Master of Technology

In

Electronics & Communication Engineering (Communication Systems & Networks)

Course Structure & Syllabus

Department of Electronics & Communication Engineering

National Institute of Technology Hamirpur

Hamirpur (HP) – 177005, India

Course Structure of M. Tech. Electronics and Communication Engineering (Communication Systems & Networks)

SEMESTER-I

Sr. No.	Course No.	Course Name	Teaching Schedule			Hours/ week	Credit
			L	T	P		
1	EC-611	Information Theory And Coding	4	0	0	4	4
2	EC-612	Mobile Communication	4	0	0	4	4
3	EC-613	Optical Networks	4	0	0	4	4
4	EC-7MN	Programme Elective-I	4	0	0	4	4
5	EC-7MN	Programme Elective-II	4	0	0	4	4
6	EC-614	Optical Communication Lab	0	0	4	4	2
	Total		**20**	**0**	**4**	**24**	**22**

Programme Elective-I& II: List of Programme Electives is given in the Annexure.

SEMESTER-II

Sr. No.	Course No.	Course Name	Teaching Schedule			Hours/ week	Credit
			L	T	P		
1	EC-621	Digital Signal Processing	4	0	0	4	4
2	EC-622	Modeling and Simulation of Communication System and Networks	4	0	0	4	4
3	EC-623	Broadband Wireless Technologies	4	0	0	4	4
4	EC-7MN	Programme Elective-III	4	0	0	4	4
5	EC-7MN	Programme Elective-IV	4	0	0	4	4
6	EC-624	Communication System & Networks Simulation Lab	0	0	4	4	2
	Total		**20**	**0**	**4**	**24**	**22**

Programme Elective –III & IV: List of Programme Electives is given in the Annexure.

SEMESTER-III

Sr. No.	Course No.	Course Name	Hours/week	Credit
1	EC-800	M.Tech. Dissertation	--	20
	Total			**20**

SEMESTER-IV

Sr. No.	Course No.	Course Name	Hours/week	Credit
1	EC-800	M.Tech. Dissertation	--	20
	Total		**--**	**20**

Total Credit of the Programme = 84

Annexure

List of Programme Electives

Programme Elective-I

EC-701 Advanced Digital Communication
EC-702 Soft Computing
EC-703 Optimization Tools and Techniques
EC-704 Advanced Antenna Design

Programme Elective-II

EC-705 Computer Communication and Networks
EC-706 Wi-Fi, Bluetooth and Zigbee Technology
EC-707 Wireless Sensor Networks
EC-708 Wi-Fi Telephony and VoIP

Programme Elective-III

EC-709 Electromagnetic Interference & Compatibility
EC-710 RF and Microwave Circuit design
EC-711 Advanced Engineering Electromagnetics
EC-712 RF & Microwave Active Circuits
EC-713 Computational Electromagnetics

Programme Elective-IV

EC-714 Digital Image Processing and Pattern Recognition
EC-715 Adaptive Signal Processing
EC-716 Signal Detection and Estimation Theory
EC-717 Multi-rate Signal Processing

Course Name: **Information Theory and Coding**
Course Code: **EC-611**
Course Type: **Core**

Contact Hours/Week: **4L** Course Credits: **04**

Course Objectives

- To impart knowledge about measuring the amount of information, capacities calculation of different channels in communication systems.
- To understand the theorems and inequalities used in information and coding theory field.
- To enable the students to design the source coding algorithms for improving transmission efficiency.
- To enable the students to design the block based error control coding algorithms for improving error performance of communication systems.

Course Content

Measures of Information and Channel Capacity; Entropy, Relative Entropy and Mutual Information, Basic Inequalities: Jensen Inequality and its Physical Application, Log–Sum Inequality and its Physical Application, Fano Inequality and its Physical Application, Data Processing Theorem and its Physical Application, Consequences of the Inequalities in the Field of Information Theory. Entropy Rate and Channel Capacity; Stationary Markov Sources: Entropy Rate and Data Compression, Definition of Capacity and its Computation of Discrete Memory Less Channels (BNC, BSC, BEC, Cascaded Channels, Noiseless Channels, Noisy Typewriter), The Channel Coding Theorem and the Physical Significance of Capacity. Data Compression by Fixed–To–Variable–Length Codes; Unique Decodability and the Prefix Condition, Kraft's Inequality, Relationship of Average Codeword Length to Source Entropy, Examples of Coding Techniques: Huffman, Shannon–Fano–Elias, Lempel–Ziv and Universal. Design of Linear Block Codes; Introduction of Linear Block Codes, Syndrome and Error Detection, Minimum Distance of a Block Code, Error Detecting and Error Correcting Capability of a Block Code, Design of Encoder and Syndrome Decoder for Linear Block Codes. Design of Cyclic Codes; Description Cyclic Codes, Generator and Parity Check Matrices of Cyclic Codes, Encoding of Cyclic Codes, Syndrome Computation and Error Detection, Decoding of Cyclic Codes, Cyclic Hamming Codes. Convolutional Codes; Encoding of Convolutional Codes, Structural Properties of Convolutional Codes, Distance Properties of Convolutional Codes, Design of Encoder and Decoder for Convolutional Codes.

Course Outcomes

Upon successful completion of the course, the students will be able to

CO1: Understand the various terminologies to estimate information content in the communication system.
CO2: Apply various inequalities and quantities to evaluate the information content and entropy rate of a DMS.
CO3: Design lossless source codes for discrete memory-less source to improve the efficiency of information transmission.
CO4: Design block based error control codes for improving the error performance of information transmission systems.

Books and References

1. Elements of Information Theory by T.M. Cover and J.A. Thomas, John Wiley.
2. Error Control Coding by S. Lin and D. J. Costello, Pearson Education.
3. Information Theory and Reliable Communication by R. G. Gallager, John Wiley & Sons.

Course Name:	**Mobile Communication**
Course Code:	**EC-612**
Course Type:	**Core**

Contact Hours/Week: **4L** Course Credits: **04**

Course Objectives

- To expose the students to understand mobile radio communication principles
- To study the recent trends adopted in cellular systems
- To introduce the students to recent wireless standards.

Course Content

Basic cellular systems, Performance criteria, Uniqueness of mobile radio environment, Operation of cellular systems, Concept of frequency reuse channels, Co–channel interference reduction factor, Desired C/I from a normal case in an Omni–directional antenna system, Handoff mechanism, Cell splitting.Cell coverage for signal and traffic, Obtaining the mobile point-to-point model, Propagation over water or flat open area, Foliage loss, Propagation in near-in distance, Long–distance propagation, Obtain path loss from a point–to–point prediction model, Cell–site antenna heights and signal coverage cells. Co-channel and adjacent-channel interference in mobile communications; Co-channel interference, Design of an Omni–directional antenna system in the worst case, Design of a directional antenna system, Lowering the antenna height, Power control, Diversity receiver, Adjacent–channel interference, Near–end–far–end interference, Effect on near-end mobile units**.** Frequency management, channel assignment and handoffs; Frequency management, Frequency–spectrum utilization, Set–up channels, Definition of channel assignment, Fixed channel assignment schemes, Non fixed channel assignment schemes, Concept of handoff, Initiation of a hard handoff, Delaying a handoff, Forced handoffs, Queuing of handoffs, Power–difference handoffs, Mobile assisted handoff, Soft handoffs, Cell–site handoff only, Intersystem handoff. Multiple access techniques and digital cellular systems; Multiple access techniques for mobile communications; Global system for mobile (GSM): GSM system architecture, GSM radio subsystem, GSM channel types, Frame structure for GSM, Signal processing in GSM; GPRS; EDGE; Overview of third generation (3G) wireless networks, 4G and 5G standards.

Course Outcomes

Upon successful completion of the course, the students will be able to

CO1: Discuss the cellular system design and technical challenges.

CO2: Analyze the Mobile radio propagation, fading, diversity concepts and the channel modeling.

