Department of Electronics and Communication Engineering
Birla Institute of Technology, Mesra, Ranchi - 835215 (India)

Institute Vision

To become a Globally Recognized Academic Institution in consonance with the social, economic and ecological environment, striving continuously for excellence in education, research and technological service to the National needs.

Institute Mission

- To educate students at Undergraduate, Post Graduate Doctoral and Post-Doctoral levels to perform challenging engineering and managerial jobs in industry.
- To provide excellent research and development facilities to take up Ph.D. programmes and research projects.
- To develop effective teaching and learning skills and state of art research potential of the faculty.
- To build national capabilities in technology, education and research in emerging areas.
- To provide excellent technological services to satisfy the requirements of the industry and overall academic needs of society.

Department Vision

To become a centre of excellence in teaching and research for creating technical manpower to meet the technological needs of the country in the field of Electronics and Communications Engineering.

Department Mission

- To facilitate state of the art Education and Research at Undergraduate, Post Graduate and Doctoral levels to enable to perform challenging engineering and managerial jobs in the field of Electronics and Communication Engineering.
- To build national capabilities in Technology, Education and Research in emerging areas in the field of Electronics and Communication Engineering.
- To create an environment to provide excellent Research and Development facilities to strengthen Ph.D. Programmes and Research Projects.
- To provide excellent Technological Services to bridge the gap between Academics and Industry in order to fulfill the overall academic needs of the society.
- To provide high quality Course Structure in order to turn out qualified professionals to meet the engineering needs of the country.
- To develop effective Teaching Skills and the Research Potentials of the faculty members.
- To ensure All Round Development of the students and to create a platform for turning out engineering professionals who can assume leadership position in society.

M. Tech. (Wireless Communication)

Programme Educational Objectives (PEOs)

PEO1	To enable students to acquire in-depth knowledge in the field of wireless communication technology with an ability to integrate existing and new knowledge with the advancement of the technology.
PEO2	To develop students to critically analyze the problems in the field of wireless communication technology and find optimal solution.
PEO3	To train students to conduct research and experiments by applying appropriate techniques and tools with an understanding of the limitations for sustainable development of society.
PEO4	To prepare students to act as a member and leader of the team to contribute positively to manage projects efficiently in the field of wireless communication technology.
PEO5	To train students to effectively communicate, write reports, create documentation and make presentations by adhering to appropriate standards.
PEO6	To stimulate students for life-long learning with enthusiasm and commitment to improve knowledge and competence continuously.

Program Outcomes (POs)

After completion of the programme, students will be able to demonstrate

PO1	**A**n ability to independently carry out research /investigation and development work to solve practical problems.
PO2	**A**n ability to write and present a substantial technical report/document.
PO3	A degree of mastery in wireless communication technology at a level higher than the requirements in the appropriate bachelor program.
PO4	An ability to create, select and apply appropriate techniques and tools to undertake activities in the field of wireless communication technology with an understanding of the limitations.
PO5	Professional and intellectual integrity, professional code of conduct, ethics of research with an understanding of responsibility to contribute in the field of wireless communication technology for sustainable development of society.
PO6	Understanding of engineering with management principles to apply the same as a member and leader in a team to manage projects efficiently in the field of wireless communication technology.

1st Semester

Programme Core

COURSE INFORMATION SHEET

Course code: EC510
Course title: Wireless Communication and Networks
Pre-requisite(s): EC369, EC327
Co- requisite(s): Nil
Credits: L: 3 T: 0 P: 0 C: 3
Class schedule per week: 03
Class: M. Tech.
Semester / Level: I/05
Branch: ECE

Course Objectives:
This course aims to develop

1	An understanding on functioning of wireless communication system and evolution of different wireless communication systems and standards.
2	An ability to compare recent technologies used for wireless communication.
3	An ability to explain the architecture, functioning, protocols, capabilities and application of various wireless communication networks.
4	An ability to explain multiple access techniques for Wireless Communication
5	An ability to evaluate design challenges, constraints and security issues associated with Ad-hoc wireless networks.

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

CO1	Demonstrate their understanding on functioning of wireless communication system and evolution of different wireless communication systems and standards.
CO2	Compare different technologies used for wireless communication systems.
CO3	Explain the architecture, functioning, protocols, capabilities and application of various wireless communication networks.
CO4	Demonstrate an ability explain multiple access techniques for Wireless Communicatio
CO5	Demonstrate an ability to evaluate design challenges, constraints and security issues associated with Ad-hoc wireless networks.

SYLLABUS

Module 1: Overview of wireless communication, cellular communication, different generations and standards in cellular communication system, satellite communication including GPS, wireless local loop, cordless phone, paging systems, RFID.

(8L)

Module 2: Recent wireless technologies: multicarrier modulation, OFDM, MIMO system, diversity-multiplexing trade-off, MIMO-OFDM system, smart-antenna; beamforming and MIMO, cognitive radio, software defined radio, communication relays, spectrum sharing.

(8L)

Module 3: Multiple access techniques in wireless communication: contention-free multiple access schemes (FDMA TDMA, CDMA, SDMA and Hybrid), contention-based multiple access schemes (ALOHA and CSMA).

(8L)

Module 4: Wireless personal area networks (Bluetooth, UWB and ZigBee), wireless local area networks (IEEE 802.11, network architecture, medium access methods, WLAN standards), wireless metropolitan area networks (WiMAX).

(8L)

Module 5: Ad-hoc wireless networks: Design Challenges in Ad-hoc wireless networks, concept of cross layer design, security in wireless networks, energy constrained networks. MANET and WSN. Wireless system protocols: mobile network layer protocol (mobile IP, IPv6, dynamic host configuration protocol), mobile transport layer protocol (traditional TCP, classical TCP improvements), support for mobility (wireless application protocol).

(8L)

Books recommended:

Textbooks:

1. Andrea Goldsmith, "Wireless Communications", Cambridge University Press, 2005.
2. Sanjay Kumar, "Wireless Communication the Fundamental and Advanced Concepts" River Publishers, Denmark, 2015 (Indian reprint).

Reference books:

1. Vijay K Garg, "Wireless Communications and Networks", Morgan Kaufmann Publishers an Imprint of Elsevier, USA 2009 (Indian reprint)
2. J. Schiller, "Mobile Communication" 2/e, Pearson Education, 2012.
3. Iti Saha Misra, "Wireless Communication and Networks: 3G and Beyond", 2/e, McGraw Hill Education (india) Private Ltd, New Delhi, 2013.

Gaps in the syllabus (to meet Industry/Profession requirements): Nil

POs met through Gaps in the Syllabus: N/A

Topics beyond syllabus/Advanced topics/Design: Current technological developments in wireless communication systems.

POs met through Topics beyond syllabus/Advanced topics/Design: PO3

Course Outcome (CO) Attainment Assessment Tools and Evaluation Procedure

Direct Assessment

Assessment Tools	% Contribution during CO Assessment
Continuous Internal Assessment	50
Semester End Examination	50

Continuous Internal Assessment	% Distribution
3 quizzes	30 (3×10)
Assignment(s)	10
Seminar before a committee	10

Assessment Components	CO1	CO2	CO3	CO4	CO5
Continuous Internal Assessment					

Semester End Examination					

Indirect Assessment

1. Student Feedback on Faculty
2. Student Feedback on Course

Course Delivery Methods

CD1	Lecture by use of boards/LCD projectors/OHP projectors
CD2	Assignments
CD3	Laboratory experiments/teaching aids/Seminars
CD4	Industrial/guest lectures
CD5	Industrial visits/in-plant training
CD6	Self- learning such as use of NPTEL materials and internets
CD7	Simulation

Mapping Between Course Outcomes and Program Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6
CO1	1	1	3	3	2	1
CO2	1	1	3	2	2	1
CO3	2	2	3	3	1	1
CO4	2	1	3	3	1	1
CO5	3	2	3	3	1	1

< 34% = 1, 34-66% = 2, > 66% = 3

Mapping Between Course Outcomes and Course Delivery Method

Course Outcomes	Course Delivery Method
CO1	CD1, CD2, CD6
CO2	CD1, CD2, CD6
CO3	CD1, CD2, CD6
CO4	CD1, CD2, CD6
CO5	CD1, CD2, CD3, CD7

COURSE INFORMATION SHEET

Course code: EC512
Course title: Stochastic Processes and Information Theory
Pre-requisite(s): EC324
Co- requisite(s):
Credits: L: 3 T: 0 P: 0 C: 3
Class schedule per week: 03
Class: M. Tech.
Semester / Level: I/05
Branch: ECE

Course Objectives

This course enables the students:

1	To conceptualize random variable and stochastic process with real time examples.
2	To impart fundamental knowledge of information theory and several source coding techniques for efficient representation.

3	To understand channel capacity and coding techniques to achieve efficient as well as reliable communication.
4	To Measure information in diverse areas of Electronics communication Engineering.
5	Demonstrate an ability to evaluate design challenges and constraints issues associated with measurement of information transfer rate for numerous applications.

Course Outcomes

After the completion of this course, students will be able to:

CO1.	Apply the concept of probability theory and stochastic process to understand the Basics of information theory.
CO2.	Measure information from a discrete as well as continuous source and evaluate entropy under several conditions.
CO3.	Compute the capacity of discrete and continuous time channels in presence and absence of noise.
CO4.	Select practical solutions to complex communication engineering problems with information theoretic view.
CO5	Demonstrate an ability to evaluate design challenges and constraints issues associated with measurement of information transfer rate for numerous applications.

SYLLABUS

MODULE 1: Random processes: stationarity; mean, correlation, and covariance functions, WSS random process; autocorrelation and cross-correlation functions; transmission of a random process through a linear filter; power spectral density; white random process; Gaussian process; Poisson process.

(8L)

MODULE 2: Introduction to Information theory: Entropy, Relative Entropy, Mutual Information; Asymptotic Equipartition Property; Entropy rates of a stochastic process, Differential entropy; Source coding: Kraft's inequality; Huffman coding; Arithmetic codes & Lempel-Ziv codes, Coding for sources with memory.

(8L)

MODULE 3: Channel Capacity and coding: Noisy channel coding theorem; Converse of noisy channel coding theorem; Channel capacity of discrete memory less channels; Gaussian Channel; Parallel Gaussian Channel.

(8L)

MODULE 4: Rate Distortion Theory: Calculation of rate- distortion function (Binary Source, Gaussian Source); Converse to the rate- distortion function; Computation of channel capacity and the rate distortion function.

(8L)

MODULE 5: Network Information Theory: Gaussian Multiple-User Channels, Multiple access channel, Encoding of correlated sources, Broad cast channel, Relay channel, Source coding with side information and Multi-terminal Networks.

(8L)

Books recommended:

Textbooks:

1. Thomas M. Cover, Joy A. Thomas, "Elements of Information Theory", 2nd Edition, John Wiley & Sons, 2006.

2. Robert G. Gallager, “Information Theory and Reliable Communications”, John Wiley & Sons, 1968.

Reference books: N/A

Gaps in the syllabus (to meet Industry/Profession requirements): Nil

POs met through Gaps in the Syllabus: N/A

Topics beyond syllabus/Advanced topics/Design: Current technological developments in stochastic processes.

POs met through Topics beyond syllabus/Advanced topics/Design: PO3

Course Outcome (CO) Attainment Assessment Tools and Evaluation Procedure

Direct Assessment

Assessment Tools	% Contribution during CO Assessment
Continuous Internal Assessment	50
Semester End Examination	50

Continuous Internal Assessment	% Distribution
3 quizzes	30 (3×10)
Assignment(s)	10
Seminar before a committee	10

Assessment Components	CO1	CO2	CO3	CO4	CO5
Continuous Internal Assessment					
Semester End Examination					

Indirect Assessment

1. Student Feedback on Faculty
2. Student Feedback on Course

Course Delivery Methods

CD1	Lecture by use of boards/LCD projectors/OHP projectors
CD2	Assignments
CD3	Laboratory experiments/teaching aids/Seminars
CD4	Industrial/guest lectures
CD5	Industrial visits/in-plant training
CD6	Self- learning such as use of NPTEL materials and internets
CD7	Simulation

Mapping of Course Outcomes onto Program Outcomes

Course Outcome	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	3	2	1	2	2
CO2	3	3	2	2	2	1
CO3	3	3	2	3	3	2
CO4	2	3	3	3	2	2
CO5	3	2	3	3	1	1

< 34% = 1, 34-66% = 2, > 66% = 3

Mapping Between Course Outcomes and Course Delivery Method

Course Outcomes	Course Delivery Method
CO1	CD1, CD2, CD6
CO2	CD1, CD2, CD6
CO3	CD1, CD2, CD6
CO4	CD1, CD2, CD6
CO5	CD1, CD2, CD3, CD7

COURSE INFORMATION SHEET

Course code: EC503
Course title: Antennas and Diversity
Pre-requisite(s): EC257 Electromagnetic Fields and Waves, EC323 Microwave Theory & Techniques
Co- requisite(s): Nil
Credits: L: 3 T: 0 P: 0 C: 3
Class schedule per week: 03
Class: M. Tech.
Semester / Level: I/05
Branch: ECE
Name of Teacher:

Course Objectives:
This course enables the students to:

1.	Develop and apply the mathematical tools to analyse radiation characteristics of aperture antennas.
2.	Design and analyse various broadband, high gain, planar antennas for wireless applications.
3.	Design and analyse the dielectric resonator antenna
4.	Understand the concept of smart antenna and beam forming techniques by using cellular radio system and its evolution
5.	Explain the need of different diversity schemes used in wireless communication

Course Outcomes:
After the completion of this course, students will be able to:

CO1	Understand the concept of aperture antennas, dielectric resonator antennas and their applications
CO2	Develop the mathematical tool to analyse radiation characteristics of antennas for wireless applications
CO3	Design the various types of aperture dielectric resonator antennas to evaluate its performance
CO4	Explain and compare different diversity scheme, smart antennas and algorithms.
CO5	Combine different diversity scheme to enhance system performance

SYLLABUS

Module I: Aperture Antennas: Radiation Equations, Rectangular Apertures: Uniform Distribution on an infinite ground plane, Uniform distribution in Space, Circular Apertures: Uniform Distribution on an infinite ground plane, Design Considerations**.**

(8L)

Module II: Antennas for Wireless Communication: Helical, Normal mode, Axial mode, Design procedure, feed design for helical antenna, Horn Antenna; E-Plane, H-Plane, Pyramidal horn, Whip antenna, Discone antenna.

(8L)

Module III: Dielectric Resonator Antenna: Introduction to Dielectric Resonator Antennas. Major Characteristics, Simple-Shaped Dielectric Resonator Antennas - The Hemispherical DRA. The Cylindrical DRA. The Rectangular DRA, Coupling to DRAs, Hybrid DRAs Bandwidth Enhancement of DRAs, Low Profile and Compact DRAs, DRAs with High Dielectric Constants, Circular-Polarized and Dual-Polarized DRAs, Ferrite Resonator Antennas.

(8L)

Module IV: Smart Antenna: Introduction, Cellular Radio Systems Evolution, Signal propagation, Diversity and Combining Techniques, Smart Antenna System, Benefits and drawbacks of Smart Antennas, Antenna beamforming**.**

(8L)

Module V: Diversity Schemes: Macroscopic diversity scheme, Microscopic diversity scheme – Space diversity, Field diversity, Polarization diversity, Angle diversity, Frequency diversity and time diversity scheme. Combining techniques for Macroscopic diversity, Combining techniques for Microscopic diversity.

(8L)

Books recommended:

Textbooks:

1. Antenna Theory, Analysis and Design, 3/E, A. Balanis, John Wiley.
2. Antennas, J. D. Kraus, TMH
3. Wireless Communications, Principles and Practices, Rappaport, PHI

Reference books:

1. Software Radio A Modern Approach to Radio Engineering, J. H. Reed, Pearson Education.
2. Wireless and Cellular Communications, William C. Y. Lee, McGraw-Hill
3. Wireless Communications, Principles and Practices, Rappaport, PHI
4. Smart Antenna, T. K. Sarkar

Gaps in the syllabus (to meet Industry/Profession requirements): Design and Development of real-time industrial projects.

POs met through Gaps in the Syllabus: PO4 & PO5

Topics beyond syllabus/Advanced topics/Design: Design optimization for industrial and Research projects.

POs met through Topics beyond syllabus/Advanced topics/Design: PO4 & PO5

Course Outcome (CO) Attainment Assessment Tools and Evaluation Procedure

Direct Assessment

Assessment Tools	% Contribution during CO Assessment
Continuous Internal Assessment	50
Semester End Examination	50

Continuous Internal Assessment	% Distribution
3 quizzes	30 (3×10)
Assignment(s)	10
Seminar before a committee	10

Assessment Components	CO1	CO2	CO3	CO4	CO5
Continuous Internal Assessment					
Semester End Examination					

Indirect Assessment

1. Student Feedback on Faculty
2. Student Feedback on Course

Course Delivery Methods

CD1	Lecture by use of boards/LCD projectors/OHP projectors
CD2	Assignments
CD3	Laboratory experiments/teaching aids/Seminars
CD4	Industrial/guest lectures
CD5	Industrial visits/in-plant training
CD6	Self- learning such as use of NPTEL materials and internets
CD7	Simulation

Mapping Between Course Outcomes and Program Outcomes

CO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3		1	3		
CO2	3	2	1	3		1
CO3	3	1	2	3	2	1
CO4	3	2	2	3	2	2
CO5	3	3	3	3	3	3

< 34% = 1, 34-66% = 2, > 66% = 3

Mapping Between Course Outcomes and Course Delivery Method

Course Outcomes	Course Delivery Method
CO1	CD1, CD6
CO2	CD1, CD2, CD3, CD7
CO3	CD1, CD2, CD3, CD6, CD7
CO4	CD1, CD3, CD6, CD7
CO5	CD1, CD2, CD3, CD4, CD5, CD7

Programme Elective – I

COURSE INFORMATION SHEET

Course code: EC513
Course title: Spread Spectrum Techniques and Multiple Access
Pre-requisite(s): EC510, EC301
Co- requisite(s): Nil
Credits: L: 3 T: 0 P: 0 C: 3
Class schedule per week: 03
Class: M. Tech.
Semester / Level: I/05
Branch: ECE

Course Objectives:
This course aims to develop

1	An understanding of spread-spectrum concept and its implementation in various systems.
2	An ability to understand binary sequences and its generation.
3	An ability to evaluate performance of various Spread–Spectrum Systems in Jamming Environments
4	An ability to design and provide solutions for practical and efficient system and Multiple Access Techniques.
5	An ability to explain various types of CDMA standards and multi user detection.

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

CO1	Demonstrate their understanding on functioning of a spread-spectrum system and minimize the design challenges.
CO2	Have an ability to demonstrate several pseudo random sequences and its applications
CO3	To design a broadband spread –spectrum under in Jamming Environments.
CO4	Demonstrate an ability to explain various multiple access techniques,
CO5	Have an ability to provide practical solutions and apply the subject expertise for the welfare of the society.

SYLLABUS

Module -1: Introduction to Spread-Spectrum Systems: Direct-sequence Spread−Spectrum for BPSK, QPSK, MSK, Frequency-Hop Spread Spectrum: Coherent and Non-coherent, Hybrid Direct−Sequence/ Frequency−Hop Spread Spectrum.

(8L)

Module -2: Binary Shift – Register Sequences for Spread- Spectrum Systems: Definitions, Finite field Arithmetic, Sequence Generator fundamentals, State –Machine Representation of Shift Register Generators, Maximal length - Sequences, Gold codes, orthogonal codes, Walsh codes.

(8L)

Module -3: Performance of Spread–Spectrum Systems in Jamming Environments: AWGN jamming, Partial – band jamming, pulsed noise jamming, single tone jamming, multiple - tone jamming.

(8L)

Module -4: Multiple Access Techniques: Frequency Division Multiple Access, Time Division Multiple Access, Code Division Multiple Access, Space Division Multiple Access and Orthogonal Frequency Division Multiple Access, ALOHA, Slotted ALOHA, Carrier Sense

Multiple Access, Packet Reservation Multiple Access, Busy Tone Multiple Access, Digital Sense Multiple Access.

(8L)

Module -5: Specific Application of CDMA Digital cellular Systems: cdma one, cdma 2000 and WCDMA: Carrier Spacing & Deployment Scenarios, Logical & Physical Channels, Hand over, Spread Spectrum Receivers: RAKE Receiver, Multiuser Detection (MUD).

(8L)

Books recommended:

Textbooks:

1. Introduction to Spread Spectrum Communications: Roger L. Peterson, R. E. Ziemer, David E. Borth , Pearson Education.

Reference books:

1. Wideband CDMA for Third Generation Mobile Communications-T. Ojanpera & R. Prasad, Artech House, 1992
2. Wireless Communication –Principles & Practice – T.S.Rappaport, Pearson Edu., 2002.
3. Cellular Mobile Systems Engineering-S. Faruque, Artech House, 1996.

