical	Tut.	Total	
SPC101	Signal Detection and Estimation Theory	04	--	--	04	--	--	04	
SPC102	Digital Signal Processing	04	--	--	04	--	--	04	
SPC103	Image Processing	04	--	--	04	--	--	04	
SPE101X	Elective I	04	--	--	04	--	--	04	
SPE102X	Elective II	04	--	--	04	--	--	04	
SPL101	Laboratory I	--	02	--	--	01	--	01	
SPL102	Laboratory II	--	02	--	--	01	--	01	
Total		20	04	--	20	02	--	22	
Subject Code	Subject Name	Examination Scheme							
		Theory					Term Work	Practical /oral	Total
Internal Assessment			End Sem. Exam	Exam Duration (in Hrs)					
Test1	Test 2	Avg							
SPC101	Signal Detection and Estimation Theory	20	20	20	80	03	--	--	100
SPC102	Digital Signal Processing	20	20	20	80	03	--	--	100
SPC103	Image Processing	20	20	20	80	03	--	--	100
SPE101X	Elective I	20	20	20	80	03	--	--	100
SPE102X	Elective II	20	20	20	80	03	--	--	100
SPL101	Laboratory I	--	--	--	--	--	25	25	50
SPL102	Laboratory II	--	--	--	--	--	25	25	50
Total		100	100	100	400	--	50	50	600

Subject Code	Elective I
SPE1011	Radar and Satellite Signal Processing and Applications
SPE1012	DSP Processors

Subject Code	Elective II
SPE1021	Speech Processing
SPE1022	VSLI Signal Processing

Semester II

Subject Code	Subject Name	Teaching Scheme (Contact Hours/week)			Credits Assigned				
		Theory	Pract.	Tut.	Theory	Pract.	Tut.	Total	
SPC201	Adaptive Signal Processing	04	--	--	04	--	--	04	
SPC202	Signal processing Algorithms and Applications	04	--	--	04	--	--	04	
SPC203	Video Processing	04	--	--	04	--	--	04	
SPE201X	Elective I	04	--	--	04	--	--	04	
SPE202X	Elective II	04	--	--	04	--	--	04	
SPL201	Laboratory III	--	02	--	--	01	--	01	
SPL202	Laboratory IV	--	02	--	--	01	--	01	
Total		20	04	--	20	02	--	22	
Subject Code	Subject Name	Examination Scheme							
		Theory							
		Internal Assessment			End Sem. Exam	Exam Duration (in Hrs)	Term Work	Pract./oral	Total
		Test 1	Test 2	Avg					
SPC201	Adaptive Signal Processing	20	20	20	80	03	--	--	100
SPC202	Signal Processing Algorithms and Applications	20	20	20	80	03	--	--	100
SPC203	Video Processing	20	20	20	80	03	--	--	100
SPE201X	Elective I	20	20	20	80	03	--	--	100
SPE202X	Elective II	20	20	20	80	03	--	--	100
SPL201	Laboratory III	--	--	--	--	--	25	25	50
SPL202	Laboratory IV	--	--	--	--	--	25	25	50
Total		100	100	100	400	--	50	50	600

Subject Code	Elective I
SPE2011	Wavelet Transform and Applications
SPE2012	Biomedical Signal Processing

Subject Code	Elective II
SPE2021	DSP Structures for VSLI
SPE2022	Wireless Network

Semester III

Subject Code	Subject Name	Teaching Scheme (Contact Hours/week)			Credits Assigned				
		Theory	Pract.	Tut.	Theory	Pract.	Tut.	Total	
SPS301	Seminar	--	06	--	--	03	--	03	
SPD302	Dissertation I	--	24	--	--	12	--	12	
Total		--	30	--	--	15	--	15	
Subject Code	Subject Name	Examination Scheme							
		Theory					Term Work	Pract. /oral	Total
Internal Assessment			End Sem. Exam	Exam Duration (in Hrs)					
Test 1	Test 2	Avg							
SPS301	Seminar	--	--	--	--	--	50	50	100
SPD302	Dissertation I	--	--	--	--	--	100	---	100
Total		--	--	--	--	--	150	50	200

Semester IV

Subject Code	Subject Name	Teaching Scheme (Contact Hours/week)			Credits Assigned				
		Theory	Pract.	Tut.	Theory	Pract.	Tut.	Total	
SPD401	Dissertation II	--	30	--	--	15	--	15	
Total		--	30	--	--	15	--	15	
Subject Code	Subject Name	Examination Scheme							
		Theory					Term Work	Pract. /oral	Total
Internal Assessment			End Sem. Exam	Exam Duration (in Hrs)					
Test 1	Test 2	Avg							
SPD401	Dissertation II	--	--	--	--	--	100	100	200
Total		--	--	--	--	--	100	100	200

The term work and oral of project II of semester IV should be assessed jointly by pair of Internal and External examiners.

Subject Code	Subject Name	Teaching Scheme			Credits Assigned			
		Theory	Practical	Tutorial	Theory	TW/ Practical	Tutorial	Total
SPC101	Signal Detection and Estimation	04	--	--	04	--	--	04

Subject Code	Subject Name	Examination Scheme								
		Theory Marks					Term Work	Practical	Oral	Total
		Internal assessment			End Sem. Exam					
		Test 1	Test 2	Ave. Of Test 1 and Test 2						
SPC101	Signal Detection and Estimation	20	20	20	80	-	-	-	100	

Prerequisite:

Signals and Systems, Random Signal Process

Course Objective:

To enable the student to understand the basic principles of random signal processing, spectral detection and estimation methods used in communication system design and their applications.

Course Outcome:

Students will be able to design System for estimation, Spectral Estimation and also able to perform wave formation Analysis of the System

Module/ Section No.	Topics	Hrs.
1.	REVIEW OF SIGNALS AND SYSTEMS	06
	Introduction, System Theory, Stochastic Processes, Gauss-Markov Models, Representation of Stochastic Process, Likelihood and Sufficiency.	
2	DETECTION THEORY	08
	Introduction, one way , two way ANOVA table, Hypothesis Testing, Decision Criteria, Multiple Measurements, Multiple-Hypothesis Testing, Composite Hypothesis Testing, Chi-square testing, Asymptotic Error Rate of LRT for Simple Hypothesis Testing, CFAR Detection, Sequential Detection : Wald's Test.	
3	DETECTION OF SIGNALS IN NOISE	08
	Introduction, Detection of Known Signals in White Noise: The Correlation Receiver, Detection of Known Signals in Colored Noise, Detection of Known Signals in Noise: Maximum SNR Criterion, Solution of Integral Equations, Detection of Signals with Unknown Parameters.	
4	ESTIMATION THEORY	10
	Introduction, Estimation of Parameters, Random Parameters: Bayes Estimates, Estimation of Nonrandom Parameters, Properties of Estimators, Linear Mean-Square	

	Estimation, Reproducing Densities.	
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Module/ Section No.	Topics	Hrs
5	SPECTRUM ESTIMATION	10
	Non-Parametric methods - Correlation method - Co-variance estimator - Performance analysis of estimators – Unbiased consistent estimators - Periodogram estimator - Barlett spectrum estimation - Welch estimation - Model based approach - AR, MA, ARMA Signal modeling – Parameter estimation using Yule-Walker method.	
6	ESTIMATION OF WAVEFORMS	10
	Introduction, Linear MMSE Estimation of Waveforms: Preliminaries, Estimation of Stationary Processes: The Wiener Filter, Estimation of Nonstationary Processes: The Kalman Filter, Relation between the Kalman and Wiener Filters, Nonlinear Estimation, Nonparametric Detection.	
		52

Recommended Books:

- 1) Introduction to Statistical Signal Processing with Application by M.D. Srinath, P.K. Rajasekaran, R. Viswanathan, Prentice-Hall, Inc. Upper Saddle River, NJ,USA.
- 2) An Introduction to Statistical Signal Processing by Robert M. Gray and Lee D. Davisson, by Cambridge University Press

Reference Books:

- 1) Fundamentals of Statistical Signal Processing Volume-I: Estimation Theory by Steven Kay, Prentice Hall
- 2) Fundamentals of Statistical Signal Processing Volume-II: Detection Theory by Steve Kay, Prentice Hall
- 3) Fundamentals of Statistical Signal Processing Volume-III: Practical Algorithm Development by Steven Kay, Prentice Hall

Internal Assessment (IA):

Two tests must be conducted which should cover at least 80% of syllabus. The average marks of both the test will be considered as final IA marks

End Semester Examination:

1. Question paper will comprise of 6 questions, each carrying 20 marks.
2. Total 4 questions need to be solved.
- 3: Question No.1 will be compulsory and based on entire syllabus wherein sub questions of 2 to 5 marks will be asked.
- 4: Remaining question will be selected from all the modules.