CO3: Analyze the design parameters, link design, smart antenna and multiple access systems.

CO4: Summarize the principles and applications of wireless systems and standards like GSM, GPRS, EDGE and 3G, 4G, 5G standards.

Books and References

1. Mobile Cellular Telecommunications: Analog and Digital Systems by W. C. Y. Lee, McGraw Hill Education.
2. Wireless Communications: Principles and Practice by T. S. Rappaport, Pearson Education India.
3. Wireless Communications and Networks: 3G and Beyond by ITI S. Misra, McGraw Hill Education.
4. Wireless Digital Communications: Modulation and Spread Spectrum Applications by K. Feher, Prentice Hall.

Course Name: **Optical Networks** Course Code: **EC-613** Course Type: **Core**	
Contact Hours/Week: **4L**	Course Credits: **04**

Course Objectives

- To understand the optical networks, optical amplifiers and multiplexers.
- To impart the knowledge of client layers of optical layer, WDM network design and access network.

Course Content

Introduction to Optical Network: Services, Circuit switching, Packet switching, Optical networks, Optical layer, Transparency and all optical networks, Optical packet switching, Transmission basics, Network evolution; Optical Amplifiers: Emission, Spontaneous emission, Erbium doped fiber amplifiers, Raman amplifiers, Semiconductor optical amplifiers, Cross talk in SOAs; Multiplexers and Filters to Wavelength Converters: Gratings, Diffraction pattern, Bragg gratings, Fiber gratings, Fabry–Perot filters, Multilayer dielectric thin-film filters, Mach–Zehnder interferometers, Arrayed waveguide grating, Acousto–optic tunable filter, High channel count multiplexer architectures, Optoelectronics approach, Optical gating, Interferometric techniques, Wave mixing; Transmission System Engineering: System model, Power penalty, Transmitter, Receiver, Optical amplifiers, Cross talk, Dispersion, Fiber nonlinearities, Wavelength stabilization design of Soliton systems, Design of dispersion–managed soliton systems; Client Layers of the Optical Layer: SONET/SDH, ATM, IP, Storage area networks, Gigabit and 10–Gigabit Ethernet; WDM Network Elements & Design: Optical line terminals, Optical line amplifiers, Optical add/drop multiplexers, Optical cross connects, Cost trade–offs: A detailed ring network example, LTD and RWA problems, Dimensioning wavelength–routing networks, Statistical dimensioning models, Maximum load dimensioning models; Access Networks: Network architecture overview, Enhanced HFC, Fiber to the Curb (FTTC).

Course Outcomes

Upon successful completion of the course, the students will be able to

CO1: Understand the basics of optical network, optical network and optical packet switching.
CO2: Analyse the different types optical amplifier.
CO3: Understand the multiplexer and filters to wavelength converters.
CO4: Understand the optical transmission system engineering and client layer of the optical layer.
CO5: Understand the WDM network elements, design and network architecture overview.

Books and References

1. Optical Networks: A Practical Perspective by R. Ramaswami, K. Sivarajan and G. Sasaki, Morgan Kaufmann Publication.
2. Fiber-Optic Communication Systems by G. P. Agarwal, John Wiley & Sons, New York.
3. Optical Communications: Components and Systems by J. H. Franz and V. K. Jain, Narosa Publications.
4. Optical Fiber Communication by G. Keiser, McGraw Hill Education.

Course Name: **Optical Communication Lab**
Course Code: **EC-614**

Contact Hours/Week: **4P** Course Credits: **02**

Course Objectives

- To study the design and deployment of optical fiber communication links.
- To understand the characteristics of optical fiber and losses in optical fiber communication link.

List of Experiments

1. Demonstrate two most used modulation formats in optical communication: non return to zero (NRZ) and return to zero (RZ).
2. To compensate fiber dispersion using the ideal fiber grating components.
3. To study the effect of optical receiver characteristics on a system's performance .
4. To set up an 850nm fiber optic analog link.
5. To set up 850nm and 650 nm digital link, and to measure the maximum bit rates supportable on these links.
6. To estimate the aperture of the 1 micron diameter.
7. To measure the losses in optical fiber communication link.
8. To analyse the v-I characteristics and p-I characteristics using LED module.
9. To study the characteristics of Avalanche photodiode (APD)
   (i). APD at zero bias
   (ii). APD at reverse bias.
10. To examine the technique of time division multiplexing (TDM).

Note: *The concerned Course Coordinator will prepare the actual list of experiments/problems at the start of semester based on above generic list.*

Course Outcomes

Upon successful completion of the course, the students will be able to

CO1: Understand the communication using optical fiber.
CO2: Set up the analog and digital communication links.
CO3: Analyse the characteristics of LED and Avalanche photodiode.

Course Name: **Digital Signal Processing**
Course Code: **EC-621**
Course Type: **Core**

Contact Hours/Week: **4L** Course Credits: **04**

Course Objectives

- To study and analyze discrete-time signals and systems in time-domain
- To study and analyze discrete-time signals and systems in transform domain
- To design and implement FIR and IIR digital filters.

Course Content

Introduction to discrete time signals and systems: Discrete time signals, Operations on sequences, Sampling process, Discrete-time systems, Time-domain characterization of LTI discrete-time systems, Random signals; Transform-domain representation of signals: Discrete-time Fourier transform, Discrete Fourier transform, DFT properties, Computation of the DFT of real sequences, Linear convolution using DFT, Z-transform, Inverse Z-transform, Properties of Z-transform; Transform-domain representation of LTI systems: Frequency response, System transfer function, Types of transfer functions, Minimum-phase and Maximum-phase transfer functions; Digital Filter Structure: Block diagram representation, Signal flow graph representation, Equivalent structures, FIR digital filter structures, IIR digital filter structures, Cascaded lattice realization of IIR and FIR filters; Digital filter design: General considerations, Review of analog filter design, IIR filter design using impulse invariance method and bilinear transformation method, FIR digital filter design using windows method and frequency sampling method.

Course Outcomes

Upon successful completion of the course, the students will be able to

CO1: Understand, characterize & analyze discrete-time signals and systems in time domain

CO2: Analyze discrete-time signals and LTI discrete-time systems in transform domain

CO3: Design and implement FIR and IIR digital filters using different methods

Books and References

1. Digital Signal Processing: A Computer Based Approach by S. K. Mitra, Tata McGraw Hill Publication
2. Digital Signal Processing Principles, Algorithms, and Applications by J. G. Proakis and D. G. Manolakis, Pearson Education.
3. Digital Signal Processing by A. V. Oppenheim and R. W. Schafer, PHI Publication.
4. Digital Signal Processing by Monson H. Hayes, McGraw Hill Publication (Schaum’s Outlines).

Course Name:	**Modeling and Simulation of Communication System and Networks**
Course Code:	**EC-622**
Course Type:	**Core**
Contact Hours/Week: **4L**	Course Credits: **04**

Course Objectives

- To provide a thorough introduction to modeling & simulation techniques of communication systems.
- To provide in depth knowledge of estimation of parameter measures and testing process of the communication system.
- To introduce the concept of performance evaluation of any communication system including channel models.
- To introduce the concepts of queuing theory and its relevance for design of communication systems.

Course Content

Univariate and Multivariate Models; Probability Density and Distribution Functions, Random Variables, Independence of Random Variables, Transformations Between Random Variables, Expectations and Moments, Conditional Expectation and Conditional Variance, Bi- and Multivariate Distributions, Random Processes, Covariance and Spectral Density, Application of Different Probability Models, Bounds and Approximation of Random Variables, Introduction to Simulation and Modeling: Steps in Simulation and Modeling. Simulation of Random Variables and Random Process; Properties of Random Numbers, Generation of Random Numbers, Techniques for Generating Random Numbers: Linear Congruential Method and Combined Linear Congruential Method, Validation of Random Number Generators: KS Test, Chi-Square Test, Runs Test, Autocorrelation Test. Random Variate Generators; Inverse Transform Technique for Generating Discrete Random and Continuous Random Variables (Examples for Exponential, Uniform, Triangular, Poisson, Binomial Distributed Random Variables), Acceptance–Rejection Technique for Generation of Discrete and Continuous Random Variables, Some Special Generators: Box Muller Method, Sum–of–12 Method for Generating Normally Distributed Random Variables, Validation of the Generation Methods using Goodness of Fit Tests. Estimation of Performance Measures: Quality of an Estimator, Estimator of SNR, Probability Density Functions of Analog Communication System, BER of Digital Communication Systems, Unbiased Estimation of Expected Value, Unbiased Estimation of Variance, Monte Carlo Method and Importance Sampling Method for Estimating the Integral (Crude Monte Carlo Method, Acceptance– Rejection Monte Carlo, Stratified Sampling, Importance Sampling Methods and their Performance Comparison). Queuing Models: Characteristics of Queuing Models, Queuing Notation, Long Run Performance Measures of Queuing Systems, Steady State Behavior of M/M/1 and M/M/1/N Queuing Models, Little Formula, Burke's Theorem M/G/1 Queuing Model, Embedded Markov Chain Analysis of TDM Systems, Polling, Random Access Systems.

Course Outcomes

Upon successful completion of the course, the students will be able to

CO1: Analyze, model and simulate the communication networks and systems.

CO2: Generate, test and estimate parameters and performance measures used in communication systems and networks.

CO3: Apply this knowledge for detection, estimation and simulation of various communication networks

CO4: Simulate and evaluate the performance measures of queuing systems.

Books and References

1. Simulation of Communication Systems Modeling, Methodology and Techniques by M. C. Jeruchim, P. Balaban and K. S. Shanmugan, Springer.
2. Simulation Modelling and Analysis by A. M. Law and W. D. Kelton, McGraw Hill Higher Education.
3. Discrete-Event System Simulation by J. Banks, J. S. Carson II, B. L. Nelson and D. M. Nicol, Pearson.

Course Name: **Broadband Wireless Technologies**
Course Code: **EC-623**
Course Type: **Core**

Contact Hours/Week: **4L** Course Credits: **04**

Course Objectives

- To understand mobile radio communication principles and to study the recent trends adopted in cellular systems and broadband wireless standards.
- To introduce the concepts of mobile radio propagation, fading, diversity and channel modeling for broadband wireless systems.

Course Content

Wireless Communications and Diversity and Broadband Wireless Channel Modeling: Fast Fading Wireless Channel Modelling, Rayleigh/Ricean Fading Channels, BER Performance in Fading Channels, Concept of Rake Receiver, Performance of RAKE Receiver in Multipath Fading Channel, Diversity Modelling for Wireless Communications, BER Performance Improvement with Diversity, Types of Diversity – Frequency, Time, Space, WSSUS Channel Modeling, RMS Delay Spread, Doppler Fading, Jakes Model, Autocorrelation , Jakes Spectrum, Impact of Doppler Fading. Principles of CDMA: The Concept oof Spreading, Capacity of CDMA System, Spreading Codes and Their Properties, Pseudo-Random Sequences, Maximal Length Linear Shift Register Sequence, Randomness Properties of MLSR Sequence. Galois Field and Primitive Polynomials, Mechanization of Linear Feedback Shift Register Binary Irreducible Polynomial, State Vector Variations For PN Sequence Phase Shifts, Shift Register Generator with Special Loading Vectors, Use of Mask To Select a Sequence Phase Shift. OFDM: Introduction to OFDM, Multicarrier Modulation and Cyclic Prefix , Channel Model and SNR Performance LTE Systems, OFDMA And SC-OFDMA, Synchronization And Channel Estimation Aspect, OFDM Issues – PAPR, Frequency and Timing Offset Issues. MIMO: Introduction to MIMO, MIMO Channel Capacity, SVD and Eigenmodes of MIMO Channel, MIMO Spatial Multiplexing – BLAST, MIMO Diversity – Alamouti, OSTBC, MRT, MIMO - OFDM. UWB (Ultrawide Band): UWB Definition and Features, UWB Wireless Channels, UWB Data Modulation, Uniform Pulse Train, Bit-Error Rate Performance of UWB.

Course Outcomes

Upon successful completion of the course, the students will be able to

CO1: Understand the cellular system design and technical challenges.
CO2: Analyze the Mobile radio propagation, fading, diversity concepts and the channel modeling.
CO3: Understand the design parameters, link design, smart antenna, beam forming and MIMO systems.
CO4: Understand Multiuser Systems, CDMA, MIMO, OFDMA and UWB Concepts

Books and References

1. CDMA: Principles of Spread Spectrum Communication by Andrew J. Viterbi, Addison-Wesley Publishing Company.
2. CDMA Systems Engineering Handbook by Jhong S. Lee and Leonard E. Miller, Artech House Publishers.
3. IS-95 CDMA and CDMA-2000 by Vijay K Garg, Pearson Education.
4. OFDM for Wireless Communications Systems by Ramjee Prasad, Artech House, Inc.
5. Fundamentals of Wireless Communications by David Tse and Pramod Viswanath, Cambridge University Press.
6. MIMO Wireless Communications by Ezio Biglieri, Cambridge University Press.
7. Theory application of OFDM and CDMA wideband wireless communication by Henrik Schulze & Cristion Luders, John Wiley & Son Ltd.
8. Wireless Communications by Andrea Goldsmith, Cambridge University Press.

Course Name: **Communication System & Networks Simulation Lab** Course Code: **EC-624**	
Contact Hours/Week: **4P**	Course Credits: **02**

Course Objectives

- To provide skills for modeling and simulation of communication systems & networks on MatLab platform.
- To provide skills for writing MatLab programs and use communication and signal processing toolboxes.
- To enable the students to implement and validate the algorithms studied in EC-622 PG Course.

List of Experiments

1. Familiarity with MatLab communication and signal processing toolbox.
2. Programs to generate uniformly distributed random variables between [0, 1] using Linear Congruential Generator.
3. Programs to generate discrete random variables based on inverse transform technique.
4. Programs to generate continuous random variables based on inverse transform technique.
5. Programs to generate discrete random variables based on acceptance rejection technique.
6. Programs to generate continuous random variables based on acceptance rejection technique.
7. Programs to validate random variable generators based on KS test.
8. Programs to validate random variable generators based on Chi square test.
9. Programs to validate independence of random variable generators based on Runs test.
10. Programs to validate independence of random variable generators based on Autocorrelation test.
11. Programs to use Monte Carlo techniques to estimate parameters of quantities used in communication system.
12. Programs to implement parameters and performance measures used in communication system design.
13. Designing the digital communication system to evaluate BER vs. SNR performance

Note: *The concerned Course coordinator will prepare the actual list of experiments/problems at the start of semester based on above generic list in sync with EC-622 course.*

Course Outcomes

CO1: Identify and abstract the simulation model design of communication systems.
CO2: Design and develop modular programming skills on MatLab platform.
CO3: Trace, debug and validate simulation models.
CO4: Able to implement the algorithms required for discrete event simulation.
CO5: Able to implement the validation tests for discrete event simulation models.

Course Name: **Advanced Digital Communication**
Course Code: **EC-701**
Course Type: **Programme Elective-I**

Contact Hours/Week: **4L** Course Credits: **04**

Course Objectives

- To study baseband data transmission over AWGN and band-limited channels
- To study different digital modulation schemes
- To study optimum receivers for different modulation schemes for AWGN channels
- To study different techniques for carrier recovery and symbol synchronization in signal demodulation .

Course Content

Baseband pulse transmission: Matched filter, Properties of matched filters, Error rate due to noise, Intersymbol interference, Nyquist's criterion for distortionless baseband binary transmission, Ideal Nyquist Channel, Raised cosine spectrum, Correlative-level coding, Duobinary signaling, Modified duobinary signaling; Signal-space analysis: Geometric representation of signals, Gram-Schmidt orthogonalization procedure, Conversion of the continuous AWGN channel into a vector channel, Statistical characterization of the correlator outputs, Likelihood functions, Coherent detection of signals in noise, Maximum likelihood decoding, Correlation receiver, Equivalence of correlation and matched filter receivers; Digital Modulation Schemes: Representation of digitally modulated signals, Memoryless modulation methods, Pulse amplitude modulation, Phase modulation, Quadrature amplitude modulation, Signaling schemes with memory, Continuous-phase frequency-shift keying, Continuous-phase modulation; Optimum Receivers for AWGN Channels: Optimal detection and error probability for band-limited signaling (ASK, PSK, QAM), Optimal detection and error probability for power-limited signaling (orthogonal signaling), Optimum receiver for CPM signals, Optimum demodulation and detection of CPM; Carrier and Symbol Synchronization: Signal parameter estimation, Carrier recovery and symbol synchronization in signal demodulation, Carrier phase estimation, Maximum-likelihood carrier phase estimation, The phase-locked loop, Symbol timing estimation, Maximum-likelihood timing estimation, Joint estimation of carrier phase and symbol timing.

Course Outcomes

Upon successful completion of the course, the students will be able to

CO1: Understand baseband data transmission over AWGN and band-limited channels
CO2: Understand and explain different digital modulation schemes
CO3: Analyze the performance of optimum receivers for different modulation schemes for AWGN channels
CO4: Analyze different techniques for carrier recovery and symbol synchronization in signal demodulation.

Books and References

1. Communication Systems by Simon Haykin, Wiley-India Edition.
2. Digital Communications by John G. Proakis and MasoudSalehi, McGraw-Hill.
3. Digital Communications – Fundamentals and Applications by Bernard Sklar and P. K. Ray Pearson Education.
4. Modern Digital and Analog Communication Systems by B. P. Lathi and Zhi Ding, Oxford University Press.
5. Principles of Communication Systems by Herbert Taub and Donald L. Schilling, McGraw-Hill.

Course Name: **Soft Computing**
Course Code: **EC-702**
Course Type: **Programme Elective-I**

Contact Hours/Week: **4L** Course Credits: **04**

Course Objectives

- To impart knowledge about the Artificial Neural networks and deep learning.
- To introduce the fundamental concepts relevant to ANN, Optimization techniques and genetic algorithms.

Course Content

Introduction: History of Deep Learning, Deep Learning fundamentals, Training Deep Architectures, Intermediate Representations: Sharing Features and Abstractions across Tasks, Sigmoid Neurons, Gradient Decent, Feedforward Neural Networks, Dropout, Back-propagation.

Deep learning fundamentals: Principal component Analysis and its interpretations, Singular Value Decomposition, Greedy Layer wise Pre-training, Better activations, Better weight initialization methods, Batch Normalization, Introduction of deep learning, How deep learning works, Introduction to Tensor flow.

Deep learning Algorithms: Gradient Descent and Back-propagation, Improving deep network, Multi-Layer Neural Networks, The Challenge of Training Deep Neural Networks, Deep Generative Architectures. Mini-batches, Unstable Gradients, and Avoiding Over-fitting, Applying deep net theory to code, Introduction to convolutional neural networks for visual recognition.

Advanced Deep Architectures: RNNs, RNNs in practice, LSTMs and GRUs, LSTMs and GRUs in practice, Reinforcement Learning, Why Unsupervised Learning is Important, Training Auto Encoder.

Applications for Communication Engineering: Shortened pipeline, error detection, correction, feature extraction, modeling

Course Outcomes

Upon successful completion of the course, the students will be able to

CO1: Describe the key components of AI, Genetic algorithms and its relation and role in Communication Engineering.

CO2: Understand the alternatives to generic designs, optimization and modeling techniques

Books and References

1. Deep Learning: Methods and Applications by Li Deng and Dong Yu, Now Publishers Inc.
2. Neural Networks and Deep Learning, Michael Nielsen, Determination Press.
3. Hands-On Machine Learning with Scikit-Learn and TensorFlow: Concepts, Tools, and Techniques to Build Intelligent Systems by Aurelien Geron, Oreilly Media.
4. Pattern Recognition and Machine Learning by Christopher Bishop, Springer-Verlag New York.
5. Deep Learning, An MIT Press book by Ian Goodfellow and Yoshua Bengio and Aaron Courville, MIT Press.

Course Name: **Optimization Tools and Techniques**
Course Code: **EC-703**
Course Type: **Programme Elective-I**

Contact Hours/Week: **4L** Course Credits: **04**

Course Objectives

- To teach basics and fundamentals of optimization.
- To build upon the theoretical and mathematical models for optimization techniques.
- To provide students with an opportunity to understand and practice optimized designing.

Course Content

Single Variable Non-Linear unconstrained optimization, One dimensional Optimization methods, Uni-modal function, Elimination methods, Fibonacci method, Golden section method, Interpolation methods, Quadratic & cubic interpolation methods. Multi variable non-linear unconstrained optimization: Direct search method, Univariant method, pattern search methods, Powell's-Hook-Jeeves, Rosenbrock search methods- gradient methods, gradient of function, Steepest decent method, Fletcher Reeves method, Variable metric method. Linear Programming: Formulation, Sensitivity analysis, Change in the constraints, Cost coefficients, Coefficients of the constraints, Addition and deletion of variable, Constraints. Integer Programming: Introduction, formulation, Gomory cutting plane algorithm, Zero or one algorithm, Branch and bound method Stochastic programming, Basic concepts of probability theory, Random variables, distributions, mean, Variance, Correlation, Co–variance, Joint probability distribution, Stochastic linear, Dynamic programming. Geometric Programming: Polynomials, arithmetic, Geometric inequality, Unconstrained, Non-traditional optimization Techniques: Genetic Algorithms, Steps, Solving simple problems Comparisons of similarities and dissimilarities between traditional and non-traditional techniques, Particle Swarm Optimization.

Course Outcomes

CO1: Comprehend the insight of optimization requirements for any system.
CO2: Identify the conventional and new state of the art optimization techniques.
CO3: Apply principles of usage of optimization techniques for electronic design.
CO4: Assess and analyse the performance of optimized designs.

Books and References

1. Optimization Theory & Applications by S. S. Rao, John Wiley & Sons.
2. Optimization for Engineering Design: Algorithms and Examples by K. Deb, Prentice Hall India Learning Private Limited.
3. Optimization: Theory and Practice by M. C. Joshi and K. M. Moudgalya, Cambridge Alpha Science International Ltd.

Course Name: **Advanced Antenna Design** Course Code: **EC-704** Course Type: **Programme Elective-I**	
Contact Hours/Week: **4L**	Course Credits: **04**

Course Objectives

- To impart knowledge about the fundamental concepts of antenna engineering.
- To introduce the basic principle relevant to wired antennas and planar antennas.
- To enable the students to understand the factors related to frequency, radiation pattern and interference.

Course Content

Introduction to Antenna, Types and Fundamental Concepts:Physical Concept of Radiation, Radiation Pattern, Near and Far-Field Regions, Reciprocity, Directivity and Gain, Effective Aperture, Polarization, Input Impedance, Efficiency, Friis Transmission Equation, Radiation Integrals and Auxiliary Potential Functions, Radiation from Wires and Loops**:** Infinitesimal Dipole, Finite-Length Dipole, Dipoles for Mobile Communication, Small Circular Loop.Aperture Antennas:Huygen's Principle, Radiation from Rectangular and Circular Apertures, Design Considerations, Babinet's Principle, Radiation from Sectoral and Pyramidal Horns, Geometrical Theory of Diffraction, Reflector Antennas.Broadband Antennas: Broadband Concept, Log-Periodic Antennas, Frequency Independent Antennas.Microstrip Antennas: Basic Characteristics of Microstrip Antennas, Feeding Methods, Methods of Analysis, Design of Rectangular and Circular Patch Antennas, Planar Antenna Miniaturization Concepts and Techniques, Circularly Polarized Patch Antenna Design Concepts and Techniques.

Antenna Arrays: Analysis of Uniformly Spaced Arrays with Uniform and Nonuniform Excitation Amplitudes, Extension to Planar Arrays.Basic Concepts of Smart Antennas: Concept and Benefits of Smart Antennas, Fixed Weight Beam Forming Basics, Adaptive Beamforming.

Course Outcomes

Upon successful completion of the course, the students will be able to

CO1: Identify the fundamental parameters of Antennas Engineering

CO2: Describe the antenna structure, antenna arrays and planar antennas at specific frequency of operation

CO3: Apply principles of radiation from the conducting surfaces and aperture surfaces at RF frequencies

CO4: Assess the numerical techniques for the analysis of the Antenna Devices

Books and References

1. Antenna Theory: Analysis and Design by C. A. Balanis, Wiley.
2. Antenna and Wave propagation by R. J Marhefka, A. S. Khan and J. D. Kraus, Mcgraw Higher Ed.
3. Antenna and Wave propagation by A. R. Harish and M. Sachidananda, Oxford University Press.

Course Name: **Computer Communication and Networks**
Course Code: **EC-705**
Course Type: **Programme Elective-II**

Contact Hours/Week: **4L** Course Credits: **04**

Course Objectives

- To introduce basic concepts of Computer communication and Data communication along with different networks.
- Enumerate the physical layer, Data Link Layer, Network Layer, Transport Layer and Application Layer.
- Understanding of switching concept and different types of switching techniques.

Course Content

Communication model, Data Communications, Computer Communication Architecture, Standard Making Organizations. Concepts and Terminology, Asynchronous and Synchronous Data Communications, Multiplexing Techniques. Communication Networking Techniques, Circuit Switching, Packet Switching, Local Area Networks. Protocols, Layered Approach, TCP/IP Protocol Suite, System Network Architecture. The Bridge and Routing, Connectionless Internetworking, Connection Oriented Internetworking, Transport and Network Services TCP / UDP.Session Characteristics, OSI Session and Service Protocol, Presentation Concepts, Encryption and Authentication Codes, Virtual Terminal Protocols, Network Management, File Transfer and Electronic Mail.Communication Switching Techniques, Frame-Mode Bearer Service, Frame Relay Congestion Control, Synchronous Transfer Mode.

Course Outcomes

Upon successful completion of the course, the students will be able to

CO1: Give the basic information of how a network can be designed, possible choice of various models for designing a network.
CO2: Understand the various network techniques between two trusted entities.
CO3: Analyse different connection mehotodolies for a communication network.
CO4: Analyse various reference models by which data can be transmitted, able to design a routing protocol implementing security mechanisms for secure transmission of data from sender to the receiver.
CO5: Understand the various switching methodologies based on subject related on course work, assignments.

Books and References

1. Data and Computer Communications by W. Stallings, Pearson Education India.
2. Computer Networks by A. S. Tanenbaum and D. J. Wetherall, Pearson Education India.
3. Data Communications, Computer Networks, and Open Systems by F. Halsall, Addison-Wesley.

Course Name: **Wi-Fi, Bluetooth and Zigbee Technology**
Course Code: **EC-706**
Course Type: **Programme Elective-II**

Contact Hours/Week: **4L** Course Credits: **04**

Course Objectives

- To understand theoretical aspects of Wi-Fi, Bluetooth and ZigBeetechonolgy.
- To design and implement WiFi/BlueTooth/Zigbee based adhoc networks.

Course Content

Wi-Fi: Architecture and Functions: WLAN Roadmap via IEEE 802.11 Family Evolutions, IEEE 802.11 Architecture, Different Physical Layers, Data Link Layer, Medium Access Control Layer, Mobility, Security, IEEE 802.11 Family and Its Derivative Standards; Bluetooth Architecture and Functions: Introduction, Architecture and Throughputs, Physical Layer and Physical Channels, Baseband Layer, Link Manager Protocol, Logical Link Control and Adaptation Protocol, RFCOMM Protocol, Service Discovery Protocol, Profiles, Host Control Interface, Bluetooth Network Encapsulation Protocol; IEEE 802.15.4 and ZigBee: General Architecture, Physical Layer, 2450 MHz Physical Layer, 868/915 MHz Physical Layer, PDU Packet Format, MAC Layer, Channel Access, Energy Detection, Active and Passive Scan, Association Procedure, Guaranteed Time Slot, Security, Frame Structures, Beacon Frame , Data Frame.

Course Outcomes

Upon successful completion of the course, the students will be able to

CO1: Use suitable principles and standards of Bluetooth, IEEE 802.15.4 and ZigBee in design and evaluation of sensor networks and wireless communication protocols for small digital transmitter/receivers.

CO2: Use the knowledge for implementation of WiFi networks.

CO3: Analysing relevant results from research literature design and implement software and system solutions for wireless embedded systems.

CO4: Demonstrate an ability to read, critically evaluate, analyse and present (verbally or in written form) the content and implications of research articles in the area.

Books and References

1. Wi-Fi™, Bluetooth™, Zigbee™ and WiMax™ by H. Labiod, H. Afifi and C. D. Santis, Springer.
2. Bluetooth Technology and Its Applications with Java and J2Me by R. A. Prathap and C. S. R. Prabhu, Prentice Hall India Learning Private Limited.
3. Bluetooth Demystified by N. J. Muller, McGraw-Hill Professional.
4. Bluetooth Application Developer’s Guide by Jennifer Bray, Brain Senese, Gordon McNutt, Bill Munday, Syngress Media.

Course Name: **Wireless Sensor Networks**
Course Code: **EC-707**
Course Type: **Programme Elective-II**

Contact Hours/Week: **4L** Course Credits: **04**

Course Objectives

- To impart knowledge about wireless sensor networks and its application area.
- To introduce the fundamental concepts relevant to deployment and localization of wireless sensor networks.
- To enable the students to understand the synchronization and dissemination of information using wireless sensor network about the target area.

Course Content

Introduction, Wireless Sensor Networks: The Vision, Networked Wireless Sensor Devices, Applications of Wireless Sensor Networks, Key Design Challenges, Network Deployment: Structured Versus Randomized Deployment, Network Topology, Connectivity in Geometric Random Graphs, Connectivity using Power Control, Coverage Metrics, Mobile Deployment, Localization And Time Synchronization: Key Issues, Localization Approaches, Coarse-Grained Node Localization Using Minimal Information, Fine-Grained Node Localization Using Detailed Information, Network- Wide Localization, Theoretical Analysis of Localization Techniques, Key Issues of Time Synchronization, Traditional Approaches, Fine-Grained Clock Synchronization, Coarsegrained Data Synchronization, Wireless Characteristics And Medium-Access: Wireless Link Quality, Radio Energy Considerations, The SINR Capture Model For Interference, Traditional MAC Protocols, Energy Efficiency In MAC Protocols, Asynchronous Sleep Techniques, Sleep-Scheduled Techniques, and Contention-Free Protocols, Sleep-Based Topology Control and Energy-Efficient Routing: Constructing Topologies for Connectivity, Constructing Topologies for Coverage, Set K-cover Algorithms, Cross-Layer Issues, Metric-Based Approaches, Routing with Diversity, Multi-Path Routing, Lifetime-Maximizing Energy-Aware Routing Techniques, Geographic Routing, Routing to Mobile Sinks, Data-Centric Networking: Data-Centric Routing, Data-Gathering with Compression, Querying, Data-Centric Storage and Retrieval, Database Perspective on Sensor Networks, Transport Reliability and Congestion Control: Basic Mechanisms and Tunable Parameters, Reliability Guarantees, Congestion Control, Real-Time Scheduling.

Course Outcomes

Upon successful completion of the course, the students will be able to

CO1: Have an understanding of the principles and characteristics of wireless sensor networks.
CO2: Apply knowledge of wireless sensor networks to various application areas.
CO3: Analyse WSN protocols in terms of their energy efficiency and design new energy efficient protocols.

Books and References

1. Networking Wireless Sensors by Bhaskar Krishnamachari, Cambridge University Press.
2. Wireless Sensor Networks-An Information Processing Approach by Feng Zhao and Leonidas Guibas, Morgan Kauffman.
3. Wireless Sensor Networks-Technology, Protocols and Applications by K. Sohraby, D. Minoli and T. Znati, John Wiley & Sons.

Course Name: **Wi-Fi Telephony and VoIP**
Course Code: **EC-708**
Course Type: **Programme Elective-II**

Contact Hours/Week: **4L** Course Credits: **04**

Course Objectives

- To have an accurate overview on Voice over IP QoS evaluation techniques.
- To introduce about new type of applications that can take advantage of internet network.
- To understand the medium access control protocols, and address physical layer issues.

Course Content

Conventional Telephony and Data protocols: The Evolution of the Telephone Network, Digitizing Speech, PSTN Architecture, Signaling in the Local Loop, Signaling in the Network, SS7, Call-Setup, Voice and Wireless Networks, The TCP/IP Transport Layer, Transmission Control Protocol, (TCP), User Datagram Protocol (UDP), Voice over IP: Motivation for VoIP, Challenges in VoIP, Putting Voice Over Internet, VoIP Architectures, Signaling Protocols, Media Gateway Control Protocol, Megaco/H248, H323, Session Initiation Protocol (SIP), Wireless LAN and VoWLAN Challenges: Network Architecture, 802.11 Framing, Accessing the Medium, PHY, VoWLAN, System Capacity and QoS, Packet Sizes, Packetization Overheads, DCF Overheads, Transmission Rate, Inherent Fairness Among All Nodes, PCF, Admission Control, Security, Roaming/Handoffs in 802.11, QoS and Security Issues: 802.11e, WME and “Vanilla” WLANs, Traffic Categories, Voice Data Coexistence, Achieving QoS for VoWLAN, System Capacity, Authentication in 802.1, Open System Authentication, Shared Key Authentication, Authentication and Handoffs, Confidentiality in 802.1, Data Integrity in 802.11, Loopholes in 802.11 Security, WPA, Roaming and Power Management: Types of Roaming, Roaming Issues, Roaming and Voice, Scanning Types, Scanning Strategies, Inter-ESS Roaming, The Need for Power Management, Power-Aware System Design, Implementing Power Management.

Course Outcomes

Upon successful completion of the course, the students will be able to

CO1: Explain the related term used in IP telephony for a set of facilities for managing the delivery of voice information using the Internet Protocol.

CO2: Describe H.323 and other protocols with an architectural overview of the Internet.

CO3: Apply principles and algorithms of security and authentication issues.

CO4: Analyze share key authentication and roaming and power management issues.

Books and References

1. Wi-Fi Telephony Challenges and Solutions for Voice over WLANs by Praphul Chandra and Lide, Elsevier Inc.
2. Internetworking With TCP/IP: Principles, Protocols, and Architecture by Douglas E Comer, PHI Learning.
3. Voice over IP Fundamentals by Jonathan Davidson and James Peters, Cisco Press.

Course Name: **Electromagnetic Interference & Compatibility**
Course Code: **EC-709**
Course Type: **Programme Elective-III**

Contact Hours/Week: **4L** Course Credits: **04**

Course Objectives

- To familiarize with the fundamentals that are essential for electronics industry in the field of EMI / EMC
- To understand EMI sources and its measurements.
- Concept of signal integrity in ICs, conducted emissions and electromagnetic radiation susceptibility, and crosstalk and shielding.
- To understand the various techniques for electromagnetic compatibility.

Course Content

Basic Concepts Introduction and Definition of EMI and EMC with examples, Various Parameters, Sources of EMI, EMI coupling modes - CM and DM, ESD Phenomena and effects, Transient phenomena and suppression, Various issues of EMC, EMC Testing categories. Coupling Mechanism Electromagnetic field sources and Coupling paths, Coupling via the supply network, Common mode coupling, Differential mode coupling, Impedance coupling, Inductive and Capacitive coupling, Radiative coupling, Ground loop coupling, Cable related emissions and coupling. EMI Mitigation Techniques Working principle of Shielding and Murphy's Law, LF Magnetic shielding, Apertures and shielding effectiveness, Choice of Materials for H, E, and free space fields, Gasketting and sealing, PCB Level shielding, Principle of Grounding, Isolated grounds, Grounding strategies for Large systems. Standard and Regulations Need for Standards, Standards for EMI/EMC, National and International EMI Standardizing Organizations: IEC, ANSI, FCC, AS/NZS, CISPR, BSI, CENELEC, and ACEC, Electro Magnetic Emission and susceptibility standards and specifications. Measurement Methods and Instrumentation EMI Shielding effectiveness tests, Open field test, TEM cell for immunity test, Shielded chamber, Shielded anechoic chamber, EMI measuring instruments.

Course Outcomes

Upon successful completion of the course, the students will be able to

CO1: Real-world EMC design constraints and make appropriate tradeoffs to achieve the most cost-effective design that meets all requirements

CO2: Designing electronic systems that function without errors or problems related to electromagnetic compatibility.

CO3: Diagnose and solve basic electromagnetic compatibility problems.

Books and References

1. Introduction to Electromagnetic compatibility by C. R. Paul, Wiley & Sons.
2. Principles of Electromagnetic Compatibility by B. Keiser, Artech House.
3. Field Theory of Guided waves, R. E. Collin by Wiley-IEEE Press.
4. Elements of Electromagnetics by M. N. O. Sadiku, Oxford University Press.

Course Name: **RF and Microwave Circuit Design**
Course Code: **EC-710**
Course Type: **Programme Elective-III**

Contact Hours/Week: **4L** Course Credits: **04**

Course Objectives

- To impart knowledge about the transmission lines theory, network anyalysis, planar Transmission Lines, circuits and their characterization and Ferromagnetic Components.

Course Content

Transmission Lines theory: Waves propagation in transmission line, Parameters, Concepts of propagation constant, Characteristic impedance, Reflection coefficient, Wave velocities and dispersion, Smith chart, Impedance transformers, Generator and load mismatches, Lossy transmission lines. Network analysis: S (scatter), Z, Y, ABCD and other multi-port parameters, Impedance matching and tuning. Planar Transmission Lines, Circuits and Characterization: Microstrip, strip line, Coplanar waveguide and other types of transmission lines, Microstrip discontinuities simple printed couplers, Filters, Power dividers, Directional couplers, Transmission line resonators, Microstrip antennas. Ferromagnetic Components: Basic properties, Plane wave propagation in ferrite, Ferrite isolators, Circulators, Phase shifters.

Course Outcomes

Upon successful completion of the course, the students will be able to

CO1: Apply transmission line theory.
CO2: Describe and utilize different network analysis parameters for solving two or multiport networks.
CO3: Design and chraterize different microwave circuits.
CO4: Design and Analyze Ferromagnetic Components.

Books and References

1. Microwave Engineering by D. M. Pozar, Wiley.
2. Foundations of Microstrip Circuit Design by T. C. Edwards and M. B. Steer, Wiley-IEEE Press.
3. Elements of Electrornagnetics by M. N. O. Sadiku, Oxford University Press, New York.

Course Name: **Advanced Engineering Electromagnetics**
Course Code: **EC-711**
Course Type: **Programme Elective-III**

Contact Hours/Week: **4L** Course Credits: **04**

Course Objectives

- To impart knowledge about the propagation of electromagnetic wave and power carried by it..
- To introduce the fundamental concepts relevant to electromagnetic wave behaiviour at media interface and its polarization.
- To enable the students to understand the electromagnetic wave propagation in different guided media and its nature if media is confind with electric and magnetic boundaries.

Course Content

Electromagnetics: Electrostatic Problems and their solutions, Separation of variables in rectangular, Cylindrical and spherical systems, Green's functions, Maxwell's equations, Electromagnetic Waves, Time domain equivalent and its relevance, Propagation of Waves in different medias like Dielectric interface etc. under normal and oblique incidence plane waves in cylindrical system, Bessel's and Hankel's function, Scattering problems under different conditions, Wave functions in planar, Cylindrical and spherical form. Transmission Lines: Telegrapher's equation, Reflection Coefficient, VSWR, Impedance matching and techniques, Single and double stub matching, Types of transmission lines. Waveguides: Full wave analysis of different types of waveguides including solutions to TE/TM/HE modes, Parallel plate waveguide, Rectangular waveguides, Cylindrical waveguides, Dielectric slab waveguide, Cylindrical dielectric waveguide, Strip line analysis, Microstrip line as resonator structure, Quasi TEM modes in microstrip line, Discontinuities in microstrip line, Boxed microstrip line, Resonant cavities: Rectangular, Cylindrical, Dielectric resonators.

Course Outcomes

Upon successful completion of the course, the students will be able to

CO1: Describe the concept of wireless communication and how radio wave propagates.
CO2: Describe the fundamental concept of PCB circuit design.
CO3: Describe the design of low loss and high power electromagnetic wave guides.
CO4: Design dirrent types of resonator and how to use them for filters and antennas application.

Books and References

1. Time Harmonic Electromagnetic Fields by R. F. Harrington, Wiley-IEEE Press
2. Field Theory of Guided waves by R. E. Collin, Wiley-IEEE Press.
3. Elements of Electromagnetics by M. N. O. Sadiku, Oxford University Press.
4. Bluetooth Electromagnetism: Theory and Applications by Ashutosh and Pramanik, Prentice Hall India Learning Private Limited.

Course Name: **RF and Microwave Active Circuits**
Course Code: **EC-712**
Course Type: **Programme Elective-III**

Contact Hours/Week: **4L** Course Credits: **04**

Course Objectives

- Explain the design considerations for RF active circuits.
- Model and analyze the characteristics of low noise amplifier.
- Analysis of characteristics of different RF diode.
- Analysis of different types of RF mixers.
- Design and analysis of different types of microwave oscillator.

Course Content

Two port power gains, Stability criterion, Low noise amplifier design for maximum gain, Constant gain and specific gain, Input and output matching networks using lumped element and distributed elements, Large signal scattering parameters, Design of power amplifier, Tunnel and backward diodes, GaAsgunn effect diodes, Read diode, TRAPATT diode, Schottky barrier diodes, PIN diode, Introduction of microwave mixers, Mixer characterization, Single ended mixer, Balanced mixer, Image rejection mixer, Double balanced mixer and FET mixer, General classification, Microwave transistor oscillators, Dielectric resonator oscillators and voltage controlled oscillators.

Course Outcomes

Upon successful completion of the course, the students will be able to

CO1: Explain the performance requirements of RF active circuits.
CO2: Design and explain RF amplifier.
CO3: Explain the difference between different RF diode with its particular applications.
CO4: Understand different mixer circuits and can design for a given specifications.
CO5: Design and explain different microwave oscillator for a given specifications.

Books and References

1. Microwave Engineering by D. M. Pozar, Wiley, India.
2. Microwave Transistor Amplifiers by G. Gonzalez, Prentice-Hall.
3. Microwave Engineering by S. Das, Oxford University Press.
4. Microwave Active Circuit Analysis and Design by C. Poole and I. Darwazeh, Elsevier.
5. Fundamentals of RF and Microwave Transistor Amplifiers by I. J. Bahl, John Wiley & Sons.

Course Name: **Computational Electromagnetics**
Course Code: **EC-713**
Course Type: **Programme Elective-III**

Contact Hours/Week: **4L** Course Credits: **04**

Course Objectives

- Students will acquire the basic understanding different numerical methods, and integral equation solvers used for numerical characterization of electromagnetic fields and waves. They will learn how to implement these methods in 1D, 2D and 3D cases.

Course Content

Review of electromagnetic theory, introduction to computational electromagnetics, different approximations based on one-dimensional wave equation, numerical dispersion & group delay. Introduction to Maxwell's equations and Yee algorithm: Stability of explicit solution, implicit formulation and stability, Maxwell's equations in 1D, 2D, and 3D, Yee algorithm, numerical dispersion, numerical stability. Source excitation: Total-Field/Scattered-Field formulation, Waveguide source excitations. Boundary conditions, analytical absorbing boundary conditions, Perfectly matched layer media, Near field to Far field transformations. modeling: lumped elements modeling, modeling of antennas, electromagnetic crystals and metamaterials, micro-cavity resonators.

Course Outcomes

Upon successful completion of the course, the students will be able to

CO1: Identify conventional and state-of-the-art computational electromagnetic techniques for modeling wireless communication devices, high speed electronic circuits, millimeter-wave ICs and antenna populations.

CO2: Apply electromagnetic wave theories and tools for the applications of wave propagation, radiation, scattering, and in particular, wireless communications.

CO3: Understand systematical numerical techniques and software packages for solving generalized practical electromagnetic problems.

Books and References

1. Computational Electromagnetics: The Finite-Difference Time-Domain by A. Taflove and S. C. Hagness, Artech House.
2. Electromagnetic Simulation Using The FDTD Method by D. M. Sullivan, Wiley IEEE Press.
3. Numerical Electromagnetics: The FDTD Method by U. S. Inan and R. A. Marshall, Cambridge University Press.

Course Name: **Digital Image Processing and Pattern recognition**
Course Code: **EC-714**
Course Type: **Programme Elective-IV**

Contact Hours/Week: **4L** Course Credits: **04**

Course Objectives

- To understand the basics of image formation and filtering in spatial and frequency domain.
- To understand the concepts of image compression, image segmentation and morphological operation on image.
- To understand the pattern recognition and Neural Network for pattern classification.

Course Content

Introduction: Steps in Digital Image Processing, Components of an Image Processing system, Applications. Human Eye and Image Formation; Sampling and Quantization, Basic Relationship among pixels- neighbour, connectivity, regions, boundaries, distance measures; Image Enhancement: Spatial Domain, Gray Level transformations, Histogram, Arithmetic/Logical Operations, Spatial filtering, Smoothing & Sharpening Spatial Filters; Frequency Domain- 2-D Fourier transform, Smoothing and Sharpening Frequency Domain Filtering; Convolution and Correlation Theorems; Image Restoration: Inverse filtering, Wiener filtering; Wavelets- Discrete and Continuous Wavelet Transform, Wavelet Transform in 2-D; Image Compression: Redundancies- Coding, Interpixel, Psycho visual; Fidelity, Source and Channel Encoding, Elements of Information Theory; Loss Less and Lossy Compression; Run length coding, Differential encoding, DCT, Vector quantization, entropy coding, LZW coding; Image Compression Standards-JPEG, JPEG 2000, MPEG; Video compression; Image Segmentation: Discontinuities, Edge Linking and boundary detection, Thresholding, Region Based Segmentation, Watersheds; Introduction to morphological operations; binary morphology- erosion, dilation, opening and closing operations, applications; basic gray-scale morphology operations; Feature extraction; Classification; Object recognition; Pattern Recognition: Introduction to pattern recognition, Pattern Recognition Methods, Pattern Recognition System Design, Statistical Pattern recognition – Classification, Principle, Classifier learning, Neural networks for pattern classification. The Wavelet Transform, Discrete-time orthogonal wavelets, continuous time orthogonal wavelet basis.

Course Outcomes

Upon successful completion of the course, the students will be able to

CO1: Understand the basic image formation model and application of image processing.
CO2: Enhancement of image in spatial and frequency domain.
CO3: Understand the Image Restoration using wavelet.
CO4: Analyse the different image compression techniques.
CO5: Understand the image segmentation and pattern recognition.

Books and References

1. Fundamentals of Digital Image processing by A. K. Jain, Pearson Education.
2. Digital Image Processing by R. C. Gonzalez and R. E. Woods, Pearson Education.
3. Digital Image Processing using MATLAB by R. C. Gonzalez , R. E. Woods and S. L Eddins, Pearson Education.
4. Digital Image Processing and Analysis by Chanda and Mazumdar, PHI.
5. Multirate Digital Signal Processing by N.J. Fliege, John Wiley and Sons.

Course Name: **Adaptive Signal Processing**
Course Code: **EC-715**
Course Type: **Programme Elective-IV**

Contact Hours/Week: **4L** Course Credits: **04**

Course Objectives

- To introduce signal processing techniques for adaptive systems.
- To understand the applications of adaptive systems in the fields of communications, radar, sonar, seismology, navigation systems and biomedical engineering.
- To study the basic principles of adaptation, various adaptive signal processing algorithms for applications like adaptive noise cancellation, interference canceling, system identification, etc.

Course Content

Linear Optimum Filtering and Adaptive Filtering, Linear Filter Structures, Adaptive Equalization, Noise Cancellation and Beam Forming. Optimum Linear Combiner and Wiener-Hopf Equations, Orthogonality Principle, Minimum Mean Square Error and Error Performance Surface, Steepest – Descent Algorithm and its Stability. LMS Algorithm and its Applications, Learning Characteristics and Convergence Behaviour, Mis-Adjustment, Normalized LMS and Affine Projection Adaptive Filters, Frequency Domain Block LMS Algorithm. Least Squares Estimation Problem and Normal Equations, Projection Operator, Exponentially Weighted RLS Algorithm, Convergence Properties of RLS Algorithm, Kalman Filter as the Basis for RLS Filter, Square-Root Adaptive Filtering and QR- RLS Algorithm, Systolic-Array Implementation of QR – RLS Algorithm. Forward and Backward Linear Prediction, Levinson-Durbin Algorithm, Lattice Predictors, Gradient-Adaptive Lattice Filtering, Least-Squares Lattice Predictor, QR-Decomposition Based Least-Squares Lattice Filters.

Course Outcomes

Upon successful completion of the course, the students will be able to

CO1: Comprehend design criteria and modeling of adaptive systems and theoretical performance evaluation.
CO2: Design a linear adaptive processor.
CO3: Apply mathematical models for error performance and stability.
CO4: Comprehend the estimation theory for linear systems and modeling algorithms.

Books and References

1. Adaptive Filter Theory by Haykin, S., Pearson Education.
2. Adaptive Signal Processing by Widrow, B. and Stearns, S.D., Pearson Education.
3. Statistical and Adaptive Signal Processing by Manolakis, D.G., Ingle, V.K. and Kogon, M.S., Artech House.
4. Statistical Signal Processing: Detection, Estimation, and Time Series Analysis by Scharf, L.L., Pearson.

Course Name: **Signal Detection and Estimation Theory**
Course Code: **EC-716**
Course Type: **Programme Elective-IV**

Contact Hours/Week: **4L** Course Credits: **04**

Course Objectives

- To enable the students to acquire the fundamental concepts of Signal Detection and Estimation.
- To get familiarize with different hypotheses in detection and estimation problems.
- To introduce the methods of detection and estimation of signals in white and non-white Gaussian noise.
- To familiarize with the detection of random signals.

Course Content

Introduction: Review of Gaussian Variables and Processes; Problem Formulation and Objective of Signal Detection and Signal Parameter Estimation in Discrete-Time Domain. Statistical Decision Theory: Bayesian, Min-Max, and Neyman-Pearson Decision Rules, Likelihood Ratio, Receiver Operating Characteristics, Composite Hypothesis Testing, Locally Optimum Tests, Detector Comparison Techniques, Asymptotic Relative Efficiency. Detection of Deterministic Signals: Matched Filter Detector and its Performance; Generalized Matched Filter; Detection of Sinusoid with Unknown Amplitude, Phase, Frequency and Arrival Time, Linear Model. Detection of Random Signals: Estimator-Correlator, Linear Model, General Gaussian Detection, Detection of Gaussian Random Signal with Unknown Parameters, Weak Signal Detection. Estimation of Signal Parameters :Minimum Variance Unbiased Estimation, Fisher Information Matrix, Cramer-Rao Bound, Sufficient Statistics, Minimum Statistics, Complete Statistics; Linear Models; Best Linear Unbiased Estimation; Maximum Likelihood Estimation, Invariance Principle; Estimation Efficiency; Bayesian Estimation: Philosophy, Nuisance Parameters, Risk Functions, Minimum Mean Square Error Estimation, Maximum Aposteriori Estimation.

Course Outcomes

Upon successful completion of the course, the students will be able to

CO1: Understand the basic concepts of signal detection and estimation
CO2: Understand the different hypotheses in detection and estimation problems
CO3: Understand the conceptual basics of detection and estimation of signals in white and non-white Gaussian noise
CO4: Understand the detection of random signals
CO5: Understand the time varying waveform detection and its estimation.

Books and References

1. Detection, Estimation and Modulation Theory: Part I, II, and III by H. L. Van Trees, John Wiley, NY.
2. An Introduction to Signal Detection and Estimation by H. V. Poor, Springer.
3. Fundamentals of Statistical Signal Processing: Estimation Theory by S. M. Kay, Prentice Hall PTR.
4. Fundamentals of Statistical Signal Processing: Detection Theory by S. M. Kay, Prentice Hall PTR.

Course Name: **Multi-rate Signal Processing**
Course Code: **EC-717**
Course Type: **Programme Elective-IV**

Contact Hours/Week: 4**L** Course Credits: **04**

Course Objectives

- To provide an in-depth treatment of both the theoretical and practical aspects of multirate signal processing.
- To provide the fundamentals of multirate, Sample rate conversion and efficient implementations using polyphase filters
- The filter bank theory and implementation, including quadrature mirror, conjugate quadrature, and cosine modulated filter banks along with their relationship to wavelet transform area also covered in this course.

Course Content

Fundamentals of Multirate systems: Introduction, Basic multirate operations, interconnection of building blocks, The polyphase representation, multistage implementation, some applications of multirate systems, special filters and filters banks. Maximally decimated filter bank: Introduction, Errors created in the QMF bank, A simple alias free QMF system, M-Channel filter bank, polyphase representation, perfect reconstruction systems, tree structure filter banks. Paraunitary Perfect Reconstruction Filter banks: Lossless Transfer matrices, filter banks properties induced by paraunitariness, Two channel FIR Paraunitary QMF banks, M –channel FIR paraunitary Filter bank. Cosine Modulated Filter Banks: The pseudo QMF bank, Design of the Pseudo QMF bank, Efficient polyphase structures, deeper properties of cosine matrices, Cosine modulated perfect reconstruction systems. Wavelet Transform and Its Relation to Multirate Filter Banks:Introduction, Short Fourier transform, The wavelet transform, Discrete-time orthogonal wavelets, continuous time orthogonal wavelet basis.

Course Outcomes

Upon successful completion of the course, the students will be able to

CO1: Understand the basic multirate operations.
CO2: Analyse the type M-channel filter bank.
CO3: Understand the perfect reconstruction filter bank.
CO4: Understand the cosine modulated filter banks.
CO5: Analyse the wavelet and its ralation to filter banks.

Books and References

1. Multirate Systems and Filter Banks by P. P .Vaidynathan, Pearson Education Inc.
2. Wavelets and filter banks by D. Strang and T. Nguyen, Wellesley-Cambridge Press.
3. Digital Signal Processing: Principles, Algorithms and Applications by J. G. Proakis and D. G. Manolakis, Pearson Education.
4. Multirate Digital Signal Processing by N.J. Fliege, John Wiley and Sons.