M. TECH

IN

ELECTRONICS & TELECOMMINICATION ENGINEERING

SYLLABUS

2019

SCHOOL OF ELECTRONICS ENGINEERING

KIIT DEEMED TO BE UNIVERSITY, BHUANESWAR

Specialization in
COMMUNICATION SYSTEM ENGINEERING

		1st semester				
Sr. No.	Subject Code	Subject	Teaching Hours			Credit
		Theory	L	T	P	
1	RS6001	Fundamentals of Research Methodology (University common subject)	3	0	0	3
2	EC6101	Advanced Digital Communication Techniques	3	1	0	4
3	EC6109	Wireless & Cellular Communication	3	1	0	4
4	EC6309	RF & Antenna Engineering	3	1	0	4
5		Dept. Elective-I	3	0	0	3
		Total Theory			**18**	**18**
		Practical				
7	EC6193	Advanced Communication Engineering lab	0	0	2	1
8	EC6391	Advanced Microwave Engineering Laboratory	0	0	2	1
		Total Practical			**4**	**2**
		Sessional				
		Total Semester Credit				**20**

		2nd Semester				
Sr. No.	Subject Code	Subject	Teaching Hours			Credit
		Theory	L	T	P	
1	EC6103	Information theory & Coding Techniques	3	0	0	3
2	EC6106	Advanced Digital Signal Processing	3	1	0	4
3	EC6320	Optimization Techniques in Engineering and its Application	3	0	0	3
4		Dept. Elective-II	3	0	0	3
5		Dept. Elective-III	3	0	0	3
		Total Theory			16	**16**
		Practical				
7	EC6192	Advanced Design Simulation Lab	0	0	2	1
		Total Practical			3	**1**
		Sessional				
8	EC6182	Seminar			2	1
9	EC6184	Comprehensive Viva-Voce		-		2

		Semester Total	**21**	**20**

		3rd Semester		
1	EC6187	Thesis Part-I	-	14
		Total		14

4th Semester

2	EC6188	Thesis Part-II	-	16
		Total M. Tech. credit		**70**

Dept. level Common Subject across all Specialization				
	EC6320	Optimization Techniques in Engineering and its Application		3
		Elective - I		
	EC6119	Optical Communication & Networks		3
	EC6121	Cognitive Radio & Co-operative communication		3
	EC6115	Biomedical Signal Analysis		3
	EC6117	RF Planning & Design		3
		Elective-II		
	EC6130	Digital Image & Video Processing		3
	EC6122	Satellite Communication systems		3
	EC6138	Statistical Signal Processing		3
	EC6128	Wireless Sensor Network		3
		Elective-III		
	EC6114	Spread Spectrum Techniques & Multiple Access		3
	EC6116	Machine learning & Artificial Intelligence		3
	EC6118	Voice and data networks		3
	EC6120	Nano Photonics		3

Specialization in
VLSI DESIGN AND EMBEDDED SYSTEMS

		1st semester				
Sr. No.	Subject Code	Subject	**Teaching Hours**			**Credit**
		Theory	L	T	P	
1	RS6001	Fundamentals of Research Methodology (University Common Subject)	3	0	3	3
2	EC6209	Digital VLSI Circuits & Systems	3	0	3	3
3	EC6217	Digital System Design and its Application	3	0	3	3
4	EC6203	MOS Device Modeling	3	0	3	3
5	EC6207	Analog CMOS VLSI Circuits	3	0	3	3
6		Dept. Elective-I	3	0	3	3
		Total Theory			18	18
		Practical				
7	EC6291	VLSI Design Lab-I	0	0	3	1.5
8	EC6293	Digital System Design Lab	0	0	3	1.5
		Total Practical			**6**	**3**
		Total Semester Credit				**21**

		2nd Semester				
Sr. No.	Subject Code	Subject	**Teaching Hours**			**Credit**
		Theory	L	T	P	
1	EC6320	Optimization Techniques in Engineering and its Application (Department Level Common Subject)	3	0	3	3
2	EC6202	Embedded System Design	3	0	3	3
3		Dept. Elective-II	3	0	3	3
4		Dept. Elective-III	3	0	3	3
5	EC6204	Testing of VLSI Circuit	3	0	3	3
		Total Theory	15		15	15
		Practical				
7	EC6292	VLSI Design Lab-II	0	0	3	1.5
8	EC6294	Embedded System Design Lab	0	0	3	1.5
		Total Practical			6	3
		Sessional				
9	EC6282	Seminar			2	1
10	EC6284	Comprehensive Viva-Voce		-		2
		Semester Total			**24**	**21**

