CURRICULUM AND SYLLABUS OF
M.TECH. DEGREE PROGRAMME IN
TELECOMMUNICATION

(Applicable from 2010 admission)

DEPARTMENT OF ELECTRONICS AND COMMUNICATION ENGINEERING

NATIONAL INSTITUTE OF TECHNOLOGY CALICUT

DEPARTMENT OF ELECTRONICS AND COMMUNICATION ENGINEERING

National Institute of Technology Calicut

Vision of the Department of Electronics and Communication Engineering:

The Department of Electronics and Communication Engineering is envisioned to be a leading centre of higher learning with academic excellence in the field of electronics and communication engineering.

Mission of the Department in pursuance of its vision:

The mission of the Department of Electronics and Communication Engineering is to impart high quality technical education by offering undergraduate, graduate and research programs in the domain of Electronics and Communication Engineering with thorough foundation in theory along with strong hands-on design and laboratory components, tools and skills necessary for the students to become successful major contributors to society and profession.

PEOs and Programme Outcomes: PG Telecommunication

Programme Educational Objectives (PEOs):

Sl. No.	Program Educational Objectives
PEO 1	Graduates apply their knowledge in mathematics, signal processing and communications for fostering skills to, identify, analyze and solve engineering problems pertaining to design, development and deployment of telecommunication systems.
PEO 2	Graduates demonstrate high levels of creativity, critical thinking, research aptitude and technical and communication skills for productive and successful careers in industries, R&D organizations and other allied professions.
PEO 3	Graduates possess commitment to professional ethics and sensitivity to diverse societal needs in their professional careers.
PEO 4	Graduates exhibit a desire for life-long learning through technical training, teaching, research and developmental activities, participation in conferences/workshops and professional societies.

Programme Outcomes (POs)

The student who completes the Master of Technology in Telecommunication will have:

Sl. No.	Program Outcome	Graduate Attribute
PO 1	In-depth knowledge in Telecommunication theory and techniques to conceptualize, design, implement and evaluate new processes and systems for wired and wireless communication.	Scholarship of Knowledge
PO 2	Capacity to investigate complex problems in communication and networking and bring out critical information that facilitates advancements in research which meets theoretical, practical and policy constraints.	Critical Thinking
PO 3	Ability to critically study problems with various resource constraints, evaluate achievable solutions and propose efficient solutions that are consistent with the welfare of the public.	Problem Solving
PO 4	Capability to gather required information from available literature, both individually and as a member of a group, to solve new challenging problems and explore the possibility of arriving at innovative solutions, that are theoretically sound and practically appealing, through systematic research methodologies	Research Skill
PO 5	Ability to formulate problems and to develop and evaluate solutions using appropriate analytical, simulation and experimental tools with engineering intuitiveness and knowledge of pertinent limitations.	Usage of Modern Tools
PO 6	Ability to collaborate and contribute in multidisciplinary projects as an individual or tem member and to demonstrate capacity for self-management and rational analysis for achieving common objectives.	Collaborative and Multidisciplinary Work
PO 7	Capability to understand the economic and managerial challenges of Communication System design and orient individual and team efforts to meet such constraints.	Project Management and Finance
PO 8	Ability to effectively communicate with target group using technical reports, oral presentations and other appropriate documentation with scientific rigor and adequate literal standards.	Communication

PO 9	Willingness to explore new developments in chosen cutting edge areas of Telecommunication Theory and Technology and to update them on a regular basis through professional societies and related publications.	Life-long Learning
PO 10	Willingness to accept social responsibilities and possess professional ethical values to contribute to the sustainable and positive growth of society.	Ethical Practices and Social Responsibility
PO 11	Willingness to introspect the actions of oneself and to accept and offer honest criticism of technical work, to acknowledge and correct errors, and to credit properly the contributions of others.	Independent and Reflective Learning

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Curriculum for M. Tech. in Telecommunication

Semester 1

S.No	Code	Title	L	T	P/S	C
1	EC6301	Random Processes	4	0	0	4
2	EC6302	Digital Communication Techniques	4	0	0	4
3	EC6303	Information Theory	4	0	0	4
4	EC6304	Communication Networks	3	0	0	3
5	EC6305	Telecommunication Lab I	0	0	3	2
6		Elective 1	3	0	0	3
		Total credits				20

Semester 2

S.No	Code	Title	L	T	P/S	C
1	EC6306	Theory of Error Control Coding	4	0	0	4
2	EC6307	Estimation & Detection Theory	4	0	0	4
3	EC6308	Telecommunication Lab II	0	0	3	2
4	EC6309	Seminar	0	0	2	1
5		Elective 1	3	0	0	3
6		Elective 2	3	0	0	3
7		Elective 3	3	0	0	3
		Total credits				20

Semester 3

S.No	Code	Title	L	T	P/S	C
1	EC7301	Project Work	0	0	40	8
		Total credits				8

Semester 4

S.No.	Code	Title	L	T	P/S	C
1	EC7302	Project Work	0	0	40	12
		Total credits				12

Minimum Requirements

Minimum number of credits to be earned by a student is 60

List of Electives

S.No.	Code	Title	Credit
1	EC6321	Wireless Communication	3
2	EC6322	Secure Communication	3
3	EC6323	Optical Communication	3
4	EC6324	Selected Topics in Networks	3
5	EC6325	MIMO Communication Systems	3
6	EC6326	Markov Modeling & Theory of Ques	3
7	EC6327	Spread Spectrum & CDMA Systems	3
8	EC6328	Communication Switching & Multiplexing	3
9	EC6329	Selected Topics in Communication	3
10	EC6330	Network Security	3

*Any other subject (core/elective) offered by the Department from time to time shall be taken as elective with the consent of course co-ordinator/faculty.

Syllabus of M. Tech. Degree Programme in Telecommunication

SEMESTER-I

EC6301: Random Processes

Course Type : Professional Theory and Laboratory Practicals
Pre-requisites: -NIL-

L	T	P	C
4	0	0	4

Course Outcomes :

- ***CO1:*** *Understand the fundamental concepts of probability space and probability axioms*
- ***CO2:*** *Acquire the knowledge to formulate random variables corresponding to random experiments and to derive their probability distribution functions*
- ***CO3:*** *Develop an understanding of discrete and continuous random variables and their characterization*
- ***CO4:*** *Understand the use of Markov and Chebyshev inequalities to obtain bounds on probability of events and the use of central limit theorem to compute probabilities*
- ***CO5:*** *Learn the use of random vectors to model experiments with multiple simultaneous outcomes and the techniques to determine the distribution function of random vectors*
- ***CO6:*** *Understand the concept of random processes and techniques to find the correlation, covariance and power spectral density of stationary random processes*
- ***CO7:*** *Learn how to apply the theory of random processes to analyse linear systems with special focus on telecommunications and signal processing*
- ***CO8:*** *Develop sound knowledge in topics such as random walks, Markov chains and series representation of random processes and their applications in telecommunications and signal processing*

Total Hours : 56 Hrs

Module I: (14 hours) Random Variables
Probability axioms, conditional probability, discrete and continuous random variables, cumulative distribution function (CDF), probability mass function (PMF), probability density

function (PDF), conditional PMF/PDF, expected value, variance, functions of a random variable, expected value of the derived random variable, multiple random variables, joint CDF/PMF/PDF, functions of multiple random variables, multiple functions of multiple random variables, independent/uncorrelated random variables, sums of random variables, moment generating function, random sums of random variables.

Module 2: (14 hours) Fundamental Theorems and Random Processes

The sample mean, laws of large numbers, central limit theorem, convergence of sequence of random variables. Introduction to random processes, specification of random processes, *n*th order joint PDFs, independent increments, stationary increments, Markov property, Markov process and martingales, Gaussian process, Poisson process and Brownian motion.

