KERALA TECHNOLOGICAL UNIVERSITY

ERNAKULAM – WEST CLUSTER

DRAFT

SCHEME AND SYLLABI

FOR

M. Tech. DEGREE PROGRAMME

IN

COMMUNICATION ENGINEERING

(2015 ADMISSION ONWARDS)

SCHEME AND SYLLABI FOR M. Tech. DEGREE PROGRAMME IN COMMUNICATION ENGINEERING

SEMESTER-1

Exam Slot	Course No:	Name	L-T-P	Internal Marks	End Semester Exam		Credits
					Marks	Duration (hrs)	
A	06EC6011/ 06EC6017	Analytical Foundations for Communication Engineering*	4-0-0	40	60	3	4
B	06EC6021/ 06EC6027	Wireless Communication*	4-0-0	40	60	3	4
C	06EC6031	Advanced Digital Communication Techniques	4-0-0	40	60	3	4
D	06EC6041	Communication Networks	3-0-0	40	60	3	3
E	06EC6X51	Elective I	3-0-0	40	60	3	3
F	06EC6061/ 06EC6067	Research Methodology*	0-2-0	100	0	0	2
G	06EC6071/ 06EC6077	Seminar I*	0-0-2	100	0	0	2
H	06EC6081/ 06EC6087	Communication Systems Engineering Lab I*	0-0-3	100	0	0	1

Credits: 23

	Elective I (06EC6X51)
06EC6151	Radiating Systems for Communications
06EC6251	Image and Video processing
06EC6351	Spread Spectrum and CDMA
06EC6451	Optical Networks

* - Common to Communication Engineering/Wireless Technology

SEMESTER-II

Exam Slot	Course No:	Name	L-T-P	Internal Marks	End Semester Exam		Credits
					Marks	Duration (hrs)	
A	06EC6012/ 06EC6018	Communication System Design*	4-0-0	40	60	3	4
B	06EC6022	Coding Theory	3-0-0	40	60	3	3
C	06EC6032	Adaptive Signal Processing	3-0-0	40	60	3	3
D	06EC6X42	Elective II	3-0-0	40	60	3	3
E	06EC6Y52	Elective III	3-0-0	40	60	3	3
F	06EC6062/ 06EC6068	Mini Project*	0-0-4	100	0	0	2
G	06EC6072/ 06EC6078	Communication Systems Engineering Lab II*	0-0-2	100	0	0	1

Credits: 19

Elective II - (06EC6X42)		Elective III - (06EC6Y52)	
06EC6142	RF Circuit Design	06EC6152	Principles of Secure Communication
06EC6242	MIMO and Multi Carrier Communications	06EC6252	Speech and Audio Signal Processing
06EC6342	Estimation and Detection Theory	06EC6352	Wireless Networks

SEMESTER-III

Exam Slot	Course No:	Name	L-T-P	Internal Marks	End Semester Exam		Credits
					Marks	Duration (hrs)	
A	06EC7X11	Elective IV	3-0-0	40	60	3	3
B	06EC7Y21	Elective V	3-0-0	40	60	3	3
C	06EC7031/ 06EC7037	Seminar II*	0-0-2	100	0	0	2
D	06EC7041/ 06EC7047	Project (Phase 1)*	0-0-12	50	0	0	6

Credits: 14

Elective-IV (06EC70X1)		Elective-V (06EC70Y1)	
06EC7111	Linear and Nonlinear Optimization	06EC7121	EMI/EMC based System Design
06EC7211	Selected Topics in Communications	06EC7221	RF MEMS
06EC7311	Spectral Analysis & Methods	06EC7321	Smart Antenna
06EC7411	Multi-rate and Multi-dimensional Signal Processing	06EC7421	Pattern Recognition

SEMESTER-IV

Exam Slot	Course No:	Name	L-T-P	Internal Marks	End Semester Exam		Credits
					Marks	Duration (hrs)	
A	06EC7012/ 06EC7018	Project (Phase 2)*	0-0-21	70	30	0	12

Credits: 12

Total Credits for all semesters: 68

Course No	Course Title	Credits	Year
06EC6011/ 06EC6017	**Analytical Foundations for Communication Engineering**	4-0-0: 4	**2015**

Pre-requisites: A basic course in Probability and Linear Algebra

Course Objectives:

- To introduce the concepts of random processes and their properties
- To analyse the effect on random signals over linear systems.
- To analyse the fundamental concepts of vector spaces in the concrete setting of $\mathbb{R}^n$.
- To introduce the concept of inner- product spaces and orthogonal projections and its applications.

Syllabus:

Review of random variables, Distributions and properties, Random processes, Power spectrum, Matrix Algebra and Linear systems , Vector spaces, Subspaces, Linear independence, Span, Basis, Dimension, Matrix representation of linear transform, Inner product spaces.

Course Outcome:

The student will be able to apply the concepts of

- random processes to communication engineering problems.
- signal & noise subspaces in detection & estimation problems encountered in communication engineering
- linear transformations and the principles of orthogonality & least squares.

Text Books:

1. *Monson H. Hayes, "Statistical Signal Processing and Modeling", John Wiley & Sons Inc, Reprint, 2013.*
2. *David C Lay, "Linear Algebra and its Applications", Pearson Education Asia, New Delhi, 2003.*

References :

3. *H. Stark, J.W Woods, "Probability and Random Processes", Pearson Education, 2002.*

4. *Alberto Leon Garcia, "Probability and Random Process for Electrical Engineers", (Second Edition), Pearson Education, 1997.*
5. *R D Yates, D J Goodman, "Probability and Stochastic Processes", John Wiley and Sons, 2005.*
6. *Richard A. Johnson, "Miller and Freund's Probability and Statistics for Engineers, 7th Edition, PHI, 2004.*
7. *Huffman, R. Kunze, "Linear Algebra", Prentice Hall of India, 1998.*
8. *Gilbert Strang, "Linear Algebra and its Applications", Brooks/Cole Ltd., New Delhi, Third Edition, 2003.*
9. *Seymour Lipschutz and Marc Lipson, "Schaum's Outline of Linear Algebra", McGraw Hill Trade; New Delhi, Third Edition, 2000.*
10. *Howard A Anton "Elementary Linear Algebra", John Wiley & Sons, Singapore, Eighth Edition, 2000.*

COURSE PLAN

Course No **06EC 6011/ 06EC 6017**	Course Title **Analytical Foundations for Communication Engineering**	Credits **4-0-0: 4**	Year **2015**
Module		Hours	End Sem Exam Marks (%)
1	Random Processes Review of random variables (RV) - (3.2.1 to 3.2.5 [1]) distributions and properties – joint pdf -characteristic functions–functions of RVs, Random processes (3.3.1 to 3.3.6 [1]) – stationarity, WSS and ergodic RP –properties –Autocorrelation matrix of random signals, RP and linear systems – (3.3.8, 3.4 ,3.5 [1]), Power spectrum – Weiner-Khinchin theorem, Gaussian and White processes-- (3.3.3, 3.3.7 [1]), Filtered noise processes (3.6 to 3.4 [1]).	**16**	**25**
2	Matrix Algebra and Linear systems System of linear equations - (1.1 to 1.5 [2]) The Matrix equation Ax=b - Solution sets of linear systems Matrix		

	operations (2.1 to 2.3, 2.9 [2]) Dimension and rank - Inverse of a matrix - Characteristics of invertible matrices, Eigenvectors & Eigen values - (5.1 to 5.4 [2]) Characteristic equation - Eigenvectors & linear transformations - Singular value decomposition- Diagonalization, Quadratic forms.	**16**	**25**
FIRST INTERNAL TEST			
3	Vector Space and Linear Transformation (4.1 to 4.7 [2]) Vector spaces - Subspaces, Linear independence, Span, basis, dimension, finite dimensional vector spaces, direct sum- Examples of finite dimensional vector spaces –$\mathbf{R}^N$, $\mathbf{C}^N$, vector space of matrices - Dimensionality of Row and Column space - Non-singular, Hermitian and Unitary matrices, Linear Transformation- range and null space - rank nullity theorem - Matrix representation of linear transform - Change of basis.	**12**	**25**
SECOND INTERNAL TEST			
4	Inner product spaces Inner Product spaces - (6.1 to 6.3, 6.5, 6.7 [2]) norm, orthogonality, Hilbert spaces, orthogonal complements, projection theorem - orthogonal projections, orthogonality and least squares - orthogonal expansion of discrete random processes using KL transform	**12**	**25**
END SEMESTER EXAM			

Course No	Course Title	Credits	Year
06EC6021/ 06EC6027	**Wireless Communications**	4-0-0: 4	**2015**

Pre-requisites: A basic course in Digital Communication

Course Objectives:

- To do a detailed analysis of various channel models;
- To provide an analytical exposure to important channel parameters like capacity and performance of digital modulation across wireless channels;
- To analyse the various diversity techniques used and the cellular systems;
- To provide exposure to various wireless communication standards.

Syllabus:

Wireless Channel Models: Path loss and shadowing models, Statistical fading models; Capacity of Wireless Channels; Performance of digital modulation over wireless channels; Diversity techniques; Cellular Systems; Overview of various generations of cellular wireless systems.

Course Outcome:

The student will be able to apply the concepts of

- wireless channel models
- capacity and performance of digital modulation across wireless channels
- various diversity techniques and its importance.
- cellular systems and have an overview of the various generations & standards of cellular wireless systems

Text Books:

1. *Andrea Goldsmith, "Wireless Communications", Cambridge University press, 2008.*
2. *A.M. Molisch, "Wireless Communications", Wiley India, 2010.*

References :

3. *T.S. Rappaport, "Wireless Communication, Principles & Practice", Pearson Education, 2010.*

4. *David Tse, Pramod Viswanath, "Fundamentals of Wireless Communications," Cambridge University Press, 2005.*
5. *Simon Haykin & Michael Moher, "Modern Wireless Communications", Pearson Education, 2007.*

COURSE PLAN

Course No **06EC 6021/ 06EC 6027**	Course Title **Wireless Communication**	Credits **4-0-0: 4**	Year **2015**
Module		Hours	End Sem Exam Marks (%)
1	Wireless Channel Models Path loss and shadowing models Radio wave propagation (Sec. 2.1 [1]), Transmit and receive signal models (Sec. 2.2 [1]), Free space path loss (Sec. 2.3 [1]), Ray Tracing (Sec. 2.4 [1]), Empirical path loss models – qualitative study (Sec. 2.5 [1]), Simplified path loss models (Sec. 2.6[1]), Shadow fading (Sec. 2.7 [1]), Combined path loss and shadowing (Sec. 2.8 [1]), Outage probability under path loss and shadowing (Sec. 2.9 [1]), Cell coverage area (Sec. 2.10 [1]) Statistical fading models Time-Varying Channel Impulse Response (Sec. 3.1 [1]), Narrowband Fading Models: Autocorrelation, Cross-Correlation, and Power Spectral Density, Envelope and Power Distributions, Level Crossing Rate and Average Fade Duration (Sec. 3.2 [1]), Wideband Fading Models-Power Delay Profile, Coherence Bandwidth, Doppler Power Spectrum and Channel Coherence Time, Transforms for Autocorrelation and Scattering Functions (Sec. 3.3 [1])	**14**	**25**
2	*Capacity of Wireless Channels*	**14**	**25**

	Capacity in AWGN (Sec. 4.1 [1]), Capacity of flat fading channels (Sec. 4.2 [1]), and frequency selective fading channels (Sec. 4.3 [1]) *Performance of digital modulation over wireless channels* AWGN Channels (Sec. 6.1 [1]), Fading channels (Sec. 6.3 [1]), Doppler spread (Sec. 6.4 [1]), Inter symbol interference (Sec. 6.5 [1]).		
FIRST INTERNAL TEST			
3	*Diversity* Realization of Independent Fading Paths (Sec. 7.1 [1]), Receiver Diversity: System Model, Selection Combining, Threshold Combining, Maximal-Ratio Combining, Equal-Gain Combining (Sec. 7.2 [1]), Transmitter Diversity: Channel Known at Transmitter, Channel Unknown at Transmitter – The Alamouti Scheme (Sec. 7.3 [1])	**14**	**25**
SECOND INTERNAL TEST			
4	*Cellular Systems* Channel Reuse (Sec. 15.2 [1]), SIR and User Capacity (Sec. 15.3 [1]), Interference Reduction Techniques (Sec. 15.4 [1]), Dynamic Resource Allocation (Sec. 15.5 [1]), Fundamental Rate Limits (Sec. 15.6 [1]) Overview of various generations of cellular wireless systems (qualitative study): GSM (Sec. 24 [2]), and IS-95 (Sec. 25 [2]), 3G systems: UMTS (Sec. 26 [2]), & CDMA 2000 (Sec. 25 [2]), LTE & 4G proposals (Sec. 27 [2]).	**14**	**25**
END SEMESTER EXAM			

Course No	Course Title	Credits	Year
06EC6031	**Advanced Digital Communication Techniques**	4-0-0: 4	**2015**

Pre-requisites: A basic course in Probability and Linear Algebra

Course Objectives:

- To analyze binary and M-ary digital modulation techniques and their performance in AWGN baseband channels.
- To introduce the concepts of amplitude, phase and quadrature- amplitude modulation and detection schemes.
- To study the design and detection of digital signals for transmission on bandlimited channels
- To introduce the need of synchronisation and equalization in communication systems.

Syllabus:

Basic digital communication system. Performance analysis of wireline and radio communication channels. Geometric representation. Binary pulse modulation. M-ary pulse modulation. Amplitude modulated digital signals. Phase modulated digital signals. Probability of error. Quadrature Amplitude modulated signals. Digital transmission through bandlimited channels. Signal design for bandlimited channels. Nyquist criterion. Symbol by symbol detection of data with zero ISI and probability of error. Equalization- Signal design. Different types of equalizers. Symbol synchronisation- different methods.

Course outcome:

The student will be able to:

- Evaluate the performance of binary and M-ary digital modulation schemes in AWGN baseband channels.
- Calculate the probability of error and compare the performance of amplitude, phase and quadrature –amplitude modulation methods.
- Design bandlimited signals with zero and controlled ISI and calculate their probability of error.
- Apply the concept of equalization and synchronisation to communication systems.