Gaps in the syllabus (to meet Industry/Profession requirements): Nil

POs met through Gaps in the Syllabus: N/A

Topics beyond syllabus/Advanced topics/Design: Current technological developments in spread spectrum techniques.

POs met through Topics beyond syllabus/Advanced topics/Design: PO3

Course Outcome (CO) Attainment Assessment Tools and Evaluation Procedure

Direct Assessment

Assessment Tools	% Contribution during CO Assessment
Continuous Internal Assessment	50
Semester End Examination	50

Continuous Internal Assessment	% Distribution
3 quizzes	30 (3×10)
Assignment(s)	10
Seminar before a committee	10

Assessment Components	CO1	CO2	CO3	CO4	CO5
Continuous Internal Assessment					
Semester End Examination					

Indirect Assessment

1. Student Feedback on Faculty
2. Student Feedback on Course

Course Delivery Methods

CD1	Lecture by use of boards/LCD projectors/OHP projectors
CD2	Assignments
CD3	Laboratory experiments/teaching aids/Seminars

CD4	Industrial/guest lectures
CD5	Industrial visits/in-plant training
CD6	Self- learning such as use of NPTEL materials and internets
CD7	Simulation

Mapping Between Course Outcomes and Program Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6
CO1	1	1	3	3	1	1
CO2	1	1	2	1	1	1
CO3	2	1	3	2	1	1
CO4	1	1	3	2	1	1
CO5	3	2	3	2	1	1

< 34% = 1, 34-66% = 2, > 66% = 3

Mapping Between Course Outcomes and Course Delivery Method

Course Outcomes	Course Delivery Method
CO1	CD1,CD2,CD6
CO2	CD1, CD2, CD6
CO3	CD1, CD2, CD6
CO4	CD1, CD2, CD6
CO5	CD1,CD2,CD3, CD7

COURSE INFORMATION SHEET

Course code: EC522
Course title: Advanced Digital Signal Processing
Pre-requisite(s): B.E. /B. Tech. in ECE/EEE with basic courses on Digital Signal Processing
Co- requisite(s): Linear Algebra
Credits: L: 3 T: 0 P: 0 C: 3
Class schedule per week: 03
Class: M. Tech.
Semester / Level: I/05
Branch: ECE
Name of Teacher:

Course Objectives:
This course enables the students to:

1.	To understand the concept of signals and systems and filters.
2.	To impart knowledge on various transformation techniques.
3.	To impart knowledge on multirate signal processing and its applications.
4.	An understanding on optimum linear filters and power spectral estimation.
5.	Enhance skills to apply the filter design and spectral estimation in various applications.

Course Outcomes:
At the end of the course, a student should be able to:

CO1	Develop an understanding to concept of signals and systems and to design filters.
CO2	Have an ability to analyze and apply various single and multi-domain transformation techniques.

CO3	Have an ability to apply multirate signal processing on various engineering applications.
CO4	Develop an ability to apply use optimum linear filters and power spectral estimation.
CO5	Aspire for pursuing a carrier in signal processing, robotics and IOT, recognize the need to learn and adapt to the change in technology and play role of team leader or supporter of team.

SYLLABUS

Module I: Review of Signals and Systems, Sampling and data reconstruction processes, Z transforms. Chirp Z Algorithm, Goertzel's Algorithm, Discrete linear systems, Digital filter design and structures: Basic FIR/IIR filter design &structures, design techniques of linear phase FIR filters,IIR filters by impulse invariance, bilinear transformation, FIR/IIR Cascaded lattice structures.

(8L)

Module II: DSP Transforms: Fourier transform, Discrete sine and cosine transform, Discrete Hartely transform, short time Fourier transform, wavelet transform, Hilbert transform, Hilbert-Huang transform, Stockwell transform.

(8L)

Module III: Multi rate DSP, Decimators and Interpolators, Sampling rate conversion, multistage decimator & interpolator, poly phase filters, QMF, digital filter banks, Multi resolution signal analysis, wavelet decomposition, Applications in subband coding.

(8L)

Module IV: Linear prediction and Optimum Linear Filters: Random signals and power spectra, Forward and backward Linear prediction, solutions of the normal equations, AR lattice and ARMA lattice-ladder filters, Wiener filters.

(8L)

Module V: Power spectrum estimation: Estimation of Spectra from Finite-Duration Observations of Signals. Nonparametric Methods for Power Spectrum Estimation, Parametric Methods for Power Spectrum Estimation, Minimum-Variance Spectral Estimation, Eigenanalysis Algorithms for Spectrum Estimation.

(8L)

Books recommended:

Textbooks:

1. J.G.Proakis and D.G.Manolakis"Digital signal processing: Principles, Algorithm and Applications", 4th Edition, Prentice Hall, 2007. (T1)
2. N. J. Fliege, "Multirate Digital Signal Processing: Multirate Systems -Filter Banks – Wavelets", 1st Edition, John Wiley and Sons Ltd, 1999.
3. S. Haykin and T. Kailath, Adaptive Filter Theory, Pearson Education, 4th Edition, 2005.

Reference books:

1. Digital Signal Processing 3/E by S.K.Mitra TMH Edition.
2. Fundamentals of adaptive filtering, A. H. Sayed, Wiley, 2003.
3. Monson H. Hayes, Statistical Digital Signal Processing and Modelling, Wiley, 2002

Gaps in the syllabus (to meet Industry/Profession requirements): Design of real-time industrial projects.

POs met through Gaps in the Syllabus: PO5 & PO6

Topics beyond syllabus/Advanced topics/Design: Design optimization for industrial projects, Adaptive systems.

POs met through Topics beyond syllabus/Advanced topics/Design: PO5 & PO6

Course Outcome (CO) Attainment Assessment Tools and Evaluation Procedure

Direct Assessment

Assessment Tools	% Contribution during CO Assessment
Continuous Internal Assessment	50
Semester End Examination	50

Continuous Internal Assessment	% Distribution
3 quizzes	30 (3×10)
Assignment(s)	10
Seminar before a committee	10

Assessment Components	CO1	CO2	CO3	CO4	CO5
Continuous Internal Assessment					
Semester End Examination					

Indirect Assessment

1. Student Feedback on Faculty
2. Student Feedback on Course

Course Delivery Methods

CD1	Lecture by use of boards/LCD projectors/OHP projectors
CD2	Assignments
CD3	Laboratory experiments/teaching aids/Seminars
CD4	Industrial/guest lectures
CD5	Industrial visits/in-plant training
CD6	Self- learning such as use of NPTEL materials and internets
CD7	Simulation

Mapping Between Course Outcomes and Program Outcomes

CO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	1	2	2	2	1	1
CO2	2	2	2	2	1	1
CO3	2	2	2	2	1	1
CO4	2	2	2	2	1	1
CO5	1	1	2	3	3	3

< 34% = 1, 34-66% = 2, > 66% = 3

Mapping Between Course Outcomes and Course Delivery Method

Course Outcomes	Course Delivery Method
CO1	CD1, CD6, CD2
CO2	CD1, CD6, CD7, CD2
CO3	CD1, CD2, CD3, CD6, CD7

CO4	CD1, CD3, CD6, CD7
CO5	CD1, CD2, CD3, CD4, CD5

COURSE INFORMATION SHEET

Course code: EC515
Course title: Wireless Adhoc and Sensor Networks
Pre-requisite(s): EC510, EC353
Co- requisite(s): Nil
Credits: L:3 T:0 P:0 C: 3
Class schedule per week: 03
Class: M. Tech.
Semester / Level: I/05
Branch: ECE

Course Objectives:
This course aims to develop

1	An understanding of the concept of wireless adhoc and wireless sensor network with its major challenges.
2	An understanding of WSN architecture and its design principles.
3	Fundamental understanding on MAC and routing protocols.
4	An ability to evaluate Localization And Positioning techniques in wireless adhoc and wireless sensor network.
5	An ability to design and provide solutions for practical low cost, energy efficient, reliable and secure wireless sensor network.

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

CO1	Have an ability to evaluate wireless adhoc & sensor network based on its performance as well as minimize the design challenges.
CO2	Have an ability to demonstrate several architectures of WSN and provide a new design solution according to the required applications.
CO3	Have an ability to design several MAC, Routing and transport protocols for WSNs.
CO4	Have an ability to provide practical solutions and apply the subject expertise for the welfare of society.
CO5	Demonstrate several Localization & Positioning techniques in wireless adhoc & sensor network.

SYLLABUS

MODULE I: Introduction to Wireless Ad Hoc And Sensor Networks: Fundamentals of Wireless Communication Technology, The Electromagnetic Spectrum, Radio propagation Mechanisms, Characteristics of the Wireless Channel, mobile ad hoc networks (MANETs) and wireless sensor networks (WSNs): concepts and architectures, Applications of Ad Hoc and Sensor networks, Design Challenges in Ad hoc and Sensor Networks.

(8L)

MODULE II: Single Node and Network Architecture**:** single node architecture: hardware and software components of a sensor node, WSN Network Architecture: typical network architectures-data relaying and aggregation strategies, Energy consumption of sensor nodes,

Operating system and execution environments, sensor network scenarios, Optimization goals and figures of merit, Design principles of WSNs.

(8L)

MODULE III: Mac Protocols for Wireless Sensor Networks**:** Fundamental of MAC protocols, MAC protocols for WSNs, Low duty cycle protocols and wakeup concepts, contention based and scheduled based protocols (LEACH, SMACS, TRAMA), IEEE 802.15.4 MAC protocols, Topology control and clustering.

(8L)

MODULE IV: Routing Protocols and Transport Control Protocols For WSN: Routing challenges and design issues in WSNs, Wireless network routing protocols, Energy efficient unicast routing, energy efficient broadcast /multicast routing, Geographical routing, traditional transport control protocols, Design issues of transport control protocols, CODA, ESRT, RMST, PSFQ, GRAUDA and Ad hoc Transport protocols (ATP).

(8L)

MODULE V: Localization and Positioning: Properties of localization and positioning procedures, Possible approaches: Proximity, Trilateration and Triangulation, Mathematical basics for the lateration problem, single hop localization, positioning in multi-hop environment.

(8L)

Books recommended:

Textbooks:

1. Kazem Sohraby, Daniel Minoli, Taieb Znati, "Wireless Sensor Networks', John Wiley & Sons Inc. Publication, 2007(8)
2. Holger Karl, and Andreas Willig, "Protocols and Architectures for Wireless Sensor Networks" John Wiley & Sons Inc. Publication.

Reference books:

1. XiangYang Li, "Wireless Adhoc and Sensor Networks: Theory and Applications", Cambridge university press, USA, 2008.

Gaps in the syllabus (to meet Industry/Profession requirements): Nil

POs met through Gaps in the Syllabus: N/A

Topics beyond syllabus/Advanced topics/Design: Current technological developments of sensor networks in emerging applications.

POs met through Topics beyond syllabus/Advanced topics/Design: PO3

Course Outcome (CO) Attainment Assessment Tools and Evaluation Procedure

Direct Assessment

Assessment Tools	% Contribution during CO Assessment
Continuous Internal Assessment	50
Semester End Examination	50

Continuous Internal Assessment	% Distribution
3 quizzes	30 (3×10)
Assignment(s)	10
Seminar before a committee	10

Assessment Components	CO1	CO2	CO3	CO4	CO5
Continuous Internal Assessment					
Semester End Examination					

Indirect Assessment

1. Student Feedback on Faculty
2. Student Feedback on Course

Course Delivery Methods

CD1	Lecture by use of boards/LCD projectors/OHP projectors
CD2	Assignments
CD3	Laboratory experiments/teaching aids/Seminars
CD4	Industrial/guest lectures
CD5	Industrial visits/in-plant training
CD6	Self- learning such as use of NPTEL materials and internets
CD7	Simulation

Mapping Between Course Outcomes and Program Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6
CO1	1	1	2	2	2	1
CO2	1	1	3	2	1	1
CO3	1	2	2	3	1	1
CO4	2	1	1	3	1	1
CO5	1	1	2	3	1	1

< 34% = 1, 34-66% = 2, > 66% = 3

Mapping Between Course Outcomes and Course Delivery Method

Course Outcomes	Course Delivery Method
CO1	CD1, CD2, CD6
CO2	CD1, CD2, CD6
CO3	CD1, CD2, CD6
CO4	CD1, CD2, CD6
CO5	CD1, CD2, CD3, CD7

COURSE INFORMATION SHEET

Course code: EC516
Course title: Wireless Multimedia Communication
Pre-requisite(s): EC431
Co- requisite(s): Nil
Credits: L: 3 T: 0 P: 0 C: 3
Class schedule per week: 03
Class: M. Tech.
Semester / Level: I/05
Branch: ECE

Course Objectives:

This course aims to develop

1	An understanding of the fundamental concept of multimedia communication and it type.
2	An understanding of multimedia processing in wireless communications, its challenges and multimedia processors.
3	An understanding, how to efficiently represent multimedia data and how to deliver them over a variety of networks. Also, able to understand distributed multimedia system and multimedia conferencing standards.
4	An understanding of state-of-the-art multimedia coding standards, including MPEG-x, H.26x, and scalable video coding (SVC).
5	An ability to design and provide solutions for practical robust, energy efficient, reliable and secure multimedia communication system.

Course Outcomes

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

CO1	Have an ability to explain a wireless multimedia communication system and its design challenges.
CO2	Demonstrate multimedia processing and various multimedia processors.
CO3	Have an ability to demonstrate several multimedia standards and provide a new design solution according to the target applications.
CO4	To design a video codec system for sending multimedia over the Internet and wireless networks, where video adaptation, error resilience, error concealment, and quality of service are also considered.
CO5	Have an ability to provide practical solutions and apply the subject expertise for the welfare of the society.

SYLLABUS:

MODULE I: Introduction: Multimedia communication through wired and wireless channels: An Introduction, multimedia sources, applications of multimedia networks, Audio-Visual Integration: Media interaction, Audio-to-Visual mapping, Joint audio-video coding.

(8L)

MODULE II: Multimedia processing in wireless communications**:** Challenges of multimedia information processing for wireless channels, Image & video coding, Signal processing for networked multimedia, NNs for multimedia processing, Multimedia processors.

(8L)

MODULE III: Distributed multimedia system and Multimedia conferencing standards**:** Main features of a distributed multimedia system, Resource management of distributed multimedia system and networking, Multimedia operating systems, Multimedia conferencing standards: H.320, H.323.

(8L)

MODULE IV: Multimedia communication standards: MPEG approach to standardization, MPEG-1, MPEG-2, MPEG-4, H.261 standard, H.264 standard, Scalable video coding, Multimedia multiplex and Synchronization.

(8L)

MODULE V: Multimedia communications across wired and wireless networks: Packet audio/video in the network environment, Video transport across generic networks, Multimedia transport across IP network, Multimedia across wireless.

(8L)

Books recommended:

Textbooks:

1. Multimedia Communication Systems: Techniques, Standards, and Networks by K.R.Rao, Zoran S. Bojkovic, and D.A. Milovanovic. Pearson Education Asia, 2002.
2. Compressed Video over Networks, edited by Ming-Ting Sun and Amy R. Reibman, Marcel Dekker Inc., Switzerland, 2000.

Reference books:

1. Multimedia over IP and Wireless Networks: Compression, networking, and Systems, by Mihaela van der Schaar. And Philip Chou, Academic Press, 2007.

Gaps in the syllabus (to meet Industry/Profession requirements): Nil

POs met through Gaps in the Syllabus: N/A

Topics beyond syllabus/Advanced topics/Design: Current technological developments in wireless multimedia communication.

POs met through Topics beyond syllabus/Advanced topics/Design: PO3

Course Outcome (CO) Attainment Assessment Tools and Evaluation Procedure

Direct Assessment

Assessment Tools	% Contribution during CO Assessment
Continuous Internal Assessment	50
Semester End Examination	50

Continuous Internal Assessment	% Distribution
3 quizzes	30 (3×10)
Assignment(s)	10
Seminar before a committee	10

Assessment Components	CO1	CO2	CO3	CO4	CO5
Continuous Internal Assessment					
Semester End Examination					

Indirect Assessment

1. Student Feedback on Faculty
2. Student Feedback on Course

Course Delivery Methods

CD1	Lecture by use of boards/LCD projectors/OHP projectors
CD2	Assignments
CD3	Laboratory experiments/teaching aids/Seminars
CD4	Industrial/guest lectures
CD5	Industrial visits/in-plant training
CD6	Self- learning such as use of NPTEL materials and internets
CD7	Simulation

Mapping Between Course Outcomes and Program Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6
CO1	2	1	2	2	2	1

CO2	1	2	3	2	1	1
CO3	1	2	3	3	1	1
CO4	2	1	1	3	1	1
CO5	1	1	2	3	1	1

< 34% = 1, 34-66% = 2, > 66% = 3

Mapping Between Course Outcomes and Course Delivery Method

Course Outcomes	Course Delivery Method
CO1	CD1, CD2, CD6
CO2	CD1, CD2, CD6
CO3	CD1, CD2, CD6
CO4	CD1, CD2, CD6
CO5	CD1, CD2, CD3, CD7

COURSE INFORMATION SHEET

Course Code: EC 517
Course title: Satellite Based Wireless Communication
Pre-requisite(s): EC357, EC419
Co-requisite(s): Nil
Credits: L: 3 T: 0 P: 0 C: 3
Class schedule per week: 03
Class: M. Tech.
Semester / Level: I/05
Branch: ECE

Course Objectives

This course aims to

1	An understanding on Satellite communication system, satellite sub system and earth station.
2	An ability to evaluate the impact of interference on the satellite communication and complete link design.
3	An ability to analyze different system parameters, causes of impairments in satellite communication system
4	An understanding of Multiple access techniques to support satellite communication and special satellite systems

Course Outcomes:

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

CO1	Demonstrate an understanding on orbital and functional principles of satellite Communication, Satellite sub system and Earth station system.
CO2	Architect, Interpret and select appropriate technologies for implementation of specified satellite communication systems.
CO3	Analyze and evaluate a satellite link and suggest enhancements to improve the link performance
CO4	Demonstrate an understanding of advancement and multiple access techniques to support satellite communication. And various satellite systems
CO5	Demonstrate an understanding of satellite communication for various applications

SYLLABUS

Module -1: Origin, History, Current Technology and Overview of Satellite Communication Sytem, Satellite Orbits, Kepler's law, Orbital Mechanics and Orbital Elements, Azimuth and Elevation, Coverage Angle and Slant Range, Look angle determination, Eclipse effect, Sun transit outage, Placement of a satellite in a geostationary orbit, Station keeping and Stabilization.

(8L)

Module -2; Basic Radio Transmission Theory, Uplink and Downlink Design, Design of Satellite Links for Specified Carrier-to-Noise plus Interference Ratio, Noise figure and Noise temperature. Absorbitive Attenuation Noise by Atmospheric Gases, Rain Attenuation, Noise due to Rain, Rain Depolarization, Tropospheric Multipath and Scintillation Effects. Interference Analysis, Interference to and from Adjacent Satellite Systems, Terrestrial Interference, Cross-polarization Interference, Intermodulation Interference.

(8L)

Module -3: Frequency Division Multiple Access-SCPC, MCPC. Time Division Multiple Access- random (ALOHA, S-ALOHA) and time synchronized access. Code Division Multiple Access-Fixed and On-demand Assignment.

(8L)

Module -4: Advantages and Disadvantages of Multibeam Satellites, Interconnection by Transponder Hopping, Interconnection by On-board Switching, Interconnection by Beam Scanning, On-Board Processing, Intersatellite Links.

(8L)

Module -5: Fixed Point Satellite Network, INTELSAT, Mobile Satellite Network, INMARSAT, Low Earth Orbit and Medium Earth Orbit Satellite Systems, Very Small Aperture Terminal (VSAT) Network, Direct Broadcast Satellite Systems, Global Positioning System.

(8L)

Books recommended:

Textbooks:

1. Digital Satellite Communications, 2/e, McGraw-Hill, 1990.Tri T. Ha

Reference books:

1. Satellite Communications, John Willey and Sons, 2000T. Pratt, C.W. Bostian
2. Satellite Communications Systems Engineering, Pearson Education, 2/e; 2003 W.L.
3. Prichard, H.G. Suyderhoud and R.A. Nelson

Gaps in the syllabus (to meet Industry/Profession requirements): Nil

POs met through Gaps in the Syllabus: NA

Topics beyond syllabus/Advanced topics/Design: Design aspects of various component of analog communication system.

