Communication Engineering and Signal Processing applications have been rapidly growing and evolving over the past few years. Ubiquitous communication is becoming a necessity for the society. The proposed M.Tech. Program is designed to offer not only in-depth theoretical knowledge in the areas of Communication Engineering, Signal Processing, and Wireless Networks, but also system modeling and integration aspects emphasizing overall system behavioural studies in a laboratory. Such courses are unique and fall in-line with the requirements from the industries. At the end of the programme the student would acquire the ability to identify pressing research issues and research directions in Communications, Signal Processing, and Wireless Networks.

Programme Outcomes

- Creation of expertise and work force in the communication engineering domain to deal with design, development, analysis, testing and evaluation of the critical aspects of system design and its core concepts to cater to the requirements of the industry and academia.

- Facilitate research opportunities in the communication engineering domain aimed at developing state-of the art technologies with value based social responsibility.

- Developing professional competence in communication engineering domain and leadership qualities with a harmonious blend of ethics leading to an integrated personality development.
## CURRICULUM

### First Semester

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* Non-credit course

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**Credits**

**Courses can also be taken from other departments**
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**TOTAL CREDITS (21+23+10+10)** 64

L- Lecture; T-Tutorial; P-Practical  
FC- Foundation Core; SC- Subject Core; E-Electives; P- Dissertation; P/F- Pass/Fail

### List of Courses

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**Project Work**

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Objectives:

- To introduce the mathematical methods applied for VLSI, signal processing and communication systems.
- To provide a unified applied treatment of fundamental mathematics, seasoned with demonstrations using standard tools.
- To develop contemporary techniques for applications in the diverse areas to improve the analytical skills.
- To comprehend the computational concepts learned in mathematical methods through numerical simulations and programming.

Keywords: Linear Algebra, Matrix Decompositions, Optimization, Random Process.

Contents:


Introduction to Probability concepts- two dimensional jointly distributed random variables, stochastic random variables, convergence and limit theorems, multi variant probability distribution covariance, and regression models. Bayesian methods of estimation. Random process, power spectrum, discrete time process, spectrum estimation

Lab component: Gram Schmidt orthonormalization on vector spaces, Solving a system of linear equations using QR decomposition, Image compression using Singular value decomposition, Computation of basis for four fundamental subspaces for a given system, Optimization using Newton’s method with line search and Broydens update.

Outcomes:

- Understanding the mathematical methods and applying it to practical problems by investigating from different perspectives.
- Enabling an analytical approach towards developing mathematical models in various domains.
- To develop competency in implementation of algorithms and numerical analysis.

TEXT BOOKS/REFERENCES:


Objectives:

- To bring the students coming with different backgrounds to a common minimum level of understanding of signal processing, systems, time, frequency and time-frequency transformation techniques

Keywords: Transform processing, Filters, Multi-rate signal processing, Wavelet transform

Contents:


Introduction to multi-rate digital signal processing – the effect of up-sampling and down sampling of the signal – applications of multi-rate signal processing – sub- band coding - Significance of joint time-frequency domains.

Short Time Fourier Transform (STFT), Continuous wavelet transforms (CWT) – DWT – Time-frequency tiling - Scaling and Wavelet Functions – Filter Banks.

Outcome:

- To make the students confident in programming and experiment with various signal processing algorithms
- To prepare them do a term work on a selected application of signal processing. Students are encouraged to take the term work based on research papers on topics not discussed in class but related to topics discussed in class

TEXT BOOKS/REFERENCES:

• To analyze error performance of a digital communication system in presence of noise.
• To understand the implementation issues with respect to carrier and symbol synchronization.

Keywords: Coherent Modulation and demodulation techniques, Error probability, Carrier and Symbol Synchronization

Contents:
Digital modulation techniques - Review of digital communication systems, modulation techniques, Advanceddigital modulation and Detection-Baseband and Pass band modulation techniques-- Phase Shift Keying, M-ary PSK, Quadrature Amplitude Modulation, FSK, MSK, GMSK.
Synchronization - Signal Parameter Estimation - Carrier Phase Estimation -Symbol timing Estimation.

Outcomes:
• To design power efficient and spectral efficient modulation and demodulation techniques
• Helps in rapid prototyping of communication system addressing real-time issues like phase offset and symbol synchronization.

TEXT BOOKS/REFERENCES:

Encoding and Decoding - Trellises for Linear Block Codes – Optimum decoding of Convolutional codes: Soft Output Viterbi algorithm (SOVA), BCJR algorithm - single level and multilevel concatenated codes.

Turbo codes- Design and properties of Turbo codes, Iterative decoding of Turbo codes - LDPC codes: Construction of LDPC codes, Bit flipping, Sum product and Min sum decoding algorithms. Polar codes – Properties, Encoding and Decoding of polar codes.