Text book:

1. *John G Proakis and Masoud Salehi, "Fundamentals of Communication Systems" – Pearson Education, 2007.*

References:

2. *J.G. Proakis, M. Salehi, "Digital Communication", MGH 5th edition, 2008.*
3. *T.T Ha, "Theory and design of Digital Communication Systems", Cambridge university press, 2011.*
4. *John B. Anderson, "Digital Transmission Engineering", Wiley India Reprint, 2012.*
5. *Edward. A. Lee and David. G. Messerschmitt, "Digital Communication", Allied Publishers (second edition), 1994.*
6. *J Marvin. K. Simon, Sami. M. Hinedi and William. C. Lindsey, "Digital Communication Techniques", PHI, 1994.*

COURSE PLAN

Course No **06EC 6031**	Course Title **Advanced Digital Communication Techniques**	Credits **4-0-0: 4**	Year **2015**
Module		Hours	End Sem Exam Marks (%)
1	Elements of an Electrical communication system [1-1.2]- Digital Communication system, [1-1.2.1], Mathematical models for communication channels [1 – 1.4] Performance Analysis for wireline and radio communication channels- regenerative repeaters, link budget analysis for radio channels [1-11.5]. Digital Modulation in an Additive White Gaussian Noise Baseband Channel Geometric representation of Signal waveforms [1-8.1], Binary Pulse Modulation- Binary Pulse Amplitude Modulation, Binary Pulse Position Modulation [1-8.2]. Optimum receivers for binary modulated signals in	**15**	**25**

	AWGN – correlation type demodulator, matched filter type demodulator. Performance of optimum detector for binary signals [1-8.3]. M-ary Pulse modulation [1-8.4]– M-ary pulse amplitude modulation [1-8.4.1], M-ary orthogonal signals [1-8.4.2], Optimum receiver for M-ary signals in AWGN[1-8.4.6]. Probability of error for M-ary pulse modulation [1-8.5]– Probability of error for M-ary pulse amplitude modulation [1-8.5.1], Probability of error for M-ary orthogonal signals [1-8.5.2], Union bound on the probability of error [1-8.5.3]		
2	Transmission of Digital Information via Carrier Modulation: Amplitude modulated digital signals – Demodulation and detection of Amplitude Modulated Signals [1-10.1], Phase modulated digital signals –Demodulation and detection of phase modulated signals. Differential phase modulation and demodulation, Probability of error for Phase coherent PSK modulation, Probability of error for DPSK [1-10.2], Quadrature Amplitude modulated digital signals – Demodulation and detection of Quadrature Amplitude modulated signals- probability of error for QAM[1-10.3].Comparison of modulation schemes [1-10.5].	**15**	**25**
FIRST INTERNAL TEST			
3	Digital transmission through bandlimited AWGN channels: Digital transmission through bandlimited channels – digital PAM transmission through bandlimited channels [1-9.1],	**14**	**25**

	Signal design for bandlimited channels- Design of bandlimited signals for zero ISI – the Nyquist criterion, design of bandlimited signals with controlled ISI – partial response signals [1-9.2], Probability of error for detection of digital PAM with zero ISI, Symbol by symbol detection of data with controlled ISI, Probability of error for symbol by symbol detection of partial response signals, Maximum likelihood sequence detection of partial response signals [1-9.3].		
SECOND INTERNAL TEST			
4	Equalization: System design in the presence of channel distortion-design of transmitting and receiving filters for a known channel, Channel equalization-maximum likelihood sequence detection, Linear equalizers, Adaptive equalizers, Decision feedback equalizer [1-9.4]. Synchronization: Symbol synchronization –early late gate synchronizers, minimum mean square error method, Maximum likelihood method, spectral line method [1-8.6]. Symbol synchronisation for carrier modulated signals [1-10.6]	**12**	**25**
END SEMESTER EXAM			

Course No	Course Title	Credits	Year
06EC6041	**Communication Networks**	3-0-0: 3	**2015**

Pre-requisites: A basic course in Computer networks & Queuing Theory

Course Objectives:

- To introduce the state-of-the-art in communication network architectures, protocols and applications.
- To obtain a working knowledge of a variety of computer communications technologies used in computer network infrastructures.
- To develop the ability to formulate a computer communications problem, analyze it, and communicate the results in written and graphical form.
- To familiarize the network queuing models and to analyse the significance of Markov process in communication network design.

Syllabus:

Introduction to Computer network, Layering, Application layer, Data link layer- Error detection and correction, Multiple access protocols, Transport layer, routing algorithms, Routing in the internet ,Protocols for Real-time interactive applications, Integrated and Differentiated services for multimedia transport Markov Process, Transition Probability Matrices of a Markov Chain, Continuous Time Markov Chains, Modelling and performance analysis of networks, M/M/1, M/M/m, M/M/infinity, M/M/m/m, M/G/1 Queuing systems.

Course Outcome:

The student will be able to apply the concepts of

- network layering, design/performance parameters in designing novel communication network architectures.
- Markov chain and network queuing models in communication networks.
- network routing protocols for interactive multimedia communication networks.

Text Book & References:

1. *James. F. Kurose and Keith. W. Ross, "Computer Networks: A top-down approach featuring the Internet", Pearson Education, 3/e, 2005. (Modules 1 & 2).*

2. *Bertsekas, D., and Gallager, R., Data Networks, Second Edn, Prentice Hall India, 2002. (Modules 1 & 2) http://web.mit.edu/dimitrib/www/datanets.html.*
3. *Alberto Leon Garcia, "Probability and Random Processes for Electrical Engineering", Pearson Education, 2nd edition. (Modules 3 & 4).*
4. *S. M. Ross, Introduction to Probability Models, Elsevier, 8th edition (Modules 3 &4).*
5. *Papoulis, S. U. Pillai, "Probability, Random Variables and Stochastic Processes"4th Edition Tata-Mc Hill (4/E), 2001. (Module 3).*
6. *Kumar, A., Manjunath, D., and Kuri, J., Communication Networking: An Analytical Approach, Morgan Kaufman Publishers, 2004. (Chapter 14-16 for module 2, module 3 &4).*
7. *S. Karlin& H.M Taylor, A First Course In Stochastic Processes, 2nd Edition, Academic Press, New York.*
8. *J. Medhi, Stochastic Processes, New Age International, New Delhi.*

COURSE PLAN

Course No **06EC 6041**	Course Title **Communication Networks**	Credits **3-0-0: 3**	Year **2015**
Module		Hours	End Sem Exam Marks (%)
1	Application and Data link layer: Computer network- a nuts-and-bolts description, services, protocol (1.1.1-1.1.3 ref.[1]), Network edge and core (1.2, 1.3 ref. [1]), Layering (1.3.1-1.3.7 ref. [2]), Application layer- FTP (2.3 ref. [1]), SMTP (2.4.1 ref. [1]), Data link layer- Error detection and correction (5.2.1-5.2.3 ref. [1]), Multiple access protocols (5.3 ref. [1]), IEEE 802.11 MAC (6.3.2 ref. [1]).	**10**	**25**
2	Transport Layer and Network Layer: Transport layer - TCP and UDP (3.3, 3.5 ref. [1]), TCP congestion control (3.7 ref. [1]), Network layer- IP (4.4 ref. [1]), routing algorithms (4.5 ref.	**10**	**25**

	[1]), Routing in the internet (4.6 ref. [1]) - Mobile IP (6.6 ref. [1]), Protocols for Real-time interactive applications (7.4 ref. [1]), Integrated and Differentiated services for multimedia transport (7.8 ref. [1]).		
FIRST INTERNAL TEST			
3	Markov Process and Markov Chains: Discrete Time Markov Chains- Definition, Examples, Transition Probability Matrices of a Markov Chain, Classification of States and Chains, Chapman Kolmogorov Equation, Basic Limit Theorem, Limiting Distribution of Markov Chains. Continuous Time Markov Chains: General Pure Birth Processes And Poisson Processes- Properties, Inter Arrival And Waiting Time Distributions, Birth And Death Processes. (Sec. 12.4 [1])	**11**	**25**
SECOND INTERNAL TEST			
4	Network Modeling and Performance analysis: Modeling and performance analysis of networks: queuing models: Little's Theorem, M/M/1, M/M/m, M/M/infinity, M/M/m/m, M/G/1 Queuing systems, Priority Queueing-Erlang's B and C formulae	**11**	**25**
FINAL SEMESTER EXAM			

Course No	Course Title	Credits	Year
06EC6151	**Radiating Systems for Communications**	3-0-0: 3	**2015**

Pre-requisites: A basic course in Electromagnetic Theory

Course Objectives:

To give the Student:-

- To do a detailed analysis of the principle of radiation, antenna parameters, and simple radiating systems;
- To provide an exhaustive exposure to the various antenna designs used in modern wireless communication primarily as handsets and in base station;
- To provide an introduction to basics of CEM commonly used in antenna studies and specifically FDTD method.

Syllabus:

Fundamentals of Radiation, Antenna parameters and the Simple radiating systems like the dipoles and loops; System applications for antennas; Antennas in Communication Systems as intentional and unintentional radiators; Low-Profile Antennas and Personal Communication Antennas & Terminal and Base Station Antennas for Wireless Applications; CEM for Antennas: Finite Difference Time Domain Method.

Course Outcome:

The student will be able to apply the concepts of

- radiation, antenna parameters and antennas in communication systems;
- FDTD based CEM method to analyse radiation;
- various low-profile antennas and personal communication antennas & terminal and base station antennas for wireless applications

Text Book:

1. *W. L. Stutzman and G. A. Thiele, "Antenna Theory and Design", John Wiley & sons, 3rd edition, 2013*.

References:

2. *C. A. Balanis, "Antenna Theory Analysis and Design", John Wiley & sons, 3rd edition, 2005.*
3. *J. D. Kraus, R. J. Marhefka and A. S. Khan, "Antennas and Wave Propagation", Tata Macgraw Hill, 4th edition, 2010.*
4. *M. N. O. Sadiku, "Numerical Methods in Electromagnetics with MATLAB", CRC Press, 3rd Edition, 2009.*

COURSE PLAN

Course No **06EC 6151**	Course Title **Radiating Systems for Communications**	Credits **3-0-0: 3**	Year **2015**
Module		Hours	End Sem Exam Marks (%)
1	*Fundamentals of Radiation* Solution of Maxwell's Equations for Radiation Problems (Sec. 2.2 [1]), The Ideal Dipole (Sec. 2.3 [1]), Radiation Patterns (Sec. 2.4 [1]), Directivity and Gain (Sec. 2.5 [1]), Antenna Impedance (Sec. 2.6 [1]), Radiation Efficiency (Sec. 2.7 [1]), Antenna Polarization (Sec. 2.8 [1]).	**10**	**25**
2	*Simple radiating systems* Electrically Small Dipoles (Sec. 3.1 [1]), Half-Wave Dipoles (Sec. 3.2 [1]), Monopoles and Image Theory (Sec. 3.3 [1]), Small Loop Antennas and Duality (Sec. 3.4 [1]), Feeding Wire Antennas (Sec. 6.4 [1]). *System applications for antennas* Receiving Properties of Antennas (Sec. 4.2 [1]), Antenna Noise and Radiometry (Sec. 4.3 [1]), Antennas in Communication	**11**	**25**

	Systems (Sec. 4.4 [1]), Antennas as Unintentional Radiators (Sec. 4.7 [1]).		
FIRST INTERNAL TEST			
3	*Low-Profile Antennas and Personal Communication Antennas & Terminal and Base Station Antennas for Wireless Applications* Microstrip Antenna Elements (Sec. 11.2 [1]), Microstrip Leaky Wave Antennas (Sec. 11.4 [1]), Fundamental Limits on Antenna Size (Sec. 11.5 [1]), Antennas for Compact Devices (Sec. 11.6 [1]), Human Body Effects on Antenna Performance (Sec. 11.9 [1]), Radiation Hazards (Sec. 11.10 [1]), Satellite Terminal Antennas (Sec. 12.1 [1]), Base Station Antennas (Sec. 12.2 [1]), Mobile Terminal Antennas (Sec. 12.3 [1]), Smart Antennas (Sec. 12.4 [1]).	**10**	**25**
SECOND INTERNAL TEST			
4	*CEM for Antennas: Finite Difference Time Domain Method* General Introduction to CEM (Sec. 14.1 [1]), Maxwell's equation for FDTD method (Sec. 2.2 [1]), Finite Differences and the Yee Algorithm (Sec. 15.2 [1]), Cell Size, Numerical Stability, and Dispersion (Sec. 15.3 [1]), Computer algorithms and FDTD implementation (Sec. 15.4 [1]), Absorbing Boundary Conditions (Sec. 15.5 [1]), Source Conditions (Sec. 15.6 [1]), Near Fields and Far Fields (Sec. 15.7 [1]), A Two-	**11**	**25**

	Dimensional Example: An E–Plane Sectoral Horn Antenna (Sec. 15.8 [1]).		
FINAL SEMESTER EXAM			

Course No	Course Title	Credits	Year
06EC6251	**Image and Video Processing**	3-0-0: 3	**2015**

Pre-requisites: A basic course in image processing

Course Objectives:

- To explore different stages of processing and analysis of a digital image.
- To know how a Digital video signal is represented and processed.

Syllabus:

Introduction To Digital Image Processing & Applications, Image Transforms, Image Segmentation, Wavelets and Multiresolution Processing, Morphological Image Processing, image Representation, Object Recognition, introduction to Video Processing, Representation of Digital Video, Spatial-Temporal Sampling, Video Compression, Standards - MPEG, H.264.

Course Outcome:

At the end of this course students will be able

- to apply transform techniques to processing of digital images
- to apply the concepts in representation and segmentation to analysis of digital images.
- to formulate suitable algorithms for object recognition

Text Books & References:

1. *R. C. Gonzalez, R. E. Woods, Digital Image Processing, Pearson Education, 2007.*
2. *Anil K. Jain, Fundamentals of Digital Image Processing, Prentice Hall Of India, 1989.*
3. *Iain E Richardson, H.264 and MPEG-4 Video Compression, John Wiley & Sons, September 2003*
4. *M. Tekalp, Digital Video Processing ,Prentice-Hall of India*
5. *Keith Jack,Digital Video and DSP, 2008,Elsevier inc.*
6. *A Bovik, Handbook Of Image & Video Processing, Academic Press, 2000*
7. *W. K. Pratt, Digital Image Processing, Prentice Hall of India*
8. *Rosenfeld and A. C. Kak, Digital Image Processing, Vols. 1 & 2, Prentice Hall.*
9. *K.R.Rao, Zoran.S Bojkovic, Dragorad A Milovanovic, Multimedia Communication Systems: Techniques, Standards and Networks, Prentice Hall of India.*

COURSE PLAN			
Course No **06EC 6251**	Course Title **Image and Video Processing**	Credits **3-0-0: 3**	Year **2015**
Module		Hours	End Sem Exam Marks (%)
1	Introduction To Digital Image Processing & Applications (Ref1, Chapter 1 page no 1-7), Elements Of Visual Perception-Mach Band Effect-, Sampling, Quantization, Basic Relationship Between Pixels (Ref 1 Chapter 2 page no 35-71), Color Image Fundamentals- RGB-HSI Models (Ref 1 chapter 6 page no 394-407), Image Transforms-Two Dimensional Orthogonal And Unitary Transforms, Separable Unitary Transforms -Basis Images, DFT, WHT, KLT, DCT and SVD (Ref 2) .	**11**	**25**
2	Image Segmentation: Pixel Classification, Bi-Level Thresholding, Multilevel Thresholding, Adaptive Thresholding, Spectral & Spatial Classification, Edge Detection, Hough Transform, Region Growing. (Ref 1 Chapter 10 page no 689-766).Wavelets and Multiresolution Processing: Multiresolution Expansions, Wavelet Transforms in One Dimension, Fast Wavelet Transform, Wavelet Packets (Ref1 Chapter 7 page no 461-510). Morphological Image Processing: Erosion and Dilation, Opening and Closing, Morphological Algorithms. (Ref1 Chapter 9 page no 627-664).	**11**	**25**
FIRST INTERNAL TEST			
3	Representation- Boundary Representation: Chain Codes- Polygonal Approximation – Boundary Segments – Boundary Descriptors - Regional Descriptors–Relational Descriptors	**11**	**25**

	(Ref 1 Chapter 11 page no 795-852) - Object Recognition- Pattern And Pattern Classes- Recognition Based On Decision Theoretic Methods. Structural Methods. (Ref1 Chapter 12 page no 861-904)		
SECOND INTERNAL TEST			
4	Video Processing : Display Enhancement, Video Mixing, Video Scaling, Scan Rate Conversion (Ref 5, chapter 5), Representation Of Digital Video (Ref 4 chapter 1 page no 1-16), Spatio-Temporal Sampling (Ref 4 chapter 3 page no 36-55), Video Compression-Motion Estimation, Intra And Inter frame Prediction (Ref 4 chapter 6 page no 419-429) , Perceptual Coding, Standards - MPEG, H.264 (Ref 4 chapter 6 page no 432-455).	**9**	**25**
END SEMESTER EXAM			

Course No	Course Title	Credits	Year
06EC6351	**Spread Spectrum and CDMA**	3-0-0: 3	**2015**

Pre-requisites: A basic course in Digital Communication

Course Objectives:

- To introduce the basic concepts of spread spectrum and CDMA
- To understand and compare the performance analysis of various types of CDMA systems
- To introduce the concepts of multicarrier modulation and OFDM

Syllabus:

Spread spectrum signals and systems- Basic definition, Classical reception problems; Multiuser environment: Synchronous and Asynchronous CDMA, asynchronous CDMA in cellular networks. Demands on ACF: Data transmission via spread spectrum, DS spread spectrum signal acquisition and tracking, Multicarrier modulation and OFDM- multicarrier DS CDMA, conventional MC transmission and OFDM, Time diversity and space-time coding in CDMA systems

Course Outcome:

The student will be able to

- appreciate the merits of spread spectrum technologies
- conduct a performance analysis of various CDMA systems
- appreciate and analyse multicarrier systems and OFDM.