		3rd Semester		
	EC6287	Thesis Part-I	-	14
		Total		14

4th Semester

	EC7288	Thesis Part-II	-	16
		Total M. Tech. credit		**72**
Electives for Specialization in VLSI Design and Embedded Systems				
		Elective - I		
	EC6211	VLSI Technology		3
	EC6213	Architectural Design of IC		3
	EC6219	ASIC and SoC Design		3
		Elective-II		
	EC6224	Low Power VLSI Design		3
	EC6234	RF IC Design		3
	EC6246	Memory Design		3
		Elective-III		
	EC6222	Mixed Signal IC Design		3
	EC6236	Mems Design		3
	EC6248	VLSI Signal Processing		3

Specialization in
RF and MICROWAVE ENGINEERING

		1st semester				
Sr. No.	Subject Code	Subject	**Teaching Hours**			**Credit**
		Theory	L	T	P	
1	RS6001	Fundamentals of Research Methodology (University Common Subject)	3	0	0	3
2	EC6319	Advanced Electromagnetics	3	0	0	3
3	EC6307	Microwave Devices	3	0	0	3
4	EC6309	RF & Antenna Engineering	3	1	0	4
5		Dept. Elective-I	3	0	0	3
		Total Theory			**17**	**16**
		Practical				
6	EC6391	Advanced Microwave Engineering Laboratory	0	0	2	1
		Total Practical			**2**	**1**
		Sessional				
		Total Semester Credit				**17**

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		2nd Semester				
Sr. No.	Subject Code	Subject	**Teaching Hours**			**Credit**
		Theory	L	T	P	
1	EC6320	Optimization Techniques in Engineering and its Application (Department Level Common Subject)	3	0	0	3
2	EC6302	RF Circuit Design	3	1	0	4
3	EC6316	Microwave Integrated Circuits	3	0	0	3
4	EC6322	Planar and Small Antennas	3	0	0	3
5		Dept. Elective-II	3	0	0	3
6		Dept. Elective-III	3	0	0	3
		Total Theory			19	19
		Practical				
7	EC6392	Microwave Design and Simulation Laboratory	0	0	2	1
		Total Practical			2	**1**
		Sessional				
8	EC6382	Seminar			2	1
9	EC6384	Comprehensive Viva-Voce				2
		Total Semester Credit				**23**

		3rd Semester		
1	EC6387	Thesis Part-I		14
		Total Semester Credit		14

		4th Semester		
1	EC6388	Thesis Part-II		16
		Total Semester Credit		16
		Total M. Tech. credit		**70**

Dept. level Common Subject across all Specialization		
EC6320	Optimization Techniques in Engineering and its Application	3

Elective-I

Sl. No	Subject Code	Subject Name	Credit
1.	EC6315	Computational Electromagnetics	3
2.	EC6311	Microwave Remote Sensing	3
3.	EC6113	Artificial Neural Network and Fuzzy Systems	3
4.	EC6108	Optical Communication & Networks	3

Elective-II

Sl. No	Subject Code	Subject Name	Credit
1.	EC6312	Electromagnetic Interference and Electromagnetic Compatibility	3
2.	EC6122	Satellite Communication Systems	3
3.	EC6128	Wireless Sensor Network	3
4.	EC6318	RF Micro-Electromechanical Systems	3

Elective-III

Sl. No	Subject Code	Subject Name	Credit
1.	EC6314	RADAR and Navigation Engineering	3
2.	EC6324	Adaptive Antennas and Smart Antennas	3
3.	EC6326	Millimetre Wave Communication Systems	3
4.	EC6114	Spread Spectrum Techniques and Multiple Access	3

Detailed Syllabus

Common Course for all M. Tech Programs (University Common Subject)

RS 6001 FUNDAMENTALS OF RESEARCH METHODOLOGY Cr-3

Course Outcome: At the end of the course, students will be able to:

CO1. conduct review of literature effectively
CO2. formulate a viable research problem
CO3. effectively write a technical paper based on research findings
CO4. analyze and interpret research data
CO5. develop awareness on IPR and allied issues
CO6. follow ethical practices in research

Module 1:

Introduction: Types of research, Literature review, Research gap, Motivation, Research objectives and specifications, Formulation of research questions, Research approach, Research hypothesis.