Module 3: (14 hours) Response of Processes to LTI Systems

Mean and correlation of random processes, stationary, wide sense stationary and ergodic processes. Random processes as inputs to linear time invariant systems: power spectral density, Gaussian processes as inputs to LTI systems, white Gaussian noise. In-Phase and quadrature representation of random processes.

Module 4: (14 hours) Other Topics

Discrete-time Markov chains: state and n-step transition probabilities, Chapman-Kolmogorov equations, first passage probabilities, classification of states, limiting state probabilities Series representation of random process: Fourier series, Karhunen-Loeve expansion, Mercer's theorem, sampled band-limited processes, filtering using series representation

References :

1. Yannis Viniotis, "Probability and Random Processes for Electrical Engineers" McGraw-Hill College, 1998
2. Albert Leon Garcia: "Probability and Random Processes for Electrical Engineering", Prentice Hall 1993
3. A. Papoulis and S. U. Pillai, "*Probability, Random Variables and Stochastic Processes*", 4th Edition, McGraw Hill 2002
4. V. Krishnan: "Probability and Random Processes", John Wiley & Sons 2006
5. Geoffrey Grimmett, "Probability and Random Processes", 3rd edition, Oxford University Press 2001
6. Henry Stark and John W. Woods, "Probability and Random Processes with Applications to Signal Processing", Prentice Hall, 3rd Edition 2001

EC 6302 : Digital Communication Techniques

Course Type : Professional Theory and Laboratory Practicals
Pre-requisites: A first course in 'Digital Communication' at the undergraduate level

L	T	P	C
4	0	0	4

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Course Outcomes:

- ***CO1:*** *Understand the limitations of communication systems for effectively utilizing the fundamental resources for communication namely bandwidth and power and to appreciate the effective use of such resources to achieve exchange of information.*
- ***CO2:*** *Systematically analyze the flow and processing of information from the source to various blocks at the transmitter side and to understand the inverse operations at the receiver to facilitate the retrieval of transmitted information.*
- ***CO3:*** *Design and analyze various processing units of a digital communication system such as line coding and pulse shaping, various modulation techniques, equalization, synchronization and detection.*
- ***CO4:*** *Develop a framework for the performance evaluation of base band and pass band digital communication systems for additive white Gaussian noise channels using the concepts of signal space and to derive expressions for the probability of error of various modulation schemes.*
- ***CO5:*** *Develop elegant ways to use the results in white noise channels to colored noise channels*
- ***CO6:*** *Develop the mathematical tools needed for synchronization and detection using the classical estimation techniques*
- ***CO7:*** *Understand and appreciate the inevitability of using the concepts of randomness in communication theory and gaining adeptness in using them*
- ***CO8:*** *Gain awareness on the need to develop communication system designs which conserve bandwidth and/or power without compromising on performance and complexity*

Total Hours : 56 Hrs

Module 1: (10 hours) Random Variables and Processes
Review of Random variables: Moment generating function, Chernoff bound, Markov's inequality, Chebyshev inequality, Central limit Theorem, Chi square, Rayleigh and Rician distributions, Correlation, Covariance matrix- Stationary processes, wide sense stationary processes, ergodic process, cross correlation and autocorrelation functions-Gaussian process

Module 2: (22 hours) Communication over Additive Gaussian Noise Channels

Characterization of Communication Signals and Systems- Signal space representation- Connecting Linear Vector Space to Physical Waveform Space- Scalar and Vector Communication over Memory less Channels. **(4 hours)**

Optimum waveform receiver in additive white Gaussian noise (AWGN) channels - Cross correlation receiver, Matched filter receiver and error probabilities. **(6 hours)**

Optimum Receiver for Signals with random phase in AWGN Channels- Optimum receiver for Binary Signals- Optimum receiver for M-ary orthogonal signals- Probability of error for envelope detection of Mary Orthogonal signals**. (6 hours)**

Optimum waveform receiver for coloured Gaussian noise channels- Karhunen Loeve expansion approach, whitening. **(6 hours)**

Module 3: (12 hours) Synchronization in Communication Systems

Carrier Recovery and Symbol Synchronization in Signal Demodulation- Carrier Phase Estimation- Effect of additive noise on the phase estimate- Maximum Likelihood phase estimation- Symbol Timing Estimation- Maximum Likelihood timing estimation- Receiver structure with phase and timing recovery-Joint Estimation of Carrier phase and Symbol Timing- Frequency offset estimation and tracking.

Module 4: (12 hours) Communication over Band limited Channels

Communication over band limited Channels- Optimum pulse shaping- Nyquist criterion for zero ISI, partial response signaling- Equalization Techniques- Zero forcing linear Equalization- Decision feedback equalization- Adaptive Equalization..

References :

1. Edward. A. Lee and David. G. Messerschmitt, “Digital Communication”, Allied Publishers (second edition).

2. J Marvin.K.Simon, Sami. M. Hinedi and William. C. Lindsey, “Digital Communication Techniques”, PHI.

3. Sheldon.M.Ross, “Introduction to Probability Models”, Academic Press, 7th edition.

4. William Feller, “An introduction to Probability Theory and its applications”, Vol 11, Wiley 2000

5.J.G. Proakis, “Digital Communication”, MGH 4TH edition, 1995.

EC 6303: Information Theory

Course Type : Professional Theory and Laboratory Practicals
Pre-requisites: A first course in Probability Theory and Random Processes

L	T	P	C
4	0	0	4

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Course Outcomes :

- ***CO1:*** *To learn models of information sources with and without memory and analyse methods for efficiently coding their output ensuring no loss of information with a clear understanding on ultimate limits on performance*
- ***CO2:*** *Develop mathematical models for practical communication channels and analyse their information carrying capacity*
- ***CO3:*** *Evaluate through analysis, the methods for ensuring reliable data transfer and the bounds on their achievable performance by observing modulation-coding trade off given by Shannon's theorems*
- ***CO4:*** *Design and develop methods for distributing energy among parallel channels of communication for maximum information transfer through water filling considerations*
- ***CO5:*** *Mathematically analyse the performance of schemes for compressing the data with trade off on rate and distortion and discuss design considerations*
- ***CO6:*** *Understand research challenges in the design and development of communication systems for real world applications and suggest solutions through innovative design concepts*

Total Hours : 56 Hrs

Module 1 :(14 hours) Entropy and Loss less Source coding
Entropy- Memory less sources- Markov sources- Entropy of a discrete Random variable- Joint, conditional and relative entropy- Mutual Information and conditional mutual information-Chain relation for entropy, relative entropy and mutual Information- Lossless source coding-Uniquely decodable codes- Instantaneous codes- Kraft's inequality - Optimal codes- Huffman code- Shannon's Source Coding Theorem.

Module 2 (15 hours) Channel Capacity and Coding Theorem
Asymptotic Equipartition Property (AEP)- High probability sets and typical sets- Method of typical sequence as a combinatorial approach for bounding error probabilities.
Channel Capacity- Capacity computation for some simple channels- Arimoto-Blahut algorithm-Fano's inequality-Proof of Shannon's Channel Coding Theorem and its converse- Channels with feed back- Joint source channel coding Theorem.

Module 3: (15 hours) Continuous Sources and Channels

Differential Entropy- Joint, relative and conditional differential entropy- Mutual information-Waveform channels- Gaussian channels- Mutual information and Capacity calculation for Band limited Gaussian channels- Shannon limit- Parallel Gaussian Channels-Capacity of channels with colored Gaussian noise- Water filling.

Module 4: (12 hours) Rate Distortion Theory

Introduction - Rate Distortion Function - Properties - Continuous Sources and Rate Distortion measure- Rate Distortion Theorem - Converse - Information Transmission Theorem - Rate Distortion Optimization.