Text Books:

1. *Valery Ipatov- Spread Spectrum and CDMA: Principles and Applications- Wiley 2005.*

References :

2. *David Tse and Pramod Viswanath, Fundamentals of wireless communication, Cambridge University Press, 2005.*
3. *Andrea Goldsmith, Wireless communication, Cambridge University Press, 2005.*
4. *K. Fazel and S Kaiser, Multicarrier and spread spectrum system, 2nd Edition, Wiley Publishers, 2004.*
5. *Ezio Biglieri, MIMO wireless communication, Cambridge Univerity Press, 2010.*
6. *Andreas Molisch Wireless communication, Wiley IEEE Press, 2010.*

COURSE PLAN			
Course No **06EC 6351**	Course Title **Spread Spectrum and CDMA**	Credits **3-0-0: 3**	Year **2015**
Module		Hours	End Sem Exam Marks (%)
1	Spread spectrum signals and systems- Basic definition. Gaussian channel, general reception problem and optimal decision rules. Binary data transmission (deterministic signals), M-ary data transmission: deterministic signals. Signal parameter estimation-problem statement and estimation rule. Amplitude estimation and phase estimation. Jamming immunity, Low probability of detection, Signal structure secrecy, and Electromagnetic compatibility, Propagation effects in wireless systems, Diversity, Multipath diversity and RAKE receiver.[Text Book 1 – Chapters 1, 2, 3]	**10**	**25**
2	Multiuser environment: code division multiple access. Multiuser systems and the multiple access problem. FDMA, TDMA, Synchronous and Asynchronous CDMA, asynchronous CDMA in cellular networks. Spread spectrum modulation, general model and categorization of discrete signals, correlation functions of APSK signals, calculating correlation functions of code sequences, correlation functions of FSK signals, Processing gain of discrete signals. .[Text Book 1 – Chapter 4, 5]	**12**	**25**
FIRST INTERNAL TEST			
3	Demands on ACF: signals with continuous frequency modulation, criterion of good aperiodic ACF of APSK signals, optimization of aperiodic PSK signals, perfect periodic ACF: minimax binary sequences, Initial knowledge on finite fields and linear sequences, periodic	**10**	**25**

	ACF of m-sequences. Data transmission via spread spectrum. [Text Book 1 – Chapters 6, 7]		
SECOND INTERNAL TEST			
4	DS spread spectrum signal acquisition and tracking: acquisition and tracking procedures, Serial search acquisition acceleration techniques, code tracking. Multiuser reception and suppressing MAI- optimal multiuser rule for synchronous CDMA, decorrelating algorithm, blind MMSE detector, Multicarrier modulation and OFDM- multicarrier DS CDMA, conventional MC transmission and OFDM, Time diversity and space-time coding in CDMA systems- transmit diversity and the space-time coding problem, efficiency of transmit diversity, time switched space-time code. Examples of operational systems- Overview of air interface of UMTS . [Text Book 1 – Chapters 8, 10, 11]	**10**	**25**
END SEMESTER EXAM			

Course No	Course Title	Credits	Year
06EC6451	**Optical Networks**	3-0-0: 3	**2015**

Pre-requisites: A basic course in Optical Communication

Course Objectives:

To provide a comprehensive understanding of optical networks. To enable the students to understand

- the infrastructure of an optical networks and its basic mechanisms. Also Synchronous Optical Networks (SONET) will be covered to good extend.
- the different components needed to build an optical network.
- the advances in packet switching in optical domain and associated challenges.
- the survivability of the networks.
- the network design and its related models, also make them familiarize with routing, switching and the resource allocation methods and the network control and management methods in vogue.

Syllabus:

The optical layer, SONET / SDH standards and architecture, MAC information's. Optical network elements; optical packet switching; Multiplexing and Demultiplexing, Optical network survivability; Optical network control and management.

Course Outcome:

Student completing this course gets the knowledge of infrastructure of an optical network and various SONET/SDH standards.

Graduate will able to build an optical network using basic components and with OTDM switching technique, also know how to manage and protect the network.

Text Book:

1. *Rajiv Ramaswami, Kumar N. Sivarajan, and Galen H. Sasaki, "Optical Networks : A Practical Perspective", Morgan Kaufmann Publishers, USA, Third Edition 2010.*

References:

2. *C. Siva Ram Moorthy and Mohan Gurusamy, "WDM Optical Networks : Concept,*

Design and Algorithms", Prentice Hall of India, Ist Edition, 2002.

3. *Uyless Black, "Optical Networks: Third Generation Transport Systems", Pearson Education, 2002.*
4. *Biswanath Mukherjee, "Optical Communication Networks", Mc-GrawHill c1997, First Edition ISBN 0-07-044435-8.*
5. *P.E. Green, Jr., "Fiber Optic Networks", Prentice Hall, NJ, 1993.*
6. *Rajiv Ramaswami and Kumar N. Sivarajan, "Optical Networks: A Practical Perspective", Harcourt Asia Pte Ltd., First Edition 2004.*

COURSE PLAN

Course No **06EC 6451**	Course Title **Optical Networks**	Credits **3-0-0: 3**	Year **2015**
Module		Hours	End Sem Exam Marks (%)
1	Optical Network Architectures Introduction to Optical Networks: Optical Networks (T1-sec 1.3), The optical layer (T1-sec 1.4), Cient Layers of the Optical Layer (T1-sec 6.1)- SONET / SDH standards (T1-sec 6.1), Multiplexing, SONET/SDH Layers, SONET Frame structure, SONET/SDH Physical Layer, Elements of SONET/SDH Infrastructure, Optical Transport Network (T1-sec 6.2)- Frame structure, Ethernet (T1-sec 6.4)- MAC,LAN, Frame structure, switches, Ethernet physical layer, IP (T1-sec 6.5), Multiprotocol Label Switching(MPL) (T1-sec 6.6), Resilient Packet Ring (T1-sec 6.7), Storage Networks (T1-sec 6.8).	**11**	**25**
2	WDM Network Elements WDM network architecture (T1-sec 7), Optical Line Terminals (T1-sec 7.1), Optical line Amplifiers (T1-sec 7.2), Optical Add/Drop Multiplexers (T1-sec 7.3)- OADM Architecture, Reconfigurable OADMs, Optical Cross connects (T1-sec 7.4) - All Optical OXC Configurations,	**11**	**25**

	Deployment Considerations (T1-sec 13)-SONET/SDH core Network (T1-sec 13.1.1), Architectural choices of next Generation Networks (T1-sec 13.1.2). Designing the Transmission Layer (T1-sec 13.2).		
FIRST INTERNAL TEST			
3	Network Survivability, Packet Switching & Access Networks Network survivability- Concepts (T1-9.1), Protection in SONET/SDH (T1-9.2), Protection in Client Layer (T1-9.3), Optical layer Protection Schemes (T1-9.5). Photonic Packet Switching (T1-12) – OTDM (T1-12.1), Multiplexing and Demultiplexing, Optical AND gates (T1-12.1.3), Synchronization (T1-12.2), Buffering (T1-12.4), Test beds (T1-12.6), Access Networks (T1-11) – Network Architecture overview (T1-11.1), Enhanced HFC (T1-11.2), FTTC (T1-11.3).	**10**	**25**
SECOND INTERNAL TEST			
4	Network Design And Management Design-LTD and RWA problems (T1-10.2), Dimensioning and wavelength Routing Networks (T110.3), Statistical Dimensioning Models (T1-10.4), Maximum load Dimensioning Models (T1-10.5). Control and Management (T1 -8) – Network management functions (T1 -8.1), Optical layer Service interfacing (T1 -8.2), Layers within optical layers (T1 -8.3), Performance and Fault management (T1 -8.5), Configuration management (T1 -8.6), Optical safety (T1 -8.7).	**10**	**25**
END SEMESTER EXAM			

Course No	Course Title	Credits	Year
06EC6061/ 06EC6067	**Research Methodology**	0-2-0: 2	**2015**

Pre-requisites: Nil

Course Objectives:

- To familiarize with the methodologies needed to follow in technical research.
- To familiarize with the scientific methods to do experiments and data analysis.

Syllabus:

Meaning of research, objectives, type of research approaches, Understanding the language of research, Ethical issues, Intellectual property rights and patent law, Reproducibility and accountability, Graphic & diagrammatic representation data, Processing and analysis of data, Interpretation and report writing, Techniques of developing measurement tools. Control &.randomization and their objectives & advantages, Experimental Designs, Defining research problem, Sampling fundamentals, Sampling, Distribution of mean- sampling distribution of proportion Testing of hypotheses, Soft wares for statistical testing.

Course Outcome:

At the end of this course students will be able

- to pursue systematic technical research.
- develop the necessary skill for technical reporting, presentations and hypothesis testing mechanisms

Text Books & References:

1. *Garg, B.L., Karadia, R., Agarwal, F. and Agarwal, U.K., 2002. An introduction to Research Methodology, RBSA Publishers.*
2. *Kothari, C.R., 1990. Research Methodology: Methods and Techniques. New Age International. 418p.*
3. *Deepak Chawla and Neena Sondhi 2011 Research Methodology concepts and cases Vikas Publishing house pvt ltd*
4. *R. Paneerselvam , 2014 Research Methodology, PHI Learning*

5. *Sinha, S.C. and Dhiman, A.K., 2002. Research Methodology, EssEss Publications. 2 volumes.*
6. *Trochim, W.M.K., 2005. Research Methods: the concise knowledge base, Atomic Dog Publishing. 270p.*
7. *Wadehra, B.L. 2000. Law relating to patents, trademarks, copyright designs and geographical indications. Universal Law Publishing.*
8. *Day, R.A., 1992.How to Write and Publish a Scientific Paper, Cambridge University Press.*
9. *Fink, A., 2009. Conducting Research Literature Reviews: From the Internet to Paper. Sage Publications.*
10. *Leedy, P.D. and Ormrod, J.E., 2004 Practical Research: Planning and Design, Prentice Hall.*

COURSE PLAN

Course No **06EC 6061/** **06EC 6067**	Course Title **Research Methodology**	Credits **0-2-0: 2**	Year **2015**
Module		Hours	End Sem Exam Marks (%)
1	Research methodology: Meaning of research, objectives, type of research approaches, research process, and criteria for good research. Concept of theory, empiricism, deductive and inductive theory. Characteristics of scientific method – Understanding the language of research – Concept, Construct, Definition, Variable. Research Process Application of results and ethics - Environmental impacts - Ethical issues - ethical committees -Commercialization – Copy right – royalty - Intellectual property rights and patent law – Trade Related aspects of Intellectual Property Rights – Reproduction of published material – Plagiarism -Citation and acknowledgement - Reproducibility and accountability	**7**	**25**
2	Techniques of developing measurement tools – scaling – important scaling techniques. Methods ofdata	**7**	**25**

	collection–collection of primary data–observation method questionnaires –other methods ofdata collection. Processing and analysis of data – processing operations – editing – coding –classification – tabulation. Interpretation and report writing-techniques of interpretation – steps in report writing. Graphic & diagrammatic representation data - Purpose of Diagrams & Graphs, Bar diagrams (Simple, Component & Percentage), Pie Charts, Line Square Diagrams, Interpretations & Comparisons, Graphical Representation of Frequency Distribution, Histograms, Frequency Polygon, Frequency Curve.		
FIRST INTERNAL TEST			
3	Defining research problem – research design, features of good design - different research designs basic principle of experimental design developing a research plan. Experimental Designs - purpose of designing experiments, methods of increasing accuracy of experiments, replication, control & randomization and their objectives & advantages - basic ideas of completely randomized , randomized block, Factorial and Latin square designs.	**7**	**25**
SECOND INTERNAL TEST			
4	Sampling fundamentals – need for sampling – important sampling distribution: Sampling Distribution of mean- sampling distribution of proportion – student's 't' distribution – F distribution–Chi-square distribution – concept of standard error - – sample size and its determination.	**7**	**25**

	Testing of hypotheses – procedure for testing hypotheses - important parametric tests: Z test, t-test, chi- square test, F test and ANOVA. Softwares for statistical testing.		
END SEMESTER EXAM			

Course No	Course Title	Credits	Year
06EC6071/ 06EC6077	**Seminar 1**	0-0-2: 2	**2015**

Course Objectives:

- To introduce the students to cutting edge technology in the area of communication engineering.
- To develop the acumen of reading & comprehending technical papers and implementing the methods as mentioned them

Syllabus:

Each student shall present a seminar on any topic of interest related to Communication Engineering topics. He/she shall select the topic based on the references from recent international journals of repute, preferably IEEE journals. They should get the paper approved by the Programme Co-ordinator/ Faculty member in charge of the seminar and shall present it in the class. Every student shall participate in the seminar. The students should undertake a detailed study on the topic and submit a report at the end of the semester. Marks will be awarded based on the topic, presentation, participation in the seminar and the report submitted.

Course Outcome:

- This course will prepare the student to comprehend technical papers in their selected areas.
- This will eventually improve the quality of their main project.
- Their ability to write and report technical results will be improved.

Course No	Course Title	Credits	Year
06EC6081/ 06EC6087	**Communication Systems Engineering Lab I**	3-0-0: 3	**2015**

Pre-requisites: A basic course in Digital Communication, Wireless Communication

Course Objectives:

To understand and analyse the concepts of Wireless Communication, Communication Networks, Advanced Digital Communication Techniques courses

Syllabus:

Tools:

Computing and Simulation Environments **–** GNU Octave / MATLAB/ Lab View/NS 2 or any other equivalent tool.

Suitable Hardware Tools like USRP (Universal Software Radio Peripheral) to supplement the simulation tools.

Suggested flow of experiments: (These are minimum requirements; Topics could be added in concurrence with the syllabus of core and elective subjects)

1. Generation of discrete time i.i.d. random processes with different distributions (Bernoulli, Binomial, Geometric, Poisson, Uniform, Gaussian, Exponential, Rayleigh, Ricianetc)
2. Visualization of Central Limit Theorem,Whitening Filter.
3. Implementation of digital modulation schemes and performance comparison, Constellation diagrams, Simulation of BER curves for the various schemes, comparison with analytical results.
4. Implementation of Matched filter, Correlation receiver & Equalizer
5. Communication System Design for Band limited Channels - Signal Design for Zero ISI and Controlled ISI - Partial Response Signaling.
6. Synchronization in Communication Systems: Carrier and Clock Synchronization- Frequency Offset Estimation and Correction.
7. Modelling and Simulation of Networks using NS 2/similar tools.

Course Outcome:

On successful completion of this course students will be able to analyse the Concepts of Wireless Communication, Communication Networks, Advanced Digital Communication Techniques courses.