Module 2:

Research Writing: Methodology to write a technical paper/short communication/research proposal/monograph, Abstract writing, Report or presentation of results, Bibliography.

Module 3:

Data Analysis: Classification of data, Methods of data collection, Statistical techniques, Design of experiments and choosing an appropriate statistical technique, Introduction to mathematical modeling (regression, model fitting), Hypothesis testing, Statistical inference.

Module 4:

Intellectual Property: Intellectual property, Patent, Trademark, GI, Copyright and related rights, Research Incentives, PCT and WIPO.

Plagiarism: Definition, Plagiarism and consequences, IPR Violation and Detection.

Module 5:

Research Ethics: Professional ethics in research, Ethical issues, Definition and importance, Ethical guidelines, Peer review, Research misconduct, Conflicts of interest.

Reference Books:

1. C. R. Kothari, Research Methodology, New Age International, 2004.
2. Panneerselvam, Research Methodology, Prentice Hall of India, New Delhi, 2012.
3. J. W. Bames, Statistical Analysis for Engineers and Scientists, Tata McGraw-Hill, New York.
4. Donald Cooper, Business Research Methods, Tata McGraw-Hill, New Delhi.
5. Leedy P. D., Practical Research: Planning and Design, McMillan Publishing Co.
6. Day R. A., How to Write and Publish a Scientific Paper, Cambridge University Press, 1989.
7. Manna, Chakraborti, Values and Ethics in Business Profession, Prentice Hall of India, New Delhi, 2012.
8. R. Subramanian, Professional Ethics, Oxford University Press, 2013.

Specialization in Communication System Engineering

EC6101 Advanced Digital Communication Techniques Cr-4

Couse outcomes: After completion of the course the students will be able to

CO1. Analyze random processes for the design of digital communication systems.
CO2. Differentiate between different digital modulation schemes.
CO3. Study to design an optimum receiver for AWGN channels.
CO4. Determination of carrier with Symbol Synchronization.
CO5. Analyze different types of adaptive equalization methods and related issues.
CO6. Study of Signal Detection and Estimation.

Prerequisite: Digital Communication

Digital Modulation Schemes: Memory-less modulation method, QAM signalling with memory, Continuous-Phase Frequency Shift Keying (CPFSK), Continuous-Phase Modulation (CPM), Power Spectral Density (PSD): digital signal with memory, linearly modulated signal with finite mean; PSD of CFPSK and CPM signals. (10)

Principles of Detection Theory: Binary and m-ary hypothesis testing. Multi-hypothesis testing; sufficient statistics; Baye's likelihood ratio test. (5)
Optimum Receiver for AWGN Channels: Correlation Receiver, Matched filter receiver, optimal detection, error probability for band limited signal, optimal detection, detection of signalling schemes with memory performance analysis for wire-line and radio communication. (8)

Synchronization: Carrier phase estimation (maximum likelihood, phase lock looped, decision-directed loop), symbol time estimation (maximum likelihood, non-decision-directed timing estimation), joint estimation of carrier phase and symbol timing. (7)

Digital Communication through Band-Limited Channels: Band-limited channel; characterization, optimal receiver for band-limited channels with ISI and AWGN. (7)

Linear equalization Adaptive Equalization: Equalization (peak distortion criteria, Mean Square Error (MSE) criteria), decision feedback equalizer, zero forcing, LMS, adaptive decision feedback, recursive least square (Kalman), blind equalization. (11)

Books

1. John G. Proakis and Masoud Salehi: Digital Communication, 5th Edition, McGraw hill International, 2008
2. Amos Lapidoth, A Foundation in Digital Communications, Cambridge University Press, 2009

Reference Books:

1. Carlson A. and Paul Crilly, Communication Systems, 5th Edition. McGraw hill International, 2009.
2. Simon Haykin, Digital Communications, John Wiley & Sons, 2000