References :

1.Robert Gallager, “Information Theory and Reliable Communication”, John Wiley & Sons.
2.R. J. McEliece, “The theory of information & coding”, Addison Wesley Publishing Co., 1977.
3.T. Bergu, “Rate Distortion Theory a Mathematical Basis for Data Compression” PH Inc. 1971.
4.Special Issue on Rate Distortion Theory, IEEE Signal Processing Magazine, November 1998.
5.Thomas M. Cover and Joy A. Thomas, “Elements of Information Theory”, John Wiley & Sons, 2006
6. David J. C. MacKay, “Information Theory, Inference and Learning Algorithms”, Cambridge University Press, 2003

EC 6304: Communication Networks

Course Type : Professional Theory and Laboratory Practicals
Pre-requisites: A basic course in Computer Networks

L	T	P	C
3	0	0	3

Course Outcomes:

- ***CO1:*** *Explain the ISO OSI layering model, functions of each layer and examples of protocols used in each layer*
- ***CO2:*** *Analyze link layer schemes and solve problems in link layer design*
- ***CO3:*** *Explain application layer protocols like HTTP, FTP and Telnet*
- ***CO4:*** *Analyze TCP and UDP protocols to find throughput and latency*
- ***CO5:*** *Analyze IntServ and DiffServ architecture and solve problems related to weighted fair queuing*
- ***CO6:*** *Solve queuing theory problems related to M/M/1, M/M/m, M/M/infinity and M/G/1 queues*

Total Hours : 42Hrs.

Module 1 (10 hrs)
Introduction: General issues in networking; architectural concepts in ISO's OSI layered model-Data link layer - Direct Link Networks- Error detection- Reliable Transmission-ARQ schemes and analysis, multiple access, LANs, CSMA/CD, IEEE 802.11 wireless LANs

Module 2 (10 hrs)
Internet Architecture: Layering in the Internet- Applications layer - HTTP, SMTP, telnet, ftp TCP/IP protocol stack. Transport layer - TCP and UDP- Network layer - IP, routing, internetworking.

Module 3 (10 hours)
Broadband services and QOS issues: Quality of Service issues in networks- Integrated service architecture- Queuing Disciplines- Weighted Fair Queuing- Random Early Detection-Differentiated Services- Protocols for QOS support- Resource reservation-RSVP- Multi protocol Label switching- Real Time transport protocol.

Module 4 (12 hours)
Introduction to Queuing theory: Markov chain- Discrete time and continuous time Markov chains- Poisson process- Queuing models for Datagram networks- Little's theorem- M/M/1

queuing systems- M/M/m/m queuing models- M/G/1 queue- Mean value analysis- Time reversibility- Closed queuing networks- Jackson's Networks.

References :

1. James. F. Kurose and Keith. W. Ross, “Computer Networks: A top-down approach featuring the Internet”, Addison Wesley publications, 3/e, 2004.
2. D. Bertsekas and R. Gallager, “Data Networks”, Prentice Hall of India, 2/e, 2000.
3. S. Keshav, “An Engineering Approach to Computer Networking”, Addison Wesley publications, 2001.
4. L. L. Peterson & B. S. Davie, “Computer Networks: A System Approach”, Morgan Kaufman publishers, 4/e.

EC 6305 : Telecommunication Lab

Course Type : Professional Theory and Laboratory Practicals
Pre-requisites: EC 6301, EC 6302 & EC 6304

L	T	P	C
0	0	3	2

Course Outcomes:

- ***CO1:*** *Simulate and verify the fundamental principles in random variables*
- ***CO2:*** *Simulate and verify the fundamental principles in random processes*
- ***CO3:*** *Simulation of digital modulation schemes in the base band*
- ***CO4:*** *Simulation and verification of existing results in performance analysis of communication systems*
- ***CO5:*** *Understand how to model a communication system using simulation tools*

Total Hours : 42 Hrs.

Course objective:

To experiment the concepts introduced in the courses EC6301 (Random Processes), EC 6302(Digital Communication techniques) and EC6304 (Communication Networks)

Tools:

Numerical Computing Environments – GNU Octave or MATLAB or any other equivalent tool.

Random Processes – Generation of discrete time i.i.d. random processes with different distributions (Bernoulli, Binomial, Geometric, Poisson, Uniform, Gaussian, Exponential, Laplacian, Rayleigh, Rician) - pmf/pdf estimation, AR, MA and ARMA processes - spectral estimation - Visualization of Central Limit Theorem, Whitening Filter.

Communication system Design for Band limited Channels - Signal Design for Zero ISI and Controlled ISI - Partial Rsponse Signaling.

Carrier Phase Modulation and Quadrature Amplitude Modulation - BER Performance in AWGN channel.

Synchronization in Communication Systems: Carrier and Clock Synchronization- Frequency Offset Estimation and Correction.

Modeling and Simulation of Networks using OPNET: Unicast Routing Basics - Measurements and Statistics of Delays, Throughput, and Packet Behavior - TCP and Packet Trace Tools - Real-Audio vs. TCP-based Traffic.

TCP Connections- Congestion and Congestion Control Parameters.

MAC Protocols: CSMA and CSMA/CD in Ethernet and LAN Environments.

Multimedia Networking applications: RTSP and Transport of Video using UDP.

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.

SEMESTER-II

EC 6306 : Theory of Error Control Coding

Course Type : Professional Theory and Laboratory Practicals
Pre-requisites: A basic course in Digital Communication

L	T	P	C
4	0	0	4

Course Outcomes :

- ***CO1:*** *Understanding groups, rings, fields and vector space with emphasis on binary Galois Field*
- ***CO2:*** *Analyze linear block codes and investigate the relationship between minimum distance and error correction/detection capabilities*
- ***CO3:*** *Apply the knowledge of Galois Field arithmetic in analyzing cyclic codes.*
- ***CO4:*** *Analyze encoder and efficient decoder algorithms for convolutional codes*
- ***CO5:*** *Explore efficient design methods and the powerful soft iterative decoding techniques for high capacity codes like LDPC codes and Turbo codes*
- ***CO6:*** *Design and implement channel encoder and decoder in hardware/ software to meet the required error performance in present day communication applications*
- ***CO7:*** *Analyze the performance of the developed codes considering constraints on resources and provide innovative solutions*

Total Hours : 56 Hrs.

Module 1: (12 hours) Finite Field Arithmetic
Introduction, Groups- Rings- Fields- Arithmetic of Galois Field- Integer Ring- Polynomial Rings- Polynomials and Euclidean algorithm, primitive elements, Construction and basic properties of Finite Fields- Computations using Galois Field arithmetic- sub fields- Minimal polynomial and conjugates- Vector space- Vector Subspace- Linear independence.

Module 2: (15 hours) Linear Block Codes
Linear Block codes- Properties- Minimum Distance- Error detection and correction- Standard Array and Syndrome decoding- Hamming codes- Perfect and Quasi-perfect codes- Extended codes- Hadamard codes.

Module 3: (10 hours) Cyclic Codes

Basic theory of Cyclic codes- Generator and Parity check matrices - Cyclic encoders- Error detection & correction- decoding of cyclic codes- Cyclic Hamming codes- Binary Golay codes- BCH codes- Decoding of BCH codes-The Berlekamp- Massey decoding algorithm. Reed Solomon codes- Generalized Reed Solomon codes- MDS codes.

Module 4: (10hours) Convolutional Codes

Generator matrices and encoding- state, tree and trellis diagram- Transfer function -- Maximum Likelihood decoding Hard versus Soft decision decoding- The Viterbi Algorithm- Free distance- Catastrophic encoders.

Soft Decision and Iterative Decoding (9 hours)

Soft decision Viterbi algorithm- Two way APP decoding- Low density parity check codes- Turbo codes- Turbo decoding

References :

1. Shu Lin and Daniel. J. Costello Jr., "Error Control Coding: Fundamentals and applications", Second Edition Prentice Hall Inc, 2004.
2. R.E. Blahut, "Theory and Practice of Error Control Coding", MGH 1983.
3. W.C. Huffman and Vera Pless, "Fundamentals of Error correcting codes", Cambridge University Press, 2003.
4. Ron M. Roth "Introduction to Coding Theory" Cambridge University Press, 2006
5. Elwyn R. Berlekamp, "Algebraic Coding Theory" ,McGawHill Book Company, 1984
6. Robert McEliece "The theory of Information and Coding", Cambridge University Press, 2002
7. Sklar, ' Digital Communication', Pearson Education.

EC 6307 : Estimation & Detection Theory

Course Type : Professional Theory and Laboratory Practicals
Pre-requisites: Linear algebra, Random Process

4	0	0	4

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Course Outcomes:

- ***CO1:*** *Appreciate the need for estimation techniques in Communication and Signal Processing problems and acquire expertise in Classical and Bayesian estimation techniques for parameters and signals, and Detection of signals in the presence of white Gaussian noise*
- ***CO2:*** *Conduct in-depth analysis of estimation problems and apply suitable estimation and detection techniques that meet the constraints of the problem such as performance, bandwidth and power overheads and computational complexity*
- ***CO3:*** *Judge the scenarios under which signal or parameter estimation techniques are preferred and develop estimation techniques that are suitable for the context from a wider perspective*
- ***CO4:*** *Appreciate prior art in some chosen area outside the syllabus through exhaustive literature review, implement an appropriate work, explore the possibility of developing better solution and validate results through appropriate tools and techniques individually as well as member of a team*
- ***CO5:*** *Present findings through technical reports and oral presentations to a target group,credit the contributions of others and be responsive to critical feedbacks*
- ***CO6:*** *Acknowledge the needs of the society while designing and implementing solutions to problems that are critical to humanity*

Total Hours : 56 Hrs

Module 1: (13 Hrs) Fundamentals of Estimation Theory
Role of Estimation in Signal Processing, Unbiased Estimation, Minimum variance unbiased(MVU) estimators, Finding MVU Estimators, Cramer-Rao Lower Bound, Linear Modeling-Examples, Sufficient Statistics, Use of Sufficient Statistics to find the MVU Estimator .

Module 2 : Estimation Techniques

Deterministic Parameter Estimation: Least Squares Estimation-Batch Processing, Recursive Least Squares Estimation, Best Linear Unbiased Estimation, Likelihood and Maximum Likelihood Estimation **(9 Hrs)**
Random Parameter Estimation: Bayesian Philosophy, Selection of a Prior PDF, Bayesian linear model, Minimum Mean Square Error Estimator, Maximum a Posteriori Estimation **(6 Hrs)**
State Estimation: Prediction, Single and Multistage Predictors, Filtering, The Kalman Filter **(5 Hrs)**

Module 3 : (13 Hrs) 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), Receiver Operating Characteristic Curves.

Module 4: (10 Hrs) Detection of Signals in White Gaussian Noise (WGN)
Binary Detection of Known Signals in WGN, M-ary Detection of Known Signals in WGN, Matched Filter Approach, Detection of signals with Random Parameters

References :

1. Jerry M. Mendel, "Lessons in Estimation Theory for Signal Processing, Communication and Control,"
Prentice Hall Inc., 1995
2. Ralph D. Hippenstiel, "Detection Theory- Applications and Digital Signal Processing", CRC Press, 2002.
3. Steven M. Kay, "Statistical Signal Processing: Vol. 1: Estimation Theory, Vol. 2: Detection Theory,"
Prentice Hall Inc., 1998.
4. Bernard C. Levy, "Principles of Signal Detection and Parameter Estimation", Springer, New York, 2008.
5. Harry L. Van Trees, "Detection, Estimation and Modulation Theory, Part 1 and 2," John Wiley & Sons Inc. 1968.
6. Neel A. Macmillan and C. Douglas Creelman, "Detection Theory: A User's Guide (Sec. Edn.)" Lawrence Erlbaum Associates Publishers, USA, 2004.
7.Monson H. Hayes, "Statistical Digital Signal Processing and Modelling," John Wiley & Sons Inc.,
1996.

EC 6308: Telecommunication Lab II

Course Type : Professional Theory and Laboratory Practicals
Pre-requisites: EC6304 Communication Networks and EC6306 Theory of Error Control Coding.

L	T	P	C
0	0	3	2

Course Outcomes:

- ***CO1:*** *Analyze communication systems using simulations in Matlab, GNU Octave and specialized tools like OPNET and NS2*
- ***CO2:*** *Evaluate performance of channel codes using simulations*
- ***CO3:*** *Analyze performance of wireless channels using simulations*
- ***CO4:*** *Analyze spread spectrum communication systems using simulations*
- ***CO5:*** *Analyze different queuing and scheduling schemes and TCP performance using simulations*
- ***CO6:*** *Analyze and design adhoc and sensor networks using simulations*

Total Hours : 42 Hrs.

Course objective*:-*To experiment the concepts introduced in the courses

EC6304 Communication Networks and EC6306 Theory of Error Control Coding.

Tools*:*-Numerical Computing Environments – GNU Octave or MATLAB or any other equivalent tool and specialized tools line OPNET/NS-2 etc.

Channel Coding: Linear Block code and Convolutional codes -Viterbi Decoding – Majority Logic Decoders - CRC-32- Modeling and Simulation of Radio Channels - Multipath Fading Channels- Jake's Model- Frequency non-selective and frequency selective fading channels realization.

Spread Spectrum Communication Systems: Direct Sequence and Frequency Hopped Systems- CDMA systems.

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 Ad hoc/Sensor Networks Simulation and Evaluation.

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.

EC6309: Seminar

Course Type : Professional Theory and Laboratory Practicals
Pre-requisites: **-**NIL-

L	T	P	C
0	0	3	2

Course Outcomes:

CO1: *Capability to critically study new challenging problems, and gather all available information from the literature related to those problems.*
CO2*: Capability to collect available material from the literature that propose hard-core solutions with technical rigor to the problems considered.*
CO3: *Skill to prepare technical documentation with scientific rigor and adequate literal standards on the identified problems and solutions, strictly abiding the professional ethical values in reporting from various recourses.*
CO6: *Skill to effectively communicate the content of the technical documentation via oral presentations using modern presentation tools*

SEMESTER-III

EC7301: PROJECT WORK

L	T	P	C
0	0	0	8

- ***CO1:*** *Envisaging applications for societal needs*
- ***CO2:*** *Ability to conduct a literature survey, identify a research topic, formulate the problem and conduct its feasibility study*
- ***CO3:*** *Unfolds creative and scientific thinking*
- ***CO4:*** *Learns to use new tools effectively and creatively*
- ***CO5:****Develops ability to write Technical / Project reports, make oral presentation and demonstration of the work done to an audience*
- ***CO6:*** *Develops ability to interpret the results, identify the limitations of the work done and make suggestions to rectify them*
- ***CO7:*** *Ability to communicate innovative work in the form of journal/ conference publication*

Syllabus:

The student will be encouraged to fix the area of the project work and conduct the literature review towards the end of second semester. The project work starts in the third semester. The topic shall be research and development oriented in the emerging areas of Communication/ allied fields, under the supervision of a faculty from the ECE Department. The project can be carried out at the institute or in an industry/research organization. (Students desirous of carrying out project in industry or other organization have to fulfill the requirements as specified in the "Ordinances and Regulations for M. Tech.").

The students are supposed to complete a good quantum of the work in the third semester. There shall be evaluation of the work carried out in the third semester by the PG evaluation committee constituted by the department for Communication Stream. The project work started in the third semester will be extended to the end of the fourth semester. There shall be evaluations of the project work by the committee and by an external examiner during and at the end of fourth semester.

SEMESTER-IV

EC7302: PROJECT WORK

L	T	P	C
0	0	0	12

LIST OF ELECTIVES

EC 6321: Wireless Communication

Course Type : Professional Theory and Laboratory Practicals
Pre-requisites: Digital Communication Techniques

L	T	P	C
3	0	0	3

Course Outcomes:

CO1: *A deep level of understanding of the wireless channel models and various techniques to combat the detrimental effects of these channels on different communication systems, and a thorough understanding of modern wireless technologies.*

CO2*: Capacity to conceptualize, design, implement and evaluate existing and new wireless systems with various resource constraints.*

CO3: *Capability to critically study new challenging problems, and gather required information from available literature to solve and explore the possibility of arriving at innovative solutions.*

CO4: *Desire to explore new developments in various existing wireless technologies so as to enable design and development of more resource efficient and eco-friendly wireless technologies in the future*

CO5: *Ability to use the analytical and simulation tools procured in the lab or available in the public domain to evaluate the performance of various wireless communication systems*

CO6: *Ability to effectively communicate the findings of the software assignments/projects carried out as technical reports as well as by oral presentations*

Total Hours : 42 Hrs

Module 1: Fading and Diversity (14 hours)
Wireless Channel Models- Path loss and Shadowing models, Statistical fading models, Narrow band and wideband fading models, Review of performance of digital modulation schemes over wireless channels
Diversity- Time diversity, Frequency and Space diversity, Receive diversity, Concept of diversity branches and signal paths, Performance gains, Combining methods- Selective combining, Maximal ratio combining, Equal gain combining, performance analysis for Rayleigh fading channels, Transmit Diversity-Alamouti Scheme

Module 2: Cellular Communication (10 hours)

Cellular Networks- Multiple Access: FDMA, TDMA, Spatial reuse, Co-channel interference analysis- Hand-off, Erlang Capacity Analysis- Spectral efficiency and Grade of Service, Improving capacity - Cell splitting and sectorization.

Module 3: Spread spectrum and CDMA(10 hours)

Motivation- Direct sequence spread spectrum (DS-SS), Frequency hopping spread spectrum (FH-SS), ISI and Narrow band interference rejection, Code design- Maximal length sequences, Gold codes- Walsh codes

Diversity in DS-SS systems- Rake Receiver- Performance analysis, CDMA Systems- Interference Analysis for Broadcast and Multiple Access Channels, Capacity of cellular CDMA networks, Reverse link power control, Hard and Soft hand off strategies.

Module 4: Capacity and Standards (4 hours)

Capacity of Wireless Channels- Capacity of flat and frequency selective fading channels

Cellular Wireless Communication Standards (4 hours)

Overview of second generation cellular wireless systems: GSM and IS-95 standards, 3G systems: UMTS & CDMA 2000 standards and specifications, vision of 4G standards.

References

1.Andrea Goldsmith, "Wireless Communications", Cambridge University press, 2006.

2.T.S. Rappaport, "Wireless Communication, principles & practice", PHI, 2002.

3.Simon Haykin and Michael Moher, " Modern Wireless Communications", Person Education, 2007.

4.G.L Stuber, "Principles of Mobile Communications", 2nd edition, Kluwer Academic Publishers, 2001.

5.R.L Peterson, R.E. Ziemer and David E. Borth, "Introduction to Spread Spectrum Communication", Pearson Education, 1995.

6.A.J.Viterbi, "CDMA- Principles of Spread Spectrum", Addison Wesley, 1995.

EC 6322 : Secure Communication

Course Type : Professional Theory and Laboratory Practicals
Pre-requisites: Basic Course in Information Theory and Coding

L	T	P	C
3	0	0	3

Course Outcomes :

- ***CO1:*** *Understand the need for various cryptographic services such as ensuring confidentiality, data integrity verification and data authentication in modern communication systems through case studies*
- ***CO2:*** *Develop strong mathematical foundations from abstract algebra and number theory for the design and analysis of various cryptographic primitives such as cipher algorithms, hash function, key exchange algorithms and digital signature algorithms*
- ***CO3:*** *Analyze thoroughly various properties of basic cryptographic primitives when applied to secure communication services and develop innovative algorithms*
- ***CO4:*** *Design and implement cryptographic systems to meet the specifications in terms of security, circuit complexity and power consumption by effectively making use of various primitives*
- ***CO5:*** *Investigate latest developments in cryptography and cryptanalysis through discussions and presentations on recent literature*
- ***CO6:*** *Explore the security challenges in modern communication systems and devise new methodologies to overcome these challenges*
- ***CO7:*** *Become aware of ethical aspects of privacy in communication and social issues associated with lack of efficient systems for protection of privacy.*

Total Hours : 42 Hrs.

Module 1: (10 hours)
Rings and fields - Homomorphism- Euclidean domains - Principal Ideal Domains - Unique Factorization Domains -- Field extensions- Splitting fields - Divisibility- Euler theorem - Chinese Remainder Theorem - Primality

Module 2: (11 hours)
Basic encryption techniques - Concept of cryptanalysis - Shannon's theory - Perfect secrecy - Block ciphers - Cryptographic algorithms - Features of DES – Linear and Differential Cryptanalysis – AES - Stream ciphers - Pseudo random sequence generators – linear complexity

- Non-linear combination of LFSRs - Boolean functions – Cryptanalysis of LFSR based stream ciphers

Module 3: (11 hours)

Private key and Public key cryptosystems - One way functions - Discrete log problem – Factorization problem - RSA encryption - Diffie Hellmann key exchange - Message authentication and hash functions -Digital signatures - Secret sharing - features of visual cryptography - other applications of cryptography -

Module 4: (10 hours)

Elliptic curves - Basic theory - Weirstrass equation - Group law - Point at Infinity -Elliptic curves over finite fields - Discrete logarithm problem on EC - Elliptic curve cryptography – Integer factorization - Diffie Hellmann key exchange over EC - Elgamal encryption over EC - ECDSA

References :

1. Douglas A. Stinson, "Cryptography, Theory and Practice", 2nd edition, Chapman & Hall, CRC Press Company, Washington
2. Wade Trappe, Lawrence C. Washington, " Introduction to Cryptography with Coding Theory" Second edition – Pearson Education, 2006
3. William Stallings, " Cryptography and Network Security", 4th edition, Pearson Education, 2006
4. Lawrence C. Washington, " Elliptic Curves", Chapman & Hall, CRC Press Company, Washington.
5. David S. Dummit, Richard M. Foote, " Abstract Algebra", John Wiley & Sons
6. Evangelos Kranakis, " Primality and Cryptography", John Wiley & Sons
7. Rainer A. Ruppel, " Analysis and Design of Stream Ciphers", Springer Verlag

EC 6323: Optical Communication

Course Type : Professional Theory and Laboratory Practicals
Pre-requisites: -NIL-

L	T	P	C
3	0	0	3

Course Outcomes:

- ***CO1:*** *Understanding how optical communication provides a huge increase in bandwidth*
- ***CO2:*** *Understanding the impediments in achieving large bandwidths*
- ***CO3:*** *Developing possible ways of overcoming the issues*
- ***CO4:*** *Developing engineering models for optical fibers in terms of their eigen values and eigen functions*
- ***CO5:*** *Developing practical models including nonlinear effects without discarding the eigen analysis*
- ***CO6:*** *Understanding the basics of optical sources, optical amplifiers& detectors*
- ***CO7:*** *Gain awareness of how modulation and demodulation are performed in the optical domain*
- ***CO8:*** *To familiarize students with the performance limitations in a complete optical communication system due to system noise and nonlinearities*

Total Hours : 42 Hrs

Module 1: (10 hours)
Solution to Maxwell's equation in a circularly symmetric step index optical fiber, linearly polarized modes, single mode and multimode fibers, concept of V number, graded index fibers, total number of guided modes (no derivation), attenuation mechanisms in fibers, dispersion in single mode and multimode fibers, dispersion shifted and dispersion flattened fibers, attenuation and dispersion limits in fibers, Kerr nonlinearity, self phase modulation, combined effect of dispersion and self phase modulation.
Module 2: (9 hours)
Optical sources - LED and laser diode - Principles of operation, concepts of line width, phase noise, switching and modulation characteristics. Optical detectors - pn detector, pin detector, avalanche photodiode - Principles of operation, concepts of responsivity, sensitivity and quantum efficiency, noise in detection, typical receiver configurations (high impedance and trans-impedance receivers).
Module 3: (12 hours)
Coherent systems - Homodyne and heterodyne systems, coherent systems using PSK, FSK, ASK and DPSK modulations, related noise effects, performance degradation induced by laser phase

and intensity noise, degradation due to fiber dispersion, degradation induced by nonlinear effects in fiber propagation.

Module 4: (11 hours)

Optical amplifiers - semiconductor amplifier, rare earth doped fiber amplifier (with special reference to erbium doped fibers), Raman amplifier, Brillouin amplifier - principles of operation, amplifier noise, signal to noise ratio, gain, gain bandwidth, gain and noise dependencies, intermodulation effects, saturation induced crosstalk, wavelength range of operation.

References :

1. Leonid Kazovsky, Sergio Benedetto and Alan Willner : `Optical Fiber Communication Systems' , Artech House, 1996.
2. John Senior: `Optical Fiber Communications', Second Edition, PHI, 1992
3. Silvello Betti, Giancarlo De Marchis and Eugenio Iannone : `Coherent Optical Communications Systems', John Wiley, 1995.
4. G.P.Agrawal : `Nonlinear Fiber Optics', Second edition, Academic Press, 2000.
5. Gerd Keiser: Optical Fibre Communications (3rd Ed.), McGraw Hill, 2000.
6. John Gowar: Optical Communication Systems (2nd Ed.), Prentice Hall, 1993
7. Govind P. Agrawal: Fiber-Optic Communication Systems (3rd Ed.), John Wiley & Sons, 2002
8. C. DeCusatis: Fibre Optic Data Communication, Technological Trends and Advances, Academic Press, 2002
9. Karminvov & T. Li: Optical Fibre Telecommunications, Vol A&B, Academic Press 2002
10. William Shieh and Ivan Djordjevic: OFDM for optical communications, Academic Press, 2009
11. Stephen B Alexander: Optical communication Receiver Design, IEE, 1997

EC6324 : Selected Topics in Networks

Course Type : Professional Theory and Laboratory Practicals
Pre-requisites: EC6304 Communication Networks, EC6321 Wireless Communication

L	T	P	C
3	0	0	3

Course Outcomes:

- ***CO1:*** *Analyze the 802.11 MAC protocol to find throughput and latency*
- ***CO2:*** *Analyze various enhancements done to TCP and IP to improve performance of wireless networks*
- ***CO3:*** *Analyze MAC and routing protocols used in adhoc networks*
- ***CO4:*** *Analyze data gathering and MAC protocols used in wireless sensor networks*
- ***CO5:*** *Analyze localization algorithms used in wireless sensor networks*

Total Hours : 42 Hrs

Module 1 (12 hours)
Wireless LANs and PANs: IEEE 802.11 WLANs - protocol architecture, physical layer, MAC layer, analysis, deployment of 802.11 infrastructure; WPANs –Bluetooth, ZigBee, UWB.

Module 2 (10 hours)
Mobile Network and Transport Layers: Mobile IP; Traditional TCP, Indirect TCP,Snooping TCP, Mobile TCP; TCP/IP protocol stack over IEEE 802.11b; wireless adaptation layer (WAL).

Module 3 (10 hours)
Mobile Ad-Hoc Networks (MANETS): Introduction; MAC Protocols - classification, comparative analysis; Routing - reactive and proactive routing, power-aware routing, performance comparison; Quality of Service.

Module 4 (10 hours)
Wireless Sensor Networks (WSNs): Overview/Architectures; Data Dissemination/Data Gathering; MAC Protocols; Power control; cross layer design; Localization.

References :

1. C. Siva Ram Murthy and B. S. Manoj, “Ad Hoc Wireless Networks: Architectures and Protocols”, Pearson Education, Inc., 2005.
2. Holger Karl and Andreas Willig, Protocols and Architectures for Wireless Sensor Networks, John Wiley & Sons, 2005.
3. Charles E Perkins, “Ad Hoc Networking”, Addison Wesley, 2001.

4. Jochen Schiller, “Mobile Communications”, Addison Wesley, 2000.
5. Ramjee Prasad and Luis Munoz, “WLANs and WPANs towards 4G wireless”, Artech House, 2003.
6.Current papers from JSAC, IEEE Trans. Networking, IEEE Trans. Wireless Communications, INFOCOM, MOBICOM.

EC 6325 : MIMO Communication Systems

Course Type : Professional Theory and Laboratory Practicals
Pre-requisites: EC6303 and EC6321

L	T	P	C
3	0	0	3

Course Outcomes :

- ***CO1:*** *Introduce Multiple Input Multiple Output (MIMO) Communication Systems*
- ***CO2:*** *Compare MIMO Systems with Single Input Single Output (SISO) Systems*
- ***CO3:*** *Analyse the Information Theoretic advantages of MIMO Systems*
- ***CO4:*** *Analyse the spatial multiplexing properties of MIMO*
- ***CO5:*** *Introduce and analyse space time codes*
- ***CO6:*** *Prove the existence of some space time codes*

Total Hours : 42 Hrs.

Module 1: (12 hours) Information Theoretic aspects of MIMO
Review of SISO fading communication channels, MIMO channel models, Classical i.i.d. and extended channels, Frequency selective and correlated channel models, Capacity of MIMO channels, Ergodic and outage capacity, Capacity bounds and Influence of channel properties on the capacity.

Module 2: (12 hours) MIMO Diversity and Spatial Multiplexing
Sources and types of diversity, analysis under Rayleigh fading, Diversity and channel knowledge. Alamouti space time code, MIMO spatial multiplexing. Space time receivers. ML, ZF, MMSE and Sphere decoding, BLAST receivers and Diversity multiplexing trade-off.

Module 3: (9 hours) Space Time Block Codes
Space time block codes on real and complex orthogonal designs, Code design criteria for quasi-static channels (Rank, determinant and Euclidean distance), Orthogonal designs, Generalized orthogonal designs, Quasi-orthogonal designs and Performance analysis.

Module 4: (9 hours) Space Time Trellis Codes
Representation of STTC, shift register, generator matrix, state-transition diagram, trellis diagram, Code construction, Delay diversity as a special case of STTC and Performance analysis.