Text Books & References:

1. *W.H. Tranter, K. Sam Shanmugham, T.S. Rappaport, and K.L. Kosbar, "Principles of Communication System Simulation with Wireless Applications," Pearson, 2004.*
2. *J.G. Proakis, and M. Salehi, "Contemporary Communication Systems using MATLAB, Bookware Companion Series, 2006.*
3. *E. Aboelela, "Network Simulation Experiments Manual," The Morgan Kaufmann Series in Networking, 2007.*

Course No	Course Title	Credits	Year
06EC6012/ 06EC6018	**Communication System Design**	4-0-0: 4	**2015**

Pre-requisites: A basic course in Communication, Wireless Communication

Course Objectives:

To address the various designs and architectures of communication system in the context of modern multimode and multistandard devices

To expose the students to

- noise in wireless receivers and how it manifests itself in circuits and components, including phase noise.
- system nonlinearity and its impact on receiver performance and design
- quantization noise, sampling clock jitter, impact of phase noise on the sampling clock, signal overloading and clipping
- ADC architectures, Δ∑ Modulators, AGCs, PLLs, and receiver architectures

Syllabus:

Transmitter & Receiver Design Fundamentals, Noise Fundamentals, Phase Noise, Non Ideal Transfer Functions & Compensation, Sampling, Distortion & Jitter, Data Conversion, Frequency Synthesizers , AGCs, PLLs, Receiver Architectures

Course Outcome:

The students will be able to

- understand transmitter & receiver design from analog front ends to mixed signal design and frequency synthesis with equal emphasis on theory and practical design.
- design futuristic wireless radios and modems, capable of supporting multiple standards and modes, is drastically different from traditional designs supporting a single standard.

Text Books & References:

1. *Scott R. Bullock, "Transceiver and System Design for Digital Communications", SciTech Publishing, Inc. Raleigh, NC, Third Edition, 2009.*
2. *Kevin McClaning, "Wireless Receiver Design for Digital Communications", SciTech Publishing, Inc. Raleigh, NC, Second Edition, 2012.*
3. *Tony J Rouphael, "Wireless Receiver Architectures and Design: Antennas, RF, Synthesizers, Mixed Signal and Digital Signal Processing", Elsevier, 2014.*

4. *Ariel Luzzatto and Gadi Shirazi, "Wireless Transceiver Design-Mastering the Design of Modern Wireless Equipment and Systems", John Wiley & Sons, 2007.*

COURSE PLAN

Course No **06EC 6012/ 06EC 6018**	Course Title **Communication System Design**	Credits **4-0-0: 4**	Year **2015**
Module		Hours	End Sem Exam Marks (%)
1	Transmitter & Receiver Design Fundamentals Transmitter Design Fundamentals (Chap 2 [1]), Receiver Design Fundamentals (Chap 3 [1]), Noise Fundamentals: Amplifier Noise Model, Signal-to-Noise Ratio, Noise Factor/Noise Figure, Cascade Performance, Minimum Detectable Signal (Chap 6 [2]), Phase Noise (Chap 9.3 [2]).	**13**	**25**
2	Non Ideal Transfer Functions & Compensation Amplifier Transfer Curve, Polynomial Approximations, Distortion Summary, Pre-selection, Narrowband and Wideband Systems, Gain Compression/Output Saturation, Compression Point, Nonlinearities and Modulated Signals (Chap 7 [2]). Sampling, Distortion & Jitter Sampling and reconstruction of low pass and band pass signals, Signal distortion due to sampling and conversion imperfections: Quantization noise, Signal to quantization noise ratio, Effect of clock jitter on sampling, Impact of phase noise on clock jitter, Overloading and clipping, Anti-aliasing filtering requirements (Chap 5 [3]).	**15**	**25**
FIRST INTERNAL TEST			
3	Data Conversion	**15**	**25**

	Track-and-Hold and Sample-and–hold amplifiers, Comparators, Nyquist convertors: The FLASH architecture, Pipelined and subranging ADC architectures, Folding ADC architectures, Δ∑ Modulators: The basic loop dynamics, Continuous time vs discrete time Δ∑ Modulators (Chap 6 [3]). AGC The purpose of AGC in the receiver, AGC architecture and strategies, Types of AGC algorithms (Chap 7.1 [3]).		
SECOND INTERNAL TEST			
4	Frequency Synthesizers PLLs: The linear PLL model, Error convergence, order and type of PLL, PLL stability and operating range parameters, the phase detector; Fractional N frequency synthesis, programmable digital counter, spurs in fractional N frequency synthesizers, Δ∑ fractional N frequency synthesizers (Chap 7.2 [3]). Receiver Architectures Direct Conversion receivers: architecture and performance; Super heterodyne receiver: architecture and performance; Low IF receivers: architecture and performance, Typical driving requirements: Sensitivity, selectivity, Image rejection, Frequency planning & generation, Linearity (Chap 8 [3]).	**13**	**25**
END SEMESTER EXAM			

Course No	Course Title	Credits	Year
06EC6022	**Coding Theory**	3-0-0: 3	**2015**

Pre-requisites: A basic course in Digital Communication, Wireless Communication

Course Objectives:

- To introduce the concepts of finite field arithmetic
- To analyse the encoding, decoding and error detection and error correction properties of linear block codes, cyclic codes and convolution codes

Syllabus:

Fields. Groups. Binary field arithmetic. Construction and basic properties of GF(2^m) fields. Vector spaces. Linear Block codes. Syndrome and Error detection. Hamming codes. Reed Muller codes. Cyclic codes. Binary and non-binary BCH codes. Reed Solomon Codes. Berlekamp Algorithm. Convolution codes-encoding, distance properties. Viterbi algorithm. Trellis based soft decision algorithm. Turbo coding. Low density parity check codes.

Course Outcome:

The student will be able to:

- perform operations using finite field arithmetic and construct Galois fields.
- apply the concepts of encoding, decoding and error detection and error correction of linear block codes, cyclic codes and convolution codes

Text Books:

1. *Shu Lin and Daniel J Costello, "Error Control Coding", 2nd edition, Pearson.*

References:

2. *A Neubauer, J Freudenberger, V Kuhn, "coding Theory, algorithms, architectures and applications", Wiley India Edition, 2012.*
3. *Robert H, Morelos-Zaragoza, "The art of error correcting coding", Wiley India Edition, 2013.*
4. *R E Blahut, "Theory and practice of error control coding", MGH 1983.*
5. *W C Huffman and Vera Pless, "Fundamentals of error correcting codes", Cambridge University Press, 2006.*

6. *Ron M Roth, "Introduction to coding theory", Cambridge University Press, 2006.*
7. *Elwyn R Berlekamp, "Algebraic coding Theory", McGraw Hill Book Company, 1984.*

COURSE PLAN

Course No **06EC 6022**	Course Title **Coding Theory**	Credits **3-0-0: 3**	Year **2015**
Module		Hours	End Sem Exam Marks (%)
1	Introduction to Coding and Finite Field Arithmetic Introduction [1-1.1], Types of codes [1-1.2], Types of errors [1-1.5], Groups [1-2.1], Fields [1-2.2], Binary Field Arithmetic [1-2.3]. Construction of Galois Field GF(2^m) [1-2.4], Basic Properties of GF(2^m) [1-2.5], Computations using GF(2^m) arithmetic [1-2.6].	**15**	**25**
2	Linear Block Codes Introduction to Vector spaces [1-2.7], Matrices [1-2.8]. Introduction to Linear Block Codes [1-3.1], Syndrome and Error Detection [1-3.2], Minimum distance of LBC [1-3.3]. Error detecting and correcting capabilities of block codes [1-3.4], Standard Array and Syndrome Decoding [1-3.5]. Important Linear Block codes: Hamming Codes [1-4.1], Reed Muller Codes [1-4.3].	**13**	**25**
FIRST INTERNAL TEST			
3	Cyclic Codes Description of cyclic codes [1-5.1], Generator and Parity Check Matrices [1-5.2], Encoding of cyclic codes [1-5.3], Syndrome computation and Error Detection [1-5.4], Decoding of cyclic codes [1-5.5], Binary BCH codes: Binary primitive BCH codes [1-6.1], Decoding of BCH codes [1-6.2],Non Binary BCH codes: q-ary Linear Block Codes [1-7.1], Primitive BCH codes over GF(q)[1-7.2],	**13**	**25**

	Reed Solomon codes [1-7.3], Decoding of Non Binary BCH and RS codes: Berlekamp algorithm [1-7.4].		
SECOND INTERNAL TEST			
4	Convolution Codes Encoding of Convolution codes [1-11.1], Structural properties of convolution codes [1-11.2], Distance properties of convolution codes [1-11.3], Viterbi algorithm [1-12.1], Soft output Viterbi algorithm [1-12.5], Trellis based soft decision algorithm: Viterbi decoding algorithm [1-14.1], Recursive Maximum likelihood decoding algorithm [1-14.2], Turbo Coding: Introduction to Turbo coding [1-16.1], Distance properties [1-16.2], Iterative decoding of turbo codes [1-16.5], Low density parity check codes: Introduction to LDPC codes [1-17.1], decoding of LDPC codes [1-17.6].	**15**	**25**
END SEMESTER EXAM			

Course No	Course Title	Credits	Year
06EC6032	**Adaptive Signal Processing**	3-0-0: 3	**2015**

Pre-requisites: A basic course in Digital Communication, Wireless Communication

Course Objectives:

1. To provide the mathematical framework for an understanding of adaptive statistical signal processing and filter structures will be introduced
2. To introduce different stochastic gradient Algorithms and their properties to develop an Adaptive filter that cater to the need of a particular application.
3. To familiarize the performance measures of the algorithms studied.
4. Introduce various other existing types of adaptive algorithms.

Syllabus:

Background and Preview, Weiner Filters, Linear Prediction, LMS adaptive Filtering, Normalized LMS Adaptive Filters, Frequency-domain Adaptive filters, Method Of Least Squares, Recursive Least-Squares Adaptive Filters, Kalman Filters, Finite Precision Effects, Tracking of Time varying Systems, Other adaptive filtering technique.

Course Outcome:

Student will be able to

- apply adaptive filtering algorithms for solving real world problems of interest in communication and signal processing
- use adaptive filters in system modelling
- demonstrate the application of adapting system identification to physical situations.

Text Books:

1. *Simon Haykin, Adaptive filter theory- 4th edition, Prentice Hall*
2. *A H Sayed, Adaptive filters, John Wiley*

References:

1. *Widrow and Stearns, Adaptive signal processing, Pearson*
2. *Ali H. Sayed, Fundamentals of Adaptive Filtering, John Wiley, 2003.*

3. *Manalokis, Ingle and Kogon, Statistical and Adaptive signal processing- Artech House INC., 2005.*
4. *A Poularikas, Z M Ramadan, Adaptive filtering primer with MATLAB –Taylor and Francis*

COURSE PLAN

Course No **06EC 6032**	Course Title **Adaptive Signal Processing**	Credits **3-0-0: 3**	Year **2015**
Module		Hours	End Sem Exam Marks (%)
1	Background and Preview: The filtering problem - Linear optimum filters - Adaptive filters - Linear Filter structures – Approaches (Text Book 1 Pages 1-18) Weiner Filters: - Linear Optimum Filtering Problem Statement - Orthogonality Principle - MMSE - Wiener-Hopf Equations - Error performance surface - Linear regression model (Text Book 1 - 2.1-2.7) Linear Prediction: Forward Linear Prediction - Backward Linear Prediction - Levinson-Durbin Algorithm - Properties of Prediction-Error Filters lattice predictors joint-process estimation (Text Book 1 - 3.1-3.4, 3.8, 3.10)	**10**	**25**
2	LMS adaptive Filtering: Method of steepest descent: Basic Idea , steepest descent algorithm applied to the wiener filter, stability, virtue and limitation.(Text Book 1 - 4.1-4.6) LMS adaptive Filters : Overview ,LMS adaptation Algorithm, Applications, Comparison of LMS Algorithm with Steepest Descent Algorithm, Convergence Analysis and Robustness of the LMS Filter (Text Book 1 - 5.1-5.3, 5.5, 5.10) Normalized LMS Adaptive Filters: Solution to constrained Optimization Problem, Stability ,Step-size control for Acoustic Echo Cancellation (Text Book 1 - 6.1, 6.2, 6.3)	**10**	**25**

	Frequency-domain Adaptive filters: Block Adaptive Filters ,Fast Block LMS Algorithm, Unconstrained Frequency Domain Adaptive Filters (Text Book 1 - 7.1, 7.2, 7.3)		
FIRST INTERNAL TEST			
3	Method Of Least Squares: Statement of linear Least Squares Estimation Problem, Data Windowing , Minimum Sum Of Error Squares ,Normal Equations and Linear Least Squares Filter, Time Average Correlation Matrix, Properties of least Squares Estimates, MVDR (Minimum Variance Distortion less Response) Spectrum Estimation, Singular-Value Decomposition ,Pseudo inverse (Text Book 1 - 8.1-8.9, 8.11, 8.12) Recursive Least-Squares Adaptive Filters: Algorithm (Text Book 1 - 9.1-9.3, 9.7, 9.9)	**11**	**25**
SECOND INTERNAL TEST			
4	Kalman Filters: Recursive Minimum Mean Square Estimation for Scalar random Variables, Statement of the Kalman Filtering Problem (Text Book 1 - 10.1, 10.2) Finite Precision Effects: Quantization Errors ,LMS Algorithm, RLS Algorithm (Text Book 1 - 13.1-13.3) Tracking of Time varying Systems :Tracking Performance of the LMS Algorithm and RLS Algorithm, Comparison (Text Book 1 - 14.3-14.6) Other adaptive filtering technique: Neural networks and multi-layer perceptrons, Adaptive IIR filtering. (Text Book 1 - 15.1,15.2,17.1,17.2)	**11**	**25**
END SEMESTER EXAM			

Course No	Course Title	Credits	Year
06EC6142	**RF Circuit Design**	3-0-0: 3	**2015**

Pre-requisites: A basic course in Analogue Integrated Circuits

Course Objectives:

- To present the concepts of RF design and analysis of RF circuits used in modern wireless communication integrated circuits.
- To analyse the effect of various MOS devices in circuit designs.
- To analyse the fundamental concepts of High frequency and power amplifiers in RF transceivers.
- To analyse the radio transceiver architectures that we are coming across in day today life.

Syllabus:

Basic Concepts in RF Design, Passive RLC networks, Passive IC Components, MOS device review, Distributed systems, High frequency amplifier design, Low noise amplifier design, RF Power amplifiers and mixers, Phased Lock Loops and Voltage controlled oscillators, Frequency synthesis, Radio architectures.

Course Outcome:

The student will be able to apply the concepts of

- parameters for various RF Circuits for transceivers.
- amplifiers and mixers used in various circuits.
- radio architectures and WLAN Transceivers.