**Outcome:**

Ability to select codes, implementation of encoding and decoding algorithms and analysis of the performance of codes for various applications

**TEXT BOOKS / REFERENCES:**


**18CE612 RF CIRCUITS AND SYSTEMS 3-0-0-3**

**Objectives:**

- To understand various linear, non-linear building blocks in RF systems from a system perspective of wireless and communication systems.
- To understand RF front end architectures, system parameters and essentials of Antennas, Transmission lines, Filters, RF amplifiers, RF oscillators and Mixers.
- To motivate and create expertise in the design aspect of radio frequency circuits and systems for wireless and strategic applications.

**Keywords:**Radio front end architectures, interconnects and transmission-lines, antennas, filters, RF amplifiers, Low Noise Amplifier, Power Amplifier, Mixers, RF Oscillators, RF impairments in systems, Applications.

**Contents:**

lines for RF integrated circuits--microstripline--coplanar waveguide (CPW)-- RF filters-- S-parameters--derivation of two port gain parameters.


Outcomes:
• Understanding the basic design principles of radio frequency components and systems leading to the design of wireless communication systems
• Enable expertise in the area of RF front-end design for strategic applications
• Motivating to pursue research and development activities in the RF systems area.

TEXT BOOKS / REFERENCES:

18CE631 COMMUNICATION ENGINEERING LAB 0 0 4 2

Objectives:
• To comprehend the communication engineering concepts through numerical simulations and programming

Contents:
(Preferred: GNU Radio)
1. Introduction to Software Defined Radio and GNU Radio
2. Pseudorandom sequence generator and analysis
3. Digital Modulation Techniques
4. Detection Techniques
5. Bit error rate analysis of modulation schemes in AWGN channels.
6. Frequency division multiplexing
7. Channel coding and decoding
8. Filter Design
Outcomes:
• Ability to design and analyze digital communication techniques and systems.

18CE613 MODELING AND SIMULATION OF COMMUNICATION SYSTEMS

Objectives:
• To comprehend system aspects of modern communication systems through modeling and simulation
• To analyze and predict the behavior of broadband and high data rate intractable communication systems

Keywords: Power efficiency, Spectral efficiency, System behavior predictions, Baseband simulation, Channel models

Contents:
Introduction, evolution of communication systems in terms spectral efficiency—challenges in design and optimization—overview of deterministic and stochastic simulations—tractable and intractable systems—role of simulations for link budgeting—implementation and behavior predictions

Simulation methodology—basic steps and aspects of simulation—simulation errors due to sampling and quantization—choice of simulation sampling frequency—baseband representation of linear and non-linear band pass signals and systems—time varying systems—modeling of system building blocks such as filters, linear and nonlinear amplifiers with internal noise, modeling oscillator phase noise

Simulation of random process and noise sources—post processing of data and waveforms—generation of eye-diagrams—spectrum and scatter-plots—BER simulations using Monte Carlo techniques—introduction to simulation of nonlinear and time varying systems—models of waveform channels—guided and unguided channels, radio channels, multi-path—and fading channel—introduction to discrete channel models—case studies of simulation of M-PSK systems with amplitude and phase noise—simulation of power amplifier nonlinearity for CDMA—simulation of OFDM systems.

Outcome:
• Enable students to be industry ready Engineers and Researchers
• Enable students to do calculations and tradeoffs of various subsystem parameters
• Enable students to do modeling and simulations of complex intractable systems with nonlinearities

TEXT BOOKS/REFERENCES:
Objectives:

- To introduce the wireless and cellular concepts with emphasis on the channel models and their parameters.
- To facilitate the importance of resource allocation in multiuser environment using multiple access techniques.
- To provide insights into the various diversity and multiplexing techniques for the design of high speed and reliable wireless communication systems.

Key words: Fading channel, AWGN, Multiple Access, Diversity, Multiplexing, Multicarrier.

Contents:


Channel estimation and Multiple Access techniques - Bit error rate (BER) of wireless systems, Channel estimation in wireless systems - frequency division multiple access (FDMA), time division multiple access (TDMA), code division multiple access (CDMA), space division multiple access (SDMA),

Diversity and multiplexing - Time diversity, frequency diversity and space diversity, Introduction to Multi input multi output (MIMO) communications and Multicarrier system (OFDM), Highlight of Performance in respect of BER, Capacity of OFDM and MIMO.

Lab component: Fading Channel modeling and parameter analysis, Channel estimation, MIMO.

Outcomes:

- Design of communication systems comprehending real-time issues
- To identify challenges in evolving communication technology and design systems conforming to industry standards

TEXT BOOKS/REFERENCES:


**18CE615 ESTIMATION AND DETECTION THEORY 3 1 0 4**

**Objectives:**
- To introduce the fundamental principles of decision making under uncertainty
- To make the students appreciate how practical problems in communication and signal processing are formulated and solved using the classical and Bayesian approaches
- To boost the mindset of application-oriented learning of random process theory through programming assignments

**Keywords:** Random processes, Estimation, Detection, Hypothesis testing, Likelihood, Bayesian

**Contents:**
Review of probability and random processes: Introduction and applications of statistical estimation and detection in communication and signal processing; Classical estimation: bias and variance, Cramer-Rao lower bound, sufficient statistic, MVUE
Fischer-Neyman factorization theorem, Rao-Blackwell theorem, maximum likelihood estimation, linear models, BLUE, least squares; Consistency, efficiency and asymptotics; Bayesian estimation: MMSE and MAP estimation; Kalman and Weiner filtering;
Detection theory: Bayesian, minimax and Neyman-Pearson detection; Composite hypothesis testing, GLRT; Sequential detection; Performance analysis; Signal detection in continuous time, KL theorem; Detection of random signals in Gaussian noise.