Subject Code	Subject Name	Teaching Scheme			Credits Assigned			
		Theory	Practical	Tutorial	Theory	TW/Practical	Tutorial	Total
SPC102	Digital Signal Processing	04	--	--	04	--	--	04

Subject Code	Subject Name	Examination Scheme								
		Theory Marks					Term Work	Practical	Oral	Total
		Internal assessment			End Sem. Exam					
		Test 1	Test 2	Ave. Of Test 1 and Test 2						
SPC102	Digital Signal Processing	20	20	20	80	-	-	-	100	

Prerequisite:

Signals and Systems, Random Signal Process

Course Objective:

To enable the student to understand the discrete-time signal transforms, digital filter design, optimal filtering, multi-rate digital signal processing

Course Outcome:

Students will be able to design adaptive filters for a given application and to design multirate DSP systems.

Module/ Section No.	Topics	Hrs.
1.	ORTHOGONAL TRANSFORMS DFT, DCT and Haar; Properties of DFT; Computation of DFT: FFT and structures, Decimation in time, Decimation in frequency; Linear convolution using DFT	07
2	BASIC FIR FILTER DESIGN FIR Filter Design- Window method, Frequency sampling method, Optimum equiripple Linear phase FIR, FIR Differentiator. Frequency Transformation. Realization Structures for FIR filters- Direct form structure, Cascade, Frequency Sampling Structure, Lattice Ladder structure. Structures for Linear phase FIR filters.	11
3	INFINITE IMPULSE RESPONSE FILTER DESIGN Design of IIR Filters- Impulse invariant method, Matched Z- Transform Method, Bilinear Transformation method. Butterworth filter. Frequency Transformation- Low pass to High pass, Band Pass and band reject filters. Realization Structures for IIR Filters – Direct form structures, Cascade and parallel realization structures for higher order structures, Lattice Ladder structure. Application examples in Telecommunication- Touch tone generation and reception for digital Telephones, Digital telephony: Dual tone multifrequency detection using Goertzel algorithm, Clock recovery for data communication	12
4	MULTIRATE SIGNAL PROCESSING Basic structures for sampling rate conversion, Decimators and Interpolators; Multistage design of interpolators and decimators; Polyphase decomposition and FIR structures; Computationally efficient sampling rate converters; Arbitrary sampling rate converters based on interpolation algorithms: Lagrange interpolation, Spline interpolation; Quadrature mirror filter banks; Conditions for perfect reconstruction; Applications in subband coding;	12
5	ANALYSIS OF FINITE WORDLENGTH EFFECT IN FIXED-POINT DSP SYSTEMS Introduction, DSP arithmetic, ADC quantization noise & signal quality, Finite wordlength effects in IIR & FIR digital filters, Hilbert transform, Hilbert transform relations for causal signals, Karhunen-Loève transform. Introduction to linear prediction, bandpass sampling	10

	theorem, bandpass signal representation.	
Total		52

Recommended Books:

1. Discrete Time signal Processing by Alan V. Oppenheim, Ronald Schafer, Pearson Education
2. Digital Signal Processing, Principles, algorithms and applications - J. Proakis, D. G. Manolakis, D. Sharma, Pearson Education.
3. Multirate Systems and Filter Banks-P.P. Vaidyanathan, Pearson.

Reference Books:

1. Fundamentals of Digital Signal Processing using MATLAB- Robert Schilling, Sandra Harris, Cengage Learning.

Internal Assessment (IA):

Two tests must be conducted which should cover at least 80% of syllabus. The average marks of both the test will be considered as final IA marks

End Semester Examination:

1. Question paper will comprise of 6 questions, each carrying 20 marks.
2. Total 4 questions need to be solved.
- 3: Question No.1 will be compulsory and based on entire syllabus wherein sub questions of 2 to 5 marks will be asked.
- 4: Remaining question will be selected from all the modules.

Subject Code	Subject Name	Teaching Scheme			Credits Assigned			
		Theory	Practical	Tutorial	Theory	TW/ Practical	Tutorial	Total
SPC103	Image Processing	04	--	--	04	--	--	04

Subject Code	Subject Name	Examination Scheme								
		Theory Marks					Term Work	Practical	Oral	Total
		Internal assessment			End Sem. Exam					
		Test 1	Test 2	Ave. Of Test 1 and Test 2						
SPC103	Image Processing	20	20	20	80	-	-	-	100	

Prerequisite:

Signals and Systems, Digital Signal Processing

Course Objective:

To understand the image fundamentals and mathematical transforms necessary for image processing and also to study the image enhancement technique, image segmentation and representation techniques.

Course Outcome:

- Upon Completion of the course, the students will be able to understand image formation and the role human visual system in perception of gray and color image data.
- Student will be able to apply image processing techniques in both the spatial and frequency domains.
- Students will be to design image analysis techniques in the form of image segmentation and to evaluate the methodologies for segmentation.

Module/ Section No.	Topics	Hrs.
1.	FUNDAMENTALS OF DIGITAL IMAGE PROCESSING Elements of visual perception, brightness, contrast, hue, saturation, mach band effect, 2D image transforms-DFT, DCT, KLT, and SVD. Image enhancement in spatial and frequency domain, Review of morphological image processing	06
2	SEGMENTATION Edge detection, Thresholding, Region growing, Fuzzy clustering, Watershed algorithm, Active contour methods, Texture feature based segmentation, Model based segmentation, Atlas based segmentation, Wavelet based Segmentation methods	07
3	FEATURE EXTRACTION First and second order edge detection operators, Phase congruency, Localized feature extraction detecting image curvature, shape features Hough transform, shape skeletonization, Boundary descriptors, Moments, Texture descriptors- Autocorrelation, Co-occurrence features, Runlength features, Fractal model based features, Gabor filter, wavelet features.	07
4	COLOUR IMAGE PROCESSING Introduction, devices for colour Imaging, colour image storages and processing, colour model, RGB, HIS, HSV, HLS and TV colour model, colour quantization, Pseudo color processing, full colour processing and colour features.	08
5	IMAGE RESTORATION Basic Framework, Interactive Restoration, Image deformation and geometric transformations, image morphing, Restoration techniques, Noise characterization, Noise restoration filters, Adaptive filters, Linear, Position invariant degradations, Estimation of Degradation functions, Restoration from projections.	08

Module/ Section No.	Topics	Hrs
6	MORPHOLOGICAL IMAGE PROCESSING	08
	Basics, Structuring Element, Erosion, Dilation, Opening, Closing, Hit-or-Miss Transform, Boundary Detection, Hole filling, Connected components, convex hull, thinning, thickening, skeletons, pruning, Geodesic Dilation, Erosion, Reconstruction by dilation and erosion.	
7	REGISTRATION AND IMAGE FUSION	08
	Registration- Preprocessing, Feature selection-points, lines, regions and templates Feature correspondence-Point pattern matching, Line matching, region matching Template matching. Transformation functions-Similarity transformation and Affine Transformation. Resampling- Nearest Neighbour and Cubic Splines Image Fusion-Overview of image fusion, pixel fusion, Multiresolution based fusion discrete wavelet transform, Curvelet transform. Region based fusion.	
	Total	52

Recommended Books:

1. John C.Russ, "The Image Processing Handbook", CRC Press, 2007.
2. Mark Nixon, Alberto Aguado, "Feature Extraction and Image Processing", Academic Press, 2008.
3. Ardeshir Goshtasby, "2D and 3D Image registration for Medical, Remote Sensing and Industrial Applications", John Wiley and Sons, 2005.

Reference Books:

1. Rafael C. Gonzalez, Richard E. Woods, Digital Image Processing', Pearson, Education, Inc., Second Edition, 2004.
2. Anil K. Jain, Fundamentals of Digital Image Processing', Pearson Education, Inc., 2002.
3. Rick S.Blum, Zheng Liu, "Multisensory image fusion and its Applications", Taylor & Francis, 2006.