Text Books:

1. *Thomas H. Lee, "The Design of CMOS Radio-Frequency Integrated Circuits", 2nd Edition, by Cambridge University Press*
2. *Behzad Razavi, "RF Microelectronics", 2nd Edition, by Prentice Hall.*

References:

3. *R. Ludwig, P. Bretchko, "RF Circuit Design", Pearson Asia Education, New Delhi, 2004.*

4. *Ulrich L. Rohde & David P. NewKirk, "RF / Microwave Circuit Design", John Wiley & Sons, 2000.*
5. *Davis W. Alan, "Radio Frequency Circuit Design", Wiley India, 2009.*
6. *Hoffman R.K, "Handbook of Microwave Integrated Circuits", Artech House, Boston, 1987.*

COURSE PLAN

Course No **06EC 6142**	Course Title **RF Circuit Design**	Credits **3-0-0: 3**	Year **2015**
Module		Hours	End Sem Exam Marks (%)
1	Basic Concepts in RF Design Nonlinearity and time variance (Sec. 2.1 [2]), Effects of nonlinearity (Sec. 2.2 [2]), Noise (Sec. 2.3 [2]), Sensitivity and dynamic range (Sec. 2.4 [2]). Passive IC Components Interconnects and skin effect (Sec. 4.2 [1]), Resistors (Sec. 4.3 [1]), Capacitors (Sec. 4.4 [1]), Inductors (Sec. 4.5 [1]). MOS device review Field Effect Transistors (Sec. 5.3 [1]), MOSFET long channel approximation (Sec. 5.4 [1]), MOSFET short channel approximation (Sec. 5.6 [1]).	**11**	**25**
2	High frequency amplifier design Rise time, delay and bandwidth (Sec.8.5 [1]), Zeros to enhance bandwidth (Sec. 9.2 [1]), Shunt-series amplifiers (Sec. 9.3 [1]), Tuned amplifiers (Sec. 9.5 [1]), Cascaded amplifiers (Sec. 9.7 [1]). Low noise amplifier design Intrinsic MOS noise parameters (Sec. 12.2 [1]), Power match versus noise match (Sec. 12.3 [1]), Large signal performance (Sec. 12.6 [1]), Design examples (Sec. 12.5 [1]).	**10**	**25**
FIRST INTERNAL TEST			

3	RF Power amplifiers and mixers Amplifiers - Class A, AB, B, C, D, E, F (Sec. 15.3 – 15.6 [1]), Mixers - conversion gain, noise figure, linearity and isolation, spurs (Sec. 13.2 [1]), Multiplier based mixers (Sec. 13.4 [1]), Subsampling mixers (Sec. 13.5 [1]). Phased Lock Loops and Voltage controlled oscillators PLL -Linearized PLL models (Sec. 16.3 [1]), Phase detectors (Sec. 16.5 [1]), VCO – resonators (Sec. 17.4 [1]), Negative resistance oscillators (Sec. 17.6 [1]).	**10**	**25**
SECOND INTERNAL TEST			
4	Frequency synthesis Introduction (Sec. 17.7 [1]), Synthesizers with static moduli (Sec. 17.7.2 [1]), Synthesizers with dithering moduli (Sec. 17.7.3 [1]), Combinational synthesizers (Sec. 17.7.4 [1]), Direct digital synthesis (Sec. 17.7.5 [1]). Radio architectures Receiver architectures (Sec.19.2 [1]), Transmitter architectures (Sec. 19.4 [1]), WLAN transceiver (Sec. 19.6.2 [1]).	**11**	**25**
END SEMESTER EXAM			

Course No	Course Title	Credits	Year
06EC6242	**MIMO and Multi Carrier Communications**	3-0-0: 3	**2015**

Pre-requisites: A basic course in Wireless Communication

Course Objectives:

- To extend the knowledge gained through the wireless communication course to MIMO scenario and identify its challenges and issues.
- To understand the design principles of Orthogonal and Quasi orthogonal real and complex space time block codes and analyze their performance.
- To study the fundamentals of multi carrier Communication systems and its challenges.

Syllabus:

Review of SISO fading communication channels, Introduction to Multiple Antennas and Space-Time Communications, MIMO channel models, Capacity of MIMO channels, Spatial Diversity, MIMO spatial multiplexing, Diversity Multiplexing Trade-off, Code design criteria for quasi-static channels, Space time block codes on real and complex orthogonal designs, Performance analysis, Representation of STTC, Data Transmission Using Multiple Carriers, Synchronization in OFDM, Channel capacity and OFDM, PAPR-Reduction with Signal Distortion.

Course Outcome:

At the end of this course students will be able

- to appreciate the problems faced in SISO and apply solutions to overcome different issues faced in SISO through MIMO.
- to design and construct Real & Complex orthogonal and Quasi orthogonal STBC
- to apply the fundamental concepts of Multicarrier Communication to design of LTE systems

Text Books & References:

1. *David Tse and Pramod Viswanath, "Fundamentals of Wireless Communication", Cambridge University Press 2005.*
2. *Andrea Goldsmith, "Wireless Communications", Cambridge University Press.*

3. *Hamid Jafarkhani, "Space-Time Coding: Theory and Practice", Cambridge University Press 2005.*
4. *Paulraj, R. Nabar and D. Gore, "Introduction to Space-Time Wireless Communications", Cambridge University Press 2003.*
5. *E.G. Larsson and P. Stoica, "Space-Time Block Coding for Wireless Communications", Cambridge University Press 2008.*
6. *Ezio Biglieri, Robert Calderbank et al "MIMO Wireless Communications" Cambridge University Press 2007.*
7. *Ahmad R.S. Bahai, B.R. Saltzberg, M. Ergen, " Multi carrier Digital Communications- Theory and Applications of OFDM", Second Edition, Springer.*
8. *Y. Li. G. Stuber, "OFDM for Wireless Communication", Springer, 2006.*
9. *R. Prasad, "OFDM for Wireless Communication", Artech House, 2006.*

COURSE PLAN

Course No **06EC 6241**	Course Title **MIMO and Multi Carrier Communications**	Credits **3-0-0: 3**	Year **2015**
Module		Hours	End Sem Exam Marks (%)
1	Information Theoretic aspects of MIMO : Review of SISO fading communication channels (Ref 1),Multiple Antennas and Space-Time Communications (Ref 2).MIMO channel models-Classical i.i.d models, Frequency selective and Extended channels, (Ref 4, Ref 5), Capacity of MIMO channels-Ergodic and outage capacity (Ref 4).Spatial Diversity: Diversity and channel knowledge, Alamouti space time code(Ref 4). MIMO spatial multiplexing-BLAST receivers and Diversity Multiplexing Trade-off (Ref 3, Ref 4).	**11**	**25**
2	Space Time Block Codes Code design criteria for quasi-static channels (Rank, determinant and Euclidean distance), Space time block codes on real and complex orthogonal designs:	**11**	**25**

	Orthogonal designs, Generalized orthogonal designs, Quasi-orthogonal designs and Performance analysis. Representation of STTC, Delay diversity as a special case of STTC and Performance analysis (Ref 2).		
FIRST INTERNAL TEST			
3	Multicarrier Communication Multi carrier Modulation: Data Transmission Using Multiple Carriers, Multicarrier Modulation with Overlapping Subchannels, Discrete Implementation of Multicarrier Modulation(Ref 2) -OFDM system model - FFT implementation , Channel capacity and OFDM, Comparison with single carrier, (Ref 8)	**11**	**25**
SECOND INTERNAL TEST			
4	Challenges in Multicarrier Communication Synchronization in OFDM: Timing and Frequency Offset in OFDM-Pilot and Non pilot based methods.(Ref 8) Challenges in Multicarrier Systems(Ref 2) -PAPR properties of OFDM,PAPR-Reduction with Signal Distortion- signals – PAPR reduction techniques with signal distortion; Techniques for distortion less PAPR reduction – Selective mapping and Optimization techniques.(Ref 8)	**9**	**25**
END SEMESTER EXAM			

Course No	Course Title	Credits	Year
06EC6342	**Estimation and Detection Theory**	3-0-0: 3	**2015**

Pre-requisites: A basic course in Linear & Matrix Algebra

Course Objectives:

- To introduce the concepts different detection methods and hypothesis testing
- To introduce the fundamentals of estimation theory and use of sufficient statistics in estimation
- To analyse various estimation techniques

Syllabus:

Fundamentals of Detection Theory, Hypothesis Testing, Fundamentals of Estimation Theory, Fundamentals of Estimation Theory, Random Parameter Estimation

Course Outcome:

The student will be able to apply the concepts of

- Minimum probable error criterion in receiver design
- Estimation in signal processing
- Least square estimation and maximum likelihood estimation.

Text Books:

1. *Steven M. Kay, "Statistical Signal Processing: Vol. 1: Estimation Theory, Detection Theory," Vol. 2: Prentice Hall Inc., 1998.*

References:

2. *M D Srinath, P K Rajasekaran, R Viswanathan, "Introduction to Statistical Signal Processing with Applications", Pearson, 1995.*
3. *H. Vincent Poor, "An Introduction to Signal Detection and Estimation", 2nd Edition, Springer, 1994.*

4. *Jerry M. Mendel, "Lessons in Estimation Theory for Signal Processing, Communication and Control," Prentice Hall Inc., 1995*

COURSE PLAN			
Course No **06EC 6342**	Course Title **Estimation and Detection Theory**	Credits **3-0-0: 3**	Year **2015**
Module		Hours	End Sem Exam Marks (%)
1	Fundamentals of Detection Theory Hypothesis Testing: Bayes' Detection, MAP Detection, ML Detection, Minimum Probability of Error Criterion, Min-Max Criterion, Neyman-Pearson Criterion, Multiple Hypothesis, Composite Hypothesis Testing: Generalized likelihood ratio test (GLRT) (chapter 2,[3]),, Receiver Operating Characteristic Curves.	**12**	**25**
2	Fundamentals of Estimation Theory Role of Estimation in Signal Processing(chapter 1,[1]), Unbiased Estimation, Minimum variance unbiased(MVU) estimators, Finding MVU Estimators(chapter 2,[1]), Cramer-Rao Lower Bound(chapter 3,[1]), Linear Modeling-Examples(chapter 4,[1]), Sufficient Statistics, Use of Sufficient Statistics to find the MVU Estimator (chapter 5,[1])	**12**	**25**
FIRST INTERNAL TEST			
3	Estimation Techniques Deterministic Parameter Estimation: Least Squares Estimation-Batch Processing, Recursive Least Squares Estimation(chapter 8,[1]), Best Linear Unbiased Estimation(chapter 6,[1]), Likelihood and Maximum Likelihood Estimation (chapter 7,[1])	**10**	**25**
SECOND INTERNAL TEST			

4	Estimation Techniques Random Parameter Estimation: Bayesian Philosophy, Selection of a Prior PDF, Bayesian linear model(chapter 10,[1]), Minimum Mean Square Error Estimator, Maximum a Posteriori Estimation (chapter 11, [1])	**10**	**25**
END SEMESTER EXAM			

Course No	Course Title	Credits	Year
06EC6152	**Principles of Secure Communication**	3-0-0: 3	**2015**

Pre-requisites: A basic course in Number Theory

Course Objectives:

- To introduce abstract algebra and their applications in cryptography.
- To introduce some of the Encryption standards and applications of symmetric and asymmetric cryptography.
- Understand the basics of Elliptic Curve Cryptography

Syllabus:

Groups, Rings and Fields, Euler's Theorem, Fermat's Theorem, Primality, Symmetric ciphers , Public key cryptosystems, Message Authentication Code, Hash Functions, Digital Signatures, Elliptic Curve Arithmetic, System Security

Course Outcome:

- The students will be able to apply the concepts of field arithmetic in different cryptographic algorithms.
- The students will be able to design good cryptographic algorithms with less hardware resources and less time complexity.

Text Books & References:

1. *William Stallings, "cryptography and Network Security", 4th Edition, Pearson Education.*

References:

1. *Dummit and Foote, "Abstract algebra", John Wiley and Sons Inc.*
2. *Douglas A. Stinson, "Cryptography, theory and practice", 2nd edition, Chapman & Hall, CRC press Company.*
3. *Lawrence C. Washington, "elliptic curves", Chapman & Hall, CRC Press.*
4. *Rainer A Ruppel, "Analysis and Design of stream ciphers", Springer Verlag.*

COURSE PLAN			
Course No **06EC 6151**	Course Title **Principles of Secure Communication**	Credits **3-0-0: 3**	Year **2015**
Module		Hours	End Sem Exam Marks (%)
1	Finite Fields and Introduction to Number Theory Groups, Rings and Fields[4.1], Modular arithmetic[4.2], Euclidean algorithm[4.3] , Arithmetic over GF(p) , polynomial arithmetic and arithmetic over GF(2^n)[4.4 - 4.6]. Prime numbers [8.1], Miller Rabin algorithm [8.3], Fermat's Theorem, Euler's Totient function, Euler's Theorem [8.2], Chinese Remainder Theorem [8.4], primitive root and Discrete logarithm [8.5].	**12**	**25**
2	Symmetric Ciphers and Confidentiality using symmetric Encryption Symmetric cipher model [2.1], Substitution Techniques: Caesar cipher, Monoalphabetic and polyalphabetic ciphers, Playfair cipher and Hill cipher [2.2]. Transposition Techniques [2.3]. Feistel Cipher [3.1], DES Encryption and Decryption Algorithms [3.2], AES Encryption and Decryption Algorithms [5.2]. Random Number Generation: Uses, Linear Congruential Generators, Pseudo Random Number Generation from counter [7.4]. Key Distribution: A key distribution scenario, Hierarchical Key Control [7.3].	**10**	**25**
FIRST INTERNAL TEST			
3	Public key cryptosystems Principles of public key cryptosystems [9.1]. RSA Algorithm: Description of the algorithm, Computational complexity, the factoring problem [9.2]. Diffie Hellman key exchange and man in the middle attack [10.2].	**10**	**25**

	Message Authentication Code (MAC): uses, requirements for MACs [11.3]. Hash Functions: simple hash function, uses, and requirements for hash function [11.4]. Digital Signatures: Direct Digital Signature, Arbitrated Digital Signature [13.1].		
SECOND INTERNAL TEST			
4	Introduction to Elliptic Curve Cryptography and System Security Elliptic Curve Arithmetic: Elliptic curves over real, Zp and GF (2^m), Geometric Description of addition [10.3], Analog of Diffie Hellman key exchange [10.4]. System Security: Intruders [18.1], intrusion detection: Audit records, Statistical anomaly detection, Honey pots [18.2]. Viruses: terminology of malicious programs, nature of viruses, types of viruses [19.1], antivirus approaches [19.2]. Firewalls: Characteristics, types of firewalls [20.1].	**10**	**25**
END SEMESTER EXAM			

Course No	Course Title	Credits	Year
06EC6252	**Speech and Audio Processing**	3-0-0: 3	**2015**

Pre-requisites: A basic course in Speech and Audio processing

Course Objectives:

- To introduce the concept of Time domain analysis and Frequency domain analysis of speech signal
- To analyse various digital speech models
- To analyse various speech coding and speech processing methods
- To introduce the concept of audio processing and various audio coding standards

Syllabus:

Speech Production, Speech Analysis, Digital Speech Models, LPC Analysis, Speech Coding, Speech Processing, Audio Processing, Music Production.

Course Outcome:

The student will be able to apply the concepts of

- Time domain and frequency domain analytical methods in speech processing
- Speech coding in communication engineering
- MPEG audio coding in audio processing applications

Text Books & References:

1. *Douglas O'Shaughnessy, Speech Communications: Human & Machine, IEEE Press, Hardcover 2nd edition, 1999; ISBN: 0780334493.*
2. *Nelson Morgan and Ben Gold, Speech and Audio Signal Processing : Processing and Perception Speech and Music, July 1999, John Wiley & Sons, ISBN: 0471351547*
3. *Rabiner and Schafer, Digital Processing of Speech Signals, Prentice Hall, 1978.4.*
4. *Rabiner and Juang, Fundamentals of Speech Recognition, Prentice Hall, 1994.*
5. *Thomas F. Quatieri, Discrete-Time Speech Signal Processing: Principles and Practice, Prentice Hall; ISBN: 013242942X; 1st edition*

6. *Donald G. Childers, Speech Processing and Synthesis Toolboxes, John Wiley & Sons, September 1999; ISBN: 0471349593*
7. *Rabiner L.R. & Gold, Theory and Applications of Digital Signal Processing, Prentice Hall of India*
8. *Jayant, N. S. and P. Noll. Digital Coding of Waveforms: Principles and Applications to Speech and Video Signal Processing Series, Englewood Cliffs: Prentice-Hall*
9. *Ben Gold & Nelson Morgan , Speech and Audio Signal Processing, John Wiley & Sons, Inc.*

COURSE PLAN

Course No **06EC 6252**	Course Title **Speech and Audio Processing**	Credits **3-0-0: 3**	Year **2015**
Module		Hours	End Sem Exam Marks (%)
1	Speech Production: - Acoustic theory of speech production- Excitation, Vocal tract model for speech analysis, Formant structure, Pitch. (Chapter 3 [1]) Speech Analysis :- Short-Time Speech Analysis (Chapter 6.2 [1]) , Time domain analysis - Short time energy, short time zero crossing Rate, ACF (Chapter 6.3 [1]) Frequency domain analysis- Filter Banks, STFT, Spectrogram, Formant Estimation &Analysis (Chapter 6.4 [1]) , Cepstral Analysis (Chapter 6.6 [1])	**10**	**25**
2	Digital Speech Models: - AR Model, ARMA model. (Chapter 6 [1]) LPC Analysis - LPC model, Auto correlation method, Covariance method, Levinson- Durbin Algorithm, Lattice form (Chapter 8 [3]) LSF, LAR, MFCC, Sinusoidal Model, GMM (Chapter 14.3 [5]), HMM (Chapter 25 [2])	**12**	**25**
FIRST INTERNAL TEST			

3	Speech coding :- Phase Vocoder, LPC, Sub-band coding, Adaptive Transform Coding , Harmonic Coding, Vector Quantization based Coders, CELP (Chapter 7 [1]) Speech processing :- Fundamentals of Speech recognition, Speech segmentation (Chapter 9 [3]) Text-to -speech conversion, speech enhancement, Issues of Voice transmission over Internet. (Chapter 30 [2])	**10**	**25**
SECOND INTERNAL TEST			
4	Audio Processing : Non speech and Music Signals Modelling -Differential, transform and sub band coding of audio signals & standards - High Quality Audio coding using Psycho acoustic models - MPEG Audio coding standard.(Chapter 35 [2]) Music Production - sequence of steps in a bowed string instrument -Frequency response measurement of the bridge of a violin (Chapter 12 [2]) Audio Data bases and applications – Content based retrieval (Chapter 38 [2])	**12**	**25**
END SEMESTER EXAM			

Course No	Course Title	Credits	Year
06EC6352	**Wireless Networks**	3-0-0: 3	**2015**

Pre-requisites: A basic course in Communication networks

Course Objectives:

- To introduce current and next-generation wireless networks, Cellular, WLANs, sensor networks, mobile ad-hoc networks and intermittently connected mobile networks.
- To propose and evaluate alternative approaches to meet specific communication Requirements.
- To design and analyze various medium access and resource allocation techniques such as power control for fixed-rate and rate-adaptive systems.
- To design and analyze network layer routing protocols by ensuring security.