**Outcome:**
- The students understand real applications of statistical decision theory for communication and signal processing
- The students gain confidence by applying various estimation and detection techniques to complete project assignments wherein they solve mini problems in communication and/or signal processing

**TEXT BOOKS/REFERENCES:**


**18CE632 COMPUTATIONAL PROGRAMMING LAB 0042**

**Objectives:**
- To provide a comprehensive introduction to the study of computer algorithms.
- To address implementation concerns of the algorithms for communication systems.
- To facilitate design of advanced and customized algorithms for engineering applications.

**Keywords:** Data structures, sorting, search, dynamic programming

**Contents: (Preferred Python)**
1. Complexity of algorithms
2. Probabilistic Analysis and Randomized Algorithms
3. Sorting
   - Heap Sort
   - Quick Sort
   - Sorting in linear time
4. Data structures
   - Elementary data structures
   - Hash tables
   - Binary search trees
5. Algorithms
   - Dynamic programming
   - Greedy algorithms

**Outcomes:**
- Understand and analyze the modern computer algorithms.
- Develop algorithms for specific and domain based applications.

**TEXT BOOK / REFERENCE:**
Unit I:

Unit II:
Problem Formulation, Understanding Modeling & Simulation, Conducting Literature Review, Referencing, Information Sources, Information Retrieval, Role of libraries in Information Retrieval, Tools for identifying literatures, Indexing and abstracting services, Citation indexes

Unit III:
Experimental Research: Cause effect relationship, Development of Hypothesis, Measurement Systems Analysis, Error Propagation, Validity of experiments, Statistical Design of Experiments, Field Experiments, Data/Variable Types & Classification, Data collection, Numerical and Graphical Data Analysis: Sampling, Observation, Surveys, Inferential Statistics, and Interpretation of Results

Unit IV:
Preparation of Dissertation and Research Papers, Tables and illustrations, Guidelines for writing the abstract, introduction, methodology, results and discussion, conclusion sections of a manuscript. References, Citation and listing system of documents

Unit V:

TEXT BOOKS/ REFERENCES:

18CE701 MILLIMETER WAVE COMMUNICATION SYSTEMS 3 0 0 3
Objectives:

- To understand the channel behavior in mm wave communication systems
- To develop mathematical theory and engineering practice of wireless communication in higher frequency of mm wave
- To understand diversity and interpretation of capacity calculations
- To learn the transceiver architecture in mm wave communication range
- To understand beam steering and beam forming techniques in multi antenna array

Keywords: Millimeter wave, 60GHz, MIMO, Diversity

Contents:

Millimeter Wave (MMW) characteristics - 60GHz MMW Case Study and Technical Challenges - Channel performance at 60 GHz - ITU Indoor Path Loss Model - Log Distance Path Loss Model - Link Budget- Development of MMW standards - Coexistence With Wireless Backhaul.

Modulation Schemes for MMW communications- PSK - OFDM. MMW Transceiver architecture- MMW Antennas- Path Loss and Antenna Directivity - Antenna Beam width - Beam steering Antenna- Need for MIMO – Channel Capacity of SISO and MIMO Systems - Water-filling algorithm


Outcome:

- Improve the confidence in mathematical modeling and understanding of different mm wave channel models
- The ability to apply knowledge of design processes in higher frequency band of mm wave
- The ability to understand and design of mm Wave transceiver
- The ability to generate innovative design to fulfill new requirements particularly in the field of wireless communications at higher frequency in mm wave

TEXT BOOKS/REFERENCES:

Objectives:

- To develop mathematical theory and engineering practice of digital communications over fading channels
- To learn multi channel/carrier techniques for fading wireless channels and mobile radios
- To analyzes and design of multi-channel techniques for communication
- To understand the synchronization issues in multicarrier environment
- To understand the challenges in the design of such multicarrier systems

Keywords: Multicarrier communications, OFDM, MIMO, Synchronizations, PAPR

Contents:


Coded OFDM- Multiple Access Extensions of OFDM- Multiband OFDM- MIMO OFDM - Performance Optimization - Channel Partitioning - Synchronization - Timing Offset Estimation - Frequency Offset Estimation -Synchronization in Cellular Systems

Channel Estimation - Pilot Structure - Training Symbol-Based Channel Estimation - DFT-Based Channel Estimation - Decision-Directed Channel Estimation -PAPR Reduction- Inter-Cell Interference Mitigation Techniques

Outcome:

- The ability to apply knowledge of design processes in multicarrier systems
- To generate innovative designs to fulfill new needs, particularly in the fields of broadband networks and mobile/wireless communication systems
- The ability to analyze the performance of multicarrier system in wireless cellular systems

TEXT BOOKS/REFERENCES:


Objectives:

- To understand software radio design and implement Multirate DSP, RF front-ends, direct digital synthesis of modulated waveforms, A/D and D/A conversion
- To appreciate performance improvement with the help of smart antennas and other adaptive array algorithms

Keywords: Digital filtering, multirate signal processing, Direct Digital Synthesis, USRP,

Contents:

Introduction to software-defined radio - Review of telecommunication concepts and systems - Analog and Digital Communication System - Front-end RF system - Link Budgets, noise, C/N and S/N ratios - Digital filtering - Signal recovery - Baseband and Band pass Sampling - Complete SDR systems - Future trends in SDR.

Multirate signal processing - Sample Rate conversion principles - Efficient Structures for Decimation and Interpolation Filters – Polyphase filters – Digital Filters Banks– Arbitrary sampling rate conversion – CIC Filter - Analog to Digital and Digital to Analog converters for SDR.

Hardware and Software Architecture for SDR: Universal Software Radio Peripheral, bladeRF, RTL-SDR, HackRF, WebSDR

Outcome:

1. Ability to use programmable DSP to implement software radio for wireless systems and sub-systems
2. Ability to appreciate the design flexibility in software defined radios by using software tools
3. To take up some case studies for implementation using software radio concepts

TEXT BOOKS/REFERENCES:


18CE704 VEHICULAR COMMUNICATIONS AND NETWORKS  3  0  0  3

Objective:

- This subject will introduce students with the emerging technologies, standards and applications in vehicular communication systems
- The students will study the design considerations and challenges of vehicle - to-infrastructure and vehicle - To – vehicle communications. Theories such as vehicular mobility modelling and vehicular technologies and standards from the physical to network layers will be introduced in the course, Examples of emerging applications of
vehicular communications in Intelligent Transportation Systems will also be studied and discussed.

**Keywords:** Vehicular Communications, V2V, V2X, ITS, VANET, Adhoc. 802.11p.

**Contents**

Introduction  Basic principles and challenges, past and ongoing VANET activities, Cooperative Vehicular Safety Applications  Enabling technologies, cooperative system architecture, safety applications;

Vehicular Mobility Modeling  Random models, flow and traffic models, behavioral models, trace and survey based models, joint transport and communication simulations; Physical Layer Consideration  for Vehicular Communications  Signal propagation, Doppler spread and its impact on OFDM systems

MAC Layer of Vehicular Communication Networks  Proposed MAC approaches and standards, IEEE 802.11p, VANET Routing protocols  Opportunistic packet forwarding, Topology based routing, geographic routing, Emerging VANET Applications Limitations, example applications, communication paradigms, message coding and composition, data aggregation, Standards and Regulations  Protocol Stack, DSRC regulations and standards

**Outcomes**

Upon completion of the subject, students will be able to:

- Grasp the professional/academic knowledge and skills
- Understand and describe the basic theories and principles, technologies, standards, and system architecture of vehicular adhoc networks (VANET) or inter-vehicle communication networks
- Analyze, design, and evaluate vehicular communication platforms for various kinds of safety and infotainment applications

**TEXT BOOKS/ REFERENCES:**

There is no specific text book. However, this reference book can be referred. We will be studying the research papers.


**18CE705 SECURITY FOR WIRELESS COMMUNICATIONS 3 0 0 3**

**Objectives:**

- To introduce the key concepts and analytical models of physical layer security in both single-user and multi-user communication systems
- To apply signal processing techniques to design physical layer security enhancements

**Keywords:** Physical layer security, secret key, cryptography, secrecy capacity

**Contents:**

Fundamentals of Physical layer security – Information theoretic secrecy metrics – channel models - Secret Communication - Coding for Security - Asymptotic Analysis - Key
Generation from wireless channels


Outcome:

- Develop skills to use the tools from game theory and graph theory to analyze and design wireless networks with physical layer security considerations
- Able to explore issues and solutions in providing physical layer security in practical wireless systems

TEXTBOOKS/REFERENCES:


18CE711 RADAR SYSTEMS 3 0 0 3

Objectives:

- Understanding the components of a radar system and their relationship to overall system performance
- Understanding basic detection theory as applied to radar
- Understanding the concepts of the matched filter, ambiguity functions and other aspects of waveform and signal processor design

Keywords: Radar range equations, SNR, Matched filter, Doppler radars, SAR

Contents:

Radar range equation, Radar cross section-Examples of simple radar systems-analysis of SNR model for system noise-radar detection in the presence of noise-matched filter detection-target effects on detection-parametric description of antennas.

Pulsed Radars-fundamentals of range measurements -range ambiguity. Doppler radar-velocity measurements. FM-CW radars-Doppler ambiguity.

SAR-signal processing-pulse compression-azimuth signal processing- imaging-design example and system implementation issues-ambiguity functions-theorems-polarimetric radars-interferometric radars.

Outcome:

- Ability to understand the system perspective of Radar Technology
TEXT BOOKS/REFERENCES:


18CE712      SATELLITE COMMUNICATION SYSTEM DESIGN            3 0 0 3

Objective:

- To understand the concepts of space missions, orbits and spacecraft systems
- To study the mechanism of guidance, controls, navigation systems and sensor technology
- To study the power communication and data handling systems, concept of small satellite requirements and design

Keywords: Spacecraft, Orbit, Launch vehicle, Navigation, EMI, EMC, Telemetry

Contents:

Space Mission Design- Introduction, Elements of a Space Mission: The mission, the spacecraft, trajectories and orbits, launch vehicles, mission operations systems, Overview of Orbit and Constellation Design: The orbit design process - Earth coverage - Simple delta-V budgets - Selecting orbits and constellations - Common Examples - The physical environment of space and spacecraft system design.


Outcome:

- Able to understand the Space Environment & its Effects
- Able to understand Spacecraft Platform Systems, design, satellite manufacture & Testing
- Able to understand Applications of Small, Low-Cost Satellites, space mission analysis & design

TEXTBOOKS/REFERENCES:


**18CE713  ANTENNA DESIGN  3 0 0 3**

**Objectives:**
- To understand the radiation concepts for wireless communication systems
- To design, develop and analyze specific antenna systems for various applications
- To motivate for pursuing project and research in the antenna domain

**Keywords:** Radiation pattern, Microstrip, Substrate

**Contents:**
Review of radiation principles, Radiation from transmission lines, planar transmission lines Microstrip Radiators - Radiation Field - Surface Waves - Rectangular Microstrip Antenna- Models for Rectangular Patch Antenna
Bandwidth Enhancement Techniques - Broad-Banding of Microstrip Antennas - Effect of Substrate Parameters on Bandwidth - Selection of Suitable Patch Shape - Selection of Suitable Feeding Technique.

**Outcomes:**
The student will be able to
- Design and analyze antenna for wireless applications
- Evaluate the antenna parameters for various applications

**TEXT BOOKS / REFERENCES:**

**18CE721  WIRELESS NETWORKS AND PROTOCOLS  3 0 0 3**

**Objectives:**
- To provide insights into the architectures and protocols currently used in practice at various layers of wireless communication systems
- To develop mathematical theory of and engineering practice in wireless networks
• To learn the existing standards of WLAN and associated technologies
• To understand and compare the performance of wireless networks

**Keywords:** WLAN, WPAN, WSN, 802.11, Protocols, MAC Layer, Ad hoc Network, ZigBee

**Contents:**
Introduction to Wireless Networks and Protocols - history, standards and market issues, evolution and trends; Wireless Networks Concepts and Systems: mobility management, bandwidth and energy management, quality of service; Physical and MAC Layer Protocols: Physical layer characteristics and technologies
Centralized access methods – TDMA, FDMA, CDMA, Reservation and Polling, Random access methods – ALOHA, CSMA; Routing in Wireless Ad Hoc and Sensor Networks; Transport layer protocols; Security and Privacy; Wireless Technology and Standards:
Wireless Local Area Networks (IEEE 802.11) – MAC and PHY layer variants, 802.11p for vehicular networks, Low Power Sensor Networks – Bluetooth (IEEE 802.15.1), ZigBee (IEEE 802.15.4), Wireless Body Area Networks (IEEE 802.15.6), Wide Area Wireless Networks – cellular systems based on TDMA, CDMA and OFDM, LTE, WiMAX.

**Outcome:**
- Able to analyze different protocols
- Ability to design protocols at different layers in WLAN
- Ability to develop authentication and security algorithm necessary in WLAN

**TEXTBOOKS/REFERENCES:**

18CE722  STOCHASTIC MODELLING AND QUEUEING THEORY  3 0 0 3

**Objectives:**
- To Provide a thorough understanding of the mathematical foundations of telecommunication and computer communication networks
• To teach the applications of Markov processes and queuing theory, to analyze the performance and address the design questions in circuit- and packet-switching networks

**Keywords:** Markov Chains, Renewal Processes, Queuing Theory, Performance Analysis, Capacity Design

**Contents:**

Review of Probability and Random Variables - memory less property of exponential and geometric random variables, moment generating function, Laplace-Stieljes transform (LST) of random variables; Stochastic Processes - stationarity, ergodicity, independence, correlation;

Stationary Increment and Independent Increment Processes - Bernoulli trials, Poisson processes, Gaussian processes; Markov Processes - discrete time Markov chains (DTMCs), continuous time Markov chains (CTMCs), recurrence, transience, stability; Renewal Processes and Markov Renewal Processes; Queuing Theory - common queuing models (M/M/1, M/M/1/K, M/M/K/K, M/G/1, M/G/1/K, G/M/1, Geo/Geo/1, M/G/x), vacation models, loss networks and delay networks, multiclass queuing models with priority, open and closed networks of queues; Fluid and Gaussian approximations;

Applications to Telecommunications and Computer Communication Networks – capacity design, dynamic channel allocation and scheduling in 4G/LTE, TCP/IP networks and telecommunication switching, throughput and delay analysis in wireless local area networks (WLANs), coverage analysis in wireless sensor networks (WSNs), spreading of computer virus and messages in intermittently connected networks (ICNs/DTNs).

**Outcome:**

After successfully finishing this course, students will

• Acquire the skill of mapping frequently occurring scenarios in telecommunication and computer networking into standard stochastic models, i.e., they will develop the ability of constructing mathematical models from the physical description of the problems

• Be able to identify appropriate solution methods in each case and physically interpret the mathematical results

**TEXTBOOKS/REFERENCES:**


**18CE731  MACHINE LEARNING  3 0 0 3**

**Objectives:**

• To strengthen the expertise of the students in machine learning algorithms
Keywords: GMM, HMM, SVM, Neural networks, Auto encoders, Restricted Boltzman machine

Contents:


Outcome:

• Training the students on the state-of-the-art machine learning algorithms
• Prepare them to apply these algorithms for their further study/research

TEXTBOOK/REFERENCES:


18CE732 CONVEX OPTIMIZATION 3 0 0 3

Objectives:

• To efficiently solve mathematical optimization problems which arise in a variety of applications
• To discover/identify various applications in areas such as, estimation and signal processing, communications and networks, electronic circuit design, data analysis and modeling, statistics, automatic control systems and finance

Keywords: Linear Programming, Quadratic Programming, Semi definite programming,
Interior Point methods, KKT conditions

Contents:
Introduction - linear algebra fundamentals - Solving linear equations with factored matrices - Block elimination and Schur complements - Convex sets - Convex functions - examples
Classes of Convex Problems - Linear optimization problems - Quadratic optimization problems - Geometric programming - Vector optimization - Reformulating a Problem in Convex Form
Lagrange Duality Theory and KKT Optimality Conditions - Interior-point methods - Primal and Dual Decompositions - Applications

Outcome:
- Develop a working knowledge of convex optimization, i.e., to develop the skills and background needed to recognize, formulate, and solve convex optimization problems
- Design sophisticated algorithms based on Convex Optimization for applications in communication and signal processing

Textbooks/References:

Objectives:
- To help the students deepen their understanding of signal processing algorithms for speech and audio processing
- To strengthen the research skills of students in speech processing

Keywords: Speech signal analysis, Speech recognition, Speaker recognition, Language modeling, Feature extraction

Contents:
Speech analysis-source filter modeling - speech sounds - lip radiation - linear prediction - lattice filters - Levinson-Durbin recursion, Feature extraction for speech processing-short term Fourier transform-wavelets - cepstrum, sinusoidal and harmonic representations –mel frequency cepstral coefficients (MFCC) - perceptual linear prediction (PLP) –mel filter bank energies– use of temporal patterns (TRAPS) in speech processing

analysis - speech signal modeling


**Outcome:**

- Enables to develop a speech/speaker recognition system
- Enables to analyze the speech signal in both time and frequency domain

**TEXTBOOKS/REFERENCES:**


**18CE742**

**ARRAY SIGNAL PROCESSING**

**Objectives:**

- To familiarize with spatial signals
- To introduce the concept behind sensor arrays
- To familiarize with spatial frequency
- To introduce different methods for direction of arrival estimation

**Keywords:**

Spatial frequency, Sensor arrays, Planar array, Random array, Aliasing

**Contents:**

Spatial Signals - Signals in space and time-spatial frequency-direction Vs. frequency-wave fields-far fields and near fields signals

Sensor Arrays - spatial sampling-Nyquist criterion-sensor arrays-uniform linear arrays-planar and random arrays-array transfer (steering) vector-array steering vector for ULA-broadband arrays

Spatial frequency- aliasing in spatial frequency domain
Outcome:

• Gain knowledge about the efficient use of different signal processing and optimization techniques in adaptive arrays

• Equip students to design and develop more efficient practical systems to meet the future requirements using adaptive arrays. spatula frequency transform-spatial spectrum-spatial domain filtering-beam forming-spatially white signal-Direction of arrival estimation: non parametric methods-beam forming and capon methods-resolution of beam forming methods-subspace methods-MUSIC-minimum Norm and ESPRIP techniques-spatial smoothing

TEXT BOOKS / REFERENCES:


18CE743 MULTIRATE SIGNAL PROCESSING FOR COMMUNICATION SYSTEMS 3 0 0 3

Objectives:

• To understand the signal processing algorithms, filter design methods, and signal processing techniques

• To provide the design engineers with the tools necessary for efficient implementation of digital transceivers

• To focus on the multirate systems arising in the communications, especially wireless and software defined radios

Keywords: Multirate systems, Resampling, Polyphase architectures, Digital up-conversion, Digital Down-conversion, CIC filters

Contents:


Polyphase FIR filter – Resampling Filter - Half-band Filters – Dyadic filter – Arbitrary Sampling Rate Conversion. Recursive polyphase filter – Cascade Integrator Comb Filter (CIC) - Cascade and multiple stage filters

Application in communication systems – Conventional Digital down converters (DDC), Aliasing DDC, Timing recovery in digital demodulation, Carrier recovery and phase recovery.

Outcome:

• Ability to design a resampling architecture for digital RF front end systems

• Ability to design efficient filter implementations for baseband transceivers

• Ability to design multirate systems for carrier, phase and timing recovery for
communication receivers

TEXTBOOKS/REFERENCES:


18CE744 IMAGE AND VIDEO PROCESSING 3 0 0 3

Objectives:

- To efficiently solve real time problems using the image processing algorithms
- To provide deep understanding of two dimensional, three dimensional transforms and video processing concepts
- To strengthen the research skills of students in image and video processing

Keywords:

2D and 3D Transforms, Image Filtering, image Compression, Video processing

Contents:

Two dimensional and three dimensional signals and systems-Sampling in 2D and 3D-Two dimensional discrete transforms– DCT –DWT- Application to images -2D Hadamard Transform, Walsh Transform, KLT

Application to images – Modes of Image acquisition in various fields -Filtering in Spatial and Frequency domain- Color Image Processing - Image Segmentation - Image Compression

Video processing concepts and Standards – Interframe and Intraframe coding-Digital Video Compression – Applications of image processing algorithms in various fields.

Outcome:

- Students will have expertise in developing programming skills to implement image and video processing algorithms
- Do a term work on a selected application of image/video processing, with minimum support from the faculty. Objective is to support the students to be placed in core companies.

TEXTBOOKS/REFERENCES:

2006.

**FRACTAL ELECTIVES**

**18CE751 INTERNET OF THINGS WITH WIRELESS TECHNOLOGY**  

**Objectives:**
- To understand how different wireless technologies used and influences the IoT
- To understand the design and various use cases with some of the technologies.

**Keywords:** IoT, Wireless technologies for IoT, NB-IoT

**Contents:**
Cellular and wireless technologies for IoT, Designing and developing IoT applications, Integrating different technologies and software, 5G wireless technology and IoT, Narrow band IoT.

**Outcomes:**
At the end of the course, the candidate will be able to
- Design and develop IoT applications using wireless technology
- Understand the concept of narrow band IoT

**TEXTBOOKS/REFERENCES**

2. *Designing the Internet of Things* By Adrian McEwen, Hakim Cassimally, Wiley

**18CE752 COOPERATIVE AND RELAY COMMUNICATION**  

**Objectives:**
- To understand the concept of cooperative and relay communication in wireless networks
- To analyze the performance of a system which use the cooperative and relay concept

**Keywords:** Cooperative communication, relay communication, multihope.

**Contents:**
Overview of cooperative and relay communication, two user cooperative transmission scheme, decode and forward, amplify and forward; cooperative transmission schemes with multiple relays and multihop communications.

**Outcomes:**
- Able to understand and appreciate cooperative, relay and multihope communication in wireless networks
• Able to analyze different methods/schemes used in these techniques.

TEXTBOOKS/ REFERENCES:

1. By Y.-W. Peter Hong, Wan-Jen Huang, C.-C. Jay Kuo, Cooperative Communications and Networking: Technologies and System Design, Springer

2. Murat Oysal, Cooperative Communications for Improved Wireless Network for virtual antenna array signals by, information science reference. Transmission: framework

18CE753 MASSIVE MIMO

Objectives:

• To carry out effective system performance analyses and develop advanced Massive MIMO techniques and algorithms

Contents:

Introduction - Large MIMO systems - MIMO encoding - MIMO detection - probabilistic data association - message passing and graphical models - Channel estimation - Precoding - MIMO channel models - Large MIMO test beds

Outcomes:

• Model and simulate a massive MIMO system and develop an experimental test bed.

• To put knowledge into practice and acquire the skill set needed to design and analyze complex wireless communication systems

TEXTBOOKS/ REFERENCES


18CE754 ADAPTIVE CODING AND MODULATION

Objectives:

• To understand the concepts for the applicability of coding in practical wireless systems.

Contents:

Introduction to coded modulation-coding and Information theory-Set partition coding-continuous phase modulation coding-PRS coded modulation-Trellis coding on fading channels.

Outcomes:

• Equip the students to apply coding theory concepts to real time applications.

TEXTBOOKS/REFERENCES:


2. Roman Rafi, Rafi Us Shan, Adaptive coding and modulation: (for 3G systems), VDM VerlagDr. Muller, 2010.
18CE755  DELAY TOLERANT NETWORKS  1 0 0 1

Objectives:

- To introduce the concepts of delay and disruption tolerant networking and illustrate the applications of DTNs to wireless networks

Contents:

History and Early Applications: DakNet, ZebraNet; Layered Architecture: The Bundle Layer; Mobility Models: exponential and power law mobility models, human mobility model; DTN Routing: opportunistic routing, single copy vs. multicopy routing, epidemic, probabilistic, geographic and social-based routing protocols; Deep-Space and Satellite Applications; Terrestrial Applications: data dissemination, delay tolerant social networks; vehicular DTNs, airborne networks; mobile robots, applications in data centre and mobile peer-to-peer networks; Underwater Applications; Performance Analysis and Optimization

Outcomes:

- Students will be able to model and analyze several communication scenarios with disruption applying the delay tolerant framework

TEXTBOOKS/REFERENCES:


18CE756  NETWORK CODING  1 0 0 1

Objectives:

- To introduce the concepts network coding and illustrate its applications to wireless networks

Contents:

Theorems of Network Multicast: min-cut max-flow theorem; the main theorem of network coding; Theoretical Frameworks: algebraic, combinatorial, information-theoretic and linear programming frameworks; Throughput Benefits; Network Code Design for Multicasting; Networks with Delays and Cycles; Applications: gossip algorithms for information dissemination, content distribution, applications in wireless networks and security

Outcomes:

- Students will be able to demonstrate the improvement in performance of wireless networks due to network coding

TEXT BOOKS/ REFERENCES:

1. Christina Fragouli and Emina Soljanin, *Network Coding Fundamentals*, Foundations and

**18CE757 WIRELESS SENSOR NETWORKS**

**Objectives:**
- To understand the theoretical aspects of wireless sensor networks with focus on signal processing and communication perspectives

**Contents:**

**Outcomes:**
- To enable state-of-the-art design of wireless sensor network with an emphasis on the large-scale sensor networks distributed signal processing, communication algorithms and novel cross-layer design paradigms.

**TEXTBOOKS/REFERENCES**

**18CE758 COMPRESSED SENSING**

**Objectives:**
- Understand the concept of compressed sensing framework and reconstruction algorithms

**Contents:**

**Outcomes:**
- Thorough understanding of compressed sensing framework.
- Design of sensing and reconstruction algorithms for inverse problems in engineering

**TEXTBOOKS/REFERENCES**

**18CE759 BIG DATA ANALYTICS**

33
Objectives:

- Introduce the concepts of big data to students
- Train the students to develop and deploy MapReduce applications
- Train the students to perform data analytics on big data

Contents:


Outcomes:

- Training the students on the fundamentals of big data and its applications in data analytics
- Prepare them to apply these algorithms for their further study/research

TEXTBOOKS/REFERENCES:


18CE760     GAME THEORY     1 0 0 1

Objectives:

- To formalize the notion of strategic thinking and rational choice by using the tools of game theory, and to provide insights into using game theory in modeling applications
- To draw the connections between game theory and its applications especially emphasizing the computational issues

Contents:


Outcomes:

- Apply Nash Equilibrium for engineering problems.
- Identify some applications that need aspects of Bayesian Games
• Implement a typical scenario using Game theory

TEXTBOOKS/REFERENCES:

18CE761 COMPLEX SYSTEMS ANALYSIS 1 0 0 1

Objectives:
• To introduce the concepts of nonlinear dynamics and chaos theory
• Understanding biomedical and communication systems as complex systems.
• Use of information science in complex system analysis and classification.

Contents:
Characteristics of nonlinear and dynamical systems-phase space analysis-periodic orbits and stability-maps and flows-chaos theory-modelling biomedical and communication systems as dynamical systems-complexity measures for signal quantification-analysis and classification of ECG and EEG signals using entropy and complexity measures.

Outcomes
• Ability to analyze traditional systems from a novel perspective
• Exposure to the state-of-the-art methods for complex system analysis
• To identify the presence of complex systems in every day signal processing applications including biomedical and communication systems.

TEXT BOOKS / REFERENCES:
3. Recent publications on ‘Complexity measures for complex system analysis’.

18CE762 PRINCIPLE OF PROJECT MANAGEMENT 1 0 0 1

Objective:
• To understand the project management, stages in project management and planning
• To understand the risk management, scheduling and related tools

Contents:

Outcomes:
• To enable planning and scheduling of a project
• To know some of the tools used in project management

TEXTBOOKS/REFERENCES:

18CE798 DISserTATION 0 0 0 10
Objectives:

• To define the problem of the proposed work.
• To apply the concepts of communication engineering and signal processing in the selected problem.
• To demonstrate the results of the design concept.

Contents:
Problems and concepts may be defined based on extensive literature survey by standard research articles. Significance of proposed problem and the state-of the art to be explored. Communication engineering and signal processing tools may be used for demonstrating the results with physical meaning and create necessary research components. Publications in reputed journals and conferences may be considered for authenticating the results.

Outcomes:

• Creation of manpower in the communication engineering and signal processing domain and specialize in the state-of the art technology.
• Enable design aptitude and complex problem solving in the communication engineering and signal processing design aspects.
• Research publications and filing of patents.

18CE799 DISserTATION 0 0 0 10
Objectives:

• To define the problem of the proposed work.
• To apply the concepts of communication engineering and signal processing design in the selected problem.
• To demonstrate the results of the design concept.

Contents:
Problems and concepts may be defined based on extensive literature survey by standard research articles. Significance of proposed problem and the state-of the art to be explored. Communication engineering and signal processing tools may be used for demonstrating the results with physical meaning and create necessary research components.
Publications in reputed journals and conferences may be considered for authenticating the results.

Outcomes:

- Creation of manpower in the communication engineering and signal processing domain and specialize in the state-of-the-art technology.
- Enable design aptitude and complex problem solving in the communication engineering and signal processing design aspects.
- Research publications and filing of patents.