EC6109 Wireless & Cellular Communication Cr-4

Couse outcomes: After completion of the course the students will be able to

CO1: Comprehend the significance of terminology associated with cellular architecture and determine the performance parameters of cell splitting, sectoring, and microcell zone techniques.
CO2: Solve problems associated with basic propagation models like two ray reflection model, Knife edge propagation model etc and able to analyze signal degradation in wireless out door propagation models.
CO3: Comprehend and analyze the concepts of channel equalization and various diversity techniques.
CO4: Comprehend and analyze the concepts of Spread Spectrum and its applications.
CO5: Comprehend and analyze the concepts of MC-CDMA and OFDMA modulation and concept MIMO antenna System.
CO6: Comprehend and analyze the concepts of Ultra-wideband Communication, various wireless standards and various research trends in wireless and cellular communication.

Prerequisites: Analog Communication Techniques, Digital Communication Techniques, Communication engineering

Overview of Cellular Concept

Introduction to cellular system, Cellular System Architecture, Frequency Reuse, Channel Assignment Strategies, Types of Interference , System Capacity, Near – Far Problem, Hand off, System capacity Improvement Techniques , Tele-traffic Theory. (8 hours)

RF Propagation & Multi-path Model

Free space propagation model, propagation mechanism, Large Scale fading, Diffraction & Scattering by high – raise structures, shadowing and path loss, Small Scale Fading, Doppler and time-delay spread, coherence Bandwidth and coherence-Time, Types of Small – Scale Fading.(8 hours)

Equalization and Diversity Techniques:

Fundamentals of Equalization, Adaptive equalizer, Concept of diversity, Types of diversity (space, time, frequency, polarization, Rake receiver (6 hours)

Spread Spectrum modulation and CDMA:

Spread Spectrum Modulation and principle, PN sequence and its properties. Direct sequence SS and frequency – hopped SS (DS – SS and FH – SS), TH – SS, Spread Spectrum for CDMA, Walsh codes, Variable Tree OVSF.(6 hours)

OFDM and Multicarrier Modulation:

Introduction to OFDM ,Multicarrier modulation and cyclic Prefix, Channel model and SNR performance, OFDM issues-PAPR, Frequency and Timing Offset issues(4 hours)

Multiple Antennas and space time communications:

Concept of Multi input multi output Antenna system, Narrow band MIMO model. MIMO channel capacity, MIMO Diversity gain, Space time Modulation & Coding, MIMO-OFDM.(4hours)

UWB (Ultra wide Band) communication:

UWB Definition and features, UWB Wireless Channels, UWB Data Modulation, Uniform Pulse Train, BER performance of UWB.(4 hours)

Wireless Standards and Current research domain in wireless and mobile communication:

GSM, GPRS, WCDMA, Wimax, LTE support technologies, Cognitive radio, mobility management, Wireless sensor networks.(8 hours)

Text books:

1. Wireless Communication – T.S.Rappaport – Pearson Education
2. Wireless Communication – Andrea Goldsmith – Cambridge Press

Referece books:

1. Wireless and Cellular Communication – C. Y. Lee – McGraw Hill
2. Mobile Communication – Schillar – Pearson Education
3. Communication System – Simon Haykin – John Willey

EC6309 RF and Antenna Engineering Cr -4

Couse outcomes: After completion of the course the students will be able to

CO1: Memorize and learn microwave vacuum tubes and principle of microwave components.
CO2: Understand antenna basics and operation commonly used antennas.
CO3: Solve the design problems of broadband antennas.
CO4: Analyze and synthesize antenna arrays.
CO5: Judge the design principle of reflector antenna and microstrip antenna.
CO6: Investigate the antenna techniques for cellular communication.

Prerequisite: Electromagnetic Theory

Microwave Tubes: Limitations of conventional vacuum tubes, Reentrant cavities, Klystron amplifier (velocity modulation, bunching process, power output, efficiency), Slow wave structure, helix TWT.
Microwave Components: Scattering matrix formulation of microwave network, Tees, waveguide directional couplers (two-hole and Bathe-hole), rat-race ring, precision variable attenuator, coaxial attenuator, microwave phase shifters, waveguide slotted section, circulator, isolator, crystal detector.