Syllabus:

Wireless LANs, MANs and PANs, Medium Access Alternatives, Integration of voice and data traffic, Handoff management, Energy Efficient Designs, Security in Wireless Networks, Adhoc and Sensor networks, Characteristics of MANETs, Fundamentals of MAC, Vehicular Area Network (VANET) ,Advances in Wireless Networks, Femto cell Network, Ultra-Wideband Technology, Cognitive Radio, Body sensor networks on healthcare, Green Cellular Networks.

Course Outcome:

The student will be able to apply the concepts of

- Radio spectrum allocation in multi-user systems.
- wireless medium access, wireless security, power saving mechanisms, routing algorithms and QoS in wireless communication networks.
- wireless networks to simulate a variety of networking scenarios using advanced network simulating softwares like ns2, SUMO etc.

Text Books & References:

1. *William Stallings, "Wireless Communications and networks" Pearson / Prentice Hall of India.*
2. *Dharma Prakash Agrawal & Qing-an Zeng, "Introduction to Wireless and Mobile Systems", Thomson India Edition, 2nd Ed., 2007.*

3. *Kaveth Pahlavan, Prashant Krishnamurthy, "Principles of Wireless Networks", Pearson Education Asia, 2002.*
4. *Ian F. Akylidiz, Vuran, "Wireless Sensor Networks", WILEY , 2010.*
5. ***http://www.comsoc.org/best-readings/***
   (i) *Green Cellular networks:* ***Z. Hasan, H. Boostanimehr, and V. K. Bhargava, "Green Cellular Networks: A Survey, Some Research Issues and Challenges," IEEE Communications Surveys and Tutorials, vol. 13, pp. 524–540, 2011.***
   (ii) *Body sensor networks on healthcare: Patel, M and Jianfeng Wang, 'Applications, challenges and Prospective in Emerging Body Area networking technologies', IEEE Wireless communications, vol.17, no.1, pp.80-88, 2010.*
6. *Vijay. K. Garg, "Wireless Communication and Networking", Morgan Kaufmann Publishers, 2007.*
7. *Clint Smith, P.E. & Daniel Collins, "3G Wireless Networks", Tata McGraw Hill, 2nd Ed,. 2007.*
8. *Gary. S. Rogers & John Edwards, "An Introduction to Wireless Technology", Pearson Education, 2007.*

COURSE PLAN

Course No **06EC 6352**	Course Title **Wireless Networks**	Credits **3-0-0: 3**	Year **2015**
Module		Hours	End Sem Exam Marks (%)
1	Wireless LANs, MANs, and PANs Introduction to wireless LANs – Wireless LAN Technology Ref. [1] (13.1-13.4) - Wi-Fi and the IEEE 802.11 Wireless LAN Standard Ref. [1] (14.1- 14.5) - Bluetooth and IEEE 802.15 Ref. [2] (15.1- 15.6) - ETSI HiperLAN Ref. [2] (15.3.2) - IEEE 802.16 based WiMAX Ref. [2] (15.4.1) - ZigBee Ref. [2] (15.7).	**10**	**25**
2	Wireless Medium Access Alternatives	**10**	**25**

	Medium Access Alternatives: Fixed-Assignment for Voice Oriented Networks (4.2) - Random Access for Data Oriented Networks (4.3), Integration of voice and data traffic (4.4), Handoff management (6.2.2), Power saving mechanisms (6.3.2), Energy Efficient Designs (6.3.3), Security in Wireless Networks (6.4).		
FIRST INTERNAL TEST			
3	Adhoc and Sensor networks Introduction to Adhoc networks - Characteristics of MANETs, Applications (13.2-13.3), Table-Driven Routing Protocols (13.5.1-13.5.3) - Source-Initiated On-Demand Routing Ref. [2] (13.6.1 and13.6.2), Location-Aided Routing Ref. [2] (13.4-13.6) - Zone Routing (13.7.1)- Power Aware Routing (13.7.7)- Vehicular Area Network (VANET) (13.8) - Classification of Sensor Networks (14.5.1) – Fundamentals of MAC Protocol for Wireless Sensor Network (14.5.2) -PEGASIS (14.6.3) - Multipath Routing in Sensor Networks (14.6.4).	**12**	**25**
SECOND INTERNAL TEST			
4	Advances in Wireless Networks Femto cell Network (16.2) - Ultra-Wideband Technology (16.3) - Cognitive Radio (16.6)- Multimedia Services Requirements (16.7)- Low-Power Design (16.13) – Wireless under water sensor networks introduction- Design Challenges Ref.[4] (16.1)- Body sensor networks on healthcare Ref.[5] – Green Cellular Networks. Ref.[5]	**10**	**25**
END SEMESTER EXAM			

Course No	Course Title	Credits	Year
06EC6062/ 06EC6068	**Mini Project**	0-0-4: 2	**2015**

Course Objectives:

- To develop practical ability and knowledge about practical tools/techniques
- To solve the actual problems related to the industry, academic institutions or similar area using the tools/technique

Syllabus:

Students can take up any application level/system level project pertaining to a relevant domain. Projects can be chosen either from the list provided by the faculty or in the field of interest of the student. For external projects, students should obtain prior permission after submitting the details to the guide and synopsis of the work. The project guide should have a minimum qualification of ME/M.Tech in relevant field of work. At the end of each phase, presentation and demonstration of the project should be conducted, which will be evaluated by a panel of examiners. A detailed project report duly approved by the guide in the prescribed format should be submitted by the student for final evaluation. Publishing the work in Conference Proceedings/ Journals with National/ International status with the consent of the guide will carry an additional weightage in the review process.

Course Outcome:

On successful completion of this course students :

- Gained practical ability and knowledge about practical tools/techniques.
- Would enable them to gain experience in solving actual problems related to the industry, academic institutions or similar area.

Course No	Course Title	Credits	Year
06EC6072/ 06EC6078	**Communication Systems Engineering Lab II**	0-0-2: 1	**2015**

Pre-requisites: A basic course in Digital Communication, Wireless Communication

Course Objectives:

To Understand and analyze the concepts introduced in Wireless Communication, Communication Networks, Coding Theory and Wireless Networks courses

Syllabus:

Tools:

Numerical Computing Environments – GNU Octave or MATLAB, Simulink, LabVIEW or any other equivalent tool and specialized tools like OPNET/NS-2 etc.

Suitable Hardware Tools like USRP (Universal Software Radio Peripheral) to supplement the simulation tools.

Suggested flow of experiments: (These are minimum requirements; Topics could be added in concurrence with the syllabus of elective subjects offered)

- Modelling and Simulation of Radio Channels - Multipath Fading Channels- Jake's Model- Frequency non-selective and frequency selective fading channels realization.
- OFDM system simulation, BER performance in fading channels
- Channel estimation and Synchronization in OFDM
- Channel Coding: Linear Block code and Convolutional codes -Viterbi Decoding – Majority Logic Decoders - CRC-32
- Scheduling and Queuing Disciplines in Packet Switched Networks: FIFO, Fair Queuing, RED- TCP Performance: with and without RED.
- Wireless Medium Access Control: MAC layer 802.11: CSMA/CA, RTS/CTS mode
- Simple Sensor/Mobile Ad hoc Networks Simulation and Evaluation.

Course Outcome:

On successful completion of this course students will be able :

- To analyze the Concepts introduced in Wireless Communication, Communication Networks, Coding Theory and Wireless Networks courses

Text Books & References:

1. *W.H. Tranter, K. Sam Shanmugham, T.S. Rappaport, and K.L. Kosbar, "Principles of Communication System Simulation with Wireless Applications," Pearson, 2004.*
2. *J.G. Proakis, and M. Salehi, "Contemporary Communication Systems using MATLAB, Bookware Companion Series, 2006.*
3. *E. Aboelela, "Network Simulation Experiments Manual," The Morgan Kaufmann Series in Networking, 2007.*

Course No	Course Title	Credits	Year
06EC7111	**Linear and Nonlinear Optimisation**	3-0-0: 3	**2015**

Pre-requisites: A basic course in Linear Algebra

Course Objectives:

- To introduce the concepts of continuous functions and quadratic forms
- To introduce the concept of optimization and linear programming
- To introduce the concept of unconstrained optimization and nonlinear programming
- To introduce the concept of constrained optimization and optimality conditions

Syllabus:

Introduction To Optimization, Linear Transformation, Linear Equations, Linear Programming, Non-Linear Programming, Unconstrained Optimization, Constrained Optimization, Lagrange Multiplier

Course Outcome:

The student will be able to apply the concepts of

- Linear equations in optimization and detection
- Linear programming and optimization in communication networks
- Nonlinear programming, constrained and unconstrained optimization

Text Books:

1. *David G Luenberger, Yinyu Ye, Linear and Non Linear Programming., 3rd Ed, Springer 2008.*
2. *S. S. Rao, Engineering Optimization, Theory and Practice; Revised 3rd Edition, New Age International Publishers, New Delhi.*

References:

1. *Fletcher R., Practical methods of optimization, John Wiley, 2nd Ed, 1987.*
2. *E.K.P Chong, Stanislow H. Zak, An introduction to optimization, Wiley, 4th Ed, 2013.*
3. *Kalyanmoy Deb, Optimization for Engineering: Design-Algorithms and Examples, Prentice Hall (India), 1998.*
4. *Hillier and Lieberman, Introduction to Operations Research, McGraw-Hill, 8th edition, 2005.*
5. *Saul I Gass, Linear programming, McGraw-Hill, 5th edition, 2005.*

6. *Bazarra M.S., Sherali H.D. & Shetty C.M., Nonlinear Programming Theory and Algorithms, John Wiley, New York*
7. *S. M. Sinha, Mathematical programming: Theory and Methods, Elsevier, 2006.*

COURSE PLAN

Course No **06EC 7111**	Course Title **Linear and Nonlinear Optimisation**	Credits **3-0-0: 3**	Year **2015**
Module		Hours	End Sem Exam Marks (%)
1	Mathematical Background: Sequences and Subsequences- Mapping and functions- Continuous functions- Infimum and Supremum of functions- Minima and maxima of functions- Differentiable functions. Vectors and vector spaces- Matrices- Linear transformation- Quadratic forms- Definite quadratic forms- Gradient and Hessian- Linear equations- Solution of a set of linear equations-Basic solution and degeneracy. Convex sets and Convex cones- Introduction and preliminary definition- Convex sets and properties- Convex Hulls- Extreme point- Separation and support of convex sets- Convex Polytopes and Polyhedra- Convex cones- Convex and concave functions- Basic properties- Differentiable convex functions (Chapter 3 [2])	**10**	**25**
2	Introduction to Optimization - Classical optimization techniques: Single and multivariable problems-Types of constraints (Chapter 2 [2]). Linear Programming: Standard form, Linear optimization algorithms - The simplex method -Basic solution and extreme point -Degeneracy-The primal simplex method - Dual linear programs - Primal, dual, and duality theory - The dual simplex method -The primal-dual algorithm.	**12**	**25**

	Interior Point Methods – Karmarkars's method.(Chapter4 [2])		
FIRST INTERNAL TEST			
3	Nonlinear Programming: First order necessary conditions, Second order conditions, Minimization and maximization of convex functions- Local & Global optimum- Convergence-Speed of convergence (Chapter 7 [1]). Unconstrained optimization: One dimensional minimization - Elimination method, Fibonacci & Golden section search (Chapter 5[2]). Gradient methods - Steepest descent method, Newton's method, Conjugate Gradient Method (Chapter 6 [2].	**10**	**25**
SECOND INTERNAL TEST			
4	Constrained optimization: Constrained optimization with equality and inequality constraints (Chapter 11 [1]). Kelley's convex cutting plane algorithm (Chapter 14 [1])- Gradient projection method (Chapter 12 [1]) - Penalty Function methods (Chapter 13 [1]). Lagrange multipliers - Sufficiency conditions – Karush Kuhn Tucker optimality conditions (Chapter 11 [1]). Quadratic programming (Chapter 10 [3]) -Convex programming. (Chapter 9 [3])	**10**	**25**
END SEMESTER EXAM			

Course No	Course Title	Credits	Year
06EC7211	**Selected Topics In Communication**	3-0-0: 3	**2015**

Pre-requisites: A basic course in Communication networks

Course Objectives:

To familiarize the topics of current research interest and open research problems in

- Compressive Sensing
- Cognitive Radio Networks
- Energy efficient communication networks
- mmWave Communication.

Syllabus:

Introduction to Compressive Sensing, An overview of Reconstruction algorithms, Introduction to Cognitive Radio Networks, Spectrum Sensing, Spectrum Decision- Spectrum Sharing and Mobility, Introduction to Cognitive Radio Networks, Spectrum Sensing, Spectrum Decision- Spectrum Sharing and Mobility, Energy efficient Communication ,Green Cellular Networks- mechanisms for green wireless communications, Millimeter wave Communication (mmWave) **,** mmWave MIMO.

Course Outcome:

At the end of this course students will be able to apply the concepts of

- Compressive sensing in communication engineering problems.
- Spectrum Sensing, Spectrum Decision and Spectrum Sharing in Cognitive radio networks.
- energy harvesting in power constrained wireless networks.
- mmWave communication to design Gigabit wireless networks.

References:
Module 1:

1. *Saad Qaisar, Rana Muhammad Bilal, Wafa Iqbal, Muqaddas Naureen and Sungyoung Lee, "Compressive Sensing: From Theory to Applications, A Survey", the Journal of Communications and Networks, IEEE, 2013.*

2. *R. G. Baraniuk, "Compressive sensing," IEEE Signal Processing Magazine, vol. 24, no. 4, pp. 118-121, July 2007.*
3. *Mark A. Davenport, Marco F. Duarte, Yonina C. Eldar and Gitta Kutyniok, "Introduction to Compressed Sensing," in Compressed Sensing: Theory and Applications, Y. Eldar and G. Kutyniok, eds., Cambridge University Press, 2011.*
4. *Gitta Kutyniok, "Compressed Sensing: Theory and Applications", http://www.inatel.br/docentes/dayan/easyfolder/TP542/Artigos/Compressed%20Sensing%20-%20Theory%20and%20Applications.pdf.*
5. *Marco F. Duarte and Yonina C. Eldar, "Structured Compressed Sensing: From Theory to Applications," IEEE Transactions on Signal Processing, Vol. 59 No. 9, pp. 4053-4085, September 2011.*
6. *R. Baraniuk, J. Romberg, and M. Wakin, "Tutorials on compressive sensing."*

Module:2

1. *Ian F. Akyildiz, Won-Yeol Lee, Mehmet C. Vuran, and Shantidev Mohanty, A Survey on Spectrum Management in Cognitive Radio Networks", Cognitive Radio Communications and Networks, IEEE Communications Magazine, April 2008.*
2. *Ian F. Akyildiz , Won-Yeol Lee and Kaushik R. Chowdhury, "CRAHNs: Cognitive radio ad hoc networks", Ad Hoc Networks, Elsevier, 2009.*
3. *Beibei Wang And K. J. Ray Liu, "Advances In Cognitive Radio Networks: A Survey" Journal of Selected Topics in Signal Processing, IEEE, vol. 5, no. 1, February 2011.*
4. *Raza Umara, Asrar and U.H. Sheikh, "A comparative study of spectrum awareness techniques for cognitive radio oriented wireless networks", Physical Communication, Elsevier, 2012.*

Module 3:

1. *Pablo Serrano, Antonio de la Oliva, Paul Patras, Vincenzo Mancuso and Albert Banchs "Greening wireless communications: Status and future directions", Computer Communications, Elsevier, 2012.*
2. *Ziaul Hasan, Hamidreza Boostanimehr and Ziaul Hasan and Hamidreza Boostanimehr "Green Cellular Networks: A Survey, Some research issues and challenges", communications surveys & tutorials, ieee , volume:13 , issue: 4 , November 2011*

3. *Xiao fei Wang et,al , "A Survey of Green Mobile Networks: Opportunities and Challenges", Mobile Networks and Applications, The Journal of Special Issues on Mobility of Systems, Users, Data and Computing, Springer Science + Business Media, vol. 17, no. 1, 2011.*
4. *Suarez et al. Greening wireless communications: Status and future directions, EURASIP Journal on Wireless Communications and Networking 2012*

Module 4:

1. *Yong Niu, et.al, "Athanasios V. Vasilakos A survey of millimeter wave communications (mmWave) for 5G: opportunities and challenges, Wireless Networks, Springer, April 2015.*
2. *Kao-Cheng Huang, Zhaocheng Wang, "Millimeter wave communication systems", John Wiley & Sons, Hoboken, New Jersey, 2011.*
3. *JonathanWells, "Multi-Gigabit Microwave and Millimeter-Wave Wireless Communications", Artech House, 2010.*
4. *Su-Khiong Yong, Pengfei Xia and Alberto Valdes-Garcia, "60GHz Technology for Gbps WLAN and WPAN: From Theory to Practice", Wiley 2010*
5. *Theodore S. Rappaport, Robert W. Heath Jr., Robert C. Daniels, James N. Murdock*
6. *"Millimeter wave wireless communications", Prentice Hall, 2014.*

COURSE PLAN

Course No **06EC7211**	Course Title **Selected Topics in Communication**	Credits **3-0-0: 3**	Year **2015**
Module		Hours	End Sem Exam Marks (%)
1	Introduction to Compressive Sensing- Compressive Signals- compressed sensing paradigm: Sparsity, Incoherence, compressive sensing problem Restricted Isometric Property (RIP), An overview of Reconstruction algorithms: Greedy iterative algorithm, Convex Relaxation, Iterative Thresholding, Combinatorial / Sublinear Algorithms, Non Convex Minimization Algorithms, Bregman	**11**	**25**

	Iterative Algorithms, Applications, CS in communications and networks, CS in Future.		
2	Introduction to Cognitive Radio Networks- Cognitive Radio Technology- Network Architecture- Spectrum and Network Heterogeneity- Comparison with Classical ad hoc networks - Spectrum Sensing- Spectrum Decision- Spectrum Sharing and Mobility- Network layer and Transport layer of CRN- Open problems and future research directions.	**11**	**25**
FIRST INTERNAL TEST			
3	Introduction to Energy consumption in wireless networks- Identifying the causes of inefficient energy consumption- Metrics for energy-efficiency- Mechanisms for improving energy efficiency- Green Cellular Networks- mechanisms for green wireless communications- Energy efficient resource management in Heterogeneous Networks Open challenges and future directions	**11**	**25**
SECOND INTERNAL TEST			
4	Introduction- mmWave characteristics-Channel performance at 60GHz, Gigabit wireless communication, mmWave standards, Applications, Challenges, new research directions, mmWave Antennas: Path loss and antenna directivity, Beam steering antenna, mmWave MIMO: Spatial Diversity of Antenna Arrays, Multiple Antennas, mmWave design consideration.	**9**	**25**
END SEMESTER EXAM			

Course No	Course Title	Credits	Year
06EC7311	**Spectral Analysis & Methods**	3-0-0: 3	**2015**

Pre-requisites: A basic course in DSP

Course Objectives:

- To introduce the basic concepts of spectral estimation
- To understand and compare the various techniques used in parametric and non-parametric estimation
- To introduce the concept of filter banks and its application in spectral analysis.

Syllabus:

Energy and Power Spectral Density, Properties, The Spectral Estimation problem, PSD Estimation - Non-parametric methods**:** Periodogram and Correlogram methods; Parametric methods**:** ARMA/AR process, Various methods, Parametric methods for line spectra, MUSIC, ESPRIT Algorithms, Filter bank methods**.**

Course Outcome:

The student will be able to

- Formulate a spectral analysis problem and identify suitable techniques for spectral estimation.
- Identify and apply suitable methods for parametric and non parametric estimation
- Apply filter bank methods to spectral analysis and estimation problems

Text Books:

1. *Stoica , Randolph L. Moses, "Introduction to Spectral Analysis" , Pearson Prentice Hall 2005*

References:

2. *Kay S. M ,"Modern Spectral Estimation Theory & Applications" , Prentice Hall 2010*
3. *Monalakis, Ingle and Kogen, "Statistical and Adaptive Signal Processing", Tata McGraw Hill 2005.*
4. *Monson H. Hayes, "Statistical Digital Signal Processing and Modelling", Wiley 2008*

COURSE PLAN			
Course No **06EC 7311**	Course Title **Spectral Analysis & Methods**	Credits **3-0-0: 3**	Year **2015**
Module		Hours	End Sem Exam Marks (%)
1	Basic Concepts: Introduction, Energy Spectral Density of deterministic signals, Power spectral density of random signals, Properties of ESD/PSD, The Spectral Estimation problem	**10**	**25**
2	PSD Estimation - Non-parametric methods: Periodogram and Correlogram method, Computation via FFT, Properties of Periodogram, Blackman-Tuckey method, Window design considerations, Refined periodogram methods : Bartlet method, Welch method	**10**	**25**
FIRST INTERNAL TEST			
3	PSD Estimation - Parametric methods: Parametric method for rational spectra: Covariance structure of ARMA process, AR signals - Yule-Walker method, Least square method - Levinson-Durbin Algorithm, MA signals, ARMA Signals - Modified Yule-Walker method. Parametric method for line spectra: Models of sinusoidal signals in noise, Non-linear least squares method, Higher order Yule-Walker method, MUSIC and Pisarenko methods, Min Norm method, ESPRIT method.	**12**	**25**
SECOND INTERNAL TEST			
4	Filterbank methods: Filterbank interpertation of periodogram, , refined filterbank method for higher resolution spectral analysis - Slepia base-band filters, Capon method, Filter Bank Reinterpretation of the periodogram	**10**	**25**
END SEMESTER EXAM			

Course No	Course Title	Credits	Year
06EC7411	**Multi-rate and Multi-dimensional Signal Processing**	3-0-0: 3	**2015**

Pre-requisites: Linear Algebra and Applications, Basic course in Estimation and Detection Theory/ Digital Communication Techniques.

Course Objectives:

- To introduce the fundamentals of Multi-rate filter bank theory
- To analyse M-channel Perfect Reconstruction filters and learn its polyphase representation
- To analyse multidimensional systems
- To analyse sampling continuous 2D signals

Syllabus:

Fundamentals of Multirate Theory - Decimation and Interpolation, Polyphase representation, M-channel perfect reconstruction filter banks, Multidimensional systems – LTI systems, 2D systems, Fourier Transform, z-transform. Sampling continuous 2D signals , Aliasing and periodic sampling

Course Outcome:

The student will be able to apply the concepts of

- decimation and interpolation to design filter banks
- polyphase representation to implement perfect reconstruction filter banks.
- Multi-dimensional signals and systems to appreciate the applications in image processing.
- sampling and reconstruction of multidimensional signals to practice.

Text Books & References:

1. *P. P. Vaidyanathan, "Multirate systems and filter banks", Prentice Hall, PTR. 1993.*
2. *Sanjit K. Mitra, "Digital Signal Processing: A computer based approach", McGraw Hill, 1998.*
3. *N. J. Fliege, "Multirate digital signal processing", John Wiley.*
4. *John Woods, "Multidimensional signal, image, and video processing and coding", Academic Press, 2006.*
5. *Dudgeon Dan E., "Multidimensional Digital Signal Processing", Prentice Hall, Englewood Cliffs, New Jersey*
6. *Fredric J. Harris, "Multirate Signal Processing for Communication Systems", Prentice Hall,*

2004.

7. *Ljiljana Milic, "Multirate Filtering for Digital Signal Processing: MATLAB Applications", Information Science Reference; 1/e, 2008.*
8. *R. E. Crochiere & L. R. Rabiner, "Multirate Digital Signal Processing", Prentice Hall, Inc. 1983.*
9. *J. G. Proakis & D. G. Manolakis, "Digital Signal Processing: Principles. Algorithms and Applications", 3rd edition, Prentice Hall India, 1999.*
10. *Jae S. Lim, "Two- Dimensional Signal and Image Processing", Prentice Hall Englewood Cliffs, New Jersey, 1990.*

COURSE PLAN

Course No **06EC 7411**	Course Title **Multi-rate and Multi-dimensional Signal Processing**	Credits **3-0-0: 3**	Year **2015**
Module		Hours	End Sem Exam Marks (%)
1	Fundamentals of Multirate Theory: The sampling theorem - sampling at sub nyquist rate - Basic Formulations and schemes. Basic Multirate operations- Decimation and Interpolation - Digital Filter Banks- DFT Filter Bank-Identities- Polyphase representation. Maximally decimated filter banks: Polyphase representation- Errors in the QMF bank- Perfect reconstruction (PR) QMF Bank - Design of an alias free QMF Bank.	**12**	**25**
2	M-channel perfect reconstruction filter banks: Uniform band and non-uniform filter bank - tree structured filter bank- Errors created by filterbank system- Polyphase representation- perfect reconstruction systems	**9**	**25**
FIRST INTERNAL TEST			
3	Multidimensional systems Fundamental operations on Multidimensional signals, Linear Shift - Invariant systems-cascade and parallel	**11**	**25**

	connection of systems- separable systems, stable systems- Frequency responses of 2D LTI Systems- Impulse response- Multidimensional Fourier transforms- z transform, properties of the Fourier and z transform.		
SECOND INTERNAL TEST			
4	Sampling continuous 2D signals Periodic sampling with rectangular geometry- sampling density, Aliasing effects created by sampling - Periodic sampling with hexagonal geometry	**10**	**25**
END SEMESTER EXAM			

Course No	Course Title	Credits	Year
06EC7121	**EMI/EMC Based System Design**	3-0-0: 3	**2015**

Pre-requisites: A basic course in Electromagnetic theory and Digital electronics

Course Objectives:

Define and highlight the effect of EMI in the present Electronics scenario with large number of high frequency devices working together specially in the nonlinear digital domain.

The importance in design to incorporate Emission reduction techniques and also make designed units not being susceptible is brought out.

Syllabus:

Definition of EMI and the essentiality of EMC. Nature and types of interferences which adversely affect other systems & modules and possible methods of reduction. Susceptibility reduction techniques of units specially the sensitive ones are covered. Design of PCBs, backplanes, power supply grounding methods for reducing emission as well as measures like zoning, isolation shielding to reduce susceptibility are covered. It is almost impossible to predict the EMI environment accurately and hence measurement of Emission levels and Susceptibility forms a very important part of the study. TEM CELL, OPEN AREA, CONTROLLED CHAMBERS and associated sensors and equipments are also covered.

Course Outcome:

An Electronics designer becomes aware of the pitfalls of not incorporating Interference reduction techniques at the design stage itself as well as Susceptibility reduction techniques for sensitive systems. EMI/EMC should not be an afterthought for it may be costly, difficult and time consuming process if a cut and try also known as Band-Aid approach is taken.

Text Books:

1. *V. P. Kodali Engineering EMC Principles, Measurements & Technologies. IEEE Press New York*
2. *Henry W. OTT Noise Reduction Techniques in Electronic Systems. A Wiley Inter Science Publication John Wiley & Sons New York*

References:

3. *Bemhard Keiser, "Principles of Electromagnetic Compatibility", Artech House Norwood*

4. *C. R. Paul, "Introduction to Electromagnetic Compatibility", John Wiley & Sons*
5. *Don R. White, Handbook of EMI/EMC.*

COURSE PLAN

Course No **06EC 7121**	Course Title **EMI/EMC Based System Design**	Credits **3-0-0: 3**	Year **2015**
Module		Hours	End Sem Exam Marks (%)
1	EMI definition, relevance in the present day scenerio.The necessity for EMC. Units used in EMI/EMC, use of Decibels. Source, Medium and Victim in the interference phenomenon. Conducted and Radiated modes of Interference and Susceptibility of the Victim. Transient coupling mode. Emi Coupling Conducted coupling through common impedance, Common power supplies. Radiated coupling—Electric, Magnetic and Electromagnetic. Digital circuit radiation Common Mode Radiation and ground loop/return Differential Mode Radiation, Magnetic Source. Increased effects foreseen in VLSI, ULSI and lower voltage operation. Principle of cross talk. Cable to Cable coupling and shielding. Field to Cable coupling and reduction—balanced, shielded schemes. Power Mains coupling of External and Internally generated transients. Common mode and Differential mode interference filtering and Common Mode Choke. Transient Reduction: Transient Suppressors/limiters, Snubbers, Transient Absorbers for AC &DC.	**12**	**25**
2	Emi Reduction Techniques	**10**	**25**

	Noise and Interference techniques include the following: Shielding, Grounding & Bonding, Balancing, Filtering Separation & Orientation, Isolation, Device selection, Signal level control, Cable Design &Routing.		
FIRST INTERNAL TEST			
3	Design For Pcbs ESD as part of EMI. Protection of Devices and Modules while being handled by Human being. Non ideal behaviour of Passive components R, C &L and their mounting. Optimum selection of Active components based on speed required, fan-out requirements and output drive. Behaviour and Design of PCB traces at high frequencies. Trace Impedance and control. Cross Talk control routing for PCBs. Analog circuit power supply decoupling, Digital circuit decoupling in PCBs. Grounding techniques in complex boards like a Mixed signal application. Zoning & Hardware grouping to minimise interference. Multilayer PCBs, Ground planes and VIAS and their functions. Termination requirements at high frequencies.	**10**	**25**
SECOND INTERNAL TEST			
4	Emi Measurements & Standards Open Test Site, TEM Cell, Shielded Mesh and Anechoic Chamber lined with Absorbing materials. Radiation Sensors, Rx/Tx Antennas. Conduction Sensors for Injection & Coupling out. Test Instruments Spectrum Analyser & Receivers. Measurement method and setup using TEM cell for Emission & Susceptibility EMI standards, Civilian	**10**	**25**

	Standards CISPR, FCC, IEC, and EN. Emission levels for Conducted and Radiation, in Commercial/Industrial and Domestic Environments. MIL standards MIL 461E & MIL462E and its relevance		
END SEMESTER EXAM			

Course No	Course Title	Credits	Year
06EC7221	**RF MEMS**	3-0-0: 3	**2015**

Pre-requisites: A basic course in Digital Communication, Wireless Communication

Course Objectives:

- To provide an introduction to micromachining techniques and their use in the fabrication of micro switches, capacitors and inductors
- To provide an exposure to MEMS and silicon technology applications to RF circuit design

Syllabus:

MEMS Actuation Schemes and Switches, MEMS Inductors and Capacitors, Micromachined RF filters, Micromachined transmission lines

Course Outcome:

The students will be exposed to

- integration of MEMS into traditional Radio Frequency (RF) circuits that has resulted in systems with superior performance levels and lower manufacturing costs
- incorporation of MEMS based fabrication technologies into micro and millimetre wave systems which offers viable routes to ICs with MEMS actuators, antennas, switches and transmission lines

Text Books:

1. *Vijay K. Varadan, K. J. Vinoy and K. A Jose, RF MEMS and their Applications, Wiley, 2003.*

References:

2. *H. J. D. Santos, RF MEMS Circuit Design for Wireless Communications, Artech House, 2002.*
3. *Gabriel M. Rebeiz , RF MEMS Theory , Design and Technology, Wiley , 2003.*
4. *Stephen D Senturia, "Microsystem Design", Kluwer Academic Publishers, 2001.*
5. *Nitaigour Premchand Mahalik, MEMS, Tata McGraw-Hill, 2007.*

COURSE PLAN			
Course No **06EC 7221**	Course Title **RF MEMS**	Credits **3-0-0: 3**	Year **2015**
Module		Hours	End Sem Exam Marks (%)
1	MEMS Actuation Schemes and Switches Introduction, Microfabrications for MEMS(T1-1.3), Electromechanical Transducers(T1-1.4) - Piezoelectric transducers(T1-1.4.1), Electrostrictive transducers(T1-1.4.2), Magnetostrictive transducers(T1-1.4.3), Electrostatic actuators(T1-1.4.4), Electromagnetic transducers(T1-1.4.5), Electro dynamic transducers (T1-1.4.6), Electro thermal actuators(T1-1.4.7), Comparison of electromechanical actuation schemes (T1-1.4.8), Piezo-resistive sensing (T1-1.5.1), Capacitive sensing(T1-1.5.2), Piezoelectric sensing(T1-1.5.3), Resonant sensing (T1-1.5.4), Surface acoustic wave sensors(T1-1.5.5), RF MEMS switches and Micro relays - Switch parameters (T1-3.2), Actuation mechanisms (T1-3.5), Bistable microrelays and micro actuators (T1-3.6), Dynamics of switching operation (T1-3.7).	**11**	**25**
2	MEMS Inductors and Capacitors MEMS Inductors(T1-4.3) - Self-inductance and mutual inductance (T1-4.3.1), Micromachined inductors (T1-4.3.2), Effect of inductor layout (T1-4.3.3), Reduction of stray capacitance of planar inductors (T1-4.3.4), Approaches for improving the quality factor (T1-4.3.5), Folded inductors (T1-4.3.6), Modeling and design issues of planar inductors (T1-4.3.7), Variable inductors (T1-4.3.8), Polymer-based inductors (T1-4.3.9). MEMS capacitors - MEMS gap-tuning capacitors (T1- 4.4.1),	**11**	**25**

	MEMS area-tuning capacitors (T1- 4.4.2), Dielectric tunable capacitors (T1-4.4.3).		
FIRST INTERNAL TEST			
3	Micromachined RF filters -Introduction (T1-5.1), Modeling of mechanical filters (T1-5.2), Modeling of resonators (T1-5.2.1), General considerations for mechanical filters (T1-5.2.3), Micromechanical filters (T1-5.3), Electrostatic comb drive(T1-5.3.1), Micromechanical filters using comb drives (T1-5.3.2), Micromechanical filters using electrostatic coupled beam structures (T1-5.3.3), Surface acoustic wave filters (T1-5.4), Basics of surface acoustic wave filter operation (T1-5.4.1), Wave propagation in piezoelectric substrates (T1-5.4.2), Design of interdigital transducers(T1-5.4.3), Single-phase unidirectional transducers (T1-5.4.4), Surface acoustic wave devices: capabilities, limitations and applications(T1-5.4.5), Bulk acoustic wave filters (T1-5.5). MEMS phase shifters-Types of phase shifters and their Limitations (T1-6.2). Switched delay lines (T1-6.3.1). Distributed MEMS phase shifters (T1-6.3.2), Polymer based phase shifters (T1-6.3.3).	**11**	**25**
SECOND INTERNAL TEST			
4	Micromachined transmission lines (T1-7.2)- Losses in transmission lines(T1-7.2.1), Coplanar transmission lines(T1- 7.2.2), Microshield and membrane-supported transmission lines (T1-7.2.3), Microshield circuit components(T1- 7.2.4), Micromachined waveguide components (T1-7.2.5). Micromachined antennas - Basic characteristics of Microstrip antennas (T1-8.2.1), Design	**9**	**25**

	parameters (T1-8.2.2), Micromachining to improve performance (T1-8.3), Reconfigurable antennas (T1-8.5).		
END SEMESTER EXAM			

Course No	Course Title	Credits	Year
06EC7321	**Smart Antenna**	3-0-0: 3	**2015**

Pre-requisites: A basic course in digital signal processing and mobile communication

Course Objectives:

- To introduce the need for smart antennas for increasing the capacity in a mobile communication scenario
- To study the required signal processing algorithms for DOA estimation and adaptive beamforming on both the base stations and mobile stations.

Syllabus:

Role of smart antennas in a mobile communication scenario, need for interference cancellation, various configurations, transmitter and receiver blocks, received signal model, autocorrelation matrix of received signal, DOA estimation both conventional, MVDR and subspace based methods, conventional beam former(BF), multiple sidelobe canceller, Linearly constrained beamformer (LCMV), statistically optimum weight vector, LMS and RLS algorithms for real time BF realisation, Use of a second antenna in mobile stations, effects of antenna spacing and correlation, methods of combining, RAKE receiver, doubling of capacity in a cell.

Course Outcome:

The student will learn

- to link the importance of various adaptive signal processing algorithms based on interference cancellation techniques
- about the usage of second antenna for the performance improvement of the whole mobile cell communications.

Text Books:

1. *Constantine A Balanis, Panayiotis I Ioannids, 'Introduction to Smart Antennas', Morgan & Claypool publishers.*
2. *Ahmed EI Zoogby, 'Smart Antenna Engineering' Artech House.*
3. *Monson H. Hayes, Statistical Signal Processing and Modeling, John Wiley & Sons Inc, Reprint 2013.*

References:

4. *MJ Bronzel ,' Smart Antennas ' John Wiley, 2004.*
5. *TS Rappaport & JC Liberty,' Smart Antennas for Wireless Communication', Prentice Hall, 1996.*
6. *R Janaswamy,' Radiowave propagation and Smart Antennas for Wireless Communication' Kluwer,*

COURSE PLAN

Course No **06EC 7321**	Course Title **Smart Antenna**	Credits **3-0-0: 3**	Year **2015**
Module		Hours	End Sem Exam Marks (%)
1	Introduction to smart antennas (4.1-4.9[1]) Need for smart antennas, Smart Antenna Configurations, Switched beam antennas, Adaptive antenna approach, Space Division Multiple Access (SDMA), Architecture of a smart antenna System, Transmitter, Receiver, Benefits and Drawbacks, Basic principles of interference suppression in ULA, Mutual coupling Effects.	**8**	**25**
2	DOA Estimation (5.1-5.8[1]) Introduction to array response vector, Received signal Model, Subspace Based data model, Signal Auto Covariance Matrices (ACM), Conventional Beamforming method, Capon's minimum variance method (MVDL), Subspace approach to DOA Estimation, MUSIC Algorithm, ESPRIT Algorithm, Uniqueness of DOA Estimates.	**12**	**25**
FIRST INTERNAL TEST			
3	Beamforming (6.1, 6.2, 6.3.1, 6.3.2, 6.3.4 [1]) The Classical beamformer, Statistically Optimum Beamforming Weight Vectors, The maximum SNR	**14**	**25**

	Beamformer, The multiple Sidelobe canceller, Maximum SINR Beam former, Minimum Mean Square Error (MMSE), Direct Matrix Inversion, Linearly constrained beamformer (LCMV), Adaptive Algorithms for beamforming, (9.1,9.2,9.2.1,9.2.2,9.2.4 [3])the Least Mean Square Algorithm(LMS), Normalised LMS, (9.4,9.4.1[3]) Recursive Least Squares Algorithm (RLS) ([3]).		
SECOND INTERNAL TEST			
4	Mobile station's smart antennas (Chapter 9 [2]) Introduction, Multiple antenna MS Design, combining techniques, Selection (switched) diversity, Maximal Ratio combining, Adaptive beamforming or Optimum combining, RAKE Receivers, Mutual coupling effects, Dual antenna Performance Improvements on MS, Downlink capacity gains.	**8**	**25**
END SEMESTER EXAM			

Course No	Course Title	Credits	Year
06EC7421	**Pattern Recognition**	3-0-0: 3	**2015**

Pre-requisites: Linear Algebra and Applications, Basic course in Estimation and Detection Theory/ Digital Communication Techniques.

Course Objectives:

- To introduce the fundamentals of Pattern Recognition
- To enrich the student with the topics under Neural Networks and SVM
- To analyse various feature extraction procedures and familiarise with various nonlinear classifiers
- To solve clustering problems through functional optimization and graph theory

Syllabus:

Introduction- supervised & unsupervised, Pattern Recognition using Bayesian Method, Pattern Recognition using Neural Networks, Non-linear classifiers, Feature Extraction/Generation, Context based Classifiers, Clustering – analysis, function optimization based, graph theory based

Course Outcome:

The student will be able to apply the concepts of

- supervised and unsupervised classifiers to problems in computer vision, speech recognition, data mining, statistics, information retrieval.
- Neural networks and SVM to appreciate the signal detection and classification encountered communication.
- feature extraction to non-linear and context based classification
- optimization and graph theory to solve clustering problems

Text Books:

1. *Sergios Theodoridis, Konstantinos Koutroumbas, "Pattern Recognition", Academic Press, 2006.*
2. *Christopher M Bishop, "Pattern Recognition and Machine Learning", Springer 2007.*

References:

1. *Richard O. Duda and Hart P.E, and David G Stork, "Pattern classification" , 2nd Edn., John Wiley & Sons Inc., 2001*

2. *Robert Schalkoff, "Pattern Recognition – Statistical, Structural and Neural Approaches", Wiley India*
3. *Earl Gose, Richard Johnsonbaugh, and Steve Jost; "Pattern Recognition and Image Analysis", PHI Pvte. Ltd., NewDelhi-1, 1999.*
4. *K. Fukunaga; Introduction to Statistical Pattern Recognition (2nd Edition), Academic Press*
5. *Andrew R. Webb, "Statistical Pattern Recognition", John Wiley & Sons, 2002.*
6. *Fu K.S., "Syntactic Pattern recognition and applications", Prentice Hall, Eaglewood cliffs, N.J., 1982*

COURSE PLAN

Course No **06EC 7421**	Course Title **Pattern Recognition**	Credits **3-0-0: 3**	Year **2015**
Module		Hours	End Sem Exam Marks (%)
1	Introduction Features, Feature vectors and classifiers, Supervised versus unsupervised pattern recognition. Classifiers based on Bayes Decision theory- Minimum Error and Minimum Risk Classifiers, Discriminant Function and Decision Boundary/Surfaces, Bayesian classification for normal distributions, Estimation of unknown probability density functions, the nearest neighbour rule.	**11**	**25**
2	Pattern Recognition using Neural Networks Single and Multilayer Perceptrons, MSE estimation, Back propagation algorithm, Networks with Weight sharing, Polynomial classifiers, Radial Basis function networks, SVM classifiers – Linear and Nonlinear cases.	**10**	**25**
FIRST INTERNAL TEST			
3	Non Linear Classifiers Decision trees, Combining classifiers. Boost approach to combine classifiers.	**10**	**25**

	Feature selection/generation Data Preprocessing, ROC Curves, Class Separability Measures, Feature Subset selection, Bayesian Information Criterion, KLT and SVD.		
SECOND INTERNAL TEST			
4	Clustering Cluster analysis, Proximity measures, Clustering Algorithms - Sequential algorithms. Hierarchical algorithms - Agglomerative algorithms, Divisive algorithms. Schemes based on function optimization - K - means algorithm. Clustering algorithms based on graph theory, vector quantization.	**11**	**25**
END SEMESTER EXAM			

Course No	Course Title	Credits	Year
06EC7031/ 06EC7037	**Seminar II**	0-0-2: 2	**2015**

Course Objectives:

- To introduce the students to cutting edge technology in the area of communication engineering.
- To develop the acumen of reading & comprehending technical papers and implementing the methods as mentioned them

Syllabus:

Each student shall present a seminar on any topic of interest related to the core / elective courses offered in the first semester of the M. Tech. Programme. He / she shall select the topic based on the references from international journals of repute, preferably IEEE journals. They should get the paper approved by the Programme Co-ordinator / Faculty member in charge of the seminar and shall present it in the class. Every student shall participate in the seminar. The students should undertake a detailed study on the topic and submit a report at the end of the semester. Marks will be awarded based on the topic, presentation, participation in the seminar and the report submitted.

Course Outcome:

This course will prepare the student to comprehend technical papers in their selected areas. This will eventually improve the quality of their main project. The ability to write and report technical results will be improved.

Course No	Course Title	Credits	Year
06EC7041/ 06EC7047	**Project (Phase 1)**	0-0-12: 6	**2015**

Course Objectives:

To prepare the student for the main project by

- identifying research problems in different areas of communication engineering.
- preparing a detailed literature review for the same by reading research journals and conference papers.

Syllabus:

In Master's Thesis Phase-I, the students are expected to select an emerging research area in the field of specialization. After conducting a detailed literature survey, they should compare and analyze research work done and review recent developments in the area and prepare an initial design of the work to be carried out as Master's Thesis. It is mandatory that the students should refer National and International Journals and conference proceedings while selecting a topic for their thesis. She/he should select a recent topic from a reputed International Journal, preferably IEEE/ACM. Emphasis should be given for introduction to the topic, literature survey, and scope of the proposed work along with some preliminary work carried out on the thesis topic.

Students should submit a copy of Phase-I thesis report covering the content discussed above and highlighting the features of work to be carried out in Phase-II of the thesis. The candidate should present the current status of the thesis work and the assessment will be made on the basis of the work and the presentation, by a panel of internal examiners in which one will be the internal guide. The examiners should give their suggestions in writing to the students so that it should be incorporated in the Phase–II of the thesis.

Course Outcome:

The student will be able to identify their domains and prepare literature review for the main project.

Course No	Course Title	Credits	Year
06EC7012/ 06EC7018	**Project (Phase 2)**	0-0-21: 12	**2015**

Course Objectives:

To enable to student to

- work on research problems on an individual basis.
- design, test and record the results on the problems chosen in their respective domains.
- deduce inferences from the results and report them in scientific journals.

Syllabus:

In the fourth semester, the student has to continue the thesis work and after successfully finishing the work, he / she has to submit a detailed bounded thesis report. The evaluation of M Tech Thesis will be carried out by a panel of examiners including at least one external examiner appointed by university and internal examiner. The work carried out should lead to a publication in a National / International Conference or Journal. The papers received acceptance before the M.Tech. evaluation will carry specific weightage.

Course Outcome:

The students will be armed with the knowledge and skill set which makes them suitable for research and academic professions after completing the course in areas of communication engineering. The student will be able to identify a research problem, work on it and develop models/solution in a scientific manner.