POs met through Topics beyond syllabus/Advanced topics/Design: PO2

Course Outcome (CO) Attainment Assessment Tools and Evaluation Procedure

Direct Assessment

Assessment Tools	% Contribution during CO Assessment
Continuous Internal Assessment	50
Semester End Examination	50

Continuous Internal Assessment	% Distribution
3 quizzes	30 (3×10)
Assignment(s)	10
Seminar before a committee	10

Assessment Components	CO1	CO2	CO3	CO4	CO5
Continuous Internal Assessment					
Semester End Examination					

Indirect Assessment

1. Student Feedback on Faculty
2. Student Feedback on Course

Course Delivery Methods

CD1	Lecture by use of boards/LCD projectors/OHP projectors
CD2	Assignments
CD3	Laboratory experiments/teaching aids/Seminars
CD4	Industrial/guest lectures
CD5	Industrial visits/in-plant training
CD6	Self- learning such as use of NPTEL materials and internets
CD7	Simulation

Mapping between Course Outcomes and Program Outcomes

CO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	2	2	1	-	-
CO2	3	3	3	3	2	-
CO3	3	3	3	3	2	-
CO4	3	3	3	3	3	-
CO5	3	3	3	3	3	-

< 34% = 1, 34-66% = 2, > 66% = 3

Mapping Between Course Outcomes and Course Delivery Method

Course Outcomes	Course Delivery Method
CO1	CD1, CD2, CD3, CD6
CO2	CD1, CD2, CD3, CD6, CD7
CO3	CD1, CD2, CD3, CD6, CD7
CO4	CD1, CD2, CD3, CD6, CD7
CO5	CD1, CD2, CD3, CD6, CD7

COURSE INFORMATION SHEET

Course code: EC509
Course title: RF Microelectronics Circuit Design
Pre-requisite(s): EC201 Electronic Devices, EC253 Analog Circuits
Co- requisite(s):
Credits: L: 3 T: 0 P: 0 C: 3
Class period per week: 03
Class: M. Tech.
Semester / Level: I/05

Branch: ECE
Name of Teacher:

Course Objectives:
This course enables the students to:

1.	Understand RF frequency response of MOSFET.
2.	Grasp the RF Technology and basic concepts in RF design and apply the same.
3.	Appraise communication concepts and analyze transceiver architectures.
4.	Appraise and evaluate the basic blocks in RF systems such as LNA, Mixer and VCO and their VLSI implementations.
5.	Comprehend the characteristics of RF synthesizers and Power Amplifiers and create their circuits.

Course Outcomes:
After the completion of this course, a student will be able to:

CO1	Illustrate and Interpret RF frequency response of MOSFET.
CO2	Sketch and explain the RF technology and basic concepts in RF design.
CO3	Diagram and explain communication concepts in transceiver architectures.
CO4	Appraise the basic blocks in RF systems such as LNA, Mixer and VCO, schematize, assess and summarize their features.
CO5	Design and schematize basic blocks in RF systems such as RF Synthesizer and Power Amplifiers. Schematize their characteristics and prepare an inference.

SYLLABUS

Module -1:
RF frequency response of MOSFET:
Derivation and estimation of MOS capacitor, MOS capacitor in cutoff, linear and saturation region, derivation and estimation of MOSFET's long-channel model including threshold voltage, body effect, transconductance (g_m), output conductance (g_{ds}), small-signal output resistance (r_o), A Medium-Frequency Small-Signal Model for the Intrinsic Part, Intrinsic Transition Frequency, Noise in MOSFET: white noise, flicker noise, High frequency Small-Signal Model, Transition Frequency (f_T) and Maximum oscillation (f_{max}) of MOSFET.

(8L)

Module -2:
RF technology and basic concepts in RF design:
Introduction to RF and Wireless Technology: Challenges in RF Design, Complexity Comparison, Design Bottleneck, Applications, Choice of Technology; Basic concepts in RF Design: Units in RF Design, Time Variance, Nonlinearity, Effects of nonlinearity; Noise as Random Process, effect of transfer function on noise, device Noise, Representation of Noise in Circuits. Sensitivity and Dynamic Range.

(8L)

Module -3:
Communication concepts and transceiver architectures:
Analog modulation, Digital modulation, Spectral Regrowth, Mobile RF Communications, Multiple Access techniques Wireless standards; Receiver Architectures: Basic Heterodyne Receivers, Modern Heterodyne Receivers, Direct-Conversion Receivers, Image Reject Receivers, Low-IF Receivers; Transmitter Architectures: Direct-Conversion Transmitters, Modern Direct-Conversion Transmitters, Heterodyne Transmitters.

(8L)

Module -4:

Basic blocks in RF systems and their VLSI implementation:
Low Noise Amplifier: General considerations, Problem of input matching, Basic LNA Topologies (Common-Source Stage with Inductive Load, Common-Source Stage with Resistive Feedback). Mixers: General Considerations, Active Down-conversion Mixers, Improved Mixer Topologies. Oscillators: Performance Parameters, Voltage-Controlled Oscillators (VCOs), LC VCOs with Wide Tuning Range, Basic concepts and effect of phase noise, Design procedure, LO Interface, Mathematical Model of VCOs, Basic concepts quadrature oscillators.

(8L)

Module -5:
Radio Frequency Synthesizer and Power Amplifiers:
Phase-locked loops: Basic concepts, Type-I PLLs, Type-II PLLs (Phase/Frequency detectors, Charge-pump PLLs). Radio Frequency Synthesizes: General considerations, Basic integer-N synthesizer, Basic concepts of fractional-N synthesizers. Power Amplifiers: General Considerations, Classification of Power Amplifiers, High-Efficiency Power Amplifiers.

(8L)

Books recommended:
Textbooks:

1. John W. M. Rogers, Calvin Plett, Radio Frequency Integrated Circuit Design, Artech House, 2010.
2. Yannis Tsividis, Colin McAndrew, Operation and Modeling of MOS Transistor, Oxford University Press, 3rd edition, 2011.
3. Behzad Razavi, RF Microelectronics, 2e, Prentice Hall, 2011.

Reference books:

1. Samuel Y. Liao, Microwave Devices and Circuits, 3e, Prentice-Hall of India, 2003.
2. Paul R. Gray, Paul J. Hurst, Stephen H. Lewis and Roberst G. Meyer, Analysis and Design of Analog Integrated Circuits, 5/e, Wiley, 2009.
3. The Design of CMOS Radio-Frequency Integrated Circuits by Thomas H. Lee. Cambridge University Press, 2004.

Gaps in the syllabus (to meet Industry/Profession requirements): Hands-on-practical for RF IC (Radio Frequency Integrated Circuit) fabrication.

POs met through Gaps in the Syllabus: PO6 will be met though RF circuit design-based assignment, which involves handling of RF equipments and CAD tools.

Topics beyond syllabus/Advanced topics/Design: Microelectronic Circuit Designs related to Digital, Analog and Mixed-Signal (such as ADC and DAC).

POs met through Topics beyond syllabus/Advanced topics/Design: PO6

Course Outcome (CO) Attainment Assessment Tools and Evaluation Procedure
Direct Assessment

Assessment Tools	% Contribution during CO Assessment
Continuous Internal Assessment	50
Semester End Examination	50

Continuous Internal Assessment	% Distribution
3 quizzes	30 (3×10)
Assignment(s)	10

Seminar before a committee	10

Assessment Components	CO1	CO2	CO3	CO4	CO5
Continuous Internal Assessment					
Semester End Examination					

Indirect Assessment

1. Student Feedback on Faculty
2. Student Feedback on Course

Course Delivery Methods

CD1	Lecture by use of boards/LCD projectors/OHP projectors
CD2	Assignments
CD3	Laboratory experiments/Teaching aids/Seminars
CD4	Mini Projects
CD5	Industrial visits/in-plant training
CD6	Self- learning such as use of NPTEL materials and internets
CD7	Simulation

Mapping between Course Outcomes and Program Outcomes

CO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	3	3	3	2	1
CO2	3	3	3	3	2	1
CO3	3	3	1	3	2	1
CO4	2	2	2	2	3	2
CO5	2	2	2	2	3	2

< 34% = 1, 34-66% = 2, > 66% = 3

Mapping between Course Outcomes and Course Delivery Method

Course Outcomes	Course Delivery Method
CO1	CD1, CD2, CD3, CD6
CO2	CD1, CD2, CD3, CD6, CD7
CO3	CD1, CD2, CD3, CD6, CD7
CO4	CD1, CD2, CD3, CD6, CD7
CO5	CD1, CD2, CD3, CD6, CD7

Open Elective-1

COURSE INFORMATION SHEET

Course code: EC548
Course title: Introduction to Wireless Communication
Pre-requisite(s): EC369
Co- requisite(s): Nil
Credits: L: 3 T: 0 P: 0 C: 3
Class schedule per week: 03
Class: M. Tech.

Semester / Level: I/05
Branch: ECE

Course Objectives:
This course aims to develop

1	An understanding on functioning of various example wireless communication systems, their evolution and standards.
2	An understanding on cellular communication system, architecture, functioning, various standards
3	An understanding on signal propagation in cellular environment
4	An ability to explain multiple access techniques for Wireless Communication
5	An understanding on architecture, functioning, protocols, capabilities and application of various wireless communication networks.

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

CO1	Demonstrate an understanding on functioning of various example wireless communication systems, their evolution and standards.
CO2	Demonstrate an understanding on cellular communication system, architecture, functioning, various standards
CO3	Demonstrate an understanding on signal propagation in cellular environment.
CO4	Demonstrate an ability explain multiple access techniques for Wireless Communication
CO5	Demonstrate an understanding on architecture, functioning, protocols, capabilities and application of various wireless communication networks.

SYLLABUS

Module1: An overview of wireless communication and future vision. Wireless communication system and standards: satellite communication system, GPS, paging system, cordless phone, wireless local loop, RFID.

(8L)

Module 2: The cellular fundamentals: cellular communication and frequency reuse, general architecture of a cellular system, channel assignment strategies, hand-off in a cellular system. Interference and cellular system capacity: co-channel interference and adjacent channel interference, power control, evolution of mobile cellular communication: different generations of mobile cellular communication (1G, 2G. 2.5G, 3G and beyond), typical cellular standards (AMPS, GSM, GPRS, WCDMA, LTE, concept of LTE-advanced), 4G features and challenges, 5G vision.

(8L)

Module 3: Signal propagation in mobile communication: mobile cellular environment, multipath propagation and fading, free space propagation model, propagation path loss, outdoor propagation models (Okumura model & Hata model), indoor propagation models, power delay profile, channel parameters (delay spread, doppler spread, coherence bandwidth, coherence time, LCR and ADF).

(8L)

Module 4: Wireless Communication Networks: Wireless Personal Area Networks (Bluetooth, UWB and ZigBee), Wireless Local Area Networks (IEEE 802.11, network architecture, medium access methods, WLAN standards), Wireless Metropolitan Area Networks (WiMAX), Ad-hoc Wireless Networks.

(8L)

Module 5: Multiple access schemes: duplexing schemes, FDMA, TDMA, SDMA, spread spectrum technique and CDMA, OFDMA, ALOHA and CSMA.

(8L)

Books recommended:

Textbooks:

1. Andrea Goldsmith, "Wireless Communications", Cambridge University Press, 2005.
2. Sanjay Kumar, "Wireless Communication the Fundamental and Advanced Concepts" River Publishers, Denmark, 2015 (Indian reprint).

Reference books:

1. Vijay K Garg, "Wireless Communications and Networks", Morgan Kaufmann Publishers an Imprint of Elsevier, USA 2009 (Indian reprint)
2. J. Schiller, "Mobile Communication" 2/e, Pearson Education, 2012.
3. Iti Saha Misra, "Wireless Communication and Networks: 3G and Beyond", 2/e, McGraw Hill Education (India) Private Ltd, New Delhi, 2013.

Gaps in the syllabus (to meet Industry/Profession requirements): Nil

POs met through Gaps in the Syllabus: N/A

Topics beyond syllabus/Advanced topics/Design: Current technological developments in wireless communication systems.

POs met through Topics beyond syllabus/Advanced topics/Design: PO3

Course Outcome (CO) Attainment Assessment Tools and Evaluation Procedure

Direct Assessment

Assessment Tools	% Contribution during CO Assessment
Continuous Internal Assessment	50
Semester End Examination	50

Continuous Internal Assessment	% Distribution
3 quizzes	30 (3×10)
Assignment(s)	10
Seminar before a committee	10

Assessment Components	CO1	CO2	CO3	CO4	CO5
Continuous Internal Assessment					
Semester End Examination					

Indirect Assessment

1. Student Feedback on Faculty
2. Student Feedback on Course

Course Delivery Methods

CD1	Lecture by use of boards/LCD projectors/OHP projectors

CD2	Assignments
CD3	Laboratory experiments/teaching aids/Seminars
CD4	Industrial/guest lectures
CD5	Industrial visits/in-plant training
CD6	Self- learning such as use of NPTEL materials and internets
CD7	Simulation

Mapping Between Course Outcomes and Program Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6
CO1	1	1	3	3	2	1
CO2	1	1	3	2	2	1
CO3	2	2	3	3	1	1
CO4	2	1	3	3	1	1
CO5	3	2	3	3	1	1

< 34% = 1, 34-66% = 2, > 66% = 3

Mapping Between Course Outcomes and Course Delivery Method

Course Outcomes	Course Delivery Method
CO1	CD1, CD2, CD6
CO2	CD1, CD2, CD6
CO3	CD1, CD2, CD6
CO4	CD1, CD2, CD6
CO5	CD1, CD2, CD3, CD7

Programme Core

COURSE INFORMATION SHEET

Course code: EC504
Course title: Antenna Lab
Pre-requisite(s): EC257 Electromagnetic Fields and Waves, EC323 Microwave Theory & Techniques
Co- requisite(s):
Credits: L: 0 T: 0 P: 4 C: 2
Class schedule per week: 04
Class: M. Tech.
Semester / Level: I/05
Branch: ECE
Name of Teacher:

Course Objectives

This course enables the students:

1.	To understand important and fundamental antenna engineering parameters.
2.	To develop the basic skills to learn software and apply in the design of various antennas.
3.	To develop the basic skills necessary to measure antenna performance parameters.
4.	To apply the concepts learnt through theory
5.	Develop the ability to analyze the performance parameters of different types of antenna

Course Outcomes

After the completion of this course, students will be able to:

CO1	Have the ability to implement the theoretical knowledge and prepare the reports and present the results.
CO2	Apply numerical modelling tools (software) to design antennas, with particular reference to low profile printed antennas.
CO3	Have the ability to perform antenna measurements.
CO4	Understand and visualize the radiation characteristics and its limitations and provide the environment friendly solutions in terms of antenna design.
CO5	Have the ability to Practically verify different microwave antenna theories.

SYLLABUS

List of Experiments

1. Design of a rectangular microstrip patch antenna for operating frequency 1.88GHz with ε_r =4.4, h=31 mils with inset feed.
   (IE3D)

2. Design of a rectangular microstrip patch antenna for operating frequency 1.88GHz with εr =4.4, h=31 mils with coaxial feed.
   (IE3D)

3. Design of a rectangular microstrip patch antenna for operating frequency 5 GHz with εr =3.2, h=0.762mm & transformer coupled microstrip feed.
   (IE3D)

4. Design of a circular microstrip patch antenna for circular polarization with dual feed. Assume resonant frequency =2.78GHz, εr =2.33, h=2.184mm, tanδ=0.0012.
   (IE3D)

5. Design of a rectangular microstrip patch antenna for operating frequency 1.88GHz with εr =4.4, h=31 mils & inset feed.
   (HFSS)

6. Design of a rectangular microstrip patch antenna for operating frequency 1.88GHz with ε_r =4.4, h=31 mils & transformer coupled microstrip feed.
   (HFSS)

7. To plot the radiation pattern of a directional antenna.

8. To plot the radiation pattern of an omnidirectional antenna.

9. To calculate the resonant frequency and estimate the VSWR of an antenna.

10. To prove inverse square law for any antenna.

11. Characterization of a linearly polarized and circularly polarized antenna.

12. The gain measurement of an antenna under test.

Books recommended:

Textbooks:

1. Antenna Theory, Analysis and Design, 3/E, A. Balanis, John Wiley.
2. Antennas, J. D. Kraus, TMH
3. Wireless Communications, Principles and Practices, Rappaport, PHI

Reference books:

1. Software Radio A Modern Approach to Radio Engineering, J. H. Reed, Pearson Education.
2. Wireless and Cellular Communications, William C. Y. Lee, McGraw-Hill.
3. Wireless Communications, Principles and Practices, Rappaport, PHI.

Gaps in the syllabus (to meet Industry/Profession requirements):

POs met through Gaps in the Syllabus:

Topics beyond syllabus/Advanced topics/Design:

POs met through Topics beyond syllabus/Advanced topics/Design:

Course Outcome (CO) Attainment Assessment Tools and Evaluation Procedure

Direct Assessment

Assessment Tools	% Contribution during CO Assessment
Progressive Evaluation	60
End Semester Evaluation	40

Progressive Evaluation	% Distribution
Day to day performance & Lab files	30
Quiz (zes)	10
Viva	20

End Semester Evaluation	% Distribution
Examination Experiment Performance	30
Quiz	10

Assessment Components	CO1	CO2	CO3	CO4	CO5
Progressive Evaluation					
End Semester Evaluation					

Indirect Assessment

1. Student Feedback on Faculty
2. Student Feedback on Course

Course Delivery Methods

CD1	Lecture by use of boards/LCD projectors/OHP projectors
CD2	Assignments

CD3	Laboratory experiments/Teaching aids/Seminars
CD4	Mini Projects
CD5	Industrial visits/in-plant training
CD6	Self- learning such as use of NPTEL materials and internets
CD7	Simulation

Mapping between Course Outcomes and Program Outcomes

CO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	2	3	3	3	2	3
CO2	2	3	3	3	2	3
CO3	2	3	3	3	2	3
CO4	2	3	3	3	2	3
CO5	2	3	3	3	2	3

< 34% = 1, 34-66% = 2, > 66% = 3

Mapping between Course Outcomes and Course Delivery Method

Course Outcomes	Course Delivery Method
CO1	CD1, CD3
CO2	CD3
CO3	CD5, CD3
CO4	CD5, CD3, CD7
CO5	CD3, CD7

COURSE INFORMATION SHEET

Course code: EC511
Course title: Wireless Communication Lab
Pre-requisite(s): EC510
Co- requisite(s): Nil
Credits: L: 0 T: 0 P: 4 C: 2
Class schedule per week: 03
Class: M. Tech.
Semester / Level: I/05
Branch: ECE

Course Objectives

This course aims to develop ability to:

1	Evaluate the impact of different propagation conditions in estimation of received signal power.
2	Configure different wireless communication systems and evaluate their functioning establishing LTE and MIMO system for two-way communication.
3	Find geographical position using survey plotting with the help of GPS system
4	Design micro strip patch antenna using suitable parameters
5	Analyse different protocols of WLAN System

Course Outcomes

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

CO1	Evaluate the impact of different propagation conditions in estimation of received signal power.

CO2	Configure different wireless communication systems and evaluate their functioning establishing LTE and MIMO system for two-way communication.
CO3	Find geographical position using survey plotting with the help of GPS system
CO4	Design micro strip patch antenna using suitable parameters
CO5	Analyse different protocols of WLAN System

SYLLABUS

List of Experiments

1. Evaluate the impact of path loss and shadowing in estimation of received signal power in mobile cellular communication using fading channel mobile communication virtual lab.

2. Calculate the boundary coverage probability in a cellular system using fading channel mobile communication virtual lab.

3. Demonstrate the impact the received power levels for hand-off in case of mobile cellular communication using fading channel mobile communication virtual lab.

4. Estimate the impact of sectoring in increasing cellular system capacity using fading channel mobile communication virtual lab.

5. Examine the impact of co-channel interference on the value of SIR in mobile cellular communication using fading channel mobile communication virtual lab.

6. Setting up of LTE 2x2 MIMO system for establishing two-way communication.

7. Study of pure ALOHA and slotted ALOHA protocols for WLAN System.

8. Configure ZigBee module as an end device and, set up a communication link with two ZigBee modules.

9. Study of RFID system and its applications.

10. Using IE3D, design a rectangular micro strip patch antenna for inset feed for operating frequency of 1.88 GHz, relative permittivity of 4.4 and length of 31 mils.

11. Using GPS system, study the graphical representation of geographical position using Survey plotting.

12. Study the PN sequence and examine Gold code with variable sequence length and analyze its correlation. Also set up voice communication using DSSS scheme using CDMA trainer kit (ST-2131-A).

Optional Experiments

1. Study the GPRS system and use it for sending an e-mail through WI-GPRS trainer.

2. Study the GSM modem and its different module for phone book, setting up a call, sending SMS and identifying call history using AT commands.

3. Interfacing of GSM modem with control unit.

4. Design a patch antenna using IE3D using different parameters.

Books recommended:

Textbooks:

1. Vijay K. Garg, "Wireless Communications and Networks", Morgan Kaufmann Publishers an Imprint of Elsevier, USA 2009 (Indian reprint).

Reference books:

1. Simon Haykin, "Communication Systems", Wiley Eastern Limited, New Delhi, 2016, 4/e.
2. J. Schiller, "Mobile Communication" 2/e, Pearson Education, 2012.

Gaps in the syllabus (to meet Industry/Profession requirements): Nil

POs met through Gaps in the Syllabus: N/A

Topics beyond syllabus/Advanced topics/Design: Experiments related to Software Defined Radio will be included.

POs met through Topics beyond syllabus/Advanced topics/Design: PO4

Course Outcome (CO) Attainment Assessment Tools and Evaluation Procedure

Direct Assessment

Assessment Tools	% Contribution during CO Assessment
Progressive Evaluation	60
End Semester Evaluation	40

Progressive Evaluation	% Distribution
Day to day performance & Lab files	30
Quiz (zes)	10
Viva	20

End Semester Evaluation	% Distribution
Examination Experiment Performance	30
Quiz	10

Assessment Components	CO1	CO2	CO3	CO4	CO5
Progressive Evaluation					
End Semester Evaluation					

Indirect Assessment

1. Student Feedback on Faculty
2. Student Feedback on Course

Course Delivery Methods

CD1	Lecture by use of boards/LCD projectors/OHP projectors
CD2	Assignments
CD3	Laboratory experiments/teaching aids/Seminars
CD4	Industrial/guest lectures
CD5	Industrial visits/in-plant training
CD6	Self- learning such as use of NPTEL materials and internets
CD7	Simulation

Mapping Between Course Outcomes and Program Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6
CO1	2	1	3	3	1	1
CO2	2	1	3	2	2	1
CO3	1	1	3	1	1	1
CO4	3	1	3	2	1	1
CO5	2	1	3	2	1	1

< 34% = 1, 34-66% = 2, > 66% = 3

Mapping Between Course Outcomes and Course Delivery Method

Course Outcomes	Course Delivery Method
CO1	CD3, CD, CD7
CO2	CD3, CD, CD7
CO3	CD3, CD, CD7
CO4	CD3, CD, CD7
CO5	CD3, CD, CD7

2nd Semester

Programme Core

COURSE INFORMATION SHEET

Course Code: EC560
Course Title: Wireless Signal Propagation and Fading
Pre-requisite(s): Basic understanding of mobile communication and signal propagation.
Co-requisite(s):
Credits: L: 3 T: 0 P: 0 C: 3
Class schedule per week: 03
Class: M. Tech.
Semester / Level: II/05
Branch: ECE

Course Objectives:
This course aims to develop

1	An understanding on the nature of wireless signal propagation, and models describing wireless signal propagation.
2	An ability to explain different characteristics of wireless communication channels, and different channel parameters.
3	An ability to analyze causes of channel impairments and compare various removal techniques.

4	An ability to evaluate capacity of wireless communication systems under different channel conditions.

Course Outcomes

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

CO1	Demonstrate understanding of the nature of wireless signal propagation and models describing wireless signal propagation.
CO2	Have an ability to explain different characteristics of wireless communication channels, and different channel parameters.
CO3	Have an ability to analyze causes of channel impairments and compare various removal techniques.
CO4	Evaluate capacity of wireless communication systems under different channel conditions.
CO5	Analyse the channel capacity in various channel fading conditions

SYLLABUS

Module 1: Wireless signal propagation, basic propagation mechanisms, wireless mobile environment, multipath propagation, fading in wireless mobile environment, channel impulse response.

(8L)

Module 2: Wireless channel models: free space propagation model, two ray ground reflection model, path loss, outdoor propagation models (Okumura model, Hata model, COST 231 model), indoor propagation models, log normal shadowing, typical small-scale fading models (Rician distribution and Rayleigh distribution).

(8L)

Module 3: Wireless channel parameters: power delay profile, delay spread, doppler spread, coherence bandwidth, coherence time, level crossing rate and average duration of fades, dispersive and non-dispersive wireless channels.

(8L)

Module 4: Channel impairments and removal techniques: diversity mechanisms (space, time, frequency and polarization), diversity gain and array gain, combining techniques (SC, MRC, TC and EGC), ISI free transmission, equalization, coding for wireless channels.

(8L)

Module 5: Wireless system capacity: AWGN channel capacity, flat fading channel capacity, frequency selective fading channel capacity, link adaptation and adaptive modulation and coding.

(8L)

Books recommended:

Textbooks:

1. Andrea Goldsmith, “Wireless Communications”, Cambridge University Press, 2005.

Reference books:

1. Vijay K Garg, “Wireless Communications and Networks”, Morgan Kaufmann Publishers an Imprint of Elsevier, USA 2009 (Indian reprint).
2. Simon Haykin and Michael Moher, “Modern Wireless Communications”, Pearson Education, Delhi, 2005.
3. Sanjay Kumar, “Wireless Communication the Fundamental and Advanced Concepts” River Publishers, Denmark, 2015 (Indian reprint).

Gaps in the syllabus (to meet Industry/Profession requirements): Hands on experience on

real time industrial project and management

POs met through Gaps in the Syllabus: PO6

Topics beyond syllabus/Advanced topics/Design: Current technological developments in channel impairments and removal techniques

POs met through Topics beyond syllabus/Advanced topics/Design: PO2

Course Outcome (CO) Attainment Assessment Tools and Evaluation Procedure

Direct Assessment

Assessment Tools	% Contribution during CO Assessment
Continuous Internal Assessment	50
Semester End Examination	50

Continuous Internal Assessment	% Distribution
3 quizzes	30 (3×10)
Assignment(s)	10
Seminar before a committee	10

Assessment Components	CO1	CO2	CO3	CO4	CO5
Continuous Internal Assessment					
Semester End Examination					

Indirect Assessment

1. Student Feedback on Faculty
2. Student Feedback on Course

Course Delivery Methods

CD1	Lecture by use of boards/LCD projectors/OHP projectors
CD2	Assignments
CD3	Laboratory experiments/teaching aids/ Seminars
CD4	Mini Projects
CD5	Industrial visits/in-plant training
CD6	Self- learning such as use of NPTEL materials and internets
CD7	Simulation

Mapping between Course Outcomes and Program Outcomes

Course Outcome #	Program Outcomes					
	PO1	PO2	PO3	PO4	PO5	PO6
CO1	2	2	3	1	-	1
CO2	2	2	3	2	-	1
CO3	3	1	3	1	1	1
CO4	3	1	3	2	1	1
CO5	3	2	3	2	1	1

< 34% = 1, 34-66% = 2, > 66% = 3

Mapping between Course Outcomes and Course Delivery Method

Course Outcomes	Course Delivery Method
CO1	CD1, CD2, CD3, CD6
CO2	CD1, CD2, CD3, CD6
CO3	CD1, CD2, CD3, CD6
CO4	CD1, CD2, CD3, CD6, CD7
CO5	CD1, CD2, CD3, CD6, CD7

COURSE INFORMATION SHEET

Course Code: EC563
Course Title: Detection and Estimation Theory
Pre-requisite(s): EC251 probability and Random Processes
Co-requisite(s):
Credits: L: 3 T: 0 P: 0 C: 3
Class schedule per week: 03
Class: M. Tech.
Semester / Level: II/05
Branch: ECE

Course Objectives:
This course enables the students to:

1	To know how to cast a generic detection problem into a hypothesis testing framework and to find the optimal test for the given optimization criterion.
2	To understand about statistical decision theory used for signal detection and estimation (Classical and Bayesian Estimation Approaches).
3	To understand about finding optimal estimators for various signal parameters, derive their properties and assess their performance.
4	To understand about the detection of deterministic and random signals using statistical models.
5	Demonstrate an ability to apply the estimation techniques to various areas of Engineering and Science.

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

CO1	Demonstrate the mathematical background of signal detection and estimation.
CO2	Use classical and Bayesian approaches to formulate and solve problems for signal detection and parameter estimation from noisy signals.
CO3	Derive and apply filtering methods for parameter estimation.
CO4	Analyse signal estimation in discrete-time domain using filters.
CO5	Develop and apply the detection and estimation theory in various engineering applications and play role of team leader in industry.

SYLLABUS

Module 1 Review of Vector Spaces: Vectors and matrices: notation and properties, orthogonality and linear Independence, bases, distance properties, matrix operations, Eigen values and eigenvectors, Properties of Symmetric Matrices: Diagonalization of symmetric matrices, symmetric positive definite and semi definite matrices.

(8L)

Module 2: Detection and decision theory Neyman Pearson Theorem, Receiver Operating Characteristics, minimum probability of error, Bayes risk, Elementary hypothesis testing, Multiple hypothesis testing, Composite Hypothesis Testing.

(8L)

Module 3: Matched filters, Multiple signals, Linear model, Detection of signals with unknown amplitude, phase and frequency, chernoff bounds, detection of signals in Gaussian Noise.

(8L)

Module 4: Estimation Theory, Minimum-variance unbiased estimator (MVUE), Cramer-Rao Lower bound, Best Linear Unbiased Estimator, Maximum likelihood Estimator, General Bayesian Estimator.

(8L)

Module 5: Linear Signal waveform estimation: least square estimation, Kalman Filter, extended Kalman Filter, Order selection criterion of AR model, Minimum-variance, Maximum entropy and Maximum likelihood spectrum estimation Harmonic models and frequency estimation techniques, Applications of detection and estimation.

(8L)

Books recommended:

Textbooks:

1. Steven M Kay, Fundamentals of Statistical Signal Processing: Estimation Theory, Vol II: Detection Theory, Prentice Hall, 1993.
2. Steven M Kay, Fundamentals of Statistical Signal Processing: Detection Theory, Prentice Hall, 1998.
3. H. V. Poor, "An Introduction to Signal Detection and Estimation," Springer, Second Edition, 1998.

Reference books:

1. Monson H. Hayes, Statistical Digital Signal Processing and Modelling, John Wiley, 1996.
2. Thomas Kailath, BabakHassibi, Ali H. Sayed, “Linear Estimation”, Prentice Hall, 2000.

Gaps in the Syllabus (to meet Industry/Profession requirements): Hands on experience on real time industrial project and management

POs met through Gaps in the Syllabus: PO5

Topics beyond Syllabus/Advanced topics/Design: Latest developments in the field

POs met through Topics beyond Syllabus/Advanced topics/Design: PO6

Course Outcome (CO) Attainment Assessment Tools and Evaluation Procedure

Direct Assessment

Assessment Tools	% Contribution during CO Assessment
Continuous Internal Assessment	50
Semester End Examination	50

Continuous Internal Assessment	% Distribution
3 quizzes	30 (3×10)
Assignment(s)	10
Seminar before a committee	10

Assessment Components	CO1	CO2	CO3	CO4	CO5

Continuous Internal Assessment					
Semester End Examination					

Indirect Assessment

1. Student Feedback on Faculty
2. Student Feedback on Course

Course Delivery Methods

CD1	Lecture by use of boards/LCD projectors/OHP projectors
CD2	Assignments
CD3	Laboratory experiments/teaching aids/ Seminars
CD4	Mini Projects
CD5	Industrial visits/in-plant training
CD6	Self- learning such as use of NPTEL materials and internets
CD7	Simulation

Mapping between Course Outcomes and Program Outcomes

CO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	1	2	2		2
CO2	3	2	2	3		1
CO3	3	2	2	3	1	1
CO4	3	3	2	3	1	2
CO5		1	1	1		2

< 34% = 1, 34-66% = 2, > 66% = 3

Mapping Between Course Outcomes and Course Delivery Method

Course Outcomes	Course Delivery Method
CO1	CD1, CD2, CD3, CD6
CO2	CD1, CD2, CD3, CD6, CD7
CO3	CD1, CD2, CD3, CD6, CD7
CO4	CD1, CD2, CD3, CD6, CD7
CO5	CD1, CD2

COURSE INFORMATION SHEET

Course code: EC564
Course title: Coding Theory and Applications
Pre-requisite(s): Knowledge of digital electronics, probability theory, basic understanding of communication system.
Co-requisite(s):
Credits: L: 3 T: 0 P: 0 C: 3
Class schedule per week: 03
Class: M. Tech.
Semester / Level: II/05
Branch: ECE

Course Objectives

This course aims to develop

1	An understanding on information coding fundamentals with several source coding techniques for efficient representation of a source.
2	An understanding of channel coding techniques to achieve efficient as well as reliable communication.
3	Fundamental understanding on block codes, cyclic codes and convolutional codes with its practical challenges.
4	The concept of encryption-decryption techniques and several application of coding algorithms.
5	An ability to design and provide solutions for practical low cost, efficient, reliable and secure communication system.

Course Outcomes

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

CO1	Explain fundamentals of several lossy & lossless source coding techniques and further elaborate its possible extension in practical scenarios.
CO2	Elaborate the concept of block codes, bounds for block codes and design aspects of linear block codes with its encoding as well as decoding.
CO3	Demonstrate the fundamentals of cyclic codes and convolutional codes with its circuit implementation. The students will be able to analyze various advance channel coding techniques.
CO4	Discuss several encryption-decryption techniques. The students will be able to apply several source coding techniques, encryption-decryption techniques and advance channel coding techniques to provide efficient, secure and reliable communication of a discrete/ continuous message source.
CO5	Have an ability to provide practical solutions and apply the subject expertise for the well fare of society.

SYLLABUS

Module -1: Source Codes: Introduction to source coding theory & error control coding, Shannon's Coding Theorems, Prefix Coding, Huffman Coding, Shannon-Fano Coding, Arithmetic Coding, Lempel-Ziv Algorithm.

(8L)

Module -2: Block Codes: Galois Fields, Hamming Weight and Hamming Distance, Linear Block Codes, Encoding and decoding of Linear Block-codes, Parity Check Matrix, Bounds for block codes, Hamming Codes, Syndrome Decoding.

(8L)

Module -3: Cyclic Codes: Introduction to cyclic code, Method for generating Cyclic Codes, Matrix description of Cyclic codes, Cyclic Redundancy Check (CRC) codes, Circuit implementation of cyclic codes, Burst error correction, BCH codes.

(8L)

Module -4: Convolutional Codes: Introduction to Convolutional Codes, Polynomial description of Convolutional Codes, Generating function, Matrix description of Convolutional Codes, Viterbi Decoding of Convolutional code, Introduction to Turbo Code and LDPC code.

(8L)

Module -5: Coding for Secure Communications: Introduction to Cryptography, Secret-Key Cryptography, Data Encryption Standard (DES), Public-Key Cryptography, RSA algorithm, Elliptic Curve Cryptography, Hash & MAC Algorithms, Digital signature and Authentication Protocols.

(8L)

Books recommended:

Textbooks:

1. "Information Theory, Coding & Cryptography", by Ranjan Bose, TMH, Second Edition.
2. "Communication Systems", by S. Haykin, 4th Edition, Wiley-Publication.

Reference books:

1. "Elements of Information Theory" by Thomas M. Cover, J. A. Thomas, Wiley-Interscience Publication.
2. "Error Correction Coding Mathematical Methods and Algorithms" by Todd K. Moon, WileyIndia Edition.
3. "Cryptography and Network Security", Fourth Edition, by William Stallings

Gaps in the syllabus (to meet Industry/Profession requirements): Hands on experience on real time industrial project and management

POs met through Gaps in the Syllabus: PO5

Topics beyond syllabus/Advanced topics/Design: Raptor coding and current coding theories.

POs met through Topics beyond syllabus/Advanced topics/Design: PO1

Course Outcome (CO) Attainment Assessment Tools and Evaluation Procedure

Direct Assessment

Assessment Tools	% Contribution during CO Assessment
Continuous Internal Assessment	50
Semester End Examination	50

Continuous Internal Assessment	% Distribution
3 quizzes	30 (3×10)
Assignment(s)	10
Seminar before a committee	10

Assessment Components	CO1	CO2	CO3	CO4	CO5
Continuous Internal Assessment					
Semester End Examination					

Indirect Assessment

1. Student Feedback on Faculty
2. Student Feedback on Course

Course Delivery Methods

CD1	Lecture by use of boards/LCD projectors/OHP projectors
CD2	Assignments
CD3	Laboratory experiments/teaching aids/ Seminars
CD4	Mini Projects
CD5	Industrial visits/in-plant training
CD6	Self- learning such as use of NPTEL materials and internets
CD7	Simulation

Mapping between Course Outcomes and Program Outcomes

CO	PO1	PO2	PO3	PO4	PO5	PO 6
CO1	1	2	3	2	-	1
CO2	2	2	3	2	2	2
CO3	2	1	3	1	1	2
CO4	3	2	3	3	2	1
CO5	3	1	1	1	2	2

< 34% = 1, 34-66% = 2, > 66% = 3

Mapping Between Course Outcomes and Course Delivery Methods

Course Outcomes	Course Delivery Method
CO1	CD1, CD2, CD3, CD6
CO2	CD1, CD2, CD3, CD6
CO3	CD1, CD2, CD3, CD6
CO4	CD1, CD2, CD3, CD6, CD7
CO5	CD1, CD2, CD3, CD6, CD7

Programme Electives-II

COURSE INFORMATION SHEET

Course Code: EC565
Course title: Space Time Wireless Communication
Pre-requisite(s): Linear Algebra, Digital Communication, and Mobile & Cellular Communication,
Co-requisite(s): N/A
Credits: L: 3 T: 0 P: 0 C: 3
Class schedule per week: 03
Class: M. Tech.
Semester / Level: II/05
Branch: ECE

Course Objectives

This course aims to develop

1	An understanding on multiple antenna and Space Time (ST) wireless communication system.
2	An in-depth knowledge on Capacity of frequency flat deterministic MIMO channel.
3	An ability to acquire the knowledge on various modulation and coding schemes for space-time wireless communications
4	An ability to analyse the transmission and decoding techniques associated with space-time wireless communications
5	An ability to evaluate capacity of space-time wireless communications under different channel conditions.

Course Outcomes

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

CO1	Demonstrate understanding of multiple-antenna systems such as multiple-input

	multiple-output (MIMO) System, nature of space time (ST) propagation and various ST channel and signal models.
CO2	Evaluate capacity of space-time wireless communications under different channel conditions.
CO3	Evaluate transmission and decoding techniques associated with space-time wireless communications and design receiver and transmitter diversity techniques.
CO4	Design and develop OFDM based MIMO systems.
CO5	Explain receiver techniques in MIMO based system

SYLLABUS

Module1: Multiple antenna and Space Time (ST) wireless communication system, ST propagation, Scattering model in macrocells, channel as a ST random field, scattering functions, degenerate channels, ST channel and signal models, ST multiuser and ST interference channels, ST channel estimation.

(8L)

Module 2: Capacity of frequency flat deterministic MIMO channel, channel unknown to the transmitter, channel known to the transmitter, capacity of random MIMO channels, influence of Ricean fading, fading correlation and degeneracy on MIMO capacity, capacity of frequency selective MIMO channels.

(8L)

Module 3: Diversity gain, receive antenna diversity, transmit antenna diversity, diversity order and channel variability, diversity performance in extended channels, combined space and path diversity, indirect transmit diversity, diversity of a ST-frequency selective fading channel.

(8L)

Module 4: Coding and interleaving architecture, ST coding for frequency flat channels, ST coding for frequency selective channels, channel knowledge at the transmitter, linear pre-filtering, optimal pre-filtering for maximum rate, optimal pre-filtering for error rate minimization, selection at the transmitter, exploiting imperfect channel knowledge.

(8L)

Module 5: Performance limits and tradeoffs in MIMO channels: error performance in fading channels, signalling rate vs. PER vs. SNR, spectral sufficiency of space time coding, Receiver techniques: D-BLAST, OSTBC, space time receivers for spatial multiplexing, receiver comparison, system design, comments on capacity, MIMO-OFDM modulation.

(8L)

Books recommended:

Textbooks:

1. Paulraj, Rohit Nabar, Dhananjay Gore, “Introduction to Space Time Wireless Communication Systems”, Cambridge University Press, 2003.

References books:

1. Hamid Jafarkhani, “Space-Time Coding: Theory and Practice”, Cambridge University press, 2005.
2. Ezio Biglieri, Robert Calderbank et. al., “MIMO wireless Communications”, Cambridge University Press.

Gaps in the syllabus (to meet Industry/Profession requirements): Hands on experience on real time industrial project and management

POs met through Gaps in the Syllabus: PO5

Topics beyond syllabus/Advanced topics/Design: Current technological developments towards next generation cellular communication, Massive MIMO and Networks

POs met through Topics beyond syllabus/Advanced topics/Design: PO2

Course Outcome (CO) Attainment Assessment Tools and Evaluation Procedure

Direct Assessment

Assessment Tools	% Contribution during CO Assessment
Continuous Internal Assessment	50
Semester End Examination	50

Continuous Internal Assessment	% Distribution
3 quizzes	30 (3×10)
Assignment(s)	10
Seminar before a committee	10

Assessment Components	CO1	CO2	CO3	CO4	CO5
Continuous Internal Assessment					
Semester End Examination					

Indirect Assessment

1. Student Feedback on Faculty
2. Student Feedback on Course

Course Delivery Methods

CD1	Lecture by use of boards/LCD projectors/OHP projectors
CD2	Assignments
CD3	Laboratory experiments/teaching aids/ Seminars
CD4	Mini Projects
CD5	Industrial visits/in-plant training
CD6	Self- learning such as use of NPTEL materials and internets
CD7	Simulation

Mapping between Course Outcomes and Program Outcomes

Course Outcome #	Program Outcomes					
	PO1	PO2	PO3	PO4	PO5	PO6
CO1	1	2	3	1	1	1
CO2	1	2	2	2	2	2
CO3	1	1	3	1	1	2
CO4	2	1	2	3	2	1
CO5	1	3	3	1	2	2

< 34% = 1, 34-66% = 2, > 66% = 3

Mapping between Course Outcomes and Course Delivery Method

Course Outcomes	Course Delivery Method
CO1	CD1, CD2, CD3, CD6
CO2	CD1, CD2, CD3, CD6
CO3	CD1, CD2, CD3, CD6
CO4	CD1, CD2, CD3, CD6, CD7

CO5	CD1, CD2, CD3, CD6, CD7

COURSE INFORMATION SHEET

Course code: EC566
Course title: Optical Wireless Communication
Pre-requisite(s): Knowledge of Semiconductor Devices, Data Communication, Fiber Optic Communication
Co- requisite(s):
Credits: L: 3 T: 0 P: 0 C: 3
Class schedule per week: 03
Class: M. Tech.
Semester / Level: II/05
Branch: ECE

Course Objectives:
This course enables the students:

1.	To understand the characteristics of Indoor and Outdoor IR systems, performance of Wireless IR link under Atmospheric turbulence.
2.	To understand the transmitter design considerations and receiver design considerations for optical wireless communication.
3.	To understand different modulation schemes and different multiple access techniques for sharing IR medium.
4.	To understand the standards of IrDA technology, features and the different layers of the IrDA protocols for optical wireless networking.

Course Outcomes:
After the completion of this course, students will be:

CO1	To explain the characteristics of Indoor and Outdoor IR systems, transmission impairments of Wireless IR communication
CO2	To design the transmitter based on LED/Laser diode for optical wireless communication.
CO3	To design the receiver based on semiconductor photodiodes for optical wireless communication.
CO4	To choose a right modulation scheme for indoor & outdoor applications and the different multiple access techniques
CO5	To apply IrDA protocols to create simple, cost-effective and low power transceivers that enable wireless IR communication in a number of devices.

SYLLABUS

Module -1:
Basic concept of Optical wireless communication, Optical Wireless channels, Light sources, Modulators, Detectors, Atmospheric transmission limitations, Effect of Rain, Fog, and Mist, Scintillation, Optical Path Length and Fermat's Principle, The Etendue or Lagrange Invariant, Edge Ray Principle.

(8L)

Module -2:
Gaussian Beam, Telescope, beam expander, Optical filter and anti- reflection coating, Optical Concentrators, Wireless IR Receiver Requirements, DTIRC Characteristics. Comparison of

Concentrators. Practical Issues. Different Shapes of DTIRCs, Tracking system, Laser beam steering device.

(8L)

Module -3:

Optical Wireless Transmitter Design, Transmitter Design Considerations, Optical Source Characteristics. Types of Optical Modulation. Driver Circuit Design Concepts. Current Steering Output Circuit, Back Termination Circuit, Predriver, Data Retiming, Automatic Power Control, Transmitters Linearization Techniques.

(8L)

Module -4:

Optical wireless receiver design, Receiver Design Considerations, Photodetection in Reverse-biased Diodes. Choosing the Photodetector, Receiver Noise Consideration, Bit Error Rate and Sensitivity, Bandwidth, Signal Amplification Techniques, Receiver Main Amplifier (RMA). Transceiver Circuit Implementation Technologies.

(8L)

Module -5:

Modulation and Multiple Access Techniques, IrDA PROTOCOLS. Wireless Protocol Standards. The Infrared Data Association, The Physical Layer Protocol, Framer/Driver, IrLAP, IrLMP, Information Access Service and Protocol, Tiny Transport Protocol, Session and Application Layer Protocols, WIRELESS IR NETWORKING, The Ad Hoc Network, Quality of Service (QoS), MIMO Wireless optical channel, Pixelated Wireless optical channel.

(8L)

Books recommended:

Textbooks:

1. "Optical and Wireless Communications", Sadiku, Matthew N. O. CRC Press
2. "Optical Wireless Communications: IR for Wireless Connectivity", Ramirez-Iniguez, Roberto Idrus, Sevia M., Auerbach Publications.

Reference books:

1. "Microwave Photonics", Chi Lee, CRC Press, 2006.
2. "Wireless Optical Communication Systems" Steve Hranilovic, Springer.

Gaps in the syllabus (to meet Industry/Profession requirements): Hands on experience on real time industrial project and management

POs met through Gaps in the Syllabus: PO5 and PO6

Topics beyond syllabus/Advanced topics/Design: OFDM based visible light communication

POs met through Topics beyond syllabus/Advanced topics/Design: PO4 and PO5

Course Outcome (CO) Attainment Assessment Tools and Evaluation Procedure

Direct Assessment

Assessment Tools	% Contribution during CO Assessment
Continuous Internal Assessment	50
Semester End Examination	50

Continuous Internal Assessment	% Distribution
3 quizzes	30 (3×10)
Assignment(s)	10
Seminar before a committee	10

Assessment Components	CO1	CO2	CO3	CO4	CO5
Continuous Internal Assessment					
Semester End Examination					

Indirect Assessment

1. Student Feedback on Faculty
2. Student Feedback on Course

Course Delivery Methods

CD1	Lecture by use of boards/LCD projectors/OHP projectors
CD2	Assignments
CD3	Laboratory experiments/teaching aids/ Seminars
CD4	Mini Projects
CD5	Industrial visits/in-plant training
CD6	Self- learning such as use of NPTEL materials and internets
CD7	Simulation

Mapping of Course Outcomes onto Program Outcomes

CO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	1	2	2	1	2
CO2	3	2	3	3	1	2
CO3	3	2	3	3	1	2
CO4	3	2	3	3	1	2
CO5	3	3	3	3	3	3

< 34% = 1, 34-66% = 2, > 66% = 3

Mapping between Course Outcomes and Course Delivery Method

Course Outcomes	Course Delivery Method
CO1	CD1, CD2, CD3, CD6
CO2	CD1, CD2, CD3, CD6
CO3	CD1, CD2, CD3, CD6
CO4	CD1, CD2, CD3, CD6, CD7
CO5	CD1, CD2, CD3, CD6, CD7

COURSE INFORMATION SHEET

Course code: EC551
Course title: RF Circuit Design
Pre-requisite(s): Electromagnetic Theory, Microwave Engineering
Co- requisite(s):
Credits: L: 3 T: 0 P: 0 C: 3
Class schedule per week: 03
Class: M. Tech.
Semester / Level: II/05
Branch: ECE

Course Objectives

This course enables the students:

1.	To explain radio frequency design concept and impart knowledge on design and implementation of high frequency transceiver system.
2.	To develop an ability to analyze various components of radio frequency communication system architecture.
3.	To develop an ability to analyze the impact of different design parameters in transceiver circuit design, besides developing an insight to make use of several high frequency design techniques.
4.	To develop the prototype models of the various RF circuit components.
5.	To review and refer the literature related to RF Circuit design and report it ethically.

Course Outcomes

After the completion of this course, students will be:

CO1	Able to explain radio frequency design concept and impart knowledge on design and implementation of high frequency transceiver system.
CO2	Able to develop an ability to analyze various components of radio frequency communication system architecture.
CO3	Able to develop an ability to analyze the impact of different design parameters in transceiver circuit design, besides developing an insight to make use of several high frequency design techniques.
CO4	Able to develop the prototype models of the various RF circuit components.
CO5	Able to review and refer the literature related to RF Circuit design and report it ethically.

SYLLABUS

Module -1: Introduction: Importance of RF Design, RF Behavior of Passive Components: High Frequency Resistors, High-Frequency Capacitors, High-Frequency Inductors. Chip Components and Circuit Board Considerations: Chip Resistors, Chip Capacitors, Surface-Mounted Inductors.

(8L)

Module -2: RF Filter Design: Basic Resonator and Filter Configurations: Filter Type and Parameters, Low-Pass Filter, High Pass Filter, Bandpass and Bandstop Filters, Insertion Loss, Special Filter Realizations: Butterworth –Type, Chebyshev and Denormalization of Standard Low-Pass Design. Filter Implementations: Unit Elements, Kuroda's Identities and Examples of Microstrip Filter Design. Coupled Filter: Odd and Even Mode Excitation, Bandpass Filter Section, Cascading Bandpass Filter Elements, Design Examples.

(8L)

Module -3: Matching and Biasing Network: Impedance Matching using Discrete Components: Two Component Matching Networks, Forbidden regions, Frequency Response and Quality Factor, Microstrip Line Matching Networks: From Discrete Components to Microstrip Lines, Single-Stub Matching Networks, Double-Stub Matching Networks, Amplifier Classes of Operation and Biasing Network: Classes of Operation and Efficiency of Amplifiers, Bipolar Transistor Biasing Networks, Field Effect Transistor Biasing Networks.

(8L)

Module -4: RF Transistor Amplifier Design: Characteristics of Amplifiers, Amplifier Power Relations: RF source, Transducer Power Gain, Additional Power Relations, Stability Considerations: Stability Circles, Unconditional Stability, Stabilization Methods, Constant Gain: Unilateral Design, Unilateral Figure of Merit, Bilateral Design, Operating and Available

Power Gain Circles. Noise Figure Circles, Constant VSWR Circles. Broadband, High Power and Multistage Amplifiers.

(8L)

Module -5: RF Oscillators and Mixers: Basic Oscillator Model: Negative Resistance Oscillator, Feedback Oscillator Design, Design Steps, Quartz Oscillators. High Frequency Oscillator Configuration: Fixed Frequency Oscillators, Dielectric Resonator Oscillators, YIG-Tuned Oscillators, Voltage Controlled Oscillators, Gunn Element Oscillator. Basic Characteristics of Mixers: Basic Concepts, Frequency Domain Considerations, Single-Balanced Mixer Double-Balanced Mixer.

(8L)

Books recommended:

Textbooks:

1. RF Circuit Design Theory and Application, Reinhold Ludwig and Pavel Bretchko, Ed. 2004, Pearson Education.

Reference books:

1. Microstrip Filters for RF/Microwave Applications, Jia-Sheng Hong, M. J. Lancaster, John Wiley & Sons, 2001.

Gaps in the syllabus (to meet Industry/Profession requirements): Hands on experience on real time industrial project and management

POs met through Gaps in the Syllabus: PO5 & PO6

Topics beyond syllabus/Advanced topics/Design: Design optimization for industrial projects, Fractional order controller

POs met through Topics beyond syllabus/Advanced topics/Design: PO5 & PO6

Course Outcome (CO) Attainment Assessment Tools and Evaluation Procedure

Direct Assessment

Assessment Tools	% Contribution during CO Assessment
Continuous Internal Assessment	50
Semester End Examination	50

Continuous Internal Assessment	% Distribution
3 quizzes	30 (3×10)
Assignment(s)	10
Seminar before a committee	10

Assessment Components	CO1	CO2	CO3	CO4	CO5
Continuous Internal Assessment					
Semester End Examination					

Indirect Assessment

1. Student Feedback on Faculty
2. Student Feedback on Course

Course Delivery Methods

CD1	Lecture by use of boards/LCD projectors/OHP projectors
CD2	Assignments
CD3	Laboratory experiments/teaching aids/ Seminars
CD4	Mini Projects
CD5	Industrial visits/in-plant training
CD6	Self- learning such as use of NPTEL materials and internets
CD7	Simulation

Mapping Between Course Outcomes and Program Outcomes

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	1	1	1	2	2	1
CO2	2	1	2	2	2	1
CO3	2	1	2	2	2	1
CO4	3	1	3	3	3	1
CO5	1	3	1	1	1	1

< 34% = 1, 34-66% = 2, > 66% = 3

Mapping Between Course Outcomes and Course Delivery Method

Course Outcomes	Course Delivery Method
CO1	CD1, CD6
CO2	CD1, CD6, CD7
CO3	CD1, CD2, CD3, CD6, CD7
CO4	CD1, CD3, CD6, CD7
CO5	CD1, CD2, CD3, CD4, CD7

COURSE INFORMATION SHEET

Course Code: EC558
Course Title: Modern Optimization Techniques
Pre-requisite(s): EC251 probability and Random Processes
Co-requisite(s):
Credits: L: 3 T: 0 P: 0 C: 3
Class schedule per week: 03
Class: M. Tech.
Semester / Level: II/05
Branch: ECE

Course Objectives:
This course enables the students to:

1	Gain understanding on optimization theory and its elements
2	Demonstrate single variable optimization, linear programming, dynamic programming concepts and techniques.
3	Demonstrate multivariable and constraint optimization concepts and techniques.
4	Understand on advance single and multi-objective optimization techniques such as GA, PSO, Pareto font, NSGA
5	Demonstrate an ability to apply the optimization techniques to various areas of Engineering and Science.

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

CO1	Develop an understanding to formulate an optimization problem and its characteristics.
CO2	Have an ability to analyse and apply algorithms for design optimization.
CO3	Have an ability to find optimum solution by applying the single and multi-objective evolutionary techniques.
CO4	Develop an ability to apply use optimization techniques to finance, economics, medical applications, control, communication, power, mechanical problems, chemical and biology.
CO5	Aspire for pursuing a carrier in Optimization, recognize the need to learn and adapt to the change in technology and play role of team leader.

SYLLABUS

Module 1:
Optimal problem formulation, Design variables constraints, Objective function, Variable bounds, Search methods: optimality Criteria, Bracketing methods: Exhaustive search methods, Region – Elimination methods; Interval halving method, Fibonacci search method, Golden section search method, Point-estimation method; Successive quadratic estimation method.

(8L)

Module 2:
Gradient-based methods: Newton-Raphson method, Bisection method, Secant method, Cauchy's steepest descent and Newton's method. Linear Programming: Graphical method, Simplex Method, Revised simplex method, Duality in Linear Programming (LP), integer linear programming, Dynamic programming, Sensitivity analysis.

(8L)

Module 3:
Optimality criteria, Unidirectional search, Direct search methods: Simplex search method, Hooke-Jeeves pattern search method. Gradient based method, conjugate gradient method, concept of Lagrangian multiplier, complex search method, characteristics of a constrained problem. Direct methods: The complex method, Cutting plane method, Indirect method: Transformation Technique, Basic approach in the penalty function method, Interior penalty function method, convex method.

(8L)

Module 4:
Genetic algorithm and its working principle, GA variants, Particle swarm optimization and its working principle, Differential evolution, Ant Colony Optimization, Applications in Engineering problems.

(8L)

Module 5: Multi objective Optimization problem, Dominance and Pareto-Optimality, Pareto font, Multi-objective Evolutionary Algorithms, Multi Objective genetic Algorithm, NSGA, Constrained Multi-objective Evolutionary Algorithms, Application to communication, medical, clustering, bioinformatics, control, finance.

(8L)

Books recommended:
Textbooks:

1. Optimization for Engineering Design - Kalyanmoy Deb, 2006, PHI
2. Kalyanmoy Deb, Multi-Objective Optimization using Evolutionary Algorithms, Wiley India publisher, 2010
3. S.S. Rao, Engineering Optimization, Theory and practice, New age International Publisher, 2012

4. D.E. Goldberg, genetic Algorithm in search, optimization and machine learning, Addison-Wesley Longman Publisher, 1989

Reference books:

1. Analytical Decision Making in Engineering Design - Siddal.
2. G. Hadley, "Linear programming", Narosa Publishing House, New Delhi, 1990.

Gaps in the Syllabus (to meet Industry/Profession requirements): Hands on experience on real time industrial project and management

POs met through Gaps in the Syllabus: PO5

Topics beyond Syllabus/Advanced topics/Design: latest developments in the Optimization Techniques

POs met through Topics beyond Syllabus/Advanced topics/Design: PO6

Course Outcome (CO) Attainment Assessment Tools and Evaluation Procedure

Direct Assessment

Assessment Tools	% Contribution during CO Assessment
Continuous Internal Assessment	50
Semester End Examination	50

Continuous Internal Assessment	% Distribution
3 quizzes	30 (3×10)
Assignment(s)	10
Seminar before a committee	10

Assessment Components	CO1	CO2	CO3	CO4	CO5
Continuous Internal Assessment					
Semester End Examination					

Indirect Assessment

1. Student Feedback on Faculty
2. Student Feedback on Course

Course Delivery Methods

CD1	Lecture by use of boards/LCD projectors/OHP projectors
CD2	Assignments
CD3	Laboratory experiments/teaching aids/ Seminars
CD4	Mini Projects
CD5	Industrial visits/in-plant training
CD6	Self- learning such as use of NPTEL materials and internets
CD7	Simulation

Mapping between Course Outcomes and Program Outcomes

CO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	1	2	2		2
CO2	3	2	2	3		1

CO3	3	2	2	3	1	1
CO4	3	3	2	3	1	2
CO5		1	1	1		2

< 34% = 1, 34-66% = 2, > 66% = 3

Mapping Between Course Outcomes and Course Delivery Method

Course Outcomes	Course Delivery Method
CO1	CD1, CD2, CD3, CD6
CO2	CD1, CD2, CD3, CD6, CD7
CO3	CD1, CD2, CD3, CD6, CD7
CO4	CD1, CD2, CD3, CD6, CD7
CO5	CD1, CD2

COURSE INFORMATION SHEET

Course code: EC559
Course title: Mixed Signal VLSI Design
Pre-requisite(s): EC253 Analog Circuits, EC203 Digital System Design
Co- requisite(s):
Credits: L: 3 T: 0 P: 0 C: 3
Class schedule per week: 03
Class: M. Tech.
Semester / Level: II/05
Branch: ECE
Name of Teacher:

Course Objectives:
This course enables the students to:

1.	Understand the basics of sampling theory
2.	Apply the mixed-signal design trends and challenges
3.	Analyze the analog and discrete time filters
4.	Appraise and evaluate different types of data converters and their VLSI implementations.
5.	Apprehend the characteristics of frequency synthesizers and phased lock loop and create their circuits.

Course Outcomes:
After the completion of this course, students will be able to:

CO1	Describe and illustrate Basics of Sampling and Aliasing
CO2	Sketch and explain the mixed-signal design trends and challenges.
CO3	Diagram and explain the analog and digital filters.
CO4	Appraise the data converters and schematize, assess and summarize their features.
CO5	Design and schematize the frequency synthesizers and phased lock loop. Schematize their characteristics and prepare an inference.

SYLLABUS

Module -1:
Basics of Sampling and Aliasing:
Sampling: Impulse Sampling, Decimation, The Sample-and-Hold (S/H), The Track-and-Hold (T/H), Interpolation, K-Path Sampling, Switched-Capacitor Circuits, Non-Overlapping Clock

Generation, Circuits: Implementing the S/H, Finite Op-Amp Gain-Bandwidth Product, Autozeroing, Correlated Double Sampling (CDS), Selecting Capacitor Sizes, The S/H with Gain, Implementing Subtraction in the S/H, A Single-Ended to Differential Output S/H.

(8L)

Module - 2:

Mixed-Signal Design Trends and Challenges:

Design flow: Top-down design, Bottom-up Design, Constraint Management, Mixed-Signal Verification, Behavioral Modeling, Mixed-Signal Hardware Description Languages, Low Power Verification, Design for Test, Mixed-Signal layout & Chip Planning, Interconnects and data transmission, Substrate Noise, AMS IP Reuse, Full-chip Signoff, IC/Package Co-Design.

(8L)

Module - 3:

Analog and Digital Filters:

Analog Filters: Integrator Building Blocks: Lowpass Filters, Active-RC Integrators, Effects of Finite Op-Amp Gain Bandwidth Product, Active-RC SNR, MOSFET-C Integrators, gm-C (Transconductor-C) Integrators, Discrete-Time Integrators, The Bilinear Transfer Function, *Digital Filters:* Sinc-Shaped Digital Filters: The Counter, Lowpass Sinc Filters, Bandpass and Highpass Sinc Filters, Interpolation using Sinc Filters, Decimation using Sinc Filters, FIR Filters, The Bilinear Transfer Function.

(8L)

Module - 4:

Data converters:

Basics of Analog to digital converters (ADC), Basics of Digital to analog converters (DAC), Parameters of data converters, Quantization Noise, Quantization Noise Voltage Spectral Density, Signal-to-Noise Ratio (SNR), Clock Jitter, Improving SNR using Averaging, ADCs: Successive approximation ADCs, Dual slope ADCs, High-speed ADCs (e.g. flash ADC, pipeline ADC and related architectures), Hybrid ADC structures, High-resolution ADC (e.g. delta-sigma converters). DACs: Resistor string, R-2R Ladder networks, Current steering, Charge scaling DACs, Cyclic DAC, Pipelined DACs

(8L)

Module - 5:

Phased lock loop:

Frequency Synthesizers and Phased lock loop: Simple PLL: Phase Detector, Basic PLL Topology, Dynamics of Simple PLL, Charge-Pump PLLs, Non-ideal Effect in PLLs: PFD/CP Nonidealities, Jitter in PLLs, Analog PLL, Digital PLL. Delay locked loops (DLL).

(8L)

Books recommended:

Textbooks:

1. CMOS mixed-signal circuit design by R. Jacob Baker, Wiley India, IEEE press, reprint 2008.
2. CMOS circuit design, layout and simulation by R. Jacob Baker, Revised second edition, IEEE press, 2008.
3. Design of analog CMOS integrated circuits by Behzad Razavi, McGraw-Hill, 2003.
4. Mixed-Signal Methodology Guide, by Jess Chen et al., First Edition, September 11, 2014
5. Tony Chan Carusone, David A. Johns and Kenneth W. Martin, Analogue Integrated Circuit Design, 2/e, John Wiley & Sons, 2012.

Reference books:

1. CMOS Integrated ADCs and DACs by Rudy V. dePlassche, Springer, Indian edition, 2005.

2. Electronic Filter Design Handbook by Arthur B. Williams, McGraw-Hill, 1981.
3. Design of analog filters by R. Schauman, Prentice-Hall 1990 (or newer additions).
4. An introduction to mixed-signal IC test and measurement by M. Burns et al., Oxford university press, first Indian edition, 2008.

Gaps in the syllabus (to meet Industry/Profession requirements): Hands-on-practical for fabrication of mixed-signal VLSI circuit.

POs met through Gaps in the Syllabus: PO6

Topics beyond syllabus/Advanced topics/Design: Fabrication of mixed-signal circuit.

POs met through Topics beyond syllabus/Advanced topics/Design: PO6

Course Outcome (CO) Attainment Assessment Tools and Evaluation Procedure

Direct Assessment

Assessment Tools	% Contribution during CO Assessment
Continuous Internal Assessment	50
Semester End Examination	50

Continuous Internal Assessment	% Distribution
3 quizzes	30 (3×10)
Assignment(s)	10
Seminar before a committee	10

Assessment Components	CO1	CO2	CO3	CO4	CO5
Continuous Internal Assessment					
Semester End Examination					

Indirect Assessment

1. Student Feedback on Faculty
2. Student Feedback on Course

Course Delivery Methods

CD1	Lecture by use of boards/LCD projectors/OHP projectors
CD2	Assignments
CD3	Laboratory experiments/Teaching aids/Seminars
CD4	Mini Projects
CD5	Industrial visits/in-plant training
CD6	Self- learning such as use of NPTEL materials and internets
CD7	Simulation

Mapping between Course Outcomes and Program Outcomes

CO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	3	3	3	2	1
CO2	3	3	3	3	2	1
CO3	3	3	1	3	2	1
CO4	2	2	2	2	3	1
CO5	2	2	2	2	3	1

< 34% = 1, 34-66% = 2, > 66% = 3

Mapping between Course Outcomes and Course Delivery Method

Course Outcomes	Course Delivery Method
CO1	CD1, CD2, CD3, CD6, CD7
CO2	CD1, CD2, CD3, CD6, CD7
CO3	CD1, CD2, CD3, CD6, CD7
CO4	CD1, CD2, CD3, CD6, CD7
CO5	CD1, CD2, CD3, CD6, CD7

Open Elective-II

COURSE INFORMATION SHEET

Course Code: EC598
Course Title: Overview of Mobile Communication
Pre-requisite(s): None
Co-requisite(s): None
Credits: L: 3 T: 0 P: 0 C: 3
Class schedule per week: 03
Class: M. Tech.
Semester / Level: II/05
Branch: ECE

Course Objectives:
This course aims to develop

1	An understanding on functioning of mobile cellular communication systems.
2	An understanding of interference in mobile cellular environment and enhancing capacity of mobile cellular systems.
2	An understanding of evolution within mobile cellular communication system and various standards.
4	An understanding of multipath propagation and current techniques used in mobile cellular communication.

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

CO1	Explain the functioning of mobile cellular communication systems.
CO2	Demonstrate an understanding interference in mobile cellular environment and enhancing capacity of mobile cellular systems.
CO3	Explain evolution within mobile cellular communication system and various standards.
CO4	Analyse the power level consideration for hand off in cellular communication.
CO5	Demonstrate an understanding of multipath propagation and current techniques used in mobile cellular communication.

SYLLABUS

Module1: Conventional mobile communication, Mobile cellular communication, Mobile cellular concept and frequency reuse, hexagonal cells, General architecture of a mobile cellular communication system, Frequency management and channel assignment, Hand-off in mobile cellular systems.

(8L)

Module 2: Downlink and uplink interference, co channel interference, relation between Q and N, locating a co channel cell, estimation of SIR in co channel cells, adjacent channel interference, power control, enhancing capacity of cellular system, cell splitting, sectorization, link adaptation, small cell deployment.

(8L)

Module 3: Historical developments within mobile cellular communication systems, characteristic features and examples of various generations of Mobile cellular communication system, challenges of 4G mobile cellular system, vision of 5G mobile cellular system.

(8L)

Module 4: Typical examples from cellular standards: AMPS operation and channels, GSM architecture, channel and identification numbers, GPRS architecture and channels, WCDMA features and architecture, LTE, LTE-Advanced, WiMax.

(8L)

Module 5: Multipath fading, diversity and combining techniques, MIMO, smart antenna, beamforming, OFDM, spectrum allocation, cognitive radio, software defined radio, Green communication.

(8L)

Books recommended:

Textbooks:

1. Sanjay Kumar, "Wireless Communication the Fundamental and Advanced Concepts" River Publishers, Denmark, 2015 (Indian reprint).

Reference books:

1. Vijay K Garg, "Wireless Communications and Networks", Morgan Kaufmann Publishers an Imprint of Elsevier, USA 2009 (Indian reprint)

Gaps in the syllabus (to meet Industry/Profession requirements): Hands on experience on real time industrial project and management

POs met through Gaps in the Syllabus: PO5

Topics beyond syllabus/Advanced topics/Design: Current technological developments in mobile communication systems.

POs met through Topics beyond syllabus/Advanced topics/Design: PO1

Course Outcome (CO) Attainment Assessment Tools and Evaluation Procedure

Direct Assessment

Assessment Tools	% Contribution during CO Assessment
Continuous Internal Assessment	50
Semester End Examination	50

Continuous Internal Assessment	% Distribution
3 quizzes	30 (3×10)
Assignment(s)	10
Seminar before a committee	10

Assessment Components	CO1	CO2	CO3	CO4	CO5
Continuous Internal Assessment					

Semester End Examination					

Indirect Assessment

1. Student Feedback on Faculty
2. Student Feedback on Course

Course Delivery Methods

CD1	Lecture by use of boards/LCD projectors/OHP projectors
CD2	Assignments
CD3	Laboratory experiments/teaching aids/ Seminars
CD4	Mini Projects
CD5	Industrial visits/in-plant training
CD6	Self- learning such as use of NPTEL materials and internets
CD7	Simulation

Mapping between Course Outcomes and Program Outcomes

CO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	-	2	3	1	-	1
CO2	1	2	3	2	2	2
CO3	1	1	3	1	1	2
CO4	3	1	3	3	2	1
CO5	1	3	3	1	2	2

< 34% = 1, 34-66% = 2, > 66% = 3

Mapping between Course Outcomes and Course Delivery Method

Course Outcomes	Course Delivery Method
CO1	CD1, CD2, CD3, CD6
CO2	CD1, CD2, CD3, CD6
CO3	CD1, CD2, CD3, CD6
CO4	CD1, CD2, CD3, CD6, CD7
CO5	CD1, CD2, CD3, CD6, CD7

Programme Core

COURSE INFORMATION SHEET

Course code: EC561
Course title: Wireless Networking Lab
Pre-requisites: Fundamental Knowledge of Communication System, basic understanding of communication process and communication media.
Co- requisite(s):
Credits: L: 0 T: 0 P: 4 C: 2
Class schedule per week: 04
Class: M. Tech.
Semester / Level: II/05

Branch: ECE

Course Objectives

This course enables the students:

1	To develop an ability to design various kind of wired networks using network simulator.
2	To develop an ability to design various kind of wireless networks using network simulator.
3	To evaluate and compare the performance of several network protocols (AODV, DYMO etc.).
4	To design and interpret wireless sensor networks and standards
5	To design and examine the hardware setup for wireless network

Course Outcomes

On the completion of this course, the students will:

CO1	Have an ability to design various kind of wired/wireless networks.
CO2	Have an ability to evaluate the performance of both wired/wireless networks.
CO3	Be able to analyze and compare the performance of various routing protocols (like AODV, DYMO etc.) for wireless adhoc network as well as for infrastructure based wireless network.
CO4	Have an ability to design and interpret wireless networks and standards (WLAN, Bluetooth etc) through simulation software as well as evaluate the impact of various system parameters on wireless standards.
CO5	Have an ability to design and analyze the hardware setup (GSM and WSN etc) for wireless network.

List of Experiments:

Compulsory:

1. To study and demonstrate the flow of operation (packets) in QualNet Network Simulator GUI.
2. To design and evaluate an Ad hoc mode scenario using QualNet Network Simulator.
3. To configure and evaluate an infrastructure mode scenario using QualNet Simulator GUI.
4. To configure and estimate the effect of mobility to the data transferred in an Ad hoc mode scenario.
5. To configure and estimate the effect of mobility to the data transferred in an infrastructure mode.
6. To configure VOIP Application layer protocol based on H.323 in an infrastructure.
7. Assembly of GSM set up and real time study of GSM 07. 05 and 07.07 AT commands (such as network registration call control call setting etc at least 10 command).
8. To configure and evaluate a multicasting application in a wired/wireless scenario.

9. To develop a code to read soil moisture and soil temperature data from sensor module attached to radio module using SENSnuts GUI platform.
10. To Interface analog sensor with Scientech 2311 W Wireless sensor network.
11. To develop a code to read temperature and light sensor data from sensor module attached to the radio module using SENSnuts GUI platform.
12. To create a LBR (level based routing) based multi-hop network using SENSnuts GUI platform.

Optional

1. Setup a wireless sensor network and test under various channel conditions.
2. To check the effect of bottleneck in a wired scenario.
3. Simulation and calculation of throughput for TCP connection (using NS2 Simulator).
4. Simulation and calculation of throughput for a STAR connection network with 2 TCP and 1 UDP connection.
5. Configure of a phone and implementation of class of Services (COS) and Class of Restriction (COR) auto call forwarding in IP telephony.
6. To compare two routing protocols (AODV and DYMO) in ad hoc mode scenario.

Reference books:

1. Vijay K. Garg, "Wireless Communications Networking", Elsevier Publication.
2. Theidore S Rappaport, "Wireless Communication: Principles and Practice" Prentice Hall of India, New Delhi, 2006, 2/e.
3. Lab. Manuals concerning each experiment.

Gaps in the syllabus (to meet Industry/Profession requirements): Hands on experience on real time industrial project and management

POs met through Gaps in the Syllabus: PO5

Topics beyond syllabus/Advanced topics/Design: Current development in wireless networking

POs met through Topics beyond syllabus/Advanced topics/Design: PO5 and PO6

Course Outcome (CO) Attainment Assessment Tools and Evaluation Procedure

Direct Assessment

Assessment Tools	% Contribution during CO Assessment
Progressive Evaluation	60
End Semester Evaluation	40

Progressive Evaluation	% Distribution
Day to day performance & Lab files	30
Quiz (zes)	10
Viva	20

End Semester Evaluation	% Distribution
Examination Experiment Performance	30
Quiz	10

Assessment Components	CO1	CO2	CO3	CO4	CO5
Progressive Evaluation					
End Semester Evaluation					

Indirect Assessment

1. Student Feedback on Faculty
2. Student Feedback on Course

Course Delivery Methods

CD1	Lecture by use of boards/LCD projectors/OHP projectors
CD2	Assignments
CD3	Laboratory experiments/teaching aids/ Seminars
CD4	Mini Projects
CD5	Industrial visits/in-plant training
CD6	Self- learning such as use of NPTEL materials and internets
CD7	Simulation

Mapping between Course Outcomes and Program Outcomes

CO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	-	2	3	1	-	1
CO2	1	2	3	2	2	2
CO3	1	1	3	1	1	2
CO4	3	1	3	3	2	1
CO5	1	3	3	1	2	2

< 34% = 1, 34-66% = 2, > 66% = 3

Mapping between Course Outcomes and Course Delivery Method

Course Outcomes	Course Delivery Method
CO1	CD1, CD2, CD3, CD6
CO2	CD1, CD2, CD3, CD6
CO3	CD1, CD2, CD3, CD6
CO4	CD1, CD2, CD3, CD6, CD7
CO5	CD1, CD2, CD3, CD6, CD7

COURSE INFORMATION SHEET

Course code: EC562
Course title: Advanced Wireless system Design Lab
Pre-requisites: Fundamental Knowledge of Microwave Engineering and Wireless communication Engineering.
Co- requisite(s):
Credits: L: 0 T: 0 P: 4 C: 2
Class schedule per week: 04
Class: M. Tech.

Semester / Level: II/05
Branch: ECE

Course Objectives
This course enables the students:

1	To develop an ability to design various kind of micro wave circuits
2	To develop an ability to fabricate the microwave circuits.
3	To develop an ability to measure performance parameters of the microwave hardware circuit
4	To develop an ability to learn various microwave circuit design software.

Course Outcomes
On the completion of this course, the students will:

CO1	Have an ability to design and evaluate various kind of micro wave circuits.
CO2	Have an ability to design and implement using FPGA kit
CO3	Be able to fabricate the microwave circuits
CO4	Have an ability to measure performance parameters of the microwave hardware circuit
CO5	Have an ability to learn various microwave circuit design software.

List of Experiments:

1. Design and simulation of 50 Ω microstripline using SONNET.
2. Design and simulation of low pass filter using SONNET.
3. Design and simulation of microstrip Band Pass Filter using SONNET.
4. Design and simulation of branchline coupler using SONNET.
5. Design and simulation of 45^0 or 90^0 phase shifter using ADS
6. Design and simulation of interdigital capacitor using ADS.
7. Fabrication and testing of any of the designed filter.
8. Fabrication and testing of any of the designed circuit components (BLC/Power divider).
9. Design and simulation of a low noise amplifier in Microwave office.
10. Design and simulation of an oscillator using Microwave office.
11. Design and simulation of a low pass filter using Microwave office.
12. FPGA implementation of convolution encoder.

Optional

1. Design and simulation of an active device Integrated antenna using Microwave office.
2. Design and simulation of frequency switchable patch antenna using Microwave office
3. Design and simulation of BW switchable BPF using ADS
4. Design and simulation of frequency switchable BSF using SONET

Reference books:

1. R. Ludwig, G. Bogdano, "RF Circit Design, Theory and Applications", Pearson
2. M.J. Lancaster,J.S. Hong, " Micrstrip Filters for RF/Microwave Applications",John Wiley and Sons
3. Narinder Lall, "FPGA-Based Wireless System Design", Xilinx, Inc. Manual.
4. Lab. Manuals concerning each experiment.

Gaps in the syllabus (to meet Industry/Profession requirements): Hands on experience on real time industrial project and management

POs met through Gaps in the Syllabus: PO5

Topics beyond syllabus/Advanced topics/Design: Current developments in wireless system design systems.

POs met through Topics beyond syllabus/Advanced topics/Design: PO5 and PO6

Course Outcome (CO) Attainment Assessment Tools and Evaluation Procedure

Direct Assessment

Assessment Tools	% Contribution during CO Assessment
Progressive Evaluation	60
End Semester Evaluation	40

Progressive Evaluation	% Distribution
Day to day performance & Lab files	30
Quiz (zes)	10
Viva	20

End Semester Evaluation	% Distribution
Examination Experiment Performance	30
Quiz	10

Assessment Components	CO1	CO2	CO3	CO4	CO5
Progressive Evaluation					
End Semester Evaluation					

Indirect Assessment

1. Student Feedback on Faculty
2. Student Feedback on Course

Course Delivery Methods

CD1	Lecture by use of boards/LCD projectors/OHP projectors
CD2	Assignments
CD3	Laboratory experiments/teaching aids/ Seminars
CD4	Mini Projects
CD5	Industrial visits/in-plant training

CD6	Self- learning such as use of NPTEL materials and internets
CD7	Simulation

Mapping of Course Outcomes onto Program Outcomes

CO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	3	3	3	-	-
CO2	3	3	3	3	-	-
CO3	3	1	1	2	-	-
CO4	3	2	3	3	-	-
CO5	3	3	-	3	-	-

< 34% = 1, 34-66% = 2, > 66% = 3

Mapping Between Course Outcomes and Course Delivery Method

Course Outcomes	Course Delivery Method
CO1	CD1, CD6
CO2	CD1, CD6, CD7
CO3	CD1, CD2, CD3, CD6, CD7
CO4	CD1, CD3, CD6, CD7
CO5	CD1, CD2, CD3, CD4, CD7

3rd Semester

Programme Core

EC600 Thesis (Part I) Credit: 8

COURSE INFORMATION SHEET

Course Code: EC601
Course Title: Advanced Wireless Communication
Pre-requisite(s): Knowledge of wireless communication and networks
Co-requisite(s):
Credits: L: 3 T: 0 P: 0 C: 3
Class schedule per week: 03
Class: M. Tech.
Semester / Level: III/06
Branch: ECE

Course Objectives:
This course aims to

1	Discuss the current and future wireless mobile communication system
2	Describe in detail various technological components which will be instrumental to realize next generation wireless communication system.
3	Develop and ability to understand wireless communication channel and channel models for the next generation wireless mobile communication
4	Explain transmission techniques and multiple access techniques to realize next generation communication system.

Course Outcomes

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

CO1	Demonstrate the knowledge of the current and future wireless mobile communication system
CO2	Explain and analyze various technologies required to realize the next generation wireless communication system.
CO3	Understand the requirements of various microwave circuits and their implementation for Wireless application requirements.
CO4	Explain and analyze wireless communication channel and channel models for the next generation wireless mobile communication
CO5	Explain and analyze transmission techniques and multiple access techniques to realize next generation communication system.

SYLLABUS

Module 1: Current trends and future vision in wireless communication, WCDMA, HSPA, LTE, LTE-Advanced, 4G vs. 5G, 5G vision.

(8L)

Module 2: Technological components for 5G-1: Massive MIMO, mm Wave Communication, CR Networks (CRN), SDR Networks (SDN), Multi RAT, HetNet, Visible Light Communication (VLC). Cooperative Cognitive Communication (CCC), Coordinated Multiple Point transmission (CoMP).

(8L)

Module 3: Technological components for 5G-2: Reconfigurable Antenna Design, Smart Antenna, Autonomous Network Configuration & Operation, Femto-cell deployment, Dynamic Adhoc Wireless Networks (DAWN), Ambient Intelligence, Cloud Radio Access Networks (CRAN), Network Function Virtualization (NFV), Support of IPv6, Flat IP Control, Multi Homing.

(8L)

Module 4: Wireless mobile environment, wireless channel parameters, fading, types of fading, types of wireless mobile channel, typical small-scale fading models, time variant representation of wireless mobile channel, channel models for next generation wireless mobile communication systems.

(8L)

Module 5: Transmission techniques and multiple access schemes for next generation wireless mobile communication system: multicarrier communications, OFDM, MIMO-OFDM, OFDMA, GFDM (Generalized Frequency division multiplexing), NOMA (Nonorthogonal multiple access), BDMA (Beam division multiple access), Vandermonde-subspace frequency division multiplexing (VFDM)

(8L)

Books recommended:

Reference books:

1. Ramjee Prasad, "5G: 2020 and beyond" River publishers, Denmark, 2014.

Research papers:

1. Cheng-Xiang Wang et. al. "Cellular Architecture and Key Technologies for 5G Wireless Communication networks" IEEE Communication Magazine, Feb, 2014.
2. Rupendra Nath Mitra, Dharma P Agrawal, "5G mobile technology: a survey", science direct January 2016 (available online www.sciencedirect.com)
3. Research papers pertaining to next generation wireless communication system.

Gaps in the syllabus (to meet Industry/Profession requirements): Hands on experience on

real time industrial project and management

POs met through Gaps in the Syllabus: PO5

Topics beyond syllabus/Advanced topics/Design: Ongoing technological developments in the field of wireless communication systems.

POs met through Topics beyond syllabus/Advanced topics/Design: PO5 and PO6

Course Outcome (CO) Attainment Assessment Tools and Evaluation Procedure

Direct Assessment

Assessment Tools	% Contribution during CO Assessment
Continuous Internal Assessment	50
Semester End Examination	50

Continuous Internal Assessment	% Distribution
3 quizzes	30 (3×10)
Assignment(s)	10
Seminar before a committee	10

Assessment Components	CO1	CO2	CO3	CO4	CO5
Continuous Internal Assessment					
Semester End Examination					

Indirect Assessment

1. Student Feedback on Faculty
2. Student Feedback on Course

Course Delivery Methods

CD1	Lecture by use of boards/LCD projectors/OHP projectors
CD2	Assignments
CD3	Laboratory experiments/teaching aids/ Seminars
CD4	Mini Projects
CD5	Industrial visits/in-plant training
CD6	Self- learning such as use of NPTEL materials and internets
CD7	Simulation

Mapping between Course Outcomes and Program Outcomes

CO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	3	3	3	-	-
CO2	3	3	3	3	3	-
CO3	3	3	1	2	3	-
CO4	3	2	2	2	2	-
CO5						

< 34% = 1, 34-66% = 2, > 66% = 3

Mapping Between Course Outcomes and Course Delivery Method

Course Outcomes	Course Delivery Method

CO1	CD1, CD6
CO2	CD1, CD6, CD7
CO3	CD1, CD2, CD3, CD6, CD7
CO4	CD1, CD3, CD6, CD7
CO5	CD1, CD2, CD3, CD4, CD7

Programme Elective – III

COURSE INFORMATION SHEET

Course Code: EC605
Course Title: Cognitive Radio Communication and Networks
Pre-requisite(s): Knowledge of communication system and networks.
Co-requisite(s): N/A
Credits: L: 3 T: 0 P: 0 C: 3
Class schedule per week: 03
Class: M. Tech.
Semester / Level: III/06
Branch: ECE

Course Objectives:
This course aims to develop

1	An understanding on software defined radio architecture and design principles.
2	An understanding on cognitive radio components, functions and capabilities.
3	An ability to evaluate different spectrum sensing mechanisms in cognitive radio.
4	An ability to analyse the spectrum management functions using cognitive radio systems and cognitive radio networks.

Course Outcomes
On the completion of this course, the students will be able to

CO1	Demonstrate an understanding on software defined radio architecture and design principles.
CO2	Demonstrate an understanding on cognitive radio components, functions and capabilities.
CO3	Evaluate different spectrum sensing mechanisms in cognitive radio.
CO4	Analyse the spectrum management functions using cognitive radio systems and cognitive radio networks.
CO5	Demonstrate an understanding on cooperative communications

SYLLABUS

Module 1: Software Defined Radio (SDR): Essential functions of the SDR, SDR architecture, design principles of SDR, traditional radio implemented in hardware and SDR, transmitter architecture and its issues, A/D & D/A conversion, parameters of practical data converters, techniques to improve data converter performance, complex ADC and DAC architectures, digital radio processing, reconfigurable wireless communication systems.

(8L)

Module 2: Cognitive Radio (CR) features and capabilities, CR functions, CR architecture, components of CR, CR cycle, CR and dynamic spectrum access, interference temperature, CR architecture for next generation networks, CR standardization.

(8L)

Module 3: Spectrum sensing and identification, primary signal detection. energy detector, cyclostationary feature detector, matched filter, cooperative sensing, spectrum opportunity, spectrum opportunity detection, fundamental trade-offs: performance versus constraint, sensing accuracy versus sensing overhead.

(8L)

Module 4: Spectrum management of cognitive radio networks, spectrum decision, spectrum sharing and spectrum mobility, mobility management of heterogeneous wireless networks, research challenges in CR.

(8L)

Module 5: Cognitive radio networks (CRN) architecture, terminal architecture of CRN, diversity radio access networks, routing in CRN, Control of CRN, Self-organization in mobile communication networks, security in CRN, cooperative communications, cooperative wireless networks, user cooperation and cognitive systems.

(8L)

Books recommended:

Textbooks:

1. Kwang-Cheng Chen and Ramjee Prasad, "Cognitive Radio Networks", John Wiley & Sons, Ltd, 2009.

Reference books:

1. Alexander M. Wyglinski, Maziar Nekovee, and Y. Thomas Hou, "Cognitive Radio Communications and Networks - Principles and Practice", Elsevier Inc., 2010.
2. Jeffrey H. Reed "Software Radio: A Modern Approach to radio Engineering", Pearson Education Asia.

Gaps in the syllabus (to meet Industry/Profession requirements): Hands on experience on real time industrial project and management

POs met through Gaps in the Syllabus: PO5

Topics beyond syllabus/Advanced topics/Design: Current technological developments in spectrum management using cognitive radio networks.

POs met through topics beyond syllabus/Advanced topics/Design: PO5 and PO6

Course Outcome (CO) Attainment Assessment Tools and Evaluation Procedure

Direct Assessment

Assessment Tools	% Contribution during CO Assessment
Continuous Internal Assessment	50
Semester End Examination	50

Continuous Internal Assessment	% Distribution
3 quizzes	30 (3×10)
Assignment(s)	10
Seminar before a committee	10

Assessment Components	CO1	CO2	CO3	CO4	CO5

Continuous Internal Assessment					
Semester End Examination					

Indirect Assessment

1. Student Feedback on Faculty
2. Student Feedback on Course

Course Delivery Methods

CD1	Lecture by use of boards/LCD projectors/OHP projectors
CD2	Assignments
CD3	Laboratory experiments/teaching aids/ Seminars
CD4	Mini Projects
CD5	Industrial visits/in-plant training
CD6	Self- learning such as use of NPTEL materials and internets
CD7	Simulation

Mapping between Course Outcomes and Program Outcomes

CO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	-	1	3	1	1	1
CO2	1	1	3	1	1	1
CO3	3	2	3	3	2	2
CO4	3	2	3	2	2	1
CO5	2	1	3	1	1	1

< 34% = 1, 34-66% = 2, > 66% = 3

Mapping between Course Outcomes and Course Delivery Method

Course Outcomes	Course Delivery Method
CO1	CD1, CD2, CD3, CD6
CO2	CD1, CD2, CD3, CD6
CO3	CD1, CD2, CD3, CD6
CO4	CD1, CD2, CD3, CD6, CD7
CO5	CD1, CD2, CD3, CD6, CD7

COURSE INFORMATION SHEET

Course code: EC606
Course title: Advanced Error control codes
Pre-requisite(s): Knowledge of digital electronics, basic understanding of digital communication and fundamentals of channel coding.
Co-requisite(s):
Credits: L: 3 T: 0 P: 0 C: 3
Class schedule per week: 03
Class: M. Tech.
Semester / Level: III/06
Branch: ECE

Course Objectives

This course aims to develop

1	An understanding of Mathematical Preliminaries for error correcting codes and fundamental knowledge of block codes.
2	An understanding of BCH and Reed-Solomon Codes with its applications.
3	Fundamental understanding on Convolutional codes & Viterbi decoding and Trellis coded modulation.
4	Fundamental understanding on Modern iterative coding (Turbo codes and LDPC codes).

Course Outcomes

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

CO1	Utilize the fundamental knowledge of block codes for concerned applications.
CO2	Demonstrate the BCH and Reed-Solomon Codes for practical applications.
CO3	Explain the Convolutional encoding with Vitebi decoding and Trellis coded modulation.
CO4	Elaborate the Modern iterative coding like Turbo codes and LDPC codes.
CO5	Have an ability to provide practical solutions and apply the subject expertise for the well fare of society.

SYLLABUS

Module1: Mathematical Preliminaries and Introduction to Block codes: Mathematical preliminaries: Fields, groups, subgroups and cosets; Basics of binary Linear Block Codes; Bounds on Block codes; Erasure decoding; Sydrome decoding.

(8L)

Module2: BCH and Reed-Solomon Codes: BCH Codes; Reed-Solomon Codes; Decoding BCH and RS Codes; Finding the Error Locator Polynomial: Berlekamp-Massey Algorithm; Non-Binary BCH and RS Decoding: Forney's Algorithm.

(8L)

Module3: Convolutional codes and Trellis coded modulation: Coding gain; ML and MAP decoders; Soft-versus hard-decision decoding; Convolutional Codes: Encoders; Trellis code; Viterbi decoding; Trellis coded modulation.

(8L)

Module4: Modern iterative coding-I: Turbo codes: Encoders, Turbo decoder; Implementation aspects of turbo codes: MAP, Log-MAP, Max-Log-MAP and SOVA decoders, Design and Architecture; Turbo codes in the WiMax/3GPP standards.

(8L)

Module5: Modern iterative coding-II: Low-density Parity-check Codes: Ensembles of LDPC codes, Message-passing decoders, Threshold phenomenon and density evolution, LDPC codes in the WiMax standard.

(8L)

Books recommended:

Textbooks:

1. "Error Correction Coding Mathematical Methods and Algorithms" by Todd K. Moon, Wiley India Edition.

Reference books:

1. Shu Lin and D. J. Costello, Error Control Coding, Second Edition, Pearson Press, 2004.

Gaps in the syllabus (to meet Industry/Profession requirements): Hands on experience on real time industrial project and management

POs met through Gaps in the Syllabus: PO5

Topics beyond syllabus/Advanced topics/Design: Current technological developments in error correction techniques.

POs met through Topics beyond syllabus/Advanced topics/Design: PO1

Course Outcome (CO) Attainment Assessment Tools and Evaluation Procedure

Direct Assessment

Assessment Tools	% Contribution during CO Assessment
Continuous Internal Assessment	50
Semester End Examination	50

Continuous Internal Assessment	% Distribution
3 quizzes	30 (3×10)
Assignment(s)	10
Seminar before a committee	10

Assessment Components	CO1	CO2	CO3	CO4	CO5
Continuous Internal Assessment					
Semester End Examination					

Indirect Assessment

1. Student Feedback on Faculty
2. Student Feedback on Course

Course Delivery Methods

CD1	Lecture by use of boards/LCD projectors/OHP projectors
CD2	Assignments
CD3	Laboratory experiments/teaching aids/ Seminars
CD4	Mini Projects
CD5	Industrial visits/in-plant training
CD6	Self- learning such as use of NPTEL materials and internets
CD7	Simulation

Mapping between Course Outcomes and Program Outcomes

CO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	1	2	3	2	-	1
CO2	1	2	3	2	2	2
CO3	2	1	3	1	1	2
CO4	2	2	3	2	2	2
CO5	3	1	1	1	2	2

< 34% = 1, 34-66% = 2, > 66% = 3

Mapping Between Course Outcomes and Course Delivery Methods

Course Outcomes	Course Delivery Method
CO1	CD1, CD2, CD3, CD6
CO2	CD1, CD2, CD3, CD6
CO3	CD1, CD2, CD3, CD6

CO4	CD1, CD2, CD3, CD6, CD7
CO5	CD1, CD2, CD3, CD6, CD7

COURSE INFORMATION SHEET

Course code: EC607
Course title: Markov Chains and Queuing Systems
Pre-requisite(s): Probability and Stochastic Processes, DSP
Co- requisite(s):
Credits: L: 3 T: 0 P: 0 C: 3
Class schedule per week: 3
Class: M. Tech.
Semester / Level: III/06
Branch: ECE

Course Objectives
This course enables the students:

1	To Understand Markov Chains.
2	To Understand regenerative processes used in modelling a wide variety of systems and phenomena.
3	To Model a system as queuing system with some aspect of the queue governed by a random
4	To Understand telecommunication systems modelling using Markov chains with special Emphasis on developing queuing models.
5	Develop advance queuing model using the concept of stochastic processes to solve complex problem.

Course Outcomes
After the completion of this course, students will be:

CO1	Able to analyse the concept of Markov Chains and regenerative processes used in modelling a wide variety of systems and phenomena.
CO2	Able to Model a system as queuing system with some aspect of the queue governed by a random.
CO3	Able to identify telecommunication systems model using Markov chains with special emphasis on developing queuing models.
CO4	Able to design advance queuing model using the concept of stochastic processes to solve complex problem.
CO5	Able to design Q-matrix, birth-death processes, quasi birth death processes.

SYLLABUS

Module 1: Renewal Processes: Basic definitions, recurrence times, rewards and renewal reward theorem, point processes, Poisson process, Walds equation, Blackwell's theorem.

(8L)

Module 2: Discrete time Markov chains: definitions and properties, matrix representation, Perron- Frobenius theory.

(8L)

Module 3: Continuous time Markov chains: basic definitions, Q-matrix, birth-death processes, quasi birth death processes; Embedded Markov processes, semi Markov processes, reversible Markov chains, Random walks.

(8L)

Module 4: Fundamental queuing results: Little's theorem, invariance of the mean delay, Conservation law. Markovian queues: Jackson and BCMP networks, numerical Algorithms. M/G/1 & G/M/1 queues and G/G/1 queues.

(8L)

Module 5: Advanced queuing models: priority, vacation and retrials in queues

(8L)

Books recommended:

Textbooks:

1. Cliffs, "Stochastic Modelling and the Theory Queues", Prentice Hall, 1989.
2. P.Bremaud, "Markov Chains", Springer-Verlag, 1999.

Reference books:

1. E.Seneta, "Non Negative Matrices and Markov Chains", Springer Series in Statistics, Springer, 1981.
2. R.Gallager, "Discrete Stochastic Processes", Kluwer Academic Press, 1996.
3. L.Kleinrock, "Queuing Systems", vols I and II, John Wiley and Sons 1976.

Gaps in the syllabus (to meet Industry/Profession requirements): Hands on experience on real time industrial project and management

POs met through Gaps in the Syllabus: PO5

Topics beyond syllabus/Advanced topics/Design: Current technological developments

POs met through Topics beyond syllabus/Advanced topics/Design: PO6

Course Outcome (CO) Attainment Assessment Tools and Evaluation Procedure

Direct Assessment

Assessment Tools	% Contribution during CO Assessment
Continuous Internal Assessment	50
Semester End Examination	50

Continuous Internal Assessment	% Distribution
3 quizzes	30 (3×10)
Assignment(s)	10
Seminar before a committee	10

Assessment Components	CO1	CO2	CO3	CO4	CO5
Continuous Internal Assessment					
Semester End Examination					

Indirect Assessment

1. Student Feedback on Faculty
2. Student Feedback on Course

Course Delivery Methods

CD1	Lecture by use of boards/LCD projectors/OHP projectors
CD2	Assignments
CD3	Laboratory experiments/teaching aids/ Seminars

CD4	Mini Projects
CD5	Industrial visits/in-plant training
CD6	Self- learning such as use of NPTEL materials and internets
CD7	Simulation

Mapping between Course Outcomes and Program Outcomes

CO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	1	2	3	2	-	1
CO2	1	2	3	2	2	2
CO3	2	1	3	1	1	2
CO4	2	2	3	2	2	2
CO5	3	1	1	1	2	2

< 34% = 1, 34-66% = 2, > 66% = 3

Mapping Between Course Outcomes and Course Delivery Methods

Course Outcomes	Course Delivery Method
CO1	CD1, CD2, CD3, CD6
CO2	CD1, CD2, CD3, CD6
CO3	CD1, CD2, CD3, CD6
CO4	CD1, CD2, CD3, CD6, CD7
CO5	CD1, CD2, CD3, CD6, CD7

COURSE INFORMATION SHEET

Course code: EC608
Course title: Statistical Signal Processing
Pre-requisite(s): Probability and Stochastic Processes, ADSP
Co- requisite(s):
Credits: L: 3 T: 0 P: 0 C: 3
Class schedule per week: 03
Class: M. Tech.
Semester / Level: III/06
Branch: ECE

Course Objectives

This course enables the students:

1	To Understand the engineering needs and problems involved in one of the mos challenging areas of signal processing namely statistical signal processing.
2	To appreciate the depth of applications of the subject.
3	To bring out the concepts related to stationary and non-stationary random signals
4	To emphasize the importance of true estimation of power spectral density.
5	To grasp the fundamentals of statistical theory of estimation and detection.

Course Outcomes

After the completion of this course, students will be:

CO1	Able to explain the statistical concept of power spectrum estimation.
CO2	Able to Analyse the implications at system level of the use of statistical signa processing techniques.

CO3	Able to differentiate the prominence of various spectral estimation techniques fo achieving higher resolution in the estimation of power spectral density.
CO4	Able to design and development of optimum filters using classical and adaptiv algorithms.
CO5	Able to analyse whitening filter, rational power spectra

SYLLABUS

Module-1: Stochastic Processes: Time average and moments, ergodicity, power spectral density, covariance matrices, response of LTI system to random process, cyclostationary process, and spectral factorization, Detection Theory: Detection in white Gaussian noise, correlator and matched filter interpretation, Bayes‘ criterion of signal detection, MAP, LMS, entropy detectors, detection in colored Gaussian noise, Karhunen-Loeve expansions and whitening filters.

(8L)

Module-2: Nonparametric Spectral Estimation: Estimation of power spectrum of stationary random signal using periodogram-various methods, Joint signal analysis and estimation of cross power spectrum.

(8L)

Module-3: Signal Model: Synthesis of coloring filter and Analysis of whitening filter, rational power spectra (AR, MA, ARMA), Relationship between filter parameters and autocorrelation sequences, Lattice- Ladder filter realization.

(8L)

Module-4: Parametric Spectral Estimation: Order selection criterion of AR model, Minimum-variance, Maximum entropy and Maximum likelihood spectrum estimation Harmonic models and frequency estimation techniques Harmonic Decomposition, MUSIC algorithm, ESPRIT algorithm.

(8L)

Module-5: Linear Optimum Filter: Optimum FIR Filter, PCA of optimum linear estimator and its frequency domain interpretation, Forward and Backward Linear prediction and optimum reflection coefficients Optimum causal and non-causal IIR Filters, Deconvolution and Signal restoration Algorithms and Structure of Optimum Linear Filters Levinson Recursion for optimum estimate, Order-recursive algorithms for optimum FIR filters and its lattice structures.

(8L)

Books recommended:

Textbooks:

1. Steven Kay, *Fundamentals of Statistical Signal Processing*, Vol I: Estimation Theory, Vol II: Detection Theory, Prentice Hall, 1993/1998.

Reference books:

1. Harry L. Van Trees, *Detection, Estimation, and Modulation Theory*, Part I, Wiley-Inter science, 2001
2. Monson H. Hayes, *Statistical Digital Signal Processing and Modeling*, John Wiley, 1996.

Gaps in the syllabus (to meet Industry/Profession requirements): Hands on experience on real time industrial project and management

POs met through Gaps in the Syllabus: PO5

Topics beyond syllabus/Advanced topics/Design: Current technological developments

POs met through Topics beyond syllabus/Advanced topics/Design: PO6

Course Outcome (CO) Attainment Assessment Tools and Evaluation Procedure

Direct Assessment

Assessment Tools	% Contribution during CO Assessment
Continuous Internal Assessment	50
Semester End Examination	50

Continuous Internal Assessment	% Distribution
3 quizzes	30 (3×10)
Assignment(s)	10
Seminar before a committee	10

Assessment Components	CO1	CO2	CO3	CO4	CO5
Continuous Internal Assessment					
Semester End Examination					

Indirect Assessment

1. Student Feedback on Faculty
2. Student Feedback on Course

Course Delivery Methods

CD1	Lecture by use of boards/LCD projectors/OHP projectors
CD2	Assignments
CD3	Laboratory experiments/teaching aids/ Seminars
CD4	Mini Projects
CD5	Industrial visits/in-plant training
CD6	Self- learning such as use of NPTEL materials and internets
CD7	Simulation

Mapping between Course Outcomes and Program Outcomes

CO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	1	2	3	2	-	1
CO2	1	2	3	2	2	2
CO3	2	1	3	1	1	2
CO4	2	2	3	2	2	2
CO5	3	1	1	1	2	2

< 34% = 1, 34-66% = 2, > 66% = 3

Mapping Between Course Outcomes and Course Delivery Methods

Course Outcomes	Course Delivery Method
CO1	CD1, CD2, CD3, CD6
CO2	CD1, CD2, CD3, CD6
CO3	CD1, CD2, CD3, CD6
CO4	CD1, CD2, CD3, CD6, CD7
CO5	CD1, CD2, CD3, CD6, CD7

COURSE INFORMATION SHEET

Course code: EC631
Course title: FPGA Based System Design
Pre-requisite(s): Fundamental knowledge of VLSI Design, Digital Electronics, Signal Processing, Communication Systems, VHDL, Verilog, MATLAB.
Co- requisite(s):
Credits: L: 3 T: 0 P: 0 C: 3
Class schedule per week: 3
Class: M. Tech.
Semester / Level: III/06
Branch: ECE

Course Objectives

This course enables the students to:

1.	Define the fundamental of FPGA & wireless systems
2.	Develop the suitable algorithm, software for FPGA based system and show the correlation between FPGA & wireless communication system
3.	Show the application of FPGA based wireless system in present market
4.	Design the highly secure, optimized and fast wireless communication system
5.	Design the FPGA based Wireless Communication System

Course Outcomes

After the completion of this course, students will be able to:

CO1	Recognize the interfacing and integration of FPGA with computing systems
CO2	Design the highly secure mobile computing systems.
CO3	Develop the programmable kit to check the entire components in a board.
CO4	Develop the FPGA based wireless systems & corresponding software as per demand of current market.
CO5	Design the FPGA based Wireless Communication System

SYLLABUS

Module 1: Analysis of FPGA Speed, Area & Power: High throughput, Low latency, Timing, Rolling Up the Pipeline, Control-Based Logic Reuse, Resource Sharing, Impact of Reset on Area, Clock Control, Input Control, Reducing the Voltage Supply, Dual-Edge Triggered Flip-Flops, Modifying Terminations.

(8L)

Module 2: Advanced Encryption Standards & High-Level Design: AES Architectures, Performance versus Area and other Optimizations, Abstract Design Techniques**,** Graphical State Machines**,** DSP Design**,** Software/Hardware Co-design**.**

(8L)

Module 3: Clock domains, Reset Circuits & Implementing Math Functions: Crossing Clock Domains**,** Gated Clocks in ASIC Prototypes, Asynchronous Versus Synchronous, Mixing Reset Types, Multiple Clock Domains, Hardware Division**,** Taylor and Maclaurin Series Expansion**,** CORDIC Algorithm, Floating-Point Formats, Pipelined Architecture.

(8L)

Module 4: Synthesis Optimization, Floorplanning, Placement & Routing: Decision Trees, Traps, Design Organization, Speed Versus Area, Resource Sharing, Pipelining, Retiming, and

Register Balancing, FSM Compilation, Black Boxes, Physical Synthesis, Design Partitioning, Critical-Path Floorplanning, Floorplanning Dangers, Optimal Floorplanning, Reducing Power Dissipation, Relationship between Placement and Routing, Placement Seed, Guided Place and Route.

(8L)

Module 5: FPGA for Wireless System: System Design and Modeling, Transmitter Design, Channel Modeling, Receiver Design, Automatic Hardware Generation, Co-Simulation and Hardware Verification, Simulation Acceleration with Simulink

(8L)

Books recommended:

Textbooks:

1. Steve Kilts, "Advanced FPGA Design: Architecture, Implementation, and Optimization", McGraw-Hill Education TAB; 1 edition (October 5, 2016)
2. Narinder Lall, "FPGA-Based Wireless System Design", Xilinx, Inc. Manual.

Reference books:

1. Blaine Readler, "A Concise Introduction for FPGA Design", Full Arc Press (April 19, 2011).

Gaps in the syllabus (to meet Industry/Profession requirements): Hands on experience on real time industrial project and management

POs met through Gaps in the Syllabus: PO6 will cover through paper writing/ technical report writing/ assignments/mini projects

Topics beyond syllabus/Advanced topics/Design: Covered with technical papers related to the course

POs met through Topics beyond syllabus/Advanced topics/Design: Teaching with research papers

Course Outcome (CO) Attainment Assessment Tools and Evaluation Procedure

Direct Assessment

Assessment Tools	% Contribution during CO Assessment
Continuous Internal Assessment	50
Semester End Examination	50

Continuous Internal Assessment	% Distribution
3 quizzes	30 (3×10)
Assignment(s)	10
Seminar before a committee	10

Assessment Components	CO1	CO2	CO3	CO4	CO5
Continuous Internal Assessment					
Semester End Examination					

Indirect Assessment

1. Student Feedback on Faculty
2. Student Feedback on Course

Course Delivery Methods

CD1	Lecture by use of boards/LCD projectors/OHP projectors
CD2	Assignments
CD3	Laboratory experiments/teaching aids/ Seminars
CD4	Mini Projects
CD5	Industrial visits/in-plant training
CD6	Self- learning such as use of NPTEL materials and internets
CD7	Simulation

Mapping of Course Outcomes onto Program Outcomes

CO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	3	3	3	2	3
CO2	2	3	3	2	2	3
CO3	3	2	3	3	2	3
CO4	3	3	3	3	2	3
CO5	3	3	3	3	3	3

< 34% = 1, 34-66% = 2, >66% = 3

Mapping Between Course Outcomes and Course Delivery Methods

Course Outcomes	Course Delivery Method
CO1	CD1, CD2, CD3, CD6
CO2	CD1, CD2, CD3, CD6
CO3	CD1, CD2, CD3, CD6
CO4	CD1, CD2, CD3, CD6, CD7
CO5	CD1, CD2, CD3, CD6, CD7

Massive Open Online Course (MOOC)

COURSE INFORMATION SHEET

Course code: EC615
Course title: Basics of Software defined Radio and Applications
Pre-requisite(s): basic knowledge of signal processing, concepts in wireless Communication and networks
Co- requisite(s):
Credits: L: 0 T: 0 P: 0 C: 2
Class schedule per week: N/A
Class: M. Tech.
Semester / Level: III/06
Branch: ECE
Name of Teacher:

Course Objectives

This course enables the students to:

1.	Understand the basic components of software defined radio.
2.	Understand the distortion parameters and nonlinear Distortion in Transmitted Signals.
3.	Calculate power requirement in power amplifier for SDR.
4.	Understand Digital Pre-distortion Techniques for Linear/Nonlinear Distortion.

5.	Appraise Digital Predistortion Techniques.

Course Outcomes

After the completion of this course, students will be to:

CO1	Able to analyse the basic components of software defined radio.
CO2	Demonstrate understanding about distortion parameters and nonlinear Distortion in Transmitted Signals
CO3	Able to calculate power requirement in power amplifier for SDR
CO4	Demonstrate understanding about Digital Pre-distortion Techniques for Linear/Nonlinear Distortion
CO5	Design and analyse the various algorithms used for software defined radio.

SYLLABUS

Module 1: Basic components of software defined radios, Software defined radio architectures- Part A, Software defined radio architectures- Part B.

Module 2: Distortion parameters, Sources and metrics of distortion in a transceiver, Nonlinear distortion and nonlinearity specifications, Power amplifiers: Nonlinear Distortion in Transmitted Signals.

Module 3: Power amplifier Line-up for linearity & power requirement calculations, Linearization Techniques for nonlinear distortion in SDR.

Module 4: Predistortion Techniques for nonlinear distortion in SDR.

Module 5: Digital Predistortion Techniques for Linear/Nonlinear Distortion.

References

https://onlinecourses.nptel.ac.in/noc18_ec01/preview

Course Outcome (CO) Attainment Assessment Tools and Evaluation Procedure

Direct Assessment

Assessment Tools	% Contribution during CO Assessment
Continuous Internal Assessment	50
Semester End Examination	50

Continuous Internal Assessment	% Distribution
3 quizzes	30 (3×10)
Assignment(s)	10
Seminar before a committee	10

Assessment Components	CO1	CO2	CO3	CO4	CO5
Continuous Internal Assessment					
Semester End Examination					

Indirect Assessment

1. Student Feedback on Faculty
2. Student Feedback on Course

Course Delivery Methods

CD1	Lecture by use of boards/LCD projectors/OHP projectors
CD2	Assignments
CD3	Laboratory experiments/Teaching aids/Seminars
CD4	Mini Projects
CD5	Industrial visits/in-plant training
CD6	Self- learning such as use of NPTEL materials and internets
CD7	Simulation

Mapping between Course Outcomes and Program Outcomes

CO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	-	2	3	1	-	1
CO2	1	2	3	2	2	2
CO3	1	1	3	1	1	2
CO4	3	1	3	3	2	1
CO5	1	3	3	1	2	2

< 34% = 1, 34-66% = 2, > 66% = 3

Mapping between Course Outcomes and Course Delivery Method

Course Outcomes	Course Delivery Method
CO1	CD1, CD2, CD3, CD6
CO2	CD1, CD2, CD3, CD6
CO3	CD1, CD2, CD3, CD6
CO4	CD1, CD2, CD3, CD6, CD7
CO5	CD1, CD2, CD3, CD6, CD7

COURSE INFORMATION SHEET

Course code: EC616
Course title: High Speed Semiconductor Devices
Pre-requisite(s): EC201 Electronics Devices
Co- requisite(s):
Credits: L: 0 T: 0 P: 0 C: 2
Class schedule per week: N/A
Class: M. Tech.
Semester / Level: III/06
Branch: ECE
Name of Teacher:

Course Objectives:
This course enables the students to:

1.	Understand the Si-CMOS, SOI-CMOS devices and their limitations for high speed operation.
2.	Apply the Materials for high speed devices and circuits.
3.	Appraise and analyze the characteristics of the Metal Semiconductor Field Effect Transistor (MESFET) and other high-speed devices.
4.	Evaluate the characteristics of the High Electron Mobility Transistors (HEMT).
5.	Comprehend the characteristics of the Hetero junction Bipolar transistors (HBTs) and create their structures.

Course Outcomes:
At the end of the course, a student should be able to:

CO1	Describe and illustrate the the Si-CMOS, SOI-CMOS devices and their limitations for high speed operation.
CO2	Sketch and explain the characteristics of the Materials for high speed devices and circuits.
CO3	Illustrate with the sketch of the structure of Metal Semiconductor Field Effect Transistor (MESFET) and other high-speed devices, diagram their characteristics and analyze them.
CO4	Appraise the principle of operation High Electron Mobility Transistors (HEMT), schematize their characteristics, assess and summarize their features.
CO5	Schematize the structure and design Hetero junction Bipolar transistors (HBTs) to observe high frequency response. Schematize their characteristics and prepare an inference.

SYLLABUS

Module -1:

Si-CMOS, SOI-CMOS devices and their limitations for high speed operation: CMOS Logic circuits with scaled down devices. Silicon on Insulator (SOI) wafer preparation methods and SOI based devices and SOI-CMOS circuits for high speed low power applications.

Module -2:

Materials for high speed devices and circuits:

Merits of III –V binary and ternary compound semiconductors (GaAs, InP, InGaAs, AlGaAs etc.), silicon-germanium alloys and silicon carbide for high speed devices, as compared to silicon-based devices. Brief outline of the crystal structure, dopants and electrical properties such as carrier mobility, velocity versus electric field characteristics of these materials. Material and device process technique with these III-V and IV – IV semiconductors.

Module -3:

Metal semiconductor Field Effect Transistor (MESFET):

Pinch off voltage and threshold voltage of MESFET. D.C. characteristics and analysis of drain current. Velocity overshoot effects and the related advantages of GaAs, InP and GaN based devices for high speed operation. Sub threshold characteristics, short channel effects and the performance of scaled down devices.

Module -4:

High Electron Mobility Transistors (HEMT):

Hetero-junction devices. The generic Modulation Doped FET(MODFET) structure for high electron mobility realization. Principle of operation and the unique features of HEMT. InGaAs/InP HEMT structures.

Module -5:

Hetero junction Bipolar transistors (HBTs):
Principle of operation and the benefits of hetero junction BJT for high speed applications. GaAs and InP based HBT device structure and the surface passivation for stable high gain high frequency performance. SiGe HBTs and the concept of strained layer devices.

Books recommended:

Textbooks:

1. Mike Golio, The RF and Microwave Handbook, 2e, CRC Press, 2008.
2. Samuel Y. Liao, Microwave Devices and Circuits, 3e, Prentice-Hall of India, 2003.
3. High Speed Devices and Circuits, NPTEL video lecture by Prof. K. N. Bhat, IIT, Madras.

Reference books:

1. S. M. Sze, Kwok K. Ng, Physics of Semiconductor Devices, 3e, Wiley-Interscience, 2006.
2. Stephen A. Campbell, The Science and Engineering of Microelectronic Fabrication, 2/e, Oxford University Press, 2001.
3. I. A. Glover, S. R. Pennock and P. R. Shepherd, Microwave Devices, Circuits and Subsystems for Communications Engineering, John Wiley & Sons, 2005.

Gaps in the syllabus (to meet Industry/Profession requirements): Hands-on-practical for fabrication of High-Speed Semiconductor Devices.

POs met through Gaps in the Syllabus: PO6.

Topics beyond syllabus/Advanced topics/Design: High Speed Diodes.

POs met through Topics beyond syllabus/Advanced topics/Design: PO6

Course Outcome (CO) Attainment Assessment Tools and Evaluation Procedure

Direct Assessment

Assessment Tools	% Contribution during CO Assessment
Continuous Internal Assessment	50
Semester End Examination	50

Continuous Internal Assessment	% Distribution
3 quizzes	30 (3×10)
Assignment(s)	10
Seminar before a committee	10

Assessment Components	CO1	CO2	CO3	CO4	CO5
Continuous Internal Assessment					
Semester End Examination					

Indirect Assessment

1. Student Feedback on Faculty
2. Student Feedback on Course

Course Delivery Methods

CD1	Lecture by use of boards/LCD projectors/OHP projectors
CD2	Assignments
CD3	Laboratory experiments/Teaching aids/Seminars
CD4	Mini Projects
CD5	Industrial visits/in-plant training
CD6	Self- learning such as use of NPTEL materials and internets
CD7	Simulation

Mapping between Course Outcomes and Program Outcomes

CO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	3	3	3	2	1
CO2	3	3	3	3	2	1
CO3	3	3	1	3	2	1
CO4	2	2	2	2	3	1
CO5	2	2	2	2	3	1

< 34% = 1, 34-66% = 2, > 66% = 3

Mapping between Course Outcomes and Course Delivery Method

Course Outcomes	Course Delivery Method
CO1	CD2, CD3, CD6, CD7
CO2	CD2, CD3, CD6, CD7
CO3	CD2, CD3, CD6, CD7
CO4	CD2, CD3, CD6, CD7
CO5	CD2, CD3, CD6, CD7

COURSE INFORMATION SHEET

Course code: EC617
Course title: Nanoelectronic Devices and Materials
Pre-requisite(s): EC201 Electronic Devices
Co- requisite(s):
Credits: L: 0 T: 0 P: 0 C: 2
Class schedule per week: N/A
Class: M. Tech.
Semester / Level: III/06
Branch: ECE
Name of Teacher:

Course Objectives:
This course enables the students to:

1.	Understand the issue in scaling MOSFET in the sub-100 nm regime and the state of the art in the areas of semiconductor device physics.
2.	Appraise and apply Fundamental Properties of Carbon Nanotube and its Synthesis techniques.
3.	Analyze how to assemble Carbon Nanotubes toward Practical Applications and Separation of Metallic and Semiconducting Single-Wall Carbon Nanotubes.
4.	Evaluate Electronic Applications of Single-Walled Carbon Nanotubes.
5.	Comprehend the characteristics of the Spintronics and Molecular electronics and create their structures.

Course Outcomes:

After the completion of this course, students will be able to:

CO1	Describe and illustrate the Basic CMOS Process flow and MOS Scaling theory
CO2	Sketch and explain Gate oxide scaling trend and integration Issues
CO3	Illustrate with the sketch the heterostructure growth techniques, diagram their characteristics and analyze them.
CO4	Appraise the Nonclassical CMOS structures and integration issues and schematize, assess and summarize their features.
CO5	Schematize the structure and design Heterostructure device and write down its synthesis techniques

SYLLABUS

Module -1:

MOS process flow and scaling theory

Overview: Nano devices, Nano materials, Nano characterization, Definition of Technology node, Basic CMOS Process flow, MOS Scaling theory, Issues in scaling MOS transistors: Short channel effects, Description of a typical 65 nm CMOS technology, Requirements for Nonclassical MOS transistor.

Module -2:

Gate oxide scaling trend and integration Issues:

MOS capacitor, Role of interface quality and related process techniques, Gate oxide thickness scaling trend, SiO2, versus High-k gate dielectrics; Integration issues of high-k, Interface states, bulk charge, band offset, stability, reliability, Metal gate transistor: Motivation, requirements, Integration Issues, Transport in Nano MOSFET, velocity saturation, ballistic transport, injection velocity, velocity overshoot.

Module -3:

Heterostructure growth techniques:

Compound semiconductor heterostructure growth and characterization: Quantum wells and, thickness measurement techniques: Contact - step height, Optical - reflectance and ellipsometry. AFM. Characterization techniques for nanomaterials: FTIR, XRD, AFM, SEM, TEM, EDAX etc.; Applications and interpretation of results; emerging nanomaterials: Nanotubes, nanorods and other nanostructures, LB technique, Soft lithography etc. Microwave assisted synthesis, Self-assembly etc.

Module -4:

Nonclassical CMOS structures and integration issues:

SOI - PDSOI and FDSOI, Ultrathin body SOI - double gate transistors, integration issues, Vertical transistors - FinFET and Surround gate FET, Metal source/drain junctions - Properties of Schottky junctions on Silicon, Germanium and compound semiconductors -work function pinning.

Module -5:

Heterostructure devices and synthesis:

Germanium Nano MOSFETs: strain, Advantages of Germanium over Silicon, PMOS versus NMOS; MOSFETs in the context of channel strain; Compound semiconductors - material properties, MESFETs; Hetero structure FETs exploiting novel materials, strain; Synthesis of Nanomaterials: CVD, Nucleation growth, ALD, Epitaxy, MBE.

Books recommended:

Textbooks:

1. Yuan Taur and T H Ning, Fundamentals of Modern VLSI Devices, 2nd Edition, Cambridge, reprint 2016.
2. Qing Zhang, Carbon Nanotubes and Their Applications - Pan Stanford Series on Carbon-Based Nanomaterials, CRC Press, 2012.
3. George W. Hanson, Fundamentals of Nanoelectronics, Pearson, 2009.
4. Nanoelectronics: Devices and Materials, NPTEL video lecture by Prof. Navakanta Bhat, Indian Institute of Science, Bangalore.

Reference books:

1. The Physics of Low-Dimensional Semiconductors, John H. Davies, Cambridge University Press, 1998.
2. Introduction to Nanotechnology, C. P. Poole Jr., F. J. Owens, Wiley (2003).
3. Silicon VLSI Technology, Plummer, Deal, Griffin, Pearson Education India.
4. Encyclopedia of Materials Characterization, Edited by: Brundle, C. Richard; Evans, Charles A. Jr.; Wilson, Shaun; Elsevier.

Gaps in the syllabus (to meet Industry/Profession requirements): Hands-on-practical for fabrication of nanoelectronic devices.

POs met through Gaps in the Syllabus: PO6.

Topics beyond syllabus/Advanced topics/Design: CNFET**,** SET, Memristor, MTJ**.**

POs met through Topics beyond syllabus/Advanced topics/Design: PO6

Course Outcome (CO) Attainment Assessment Tools and Evaluation Procedure

Direct Assessment

Assessment Tools	**% Contribution during CO Assessment**
Continuous Internal Assessment	50
Semester End Examination	50

Continuous Internal Assessment	**% Distribution**
3 quizzes	30 (3×10)
Assignment(s)	10
Seminar before a committee	10

Assessment Components	**CO1**	**CO2**	**CO3**	**CO4**	**CO5**
Continuous Internal Assessment					
Semester End Examination					

Indirect Assessment

1. Student Feedback on Faculty
2. Student Feedback on Course

Course Delivery Methods

CD1	Lecture by use of boards/LCD projectors/OHP projectors
CD2	Assignments

CD3	Laboratory experiments/Teaching aids/Seminars
CD4	Mini Projects
CD5	Industrial visits/in-plant training
CD6	Self- learning such as use of NPTEL materials and internets
CD7	Simulation

Mapping between Course Outcomes and Program Outcomes

CO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	3	3	3	2	1
CO2	3	3	3	3	2	1
CO3	3	3	1	3	2	1
CO4	2	2	2	2	3	1
CO5	2	2	2	2	3	1

< 34% = 1, 34-66% = 2, > 66% = 3

Mapping between Course Outcomes and Course Delivery Method

Course Outcomes	Course Delivery Method
CO1	CD2, CD3, CD6, CD7
CO2	CD2, CD3, CD6, CD7
CO3	CD2, CD3, CD6, CD7
CO4	CD2, CD3, CD6, CD7
CO5	CD2, CD3, CD6, CD7

4th Semester

Programme Core

EC650 Thesis (Part II) Credit: 16