Antenna Basics: Radiation mechanism, far field & near field, radiation pattern, E-plane & H-plane, radiation resistance, efficiency, effective aperture area, directivity, gain, beamwidth, bandwidth, linear & elliptic polarizations, cross polarization, antenna factor, antenna-noise temperature, equivalence theorem, Friis transmission formula.

Antennas: Dipole & monopole antennas, sleeve antenna. Waveguide antenna, pyramidal and conical horns, sectoral horns, Helical antenna and dielectric resonator antenna, Discone antenna, turnstile antenna, plasma antenna, Vivaldi antenna, electrically small antennas and their fundamental limits.

Broadband and Frequency-independent Antennas: Rumsay's principle, planar log-spiral antenna, log-periodic antenna, Yagi-Uda array.

Antenna Arrays: Uniform n-element linear array, grating lobes, planar antenna array, phased array antenna, adaptive antennas, Dolph-Tchebyscheff array, basic concept of thinned array antennas and methods of array thinning.

Reflector Antennas: Corner reflectors, parabolic reflector, losses in parabolic reflector, tilted and offset-fed parabolic reflector, Cassegrain antenna.

Microstrip Antennas: Advantages and disadvantages of microstrip patch antennas, radiation from microstrip antenna, field configurations, design equations for rectangular and circular microstrip patches. Analysis of microstrip antennas using transmission line model and cavity method, Stacked, proximity-coupled and aperture-coupled microstrip antennas, ceramic antenna, PIFA.

Special Antenna Techniques for Wireless Communications: Antenna Diversity Techniques, base station and mobile station antennas, Sector Antennas, Smart Antennas, MIMO antennas, SDMA Antennas, concept of UWB antennas.

Text Books:

1. Antennas for All Applications-J. D. Kraus & R. J. Marhefka, Tata McGraw Hill, 3rd Ed., 2007.
2. Antenna Theory – Analysis and Design-C. A. Balanis, Harper & Row, 3rd Ed., 2005.

Reference Books:

1. Antennas and Radio Wave Propagation-R. E. Collin, McGraw Hill, 1st Ed., 1985.

EC–6103 INFORMATION THEORY AND CODING TECHNIQUES Cr - 4

Couse outcomes: After completion of the course the students will be able to

CO1: Understand the different sources of information and formulate their corresponding mathematical expression.
CO2: Develop the problem solving skills on source coding techniques.
CO3: Analyse the different channel coding schemes and evaluate the different coding channels performance.
CO4: Compare and evaluate various error detecting codes.
CO5: Analyse and evaluate various error correcting codes.
CO6: Design and implement of various coding techniques and application in real time communication system.

Prerequisite: - Digital Communication Techniques.

Information & Entropy: Introduction to information theory, self information, mutual information, conditional self information, average mutual information. Entropy & information, conditional entropy, properties of binary entropy function.
Source Coding: Analog source, Digital sources, Discrete Memoryless Sources. Noiseless coding, entropy coding, instantaneous codes, code efficiency & redundancy, information rate, source coding theorem, VLC, FLC, prefix codes, Kraft inequality, Shannon-Fano algorithm, Huffman coding algorithm, Lempel-Ziv algorithm, Run length encoding, Shannon's first and second fundamental theorems, extension of zero-memory sources, Markov sources and extension of Markov sources.

Channel Capacity & Coding: Discrete Memoryless channel, hard decision decoding and soft decision decoding, discrete channel with discrete noise, channel capacity and channel efficiency, channel matrix, binary symmetric channel (BSC), binary erase channel (BEC), lossless channel, deterministic channel, noiseless channel. Channel coding theorem, critical rate, information capacity theorem (channel capacity theorem), the Shannon limit.

Channel Coding (Error Control Coding)-I: Introduction to error correcting codes, definitions of word, codeword, code, weight, distance, Galois field, vectors, matrices, generator matrix. FEC & ARQ. Linear code and linear block code, theorems of linear block code, code rate, matrix description of linear block codes, parity check matrix, systematic code, decoding of linear block codes, a standard array, syndrome decoding, error probability after coding. Hadamard codes and Hamming codes, optimal linear codes, maximum distance separable codes, Hamming bound and perfect code, binary Golay code.