References :

1. David Tse and Pramod Viswanath, “Fundamentals of Wireless Communication”, Cambridge University Press 2005
2. Hamid Jafarkhani, “Space-Time Coding: Theory and Practice”, Cambridge University Press 2005
3. Paulraj, R. Nabar and D. Gore, “ *Introduction to Space-Time Wireless Communications”*, Cambridge University Press 2003
4. E.G. Larsson and P. Stoica, “Space-Time Block Coding for Wireless Communications”, Cambridge University Press 2008
5. Ezio Biglieri , Robert Calderbank et al “MIMO Wireless Communications” Cambridge University Press 2007

EC6326 : Markov Modeling & Theory of Queues

Course Type : Professional Theory and Laboratory Practicals
Pre-requisites: EC6301 Random Processes

L	T	P	C
3	0	0	3

Course Outcomes :

- ***CO1:*** *Understand the mathematical preliminaries required for the performance modeling of telecommunication networks*
- ***CO2:*** *Demonstrate knowledge in the domain of discrete event stochastic processes including renewal and regenerative processes, Markov processes and Semi-Markov processes.*
- ***CO3:*** *Understand the theory of discrete and continuous time Markov chains and their characterization*
- ***CO4:*** *Develop an understanding of the various queueing models and their applications in telecommunications and networking*
- ***CO5:*** *Acquire the expertise to analyse a given queueing model and evaluate some key performance measures such as blocking probability, average queue length and delay statistics using first principles*
- ***CO6:*** *Demonstrate the ability to build simulation model for a queuing system, conduct performance evaluation and present the results in the form of technical reports and oral presentations*
- ***CO7:*** *Demonstrate the ability to analyse open and closed open queueing networks*
- ***CO8:*** *Develop an aptitude for doing research in the broad area of communication networking*

Total Hours : 42 Hrs

Module 1:(12hrs)
Stochastic Processes: Renewal Processes - Reward and Cost Models, Poisson Process; Point Processes; Regenerative Processes; Renewal Theorems. (12hrs)

Module 2 : (10hrs)

Markov Models: Discrete Time Markov Chain - Transition Probabilities, Communication Classes, Irreducible Chains; Continuous Time Markov Chain - Pure-Jump Continuous-Time Chains, Regular Chains, Birth and Death Process, Semi-Markov Processes.

Module 3 : (10hrs)

Single Class & Multi-class Queuing Networks: Simple Markovian queues; M/G/1 queue; G/G/1 queue; Open queuing networks; Closed queuing networks; Mean value analysis; Multi-class traffic model; Service time distributions; BCMP networks; Priority systems.

Module 4 : (10hrs)

Time Delays and Blocking in Queuing Networks: Time delays in single server queue; Time delays in networks of queues; Types of Blocking; Two finite queues in a closed network; Aggregating Markovian states.

References :

1. Ronald W. Wolff, Stochastic Modeling and The Theory of Queues, Prentice-Hall International, Inc, 1989.
2. Peter G. Harrison and Naresh M. Patel, Performance Modeling of Communication Networks and Computer Architectures, Addison-Wesley, 1992.
3. Gary N. Higginbottom, Performance Evaluation of Communication Networks, Artech House, 1998.
4. Anurag Kumar, D. Manjunath, and Joy Kuri, Communication Networking: An Analytical Approach, Morgan Kaufman Publ. 2004.
5. D. Bertsekas and R. Gallager, Data Networks, Prentice Hall of India, 2001.
6. Ross, K.W., Multiservice Loss Models for Broadband Telecommunication Networks, Springer-Verlag, 1995.
7. Walrand, J., An Introduction to Queueing Networks, Prentice Hall, 1988.
8. Cinlar, E., Introduction to Stochastic processes, Prentice Hall, 1975.
9. Karlin, S. and Taylor, H., A First course in Stochastic Processes, 2nd edition Academic press, 1975.

EC6327 : Spread Spectrum & CDMA Systems

Course Type : Professional Theory and Laboratory Practicals
Pre-requisites: EC 6321: Wireless Communication/ EC6302Digital communication techniques

L	T	P	C
3	0	0	3

Course Outcomes:

- ***CO1:*** *Justify the need for spread spectrum systems over narrow band systems.*
- ***CO2:*** *Study different spreading sequences and assess their correlation properties*
- ***CO3:*** *Analyze the performance of spread spectrum systems under jamming and fading environments*
- ***CO4:*** *Introduction to cellular principles and capacity assessment*
- ***CO5:*** *Survey of different multiuser detectors and their interference mitigation capabilities*
- ***CO6:*** *State of the art of recent practical CDMA systems*

Total Hours : 42 Hrs.

Module 1: (10 Hrs) Fundamentals of Spread Spectrum
Introduction to spread spectrum communication, direct sequence spread spectrum, frequency-hop spread spectrum system. Spreading sequences- maximal-length sequences, gold codes, Walsh orthogonal codes- properties and generation of sequences. Synchronization and Tracking: delay lock and tau-dither loops, coarse synchronization- principles of serial search and match filter techniques.

Module 2: (11 Hrs) Performance Analysis of SS system
Performance of spread spectrum system in jamming environments- Barrage noise jamming, partial band jamming, pulsed noise jamming and single tone jamming. Error probability of DS-CDMA system under AWGN and fading channels, RAKE receiver

Module 3: (13 Hrs) Capacity, Coverage and multiuser detection
Basics of spread spectrum multiple access in cellular environments, reverse Link power control, multiple cell pilot tracking, soft and hard handoffs, cell coverage issues with hard and soft handoff, spread spectrum multiple access outage, outage with imperfect power control, Erlang capacity of forward and reverse links. Multi-user Detection -MF detector, decorrelating detector, MMSE detector. Interference Cancellation: successive, Parallel Interference Cancellation, performance analysis of multiuser detectors and interference cancellers.

Module 4: (8 Hrs) CDMA Systems

General aspects of CDMA cellular systems, IS-95 standard, Downlink and uplink, Evolution to Third Generation systems, WCDMA and CDMA-2000 standards, Principles of Multicarrier communication, MCCDMA and MC-DS-CDMA.

References :

1.R. L. Peterson, R. Ziemer and D. Borth, “Introduction to Spread Spectrum Communications,” Prentice Hall, 1995.
2.A. J. Viterbi, “CDMA - Principles of Spread Spectrum Communications,” Addison-Wesley, 1997.
3.S. Verdu, “ Multiuser Detection” , Cambridge University Press- 1998
4.M. K. Simon, J. K. Omura, R. A. Scholts and B. K. Levitt, “ Spread Spectrum Communications Handbook”, McGraw- Hill, Newyork-1994
5.Cooper and McGillem, “Modern Communications and Spread Spectrum” McGraw- Hill, 1985.
6.J. G. Proakis, “Digital Communications,” McGraw Hill, 4th ed.
7.S. Glisic and B. Vucetic, “Spread Spectrum CDMA Systems for Wireless Communications,” Artech House, 1997

EC6328 : Communication Switching & Multiplexing

Course Type : Professional Theory and Laboratory Practicals
Pre-requisites: EC6304 Communication Networks

L	T	P	C
3	0	0	3

Course Outcomes:

CO1: *A deep level of understanding of the mathematical theory of switching, circuit switching and packet switching principles and architectures, and a thorough understanding of the performance of switched networks.*

CO2*: Capacity to conceptualize, design, implement and evaluate wired and wireless communication systems that involve circuit or packet switches and/or statistical multiplexing*

CO3: *Desire to explore new developments in various existing and evolving resource allocation and sharing techniques so as to enable design and development of more resource efficient and eco-friendly network technologies in the future.*

CO4: *Ability to use the analytical, simulation, and experimental tools procured in the lab or available in the public domain to evaluate the performance of various communication and network systems*

CO5: *Ability to effectively communicate the findings of the software assignments/projects carried out as technical reports as well as by oral presentations*

Total Hours : 42 Hrs.

Module 1: (10 hours)
Switching: Performance and architectural issues: Packet switches- Circuit switches. Time and Space division switching - Point to point circuit switching - multistage switching network - Paull's matix for representing connections - Strict sense non-blocking Clos network. Generalized circuit switching- Cross Point Complexity (CPC)- Fast packet switching- Self routing Banyan networks- Combinatorial limitations of Banyan networks.

Module 2: (10 hours)
Types of blocking for a packet switch- Output conflicts- HOL blocking. Traffic analysis: Traffic measurements, arrival distributions, Poisson process, holding/service time distributions, loss systems, lost calls cleared – Erlang-B formula, lost calls returning and lost calls held models, lost calls cleared and held models with finite sources, delay systems, Little's theorem, Erlang-C formula , M/G/1 model. Blocking probability: Analysis of single stage and multistage networks –

Blocking for Unique path routing- Alternate path routing- The Lee approximation – The Jacobaeus method.

Module 3:(10 hours)
Multiplexing: Network performance and source characterization; Stream sessions in packet networks - deterministic analysis, stochastic analysis, circuit multiplexed networks; Elastic transfers in packet networks - adaptive bandwidth sharing.

Module 4: (12 hours)
Statistical multiplexing: blocking analysis in circuit multiplexed networks, with single rate or multirate traffic- Models for performance analysis of integrated packet networks; deterministic models, worst case analysis; stochastic models, large deviations analysis. The effective Bandwidth approach for Admission control - Models for traffic flow in packet networks, long range dependence and self similar processes.

References

1. A. Kumar, D. Manjunath, J. Kuri, Communication Networking: An Analytical Approach, Morgan Kaufman Publishers, 2004.
2. Hui, J.Y., Switching and Traffic Theory for Integrated Broadband Networks, Kluwer, 1990

EC6329: Selected Topics in Communication

Course Type : Professional Theory and Laboratory Practicals
Pre-requisites: EC6304 Communication Networks, EC6321 Wireless Communication & EC6302 Digital Communication Techniques

L	T	P	C
3	0	0	3

Course Outcomes :

- ***CO1:*** *Design sophisticated equalization techniques to correct the amplitude and phase distortion effects that may be present in signals received through a wireless communication channel*
- ***CO2:*** *Gain insight on the need for advanced digital modulation techniques that saves bandwidth and/or power depending on the constraints of applications and evaluate the performance of such modulation techniques*
- ***CO3:*** *Appreciate the need for multicarrier communication techniques for providing next generation wireless communication services at high data rate and high mobility and possess knowledge on dealing with the impairments that can be experienced by such systems*
- ***CO4:*** *Mathematically model multiuser communication systems from an information theoretic point of view under various types of channel conditions*
- ***CO5:*** *Appreciate the latest developments outside the syllabus in cutting edge areas of communication through exhaustive literature review and implementation of an appropriate work through appropriate tools and techniques individually or member of a team*
- ***CO6:*** *Present findings through technical reports and oral presentations to a target group through individual or group activities*
- ***CO7:*** *Acknowledge the needs of the society while designing and implementing solutions to advanced communication problems that are critical to humanity*

Total Hours : 42 Hrs.

Module 1:(10 Hrs)
Communication over band limited channels: Optimum Pulse shape design for digital signaling through band limited AWGN channels- Optimum demodulation of digital signals in the presence of ISI and AWGN- Equalization- Zero forcing equalizer, fractionally spaced equalizer, transversal

filter equalizer, constrained complexity equalizer, adaptive linear equalizer, adaptive DFE, pass band equalization.

Module 2: (10 Hrs)
Constant Envelope Modulation Schemes: QPSK- Staggered QPSK- Differentially encoded QPSK- QPSK - Power Spectral Density considerations. Continuous Phase Modulation (CPM) schemes- CPFSK, MSK, SFSK, Gaussian MSK. Coding for bandwidth constrained channels- Trellis Coded Modulation (TCM) – Unger boeck Trellis Coding -TCM Encoding & Decoding.

Module 3: (12Hrs)
Multicarrier Digital Communication: Introduction to OFDM- Modeling of OFDM for Time varying random channels- Clipping in Multicarrier Systems- Bit loading and Peak-to average Power ratio- Synchronization in OFDM Systems- Time & frequency offset-Timing and frame synchronization- Phase Noise effects- Channel estimation and Equalization- Channel Coding in OFDM Systems - OFDM based multiple access technologies.

Module 4: (10Hrs)
Multiuser Information Theory: Review of Information Theory- Basics Entropy, mutual information, AEP, Source & Channel Coding Theorems- Single User Gaussian Channels AWGN Channel, Parallel Channels, Fading Channels, MIMO channels- Multiple-Access Channels: Discrete Memory less, Gaussian, and MIMO. - Broadcast Channel: Discret Memory less, Degraded, Gaussian, and MIMO. Interference Channel: Discrete Memory less, Strong & Very Strong Interference, Gaussian. Relay Channel: Discrete Memory less, Degraded, and Gaussian.

References :

1. Edward A. Lee & David G. Messerschmitt: “Digital Communication”, Kluwer Academic Publishers, 3/e, 2003.
2. Ahmad R. S. Bahai, Burton R. Saltzberg, Mustafa Ergen, “Multi-carrier Digital Communications: Theory and Applications of OFDM”, Springer, 2/e, 2004.
3. T. Cover and Thomas, “Elements of Information Theory”, John Wiley & Sons, 2/e

EC6330: Network Security

Course Type : Professional Theory and Laboratory Practicals
Pre-requisites: EC6304 Communication Networks

L	T	P	C
3	0	0	3

Course Outcomes:

CO1: Knowledge of the objectives for various cryptographic services such as confidentiality, data integrity verification and data authentication in communication networks

CO2: A deep understanding of the mathematical foundations from abstract algebra and number theory for the design and analysis of various cryptographic primitives such as cipher algorithms, hash function, key exchange algorithm, digital signature algorithms, and key management.

CO3: Ability to analyze thoroughly various properties of basic cryptographic primitives when applied to different types of wireless networks and develop innovative algorithms to address the security challenges in evolving wireless networks

CO4: Investigate latest developments in cryptography and cryptanalysis through discussions and presentations on recent literature

CO5: Become aware of ethical aspects of privacy in communication and social issues associated with lack of efficient systems for protection of privacy.

Total Hours : 42 Hrs

Module 1: (10 hours)
Introduction: Basic objectives of cryptography, secret-key and public-key cryptography, Block ciphers: Modes of operation, DES and its variants, AES, linear and differential cryptanalysis, stream ciphers, message digest algorithms: properties of hash functions, MD5 and SHA-1, keyed hash functions, attacks on hash functions.

Module 2:(12 hours)
Modular arithmetic, gcd, primality testing, Chinese remainder theorem, finite fields. Intractable problems: Integer factorization problem, RSA problem, discrete logarithm problem, Diffie-Hellman problem, Publickey encryption: RSA, Elliptic curve cryptography. Key exchange: Diffie-

Hellman algorithms. Digital signatures: RSA, DSS, DSA, ECDSA, blind signatures, threshold cryptography, key management.

Module 3:(15 hours)

Network Security – Electronic Mail Security- Pretty Good Privacy – S/MIME – IP security – overview and architecture – authentication header – encapsulating security payload – combing security associations – web security requirements Secure Socket Layer and Transport Layer Security – secure electronic transactions, Authentication applications: X-509, Kerberos, RADIUS.

Module 4: (5 hours)

Wireless network security - WEP, WPA2 (802.11i), security in Bluetooth.

References

1. Stallings, W. "Cryptography and network security : principles and practice". 4th ed. Upper Saddle River: Prentice Hall, 2006. ISBN 0-13-187316-4.

2. Stallings, "Network security essentials applications and standards", Pearson education, 1999.

3. Menezes, A. J.; Van Oorschot, P. C.; Vanstone, S. A. "Handbook of applied cryptography", Boca Ratón [etc.]: CRC Press, 1997. ISBN 0-8493-8523-7.

4. Stajano, F. Security for ubiquitous computing. Chichester: John Wiley and Sons, 2002. ISBN 0-470- 84493-0.