Internal Assessment (IA):

Two tests must be conducted which should cover at least 80% of syllabus. The average marks of both the test will be considered as final IA marks

End Semester Examination:

1. Question paper will comprise of 6 questions, each carrying 20 marks.
2. Total 4 questions need to be solved.
- 3: Question No.1 will be compulsory and based on entire syllabus wherein sub questions of 2 to 5 marks will be asked.
- 4: Remaining question will be selected from all the modules

Subject Code	Subject Name	Teaching Scheme			Credits Assigned			
		Theory	Practical	Tutorial	Theory	TW/Practical	Tutorial	Total
SPE1011	Radar and Satellite Signal Processing	04	--	--	04	--	--	04

Subject Code	Subject Name	Examination Scheme								
		Theory Marks					Term Work	Practical	Oral	Total
		Internal assessment			End Sem. Exam					
		Test 1	Test 2	Ave. Of Test 1 and Test 2						
SPE1011	Radar and Satellite Signal Processing	20	20	20	80	-	-	-	100	

Prerequisite:

Radar Engineering, Wave Propagation, Satellite Communication

Course Objective:

To understand the Radar Signal acquisition and sampling in multiple domains to provide clear instruction in radar DSP basics and to equip the skills needed in both design and analysis of common radar algorithms.

Course Outcome:

Upon Completion of the course, the students will be able to understand application of signal processing in radar system, different types of signal models used in radar, types of differential GPS systems and applications of signal processing in remote sensing.

Module/ Section No.	Topics	Hrs.
1.	INTRODUCTION TO RADAR SYSTEMS	08
	History and application of radar, basic radar function, elements of pulsed radar, review of signal processing concepts and operations, A preview of basic radar signal processing, radar system components, advanced radar signal processing	
2	SIGNAL MODELS	08
	Components Of Radar Signals, Amplitude models, types of clutters, noise model and signal to noise ratio, frequency models, the doppler shift, spatial models, spectral model	
3	SAMPLING AND QUANTIZATION OF PULSED RADAR SIGNALS	09
	Domains and criteria for sampling radar signals, Sampling in the fast time dimension, Sampling in slow time: selecting the pulse repetition interval, sampling the doppler spectrum, Sampling in the spatial and angle dimension, Quantization, I/Q Imbalance and Digital I/Q.	
4	NAVIGATION, TRACKING AND SAFETY SYSTEMS	09
	Global Navigation Satellite Systems - Basic concepts of GPS. Space segment, Control segment, user segment, GPS constellation, GPS measurement characteristics, selective availability (AS), Anti spoofing (AS). Applications of Satellite and GPS for 3D position, Velocity, determination as function of time, Interdisciplinary applications. Regional Navigation Systems- Distress and Safety-Cospas-Sarsat- Inmarsat Distress System- Location-Based service.	
5	INERTIAL NAVIGATION AND DIFFERENTIAL GPS SYSTEMS	09
	Introduction to Inertial Navigation- Inertial Sensors - Navigation Coordinates-System Implementations- System-Level Error Models- Introduction to Differential GPS- LADGPSWADGPS- WAAS - GEO Uplink Subsystem (GUS) - GEO Uplink Subsystem (GUS) Clock Steering Algorithms - GEO Orbit Determination - Problems	

Module/ Section No.	Topics	Hrs
6	REMOTE SENSING SYSTEMS AND TECHNIQUES	09
	Introduction - Commercial Imaging – Digital Globe – Geo Eye - Meteorology – Meteosat – Land Observation – Landsat- Remote Sensing Data- Sensors- Overview - Optical Sensors: Cameras- Non-Optical Sensors- Image Processing - Image Interpretation- System Characteristics.	
	Total	52

Recommended Books:

1. Fundamentals of Radar Signal Processing, Mark A. Richards McGraw-Hill, New York, 2005
2. Radar systems, Peak Detection and Tracking, Michael O Kolawole, 2010, Elseveir
3. Introduction to Radar Systems 3/E, Skolnik, McGraw Hill.
4. Satellite systems for personal Applications, Madhavendra Richharia, A John Wiley and Sons, Ltd., Publication.
5. Dennis Roddy, ‘Satellite Communication’, McGraw Hill International, 4th Edition, 2006.
6. Wilbur L. Pritchard, Hendri G. Suyderhoud, Robert A. Nelson, ‘Satellite Communication Systems Engineering’, Prentice Hall/Pearson, 2007 (Books to be added)

Reference Books:

- 1) Principles of Radar and Sonar Signal Processing, Francois Le Chevalier, Artech House
- 2) Radar Principles, Peyton Z. Peebles, 2009 Wiley India
- 3) Radar Design Principles-Signal Processing and the environment, Fred E. Nathanson, PHI
- 4) Global Positioning Systems, Inertial Navigation, and Integration. MOHINDER S. GREWAL California State University at Fullerton, A John Wiley & Sons, Inc. Publication.

Internal Assessment (IA):

Two tests must be conducted which should cover at least 80% of syllabus. The average marks of both the test will be considered as final IA marks

End Semester Examination:

1. Question paper will comprise of 6 questions, each carrying 20 marks.
2. Total 4 questions need to be solved.
- 3: Question No.1 will be compulsory and based on entire syllabus wherein sub questions of 2 to 5 marks will be asked.
- 4: Remaining question will be selected from all the modules.

Subject Code	Subject Name	Teaching Scheme			Credits Assigned			
		Theory	Practical	Tutorial	Theory	TW/Practical	Tutorial	Total
SPE1012	DSP Processors	04	--	--	04	--	--	04

Subject Code	Subject Name	Examination Scheme								
		Theory Marks					Term Work	Practical	Oral	Total
		Internal assessment			End Sem. Exam					
		Test 1	Test 2	Ave. Of Test 1 and Test 2						
SPE1012	DSP Processors	20	20	20	80	-	-	-	100	

Prerequisite:

Basics of Microprocessors

Course Objective:

To enable the students to understand the basic principles of working of DSP Processors, their architectures and applications.

Course Outcome:

Students will be able to understand the development of digital processors and Advanced DSP processors.

Module/ Section No.	Topics	Hrs.
1.	FUNDAMENTALS OF PROGRAMMABLE DSPs Introduction to DSP Processors: Differences between DSP and other μ p architectures, their comparison and need for special ASPs, RISC & CISC CPUs. Multiplier and Multiplier accumulator – Modified Bus Structures and Memory access in PDSPs – Multiple access memory – Multi-port memory – VLIW architecture- Pipelining – Special Addressing modes in P-DSPs – On chip Peripherals.	10
2	TMS320C5X PROCESSOR Architecture – Assembly language syntax - Addressing modes – Assembly language Instructions - Pipeline structure, Operation – Block Diagram of DSP starter kit – Application Programs for processing real time signals.	10
3	TMS320C6X PROCESSOR Architecture of the C6x Processor - Instruction Set - DSP Development System: Introduction – DSP Starter Kit Support Tools- Code Composer Studio - Support Files - Programming Examples to Test the DSK Tools – Application Programs for processing real time signals.	10
4	ADSP PROCESSORS Architecture of ADSP-21XX and ADSP-210XX series of DSP processors- Addressing modes and assembly language instructions – Application programs –Filter design, FFT calculation.	12
5	ADVANCED PROCESSORS Architecture of TMS320C54X: Pipe line operation, Code Composer studio – Architecture of TMS320C6X - Architecture of Motorola DSP563XX – Comparison of the features of DSP family processors.	10
	Total	52

Recommended Books:

1. B.Venkataramani and M.Bhaskar, "Digital Signal Processors – Architecture, Programming and Applications" – Tata McGraw – Hill Publishing Company Limited. New Delhi, 2003.
2. Avtar Singh and S. Srinivasan, Digital Signal Processing – Implementations using DSP Microprocessors with Examples from TMS320C54xx, cengage Learning India Private Limited, Delhi 2012

Reference Books:

1. User guides Texas Instrumentation, Analog Devices, Motorola.
2. Rulph Chassaing, Digital Signal Processing and Applications with the C6713 and C6416 DSK, A JOHN WILEY & SONS, INC., PUBLICATION, 2005

Internal Assessment (IA):

Two tests must be conducted which should cover at least 80% of syllabus. The average marks of both the test will be considered as final IA marks

End Semester Examination:

1. Question paper will comprise of 6 questions, each carrying 20 marks.
2. Total 4 questions need to be solved.
- 3: Question No.1 will be compulsory and based on entire syllabus wherein sub questions of 2 to 5 marks will be asked.
- 4: Remaining question will be selected from all the modules.

Subject Code	Subject Name	Teaching Scheme			Credits Assigned			
		Theory	Practical	Tutorial	Theory	TW/Practical	Tutorial	Total
SPE1021	Speech Processing	04	--	--	04	--	--	04

Subject Code	Subject Name	Examination Scheme								
		Theory Marks					Term Work	Practical	Oral	Total
		Internal assessment			End Sem. Exam					
		Test 1	Test 2	Ave. of Test 1 and Test 2						
SPE1021	Speech Processing	20	20	20	80	-	-	-	100	

Prerequisite:

Signals and Systems, Digital Signal Processing

Course Objective:

- To study the basic concepts of speech and audio and to the analysis of various M-band filter banks for audio coding.
- To learn various transform coders for audio coding, to study the speech processing methods in time and frequency domain.

Course Outcome:

- At the end of this course students are able to understand the applications of different coders for compression of speech signal.

Module/ Section No.	Topics	Hrs.
1.	MECHANICS OF SPEECH AND AUDIO Introduction - Review Of Signal Processing Theory-Speech production mechanism – Nature of Speech signal – Discrete time modelling of Speech production – Classification of Speech sounds Phones – Phonemes – Phonetic and Phonemic alphabets – Articulatory features. Absolute Threshold of Hearing - Critical Bands- Simultaneous Masking, Masking-Asymmetry, and the Spread of Masking- Non simultaneous Masking - Perceptual Entropy - Basic measuring philosophy -Subjective versus objective perceptual testing - The perceptual audio quality measure (PAQM) - Cognitive effects in judging audio quality.	08
2	TIME-FREQUENCY ANALYSIS: FILTER BANKS AND TRANSFORMS Introduction -Analysis-Synthesis Framework for M-band Filter Banks- Filter Banks for Audio Coding: Design Considerations - Quadrature Mirror and Conjugate Quadrature Filters- Tree-Structured QMF and CQF M-band Banks - Cosine Modulated “Pseudo QMF” M-band Banks - Cosine Modulated Perfect Reconstruction (PR) M-band Banksand the Modified Discrete Cosine Transform (MDCT) - Discrete Fourier and Discrete Cosine Transform - Pre-echo Distortion-Preecho Control Strategies.	10
3	AUDIO CODING AND TRANSFORM CODERS Introduction, Detection of Known Signals in White Noise: The Correlation Receiver, Detection of Known Signals in Colored Noise, Detection of Known Signals in Noise: Maximum SNR Criterion, Solution of Integral Equations, Detection of Signals with Unknown Parameters.	10

Module/ Section No.	Topics	Hrs.
4	TIME AND FREQUENCY DOMAIN METHODS FOR SPEECH PROCESSING Time domain parameters of Speech signal – Methods for extracting the parameters Energy Average Magnitude – Zero crossing Rate – Silence Discrimination using ZCR and energy Short Time Fourier analysis – Formant extraction – Pitch Extraction using time and frequency domain methods HOMOMORPHIC SPEECH ANALYSIS: Cepstral analysis of Speech – Formant and Pitch Estimation – Homomorphic Vocoders.	12
5	LINEAR PREDICTIVE ANALYSIS OF SPEECH Formulation of Linear Prediction problem in Time Domain – Basic Principle – Auto correlation method – Covariance method – Solution of LPC equations – Cholesky method – Durbin's Recursive algorithm – lattice formation and solutions – Comparison of different methods – Application of LPC parameters – Pitch detection using LPC parameters – Formant analysis – VELP – CELP.	12
	Total	52

Recommended Books:

1. Digital Audio Signal Processing, Second Edition, Udo Zolzer, A John Wiley & sons Ltd. Publications
2. Applications of Digital Signal Processing to Audio and Acoustics Mark Kahrs, Karlheinz Brandenburg, KLUWER ACADEMIC PUBLISHERS NEW YORK, BOSTON, DORDRECHT, LONDON, MOSCOW

Reference Books:

1. Digital Processing of Speech signals – L.R.Rabiner and R.W.Schaffer - Prentice Hall --1978

Internal Assessment (IA):

Two tests must be conducted which should cover at least 80% of syllabus. The average marks of both the test will be considered as final IA marks

End Semester Examination:

1. Question paper will comprise of 6 questions, each carrying 20 marks.
2. Total 4 questions need to be solved.
3. Question No.1 will be compulsory and based on entire syllabus wherein sub questions of 2 to 5 marks will be asked.
4. Remaining question will be selected from all the modules.

Subject Code	Subject Name	Teaching Scheme			Credits Assigned			
		Theory	Practical	Tutorial	Theory	TW/Practical	Tutorial	Total
SPE1022	VLSI Signal Processing	04	--	--	04	--	--	04

Subject Code	Subject Name	Examination Scheme								
		Theory Marks					Term Work	Practical	Oral	Total
		Internal assessment			End Sem. Exam					
		Test 1	Test 2	Ave. Of Test 1 and Test 2						
SPE1022	VLSI Signal Processing	20	20	20	80	-	-	-	100	

Prerequisite:

Basics of VLSI, Signals and Systems, Digital Signal Processing.

Course Objective:

To introduce various techniques for the efficient mapping of DSP algorithms on hardware platform.

Course Outcome:

Students will be able to understand the various techniques for the representation and efficient hardware implementation of DSP algorithms.

Module/ Section No.	Topics	Hrs.
1.	TYPICAL DSP ALGORITHMS AND REPRESENTATION Review of typical DSP algorithms: Convolution, Correlation, Discrete Cosine Transform (DCT), Vector Quantization, Decimator and Expander, Discrete Wavelet Transform (DWT), Digital Filter. Representation of DSP Algorithm: Block diagram, signal flow graph, data flow graph and dependence graph, DSP application demands and CMOS technologies.	06
2	ITERATION BOUND Loop Bound and Iteration Bound, Longest Path Algorithm, Minimum Cycle Algorithm, Iteration bound of Multirate Data	08
3	PIPELINING AND PARALLEL PROCESSING Pipelining of FIR Digital Filters, Data Broadcast Structures, Fine Grain pipelining. Parallel Processing, Designing of Parallel Processing system, pipelining and parallel processing for low power, combining pipelining and parallel processing	10
4	RETIMING Definition, Quantitative Description of Retiming, Prosperities of Retiming, Solving systems of inequalities, Cutset retiming and Pipelining, Retiming for clock period and register minimization	10
5	UNFOLDING AND FOLDING Algorithm for unfolding, Properties of Unfolding, Applications of unfolding: Sample period reduction, word-level and bit-level parallel processing. Folding Transformations, Register Minimization Techniques in Folded Architectures: Life time Analysis, Forward-Backward register allocation, register minimization of biquad and IIR filter, folding of multirate system	10
6	FAST CONVOLUTION Cook-Toom Algorithm, Winograd Algorithm, Iterated Convolution, Cyclic Convolution	08
	Total	52

Recommended Books:

1. “VLSI Digital Signal Processing Systems, Design and Implementation”, by Keshab Parhi, John-Wiley & sons.
2. “FPGA-based Implementation of Signal Processing Systems” by Roger Woods, John McAllister, Gaye Lightbody, Ying Yi, Wiley, John-Wiley and Sons

Reference Books:

1. “Principles of CMOS VLSI Design”, by Neil H.E.Weste, Kamran Eshraghian, Pearson Education.
2. “DSP Integrated Circuits”, by Lars Wanhammar, Linkoping University, Academic Press Series in Engineering.

Internal Assessment (IA):

Two tests must be conducted which should cover at least 80% of syllabus. The average marks of both the test will be considered as final IA marks

End Semester Examination:

1. Question paper will comprise of 6 questions, each carrying 20 marks.
2. Total 4 questions need to be solved.
3. Question No.1 will be compulsory and based on entire syllabus wherein sub questions of 2 to 5 marks will be asked.
4. Remaining question will be selected from all the modules.

Subject Code	Subject Name	Teaching Scheme			Credits Assigned			
		Theory	Practical	Tutorial	Theory	TW/Practical	Tutorial	Total
SPL101	Laboratory I	--	02	--	--	01	--	01

Subject Code	Subject Name	Examination Scheme								
		Theory Marks					Term Work	Practical	Oral	Total
		Internal assessment			End Sem. Exam					
		Test 1	Test 2	Ave. Of Test 1 and Test 2						
SPL101	Laboratory I	--	--	--	--	25	25	-	50	

Term Work:

At least minimum ten experiments covering entire syllabus of Digital Signal Processing and Image Processing should be set to have well predefined inference and conclusion. The experiments should be student's centric and attempt should be made to make experiments more meaningful, interesting and innovative. Term work assessment must be based on oral performance of the student with every experiment. The grade must be converted to marks as per credit & grading system manual, and should be added and average. Base on above scheme grading & term work assessment should be done.

Practical & oral examination will be based on entire syllabus.

Subject Code	Subject Name	Teaching Scheme			Credits Assigned			
		Theory	Practical	Tutorial	Theory	TW/Practical	Tutorial	Total
SPL102	Laboratory II	--	02	--	--	01	--	01

Subject Code	Subject Name	Examination Scheme								
		Theory Marks					Term Work	Practical	Oral	Total
		Internal assessment			End Sem. Exam					
		Test 1	Test 2	Ave. Of Test 1 and Test 2						
SPL102	Laboratory II	--	--	--	--	25	25	-	50	

Term Work:

At least minimum ten experiments covering entire syllabus of Elective I and Elective II subjects should be set to have well predefined inference and conclusion. The experiments should be student's centric and attempt should be made to make experiments more meaningful, interesting and innovative. Term work assessment must be based on oral performance of the student with every experiment. The grade must be converted to marks as per credit & grading system manual, and should be added and average. Base on above scheme grading & term work assessment should be done.

Practical & oral examination will be based on entire syllabus.

Subject Code	Subject Name	Teaching Scheme			Credits Assigned			
		Theory	Practical	Tutorial	Theory	TW/Practical	Tutorial	Total
SPC201	Adaptive Signal Processing	04	--	--	04	--	--	04

Subject Code	Subject Name	Examination Scheme							
		Theory Marks				Term Work	Practical	Oral	Total
		Internal assessment			End Sem. Exam				
		Test 1	Test 2	Ave. Of Test 1 and Test 2					
SPC201	Adaptive Signal Processing	20	20	20	80	-	-	-	100

Prerequisite:

Signals and Systems, Digital Signal Processing

Course Objective:

To enable the student to understand the basic principles of adaptive signal processing, spectral detection and estimation methods used in communication and their applications.

Course Outcome:

Students will be able to understand the different types of adaptive filters used in signal processing applications.

Module/ Section No.	Topics	Hrs.
1.	INTRODUCTION Introduction to Adaptive Processing General properties, filtering, prediction and smoothing, applications in Communications: Equalization, Echo cancellation, Noise cancellation.	07
2	ORTHOGONALIZED ADAPTIVE FILTERS Optimal Signal Processing Principles of orthogonality, minimum square error, Wiener Hopf equations, state space model, innovations process, Kalman filter equations. Linear Adaptive Equalization Gradient search and steepest descent adaptation algorithms, effect of Eigen value spread on stability and rate of convergence.	12
3	LEAST MEAN SQUARES ADAPTIVE FILTER stochastic gradient descent using Least Mean Squares (LMS) algorithms, transient and steady state properties including convergence rate and mis-adjustment, least square estimation, normal equations, Recursive Least Squares (RLS) algorithms, relationship between RCS and Kalman filters.	12
4	KALMAN FILTER THEORY Kalman Filter theory; Introduction; recursive minimum mean square estimation for scalar random variables; statement of the kalman filtering problem: the innovations process, Estimation of state using the innovations process.	10
5	FAST RECURSIVE ALGORITHMS AND APPLICATIONS Introduction to Fast Recursive Algorithms for Equalization Adaptive linear prediction, lattice filtering for RLS. Other Applications Echo cancellation in wowire systems, Noise cancellation	11
	Total	52

Text Books:

1. Adaptive Signal Processing, B. Widrow, S. Stearns, Prentice-Hall, 1985
2. Adaptive Signal Processing, L. Sibil, Ed., IEEE Press, 1987
3. Adaptive Filters: Structures, Algorithms and Applications, M. Honig, D. Messerschmitt, Kluwer, 1984.

Reference Books:

1. Statistical and Adaptive Signal Processing: Spectral Estimation, Signal Modeling, Adaptive Filtering and Array Processing, D. Manolakis, V. Ingle, S. Kogan, McGraw Hill, 1999.
2. Fundamentals of Adaptive Filtering, Ali H. Sayed, John Wiley, 2003.
3. Mohinder S. Grewal, Angus P. Andrews, Kalman Filtering: Theory and Practice Using MATLAB, John Wiley & Sons. 2008

Internal Assessment (IA):

Two tests must be conducted which should cover at least 80% of syllabus. The average marks of both the test will be considered as final IA marks

End Semester Examination:

1. Question paper will comprise of 6 questions, each carrying 20 marks.
2. Total 4 questions need to be solved.
- 3: Question No.1 will be compulsory and based on entire syllabus wherein sub questions of 2 to 5 marks will be asked.
- 4: Remaining question will be selected from all the modules.

Subject Code	Subject Name	Teaching Scheme			Credits Assigned			
		Theory	Practical	Tutorial	Theory	TW/ Practical	Tutorial	Total
SPC202	Signal Processing Algorithms and Applications	04	--	--	04	--	--	04

Subject Code	Subject Name	Examination Scheme								
		Theory Marks					Term Work	Practical	Oral	Total
		Internal assessment			End Sem. Exam					
		Test 1	Test 2	Ave. Of Test 1 and Test 2						
SPC202	Signal Processing Algorithms and Applications	20	20	20	80	-	-	-	100	

Pre-requisite : Signals and Systems , Random Signal Processing

Course Objective:

- To enable the student to understand the basic principles of random signal processing, spectral detection and estimation methods used in communication system design and their applications.

Course Outcome:

Students will be able to design adaptive filters for a given application and to design multirate DSP systems

Module/ Section No.	Topics	Hrs.
1.	ORTHOGONAL TRANSFORMS DFT, DCT and Haar; Properties of DFT; Computation of DFT: FFT and structures, Decimation in time, Decimation in frequency; Linear convolution using DFT	7
2.	DIGITAL FILTER STRUCTURES Basic FIR/IIR filter structures, FIR/IIR Cascaded lattice structures, Parallel allpass realization of IIR transfer functions, Sinecosine generator; Computational complexity of filter structures	5
3.	DATA COMPRESSION: An information theory primer: Historic notes and information entropy, Source coding: Huffman algorithm, Delta Modulation, adaptive delta modulation and continuously variable slope delta modulation, differential Pulse code modulation and adaptive differential pulse code modulation.	10
4	SIGNAL PROCESSING IN COMMUNICATION RECEIVER Temporal Equalization, Space Time Equalization, Frequency Domain Equalization, Symbol Timing Recovery, Channel Quality Estimation, Automatic Frequency Control, Overall Receiver Block.	8
5	ERROR CORRECTING CODES: CHANNEL CODING: THE CHANNEL MODEL, THE CHANNEL CAPACITY Error Correcting codes: Hamming distance and error correction, liner blocks codes, cyclic codes, Bose, Chaudhari and Hocquenghem codes, convolution codes, Viterbi decoding, interleaving and concatenated codes and turbo codes.	8
6	SPEECH CODING: Speech coding, adaptive predictive coding and sub-band coding, vocoders and liner predictive coding, Image coding, joint Photo graphic expert group(JPEG), moving pictures expert group(MPEG), the layer-3 of MPEG-1 algorithms(MP3), the Lempel-ZIV algorithms	8
7	Recognition techniques: A general problem formulation, speech recognition and Image	6

	recognition	
		Total 52

Recommended Books:

1. R. Chassaing and D. Reay, Digital signal processing and applications with TMS320C6713 and TMS320C6416, Wiley, 2008.
2. S. K. Mitra, Digital Signal Processing: A Computer Based Approach, 3rd Edn., MH, 2008.
3. J. G. Proakis and D. G. Manolakis, Digital Signal Processing: Principles, Algorithms and Applications, Pearson Prentice Hall, 2007
4. Day Stranneby and William Walker, "Digital Signal processing and Applications", Elsevier Publications, second edition 2013.

Internal Assessment (IA):

Two tests must be conducted which should cover at least 80% of syllabus. The average marks of both the test will be considered as final IA marks

End Semester Examination:

1. Question paper will comprise of 6 questions, each carrying 20 marks.
2. Total 4 questions need to be solved.
- 3: Question No.1 will be compulsory and based on entire syllabus wherein sub questions of 2 to 5 marks will be asked.
- 4: Remaining question will be selected from all the modules.

Subject Code	Subject Name	Teaching Scheme			Credits Assigned			
		Theory	Practical	Tutorial	Theory	TW/Practical	Tutorial	Total
SPC203	Video Processing	04	--	--	04	--	--	04

Subject Code	Subject Name	Examination Scheme								
		Theory Marks					Term Work	Practical	Oral	Total
		Internal assessment			End Sem. Exam					
		Test 1	Test 2	Ave. Of Test 1 and Test 2						
SPC203	Video Processing	20	20	20	80	-	-	-	100	

Prerequisite:

Basic knowledge of error control and coding for communication and Image processing is expected.

Course Objective: To enable the student to understand basics of video, processing methods and different video coding techniques

Course Outcome: The students will be able to do video coding with the help of different coding techniques.

Module/ Section No.	Topics	Hrs.
1.	Video Formation, Perception and Representation	6
	1.1 Video Capture and Display Principles of Color Video, Video Cameras , Video Cameras, Composite versus Component Models, Gamma Connection ,Digital video.	
	1.2 Analog Video Raster: Progressive vs Interlaced scans, Characterization of Video Raster, Spatial and Temporal resolution, Signal Bandwidth, Multiplexing of Luminance, Chrominance and Audio.	
	1.3 Digital Video: Notation, ITU-R.BT.601 Digital Video Format, Other Digital Video Formats and Applications Digital Video Quality Measure.	
2	Fourier Analysis of Video Signals and Frequency Response of the Human Visual System.	6
	2.1 Multidimensional Continuous-Space Signals and Systems, Multidimensional discrete-Space Signals and systems	
	2.2 Frequency Domain Characterization of Video Signals: Spatial and Temporal Frequencies. Temporal Frequencies Caused by Linear Motion.	
	2.3 Frequency Response of the Human Visual System: Temporal Frequency Response and Flicker Perception, Spatial Frequency Response, Spatiotemporal Frequency Response, Smooth Pursuit Eye Movement.	
3	Video Sampling	10
	3.1 Basics of the Lattice Theory	
	3.2 Sampling of Video Signals Over Lattices : Required Sampling Rates, Sampling Video in Two Dimensions, Progressive versus Interlaced Scans, Sampling a Raster Scan: BT.601 Format Revisited, Sampling Video in Three Dimension, Spatial and Temporal Aliasing	
	3.2 Filtering Operations in Cameras and Display: Devices, Camera Apertures. Display Apertures.	

Module/ Section No.	Topics	Hrs
4	VIDEO SAMPLING RATE CONVERSION	10
	4.1 Conversion of Signals Sampled on Different Lattices: Up-Conversion, Down-Conversion, Conversion between Arbitrary Lattices, Filter Implementation and Design, and other Interpolation Approaches.	
	4.2 Sampling Rate Conversion of Video Signals: Deinterlacing, Conversion between PAL and NTSC Signals, Motion-Adaptive Interpolation.	
5	Two-Dimensional Motion Estimation	10
	5.1. Optical Flow: Two-Dimensional Motion versus Optical Flow, Optical Flow Equation and Ambiguity in Motion Estimation.	
	5.2. General Methodologies: Motion Representation. Motion Estimation Criteria. Optimization Methods.	
	5.3. Pixel-Based Motion Estimation: Regularization Using the Motion Smoothness Constraints, Using a Multipoint Neighborhood, Pel-Recursive Methods,	
	5.4. Block-Matching Algorithm : The Exhaustive Block-Matching Algorithm, Fractional Accuracy Search, Fast Algorithm, Imposing Motion Smoothness Constraints, Phase Correlation Method, Binary Feature Matching	
	5.5. Multiresolution Motion Estimation: General Formulation, Hierarchical Block Matching Algorithm,	
	5.6. Application of Motion Estimation in Video Coding.	
6	Waveform-Based Video Coding	10
	6.1. Block-Based Transform Coding. : Overview, One-Dimensional Unitary Transform, Two-Dimensional Unitary Transform, The Discrete Cosine Transform, Bit Allocation and Transform Coding Gain, Optimal Transform Design and the KLT, DCT-Based Image Coders and the JPEG Standard, Vector Transform Coding	
	6.2 Predictive Coding: Overview, Optimal Predictor Design and Predictive Coding Gain, Spatial-Domain linear Prediction, Motion-Compensated Temporal Prediction.	
	6.3 Video Coding Using Temporal Prediction and Transform Coding: Block-Based Hybrid Video Coding ,Overlapped Block Motion Compensation, Coding Parameter Selection, Rate Control, Loop Filtering	
	Total	52

Recommended Books:

1. "Multimedia Communication Technology", J.R.Ohm, Springer Publication.
2. "Video Coding for Mobile Communications" David Bull et al, Academic Press.
3. "Handbook on Image and Video Processing", A.I.Bovik, Academic Press.
4. "Digital Video", Tekalp, Prentice Hall.

Reference Books:

1. "Video Processing and Communications" Yao Wang, Jorn Ostermann, Ya-Qin Zhang, Prentice Hall, 2002
2. "The Essential Guide to Video Processing" Alan C. Bovik, , Elsevier Science, edition 2, 2009
3. "Digital Video Processing" A. Murat Tekalp, Prentice Hall, edition 1, 1996

Internal Assessment (IA):

Two tests must be conducted which should cover at least 80% of syllabus. The average marks of both the test will be considered as final IA marks

End Semester Examination:

1. Question paper will comprise of 6 questions, each carrying 20 marks.
2. Total 4 questions need to be solved.
- 3: Question No.1 will be compulsory and based on entire syllabus wherein sub questions of 2 to 5 marks will be asked.
- 4: Remaining question will be selected from all the modules.

Subject Code	Subject Name	Teaching Scheme			Credits Assigned			
		Theory	Practical	Tutorial	Theory	TW/Practical	Tutorial	Total
SPE2011	Wavelet Transform and Applications	04	--	--	04	--	--	04

Subject Code	Subject Name	Examination Scheme							
		Theory Marks				Term Work	Practical	Oral	Total
		Internal assessment			End Sem. Exam				
		Test 1	Test 2	Ave. Of Test 1 and Test 2					
SPE2011	Wavelet Transform and Applications	20	20	20	80	-	-	-	100

Prerequisite:

Digital Signal Processing, Detection and Estimation Theory.

Course Objective:

To enable the student to understand the basics of wavelet transform, multi resolution analysis, continuous and discrete time wavelet transform.

Course Outcome:

At the end of this course the students are able to use the wavelet methods for compression of signals and image denoising.

Module/ Section No.	Topics	Hrs.
1.	FUNDAMENTALS Vector Spaces – Properties– Dot Product – Basis – Dimension, Orthogonality and Orthonormality – Relationship Between Vectors and Signals – Signal Spaces – Concept of Convergence – Hilbert Spaces for Energy Signals- Fourier Theory: Fourier series expansion, Fourier transform, Short time Fourier transform, Time-frequency analysis	8
2	MULTI RESOLUTION ANALYSIS Definition of Multi Resolution Analysis (MRA) – Haar Basis – Construction of General Orthonormal MRA – Wavelet Basis for MRA – Continuous Time MRA Interpretation for the DTWT – Discrete Time MRA – Basis Functions for the DTWT – PRQMF Filter Banks.	11
3	CONTINUOUS WAVELET TRANSFORMS Wavelet Transform – Definition and Properties – Concept of Scale and its Relation with Frequency – Continuous Wavelet Transform (CWT) – Scaling Function and Wavelet Functions (Daubechies Coiflet, Mexican Hat, Sinc, Gaussian, Bi Orthogonal) – Tiling of Time – Scale Plane for CWT.	11
4	DISCRETE WAVELET TRANSFORM Filter Bank and Sub Band Coding Principles – Wavelet Filters – Inverse DWT Computation by Filter Banks – Basic Properties of Filter Coefficients – Choice of Wavelet Function Coefficients – Derivations of Daubechies Wavelets – Mallat's Algorithm for DWT – MultiBand Wavelet Transforms Lifting Scheme- Wavelet Transform Using Polyphase Matrix Factorization – Geometrical Foundations of Lifting Scheme – Lifting Scheme in Z – Domain.	12
5	APPLICATIONS Wavelet methods for signal processing- Image Compression Techniques: EZW–SPHIT Coding – Image Denoising Techniques: Noise Estimation – Shrinkage Rules – Shrinkage Functions – Edge Detection and Object Isolation, Image Fusion, and Object Detection.	10

Recommended Books:

1. Rao R M and A S Bopardikar, —Wavelet Transforms Introduction to theory and Applications, Pearson Education, Asia, 2000.
2. L.Prasad & S.S.Iyengar, Wavelet Analysis with Applications to Image Processing, CRC Press, 1997.

References:

1. J. C. Goswami and A. K. Chan, "Fundamentals of wavelets: Theory, Algorithms and Applications" Wiley Interscience Publication, John Wiley & Sons Inc., 1999.
2. M. Vetterli, J. Kovacevic, "Wavelets and subband coding" Prentice Hall Inc, 1995.
3. Stephen G. Mallat, "A wavelet tour of signal processing" 2 nd Edition Academic Press, 2000.
4. Soman K P and Ramachandran K I, —Insight into Wavelets From Theory to practice, Prentice Hall, 2004.

Internal Assessment (IA):

Two tests must be conducted which should cover at least 80% of syllabus. The average marks of both the test will be considered as final IA marks

End Semester Examination:

1. Question paper will comprise of 6 questions, each carrying 20 marks.
2. Total 4 questions need to be solved.
- 3: Question No.1 will be compulsory and based on entire syllabus wherein sub questions of 2 to 5 marks will be asked.
- 4: Remaining question will be selected from all the modules.

Subject Code	Subject Name	Teaching Scheme			Credits Assigned			
		Theory	Practical	Tutorial	Theory	TW/ Practical	Tutorial	Total
SPE2012	Biomedical Signal Processing	04	--	--	04	--	--	04

Subject Code	Subject Name	Examination Scheme								
		Theory Marks					Term Work	Practical	Oral	Total
		Internal assessment			End Sem. Exam					
		Test 1	Test 2	Ave. Of Test 1 and Test 2						
SPE2012	Biomedical Signal Processing	20	20	20	80	-	-	-	100	

Prerequisite:
Digital Signal Processing, Random Signal Processing, Basics of Biomedical Engineering

Course Objective:
To enable the student to understand the basic biomedical signals and its processing such as averaging, polishing.

Course Outcome:
At the end of this course the students are able to process the cardiological and neurological signal and to remove the noise from those signals.

Module/ Section No.	Topics	Hrs.
1.	INTRODUCTION Cell structure, basic cell function, origin of bio-potentials, electric activity of cells.	6
2	BIOTRANSDUCERS Physiological parameters and suitable transducers for its measurements, operating principles and specifications for the transducers to measure parameters like blood flow, blood pressure, electrode sensor, temperature, displacement transducers. Cardiovascular system: Heart structure, cardiac cycle, ECG (electrocardiogram) theory (B.D.), PCG (phonocardiogram). EEG, X-Ray, Sonography, CT-Scan, The nature of biomedical signals.	10
3	DIFFERENT SOURCES OF NOISE Noise removal and signal compensation. Software based medical signal detection and pattern recognition.	8
4	CARDIOLOGICAL SIGNAL PROCESSING Pre-processing. QRS Detection Methods. Rhythm analysis. Arrhythmia Detection Algorithms. Automated ECG Analysis. ECG Pattern Recognition. Heart rate variability analysis. Adaptive Noise Cancelling: Principles of Adaptive Noise Cancelling. Adaptive Noise Cancelling with the LMS Adaptation Algorithm. Noise Cancelling Method to Enhance ECG Monitoring. Fetal ECG Monitoring.	10
5	SIGNAL AVERAGING AND POLISHING Mean and trend removal, Prony's method, Prony's Method based on the Least Squares Estimate, Linear prediction. Yule – walker (Y – W) equations, Analysis of Evoked Potentials.	10
6	NEUROLOGICAL SIGNAL PROCESSING Modeling of EEG Signals. Detection of spikes and spindles Detection of Alpha, Beta and Gamma Waves. Auto Regressive (A.R.) modeling of seizure EEG. Sleep Stage analysis. Inverse Filtering. Least squares and polynomial modeling.	8
	Total	52

Recommended Books:

1. “Simulation of Communication Systems, Modeling, Methodology and Techniques”, M.C. Jeruchim, P.Balaban, K.S. Shanmugan, Cluwer Academic Publishers, 2nd Edition 2002, ISBN 0-306-46267-2.
2. Biomedical Signal Processing- Principles and Techniques - D.C.Reddy, 2005,TMH.

Reference Books:

1. Digital Bio signal Processing - Weitkumat R, 1991, Elsevier.
2. Biomedical Signal Processing - Akay M, IEEE Press.
3. Biomedical Signal Processing -Vol. I Time & Frequency Analysis - Cohen.A, 1986, CRC Press.

Internal Assessment (IA):

Two tests must be conducted which should cover at least 80% of syllabus. The average marks of both the test will be considered as final IA marks

End Semester Examination:

1. Question paper will comprise of 6 questions, each carrying 20 marks.
2. Total 4 questions need to be solved.
- 3: Question No.1 will be compulsory and based on entire syllabus wherein sub questions of 2 to 5 marks will be asked.
- 4: Remaining question will be selected from all the modules.

Subject Code	Subject Name	Teaching Scheme			Credits Assigned			
		Theory	Practical	Tutorial	Theory	TW/Practical	Tutorial	Total
SPE2021	DSP Structures for VLSI	04	--	--	04	--	--	04

Subject Code	Subject Name	Examination Scheme								
		Theory Marks					Term Work	Practical	Oral	Total
		Internal assessment			End Sem. Exam					
		Test 1	Test 2	Ave. Of Test 1 and Test 2						
SPE2021	DSP Structures for VLSI	20	20	20	80	-	-	-	100	

Prerequisite:

Signals and Systems, Digital Signal Processing

Course Objective:

To enable the student to understand the basic principles of random signal processing, spectral detection and estimation methods used in communication system design and their applications.

Course Outcome:

Upon Completion of the course, the students will be able to understand signal processing algorithms and application of these algorithms in compression technique.

Module/ Section No.	Topics	Hrs.
1.	SYSTOLIC ARCHITECTURE DESIGN Systolic Array Design Methodology, FIR Systolic Arrays, Scheduling Vector, Matrix-Matrix Multiplication, 2D systolic Array Design, Systolic Design for Delays	06
2	DIGITAL FILTER STRUCTURES Pipeline Interleaving in Digital Filters, Pipelining in 1 st and Higher order IIR Filters, Parallel Processing for IIR Filters, Combined pipelining and parallel processing for IIR Filters, Low Power Design of IIR Filters, Pipelined Adaptive Digital Filters	12
3	BIT –LEVEL ARITHMETIC ARCHITECTURES Parallel Multipliers, Interleaved Floor-plan and Bit-Plane Based Digital Filters, Bit-Serial Multipliers, Bit-Serial Filter Design and implementation, Canonic Signal Digit Arithmetic, Distributed Arithmetic.	12
4	SYNCHRONOUS, WAVE, AND ASYNCHRONOUS PIPELINES Synchronous Pipelining and Clocking Styles, Clock Skew and Clock Distribution in Bit-Let VLSI design, Wave Pipelining, Constraint Space Diagram and Degree of Wave Pipelining, Implementation of Wave-Pipelined Systems, Implementation of Wave-Pipelined Systems, Asynchronous Pipelining, Signal Transition Graphs, Use of STG to Design Implementation Circuits, Implementation of Computation Circuits.	10
5	LOW POWER DESIGN Theoretical Background, Scaling versus Power Consumption, Power analysis, Power reduction Techniques, Power Estimation techniques.	06
6	PROGRAMMABLE DSP PROCESSORS Evolution of Programmable DSP processor, Important Features of DSP processor, DSP processors for Mobile and Wireless Communication, Processors for Multimedia Signal processing.	06
Total		52

Recommended Books:

1. “VLSI Digital Signal Processing Systems, Design and Implementation”, by Keshab Parhi, John-Wiley & sons.
2. “FPGA-based Implementation of Signal Processing Systems” by Roger Woods, John McAllister, Gaye Lightbody, Ying Yi, Wiley, John-Wiley and Sons
3. “Digital Signal processing with Field Programmable Gate Arrays”, by Uwe Meyer-Baese, 3rd Edition, Springer.
4. “DSP Integrated Circuits”, by Lars Wanhammar, Linkoping University, Academic Press Series in Engineering.

Reference Books:

1. CMOS Digital Integrated Circuits Analysis and Design by Kang Leblebici, McGraw Hill Publication.
2. “Principles of CMOS VLSI Design”, by Neil H.E.Weste, Kamran Eshraghian, Pearson Education.

Internal Assessment (IA):

Two tests must be conducted which should cover at least 80% of syllabus. The average marks of both the test will be considered as final IA marks

End Semester Examination:

1. Question paper will comprise of 6 questions, each carrying 20 marks.
2. Total 4 questions need to be solved.
- 3: Question No.1 will be compulsory and based on entire syllabus wherein sub questions of 2 to 5 marks will be asked.
- 4: Remaining question will be selected from all the modules.

Subject Code	Subject Name	Teaching Scheme			Credits Assigned			
		Theory	Practical	Tutorial	Theory	TW/Practical	Tutorial	Total
SPE2022	Wireless Network	04	--	--	04	--	--	04

Subject Code	Subject Name	Examination Scheme								
		Theory Marks					Term Work	Practical	Oral	Total
		Internal assessment			End Sem. Exam					
		Test 1	Test 2	Ave. Of Test 1 and Test 2						
SPE2022	Wireless Network	20	20	20	80	-	-	-	100	

Prerequisite:

Random Signal Analysis, Wireless Communication

Course Objective:

To introduce the concepts of wireless communication and to make the students to know about the various propagation methods, Channel models, capacity calculations multiple antennas and multiple user techniques used in the mobile communication. To enhance the understanding of Wi-fi, 3G systems and 4G networks.

Course Outcome:

The students understand the state of art techniques in wireless communication. Students are enriched with the knowledge of present day technologies to enable them to face the world and contribute back as researchers.

Module/ Section No.	Topics	Hrs.
1.	WIRELESS CHANNEL PROPAGATION AND MODEL Propagation of EM signals in wireless channel – Reflection, diffraction and Scattering-Small scale fading- channel classification- channel models – COST -231 Hata model, Longley-Rice Model, NLOS Multipath Fading Models: Rayleigh, Rician, Nakagami, Composite Fading – shadowing Distributions, Link power budget Analysis.	12
2	DIVERSITY Capacity of flat and frequency selective fading channels-Realization of independent fading paths, Receiver Diversity: selection combining, Threshold Combining, Maximum-ratio Combining, Equal gain Combining. Transmitter Diversity: Channel known at transmitter, channel unknown at the transmitter.	10
3	MIMO COMMUNICATIONS Narrowband MIMO model, Parallel decomposition of the MIMO channel, MIMO channel capacity, MIMO Diversity Gain: Beamforming, Diversity-Multiplexing trade-offs, Space time Modulation and coding: STBC, STTC, Spacial Multiplexing and BLAST Architectures.	10
4	MULTI USER SYSTEMS Multiple Access : FDMA, TDMA, CDMA, SDMA, Hybrid techniques, Random Access: ALOHA, SALOHA, CSMA, Scheduling, power control, uplink downlink channel capacity, multiuser diversity, MIMO-MU systems.	10
5	WIRELESS NETWORKS 3G Overview, Migration path to UMTS, UMTS Basics, Air Interface, 3GPP Network Architecture, 4G features and challenges, Technology path, IMS Architecture - Introduction to wireless LANs - IEEE 802.11 WLANs - Physical Layer- MAC sublayer.	10
	Total	52

Recommended Books:

1. Andrea Goldsmith, Wireless Communications, Cambridge University Press, 2007.
2. HARRY R. ANDERSON, "Fixed Broadband Wireless System Design" John Wiley – India, 2003.
3. Andreas.F. Molisch, "Wireless Communications", John Wiley – India, 2006.
4. Simon Haykin & Michael Moher, "Modern Wireless Communications", Pearson Education, 2007.
5. Rappaport. T.S., "Wireless communications", Pearson Education, 2003.

Reference Books:

1. Clint Smith. P.E., and Daniel Collins, "3G Wireless Networks", 2nd Edition, Tata McGraw Hill, 2007.
2. Vijay. K. Garg, "Wireless Communication and Networking", Morgan Kaufmann Publishers, <http://books.elsevier.com/9780123735805>, 2007.
3. Kaveth Pahlavan, K. Prashanth Krishnamuorthy, "Principles of Wireless Networks", Prentice Hall of India, 2006.
4. William Stallings, "Wireless Communications and networks" Pearson / Prentice Hall of India, 2nd Ed., 2007.
5. Sumit Kaseria and Nishit Narang, "3G Networks – Architecture, Protocols and Procedures", Tata McGraw Hill, 2007.

Internal Assessment (IA):

Two tests must be conducted which should cover at least 80% of syllabus. The average marks of both the test will be considered as final IA marks

End Semester Examination:

1. Question paper will comprise of 6 questions, each carrying 20 marks.
2. Total 4 questions need to be solved.
3. Question No.1 will be compulsory and based on entire syllabus wherein sub questions of 2 to 5 marks will be asked.
4. Remaining question will be selected from all the modules.

Subject Code	Subject Name	Teaching Scheme			Credits Assigned			
		Theory	Practical	Tutorial	Theory	TW/Practical	Tutorial	Total
SPL201	Laboratory III	--	02	--	--	01	--	01

Subject Code	Subject Name	Examination Scheme								
		Theory Marks					Term Work	Practical	Oral	Total
		Internal assessment			End Sem. Exam					
		Test 1	Test 2	Ave. Of Test 1 and Test 2						
SPL201	Laboratory III	--	--	--	--	25	25	-	50	

Term Work:

At least minimum ten experiments covering entire syllabus of signal processing algorithm and application should be set to have well predefined inference and conclusion. The experiments should be student's centric and attempt should be made to make experiments more meaningful, interesting and innovative. Term work assessment must be based on oral performance of the student with every experiment. The grade must be converted to marks as per credit & grading system manual, and should be added and average. Base on above scheme grading & term work assessment should be done.

Practical & oral examination will be based on entire syllabus.

Subject Code	Subject Name	Teaching Scheme			Credits Assigned			
		Theory	Practical	Tutorial	Theory	TW/Practical	Tutorial	Total
SPL202	Laboratory IV	--	02	--	--	01	--	01

Subject Code	Subject Name	Examination Scheme								
		Theory Marks					Term Work	Practical	Oral	Total
		Internal assessment			End Sem. Exam					
		Test 1	Test 2	Ave. Of Test 1 and Test 2						
SPL202	Laboratory IV	--	--	--	--	25	25	-	50	

Term Work:

At least minimum ten experiments covering entire syllabus Elective I & II subjects should be set to have well predefined inference and conclusion. The experiments should be student's centric and attempt should be made to make experiments more meaningful, interesting and innovative. Term work assessment must be based on oral performance of the student with every experiment. The grade must be converted to marks as per credit & grading system manual, and should be added and average. Base on above scheme grading & term work assessment should be done.

Practical & oral examination will be based on entire syllabus.

Subject Code	Subject Name	Credits
SPS301	Seminar	03

Guidelines for Seminar

- o Seminar should be based on thrust areas in Electronics and Telecommunication Engineering.
- o Students should do literature survey and identify the topic of seminar and finalize in consultation with Guide/Supervisor. Students should use multiple literature and understand the topic and compile the report in standard format and present in front of Panel of Examiners appointed by the Head of the Department/Institute of respective Programme.
- o Seminar should be assessed based on following points
 - Quality of Literature survey and Novelty in the topic
 - Relevance to the specialization
 - Understanding of the topic
 - Quality of Written and Oral Presentation

IMPORTANT NOTE:

1. Assessment of Seminar will be carried out by a pair of Internal and External examiner. The external examiner should be selected from approved panel of examiners for Seminar by University of Mumbai, OR faculty from Premier Educational Institutions /Research Organizations such as IIT, NIT, BARC, TIFR, DRDO, etc. OR a person having minimum Post-Graduate qualification with at least five years' experience in Industries.
2. Literature survey in case of seminar is based on the broader area of interest in recent developments and for dissertation it should be focused mainly on identified problem.
3. At least 4-5 hours of course on Research Methodology should be conducted which includes Literature Survey, Problems Identification, Analysis and Interpretation of Results and Technical Paper Writing in the beginning of 3rd Semester.

Subject Code	Subject Name	Credits
SPD301 / SPD401	Dissertation (I and II)	12 +15

Guidelines for Dissertation

○ Students should do literature survey and identify the problem for Dissertation and finalize in Consultation with Guide/Supervisor. Students should use multiple literature and understand the problem. Students should attempt solution to the problem by analytical/simulation/experimental methods. The solution to be validated with proper justification and compile the report in standard format.

Guidelines for Assessment of Dissertation I

- Dissertation I should be assessed based on following points.
 - Quality of Literature survey and Novelty in the problem.
 - Clarity of Problem definition and Feasibility of problem solution.
 - Relevance to the specialization.
 - Clarity of objective and scope.
- Dissertation I should be assessed through a presentation by a panel of Internal examiners appointed by the Head of the Department/Institute of respective Programme.

Guidelines for Assessment of Dissertation II

- Dissertation II should be assessed based on following points
 - Quality of Literature survey and Novelty in the problem
 - Clarity of Problem definition and Feasibility of problem solution
 - Relevance to the specialization or current Research / Industrial trends
 - Clarity of objective and scope
 - Quality of work attempted
 - Validation of results
 - Quality of Written and Oral Presentation
 - Dissertation II should be assessed through a presentation jointly by Internal and External Examiners appointed by the University of Mumbai
- Students should publish at least one paper based on the work in reputed International / National Conference (desirably in Refereed Journal)