Channel Coding (Error Control Coding)-II: Binary cyclic codes, method of generating cyclic codes, burst error correction, Fire codes, circuit implementation of cyclic codes, cyclic redundancy check (CRC) codes, Meggitt decoder. Primitive element & minimal polynomial, Bose-Chaudhuri-Hocquenghem (BCH) codes, generator polynomial for BCH code, examples of BCH codes, Reed-Solomon codes, nested codes. Convolutional codes, tree codes & trellis codes, polynomial description of convolutional codes, Viterbi decoding of convolutional codes.

Text Books:

1. Information Theory, Coding and Cryptography – R. Bose, 2nd Edition, Tata McGraw Hill.
2. Elements of Information Theory - T. M. Cover & J. A. Thomas, 2nd edition, Wiley & Sons

Reference Books:

1. Digital Communication – J. G. Proakis, 4th Edition, Tata McGraw Hill
2. Principles of Digital Communication – J. Das, S. K. Mullick& P. K. Chatterjee

EC-6106 ADVANCED DIGITAL SIGNAL PROCESSING Cr-4

Couse outcomes: After completion of the course the students will be able to

CO1	Design digital FIR and IIR filters
CO2	Analyze and design different multirate systems
CO3	Differentiate between different transformations to analyze non-stationary signals
CO4	Analyze wavelet transforms and apply it for signal decomposition
CO5	Design of adaptive filters for different applications
CO6	Differentiate between parametric and non-parametric spectrum estimation techniques

Introduction:

Fundamentals Frequency domain analysis and Fourier Transform, Basic Filters, Ideal Filer Characteristics, Characteristics of Practical Frequency selective Filters, Fundamentals of FIR and IIR Filters , Structural Realization of FIR & IIR Filters.

Multirate Digital Signal Processing
Review of sampling theory, Sampling rate conversion, Polyphase implementation of FIR filters for rate conversion, Multistage implementations, Applications of Multirate Signal Processing, Digital Filter Banks, Subband Coding Basics, Subband Decomposition and Two-Channel Perfect Reconstruction Quadrature Mirror Filter Bank, M-Channel Quadrature Mirror Filter Bank.

Wavelet and Short Time Fourier Analysis
Fourier Transform : Its power and Limitations , Short Time Fourier Transform, The Gabor Transform, Continuous Wavelet Transform, Wavelet Transform Ideal Case-Perfect Reconstruction Filter Banks and wavelets, multi-resolution decomposition, Haar Wavelet.

Adaptive Filtering
Wiener filtering. Optimum linear prediction. Levinson- Durbin algorithm. Prediction error filters. Adaptive filters. FIR adaptive LMS algorithm. Convergence of adaptive algorithms. Fast algorithms. Applications; Noise canceller, echo canceller and equalizer. Recursive least – squares algorithms. Matrix inversion lemma. Convergence analysis of the RLS algorithm. Kalman filtering.

Spectral Estimation
Review of the theory of random processes , Spectrum estimation. Estimation of autocorrelation. Periodogram method. Nonparametric methods. Parametric methods.

Text Books

3. Digital Signal Processing – J. G. Proakis & D. G. Manolakes, 4^{th} edition – PHI
4. A Wavelet Tour of Signal Processing the Sparse Way, Stephane Mallat, , Elsevier, 2009

Reference Books

1. Multirate Systems and Filter Banks, P. P. Vaidyanathan, Prentice-Hall, 1993.
2. Wavelets and Signal Processing, Hans-Georg Stark, Springer, 2005
3. Statistical Digital Signal Processing and Modeling, M. Hayes, Wiley, 1996.
5. Statistical and Adaptive Signal Processing, D.G.Manolakis V. K. Ingle, and S. M. Kogon, McGraw-Hill,2005

EC6320 Optimization Techniques in Engineering and its Application Cr-3

Couse outcomes: After completion of the course the students will be able to

CO1	Describe clearly an engineering problem, identify its parts and formulate the optimal problem.
CO2	Frame fitness functions and cost functions for engineering optimization problems and specify the constraints as required.
CO3	Implement different single variable optimization algorithms including the gradient based methods.

CO4 Apply and implement fuzzy logic and fuzzy inference schemes to engineering and real world problems.

CO5 Implement Bio-inspired optimization algorithms for solving complex engineering problems.

CO6 Implement different types of neural networks, training algorithms, in context of modelling engineering systems.

Optimization: Optimal problem formulation, single variable optimization algorithms: exhaustive search method, golden section search method, Newton-Raphson method and other methods. Multivariable optimization algorithms: direct search methods, gradient-based methods and other methods. Constrained optimization. Local and global optimization. Single objective and multi-objective optimization.

Integer programming, Geometric programming, simulated annealing,

Evolutionary Computing and Swarm Intelligence: Genetic algorithm, particle swarm optimization, Bacterial Foraging Optimization and other biologically inspired algorithms.

Artificial Neural Network: Introduction, Typical applications of ANNs : Classification, Clustering, Vector Quantization, Pattern Recognition, Function Approximation, Forecasting, Control, Optimization; NN model, NN architecture, Single-layer networks; Perceptron-Linear separability, Training algorithm, Limitations; Multi-layer networks- Architecture, Back Propagation Algorithm (BTA) and other training algorithms, Applications. Feed-forward networks, Radial-Basis-Function (RBF) and adaptive NN. Introduction to fuzzy logic.

Text Books:

1. Optimization for Engineering Design: Algorithms and Examples, Kalyanmoy Deb, 2' edition PHI, 2012
2. Genetic Algorithms in search, Optimization and machine learning, D. E. Goldberg, Pearson, 2013.

Reference Books:

1. E. Bonabeau, M. Dorigo and G. Theraulaz, Swarm Intelligence : From natural to Artificial Systems, 1999.
2. R. C. Eberhart, Y. Sai and J. Kennedy, Swarm Intelligence, The Morgan Kaufmann Series in artificial Intelligence, 2001.
3. K. Mehrotra, C.K. Mohan and Sanjay Ranka, Elements of Artificial Neural Networks, MIT Press, 1997 - [Indian Reprint Penram International Publishing (India), 1997]
4. Simon Haykin, Neural Networks - A Comprehensive Foundation, Pearson, 2009.
5. Martin T. Hagan, Howard B. Demuth, Mark H. Beale; Neural Network Design; Thomson 2002
6. A Cichocki and R. Unbehauen, Neural Networks for Optimization and Signal Processing, John Wiley and Sons, 1993.
7. J. M. Zurada, Introduction to Artificial Neural Networks, (Indian edition) Jaico Publishers, Mumbai, 1[il] edition, 1999.

EC-6119 Optical Communication & Networks CR-3

Course Outcome: At the end of this course, students will be able to:

CO1. gain knowledge on light propagation and types of modes through optical fiber.

CO2. analyze various types of losses, dispersion and bandwidth requirement forfiber-optic communication.
CO3. gain knowledge on the modulation and design of various optical transmitters.
CO4. differentiate between types of optical receivers, SNR, NEP and BER.
CO5. contribute in the areas of optical network and WDM design.
CO6. implement simple optical network and understand technology developments for future enhanced network.

Introduction to optical communication:
Brief overview of optical fibers, optical frequencies, principle of Light Propagation in a fiber, advantages of optical fiber communication, fiber optic communication systems, fiber optic components and cables, materials used for fabrication of optical fiber.

Wave Propagation in optical fiber:
Relation between refractive index and velocity of light, basic structure and ray diagram of optical path in an optical fibre, acceptance cone, numerical aperture, concepts of modes, qualitative analysis of EM wave propagation in cylindrical waveguide, different types of mode in optical fibers, cut-off condition for guided modes, boundary conditions, single mode, muti-mode graded index fiber, concept of V-numbers and its importance, connectors and splices

Losses in optical fiber:
Attenuation, pulse spreading, Rayleigh scattering loss, absorption loss, bending loss, leaky modes, core and cladding loss, concept of dispersion, intermodal dispersion, intermodal dispersion, wave guide and material dispersion, minimization of dispersion.

Optical Transmitter and Modulation:
Characteristics of a good optical source, principle of operation of LED, LED driver circuits, types of LED structure, principle of operation of Laser diode, Laser driver circuits, Laser structure, comparison of LED/Laser. Intensity modulation using LED and Laser diode, analog and digital modulation of LED/Laser, digital modulation formats, pulse code modulation, Optical Time-Division Multiplexing(OTDM).

Optical Receivers and Measurements:
Photo detectors - principles, technology, parameters and characteristics, principle of operation of PIN diode based receiver, structure, current characteristics, principle of operation of APD based receiver, structure, current characteristics, comparison of PIN/APD, receiver amplifiers, noises(thermal noise and shot noise) at optical receivers, SNR and Noise equivalent power. Numerical aperture measurement, fiber attenuation and scattering loss measurement, optical time domain reflectometer (OTDR), dispersion loss measurement.

Digital Optical Communication Links:
BER in quantum limit, BER analysis in presence for PIN based and APD based receivers in presence of shot and thermal noise components, link design, power budget and rise-time budget.

Optical Networks:
Basics Networks- SONET/SDH, High-Speed Lightwave Links, Optical Add/Drop Multiplexing(OADM), Optical Switching, burst switching, Principle of operation of WDM, WDM Networks examples, PassiveOptical Networks(PON), GPON, IP over DWDM, Optical Ethernet.

Text Books

1. Optical Fiber Communication Systems, Gerd Keiser, Tata Mc-Graw Hill, 2013
2. Fiber Optics Communications, J.C. Palais, Pearson Education, 2005

Reference Books:
1. Optical Fiber Communications, John M Senior, Pearson Education.
2. Fiber-Optic Communication Systems, Govind P. Agrawal, Wiley Publication.

EC6121 Cognitive Radio and Co-operative Communication Cr-3

Couse outcomes: After completion of the course the students will be able to

CO1	Comprehend the significance of terminology associated with cognitive radio architecture and components of spectrum sensing, spectrum analysis.
CO2	Analyze Spectrum sensing , collaborative sensing and implementation.
CO3	Differentiate between different optimization techniques of spectrum allocation.
CO4	Study and implementation of algorithms in spectrum management.
CO5	Comprehend the significance of terminology associated with Spectrum Trading.
CO6	Analyze the Research Challenges and issues in Cognitive Radio.

Unit 1
Introduction to Cognitive Radios: Digital dividend, cognitive radio (CR) architecture, functions of cognitive radio, dynamic spectrum access (DSA), components of cognitive radio, spectrum sensing, spectrum analysis and decision, potential applications of cognitive radio.
Unit 2
Spectrum Sensing: Spectrum sensing, detection of spectrum holes (TVWS), collaborative sensing, geo-location database and spectrum sharing business models (spectrum of commons, real time secondary spectrum market).
Unit 3
Optimization Techniques of Dynamic Spectrum Allocation: Linear programming, convex programming, non-linear programming, integer programming, dynamic programming, stochastic programming.
Unit 4
Dynamic Spectrum Access and Management: Spectrum broker, cognitive radio architectures, centralized dynamic spectrum access, distributed dynamic spectrum access, learning algorithms and protocols.
Unit 5
Spectrum Trading: Introduction to spectrum trading, classification to spectrum trading, radio resource pricing, brief discussion on economics theories in DSA (utility, auction theory),classification of auctions (single auctions, double auctions, concurrent, sequential).
Unit 6
Research Challenges in Cognitive Radio: Network layer and transport layer issues, crosslayer design for cognitive radio networks.

Books:

1. Ekram Hossain, Dusit Niyato, Zhu Han, “Dynamic Spectrum Access and Management in Cognitive Radio Networks”, Cambridge University Press, 2009.

2. Kwang-Cheng Chen, Ramjee Prasad, “Cognitive radio networks”, John Wiley & Sons Ltd., 2009.
3. Bruce Fette, “Cognitive radio technology”, Elsevier, 2nd edition, 2009.
4. Huseyin Arslan, “Cognitive Radio, Software Defined Radio, and Adaptive Wireless Systems”, Springer, 2007.
5. Francisco Rodrigo Porto Cavalcanti, Soren Andersson, “Optimizing Wireless Communication Systems” Springer, 2009.
6. Linda Doyle, “Essentials of Cognitive Radio”, Cambridge University Press, 2009.

EC6115 Biomedical Signal Analysis Cr-3

Couse outcomes: After completion of the course the students will be able to

CO1: Understand the origin of different types of biomedical signals
CO2: Apply different transform techniques in biomedical signals
CO3: Apply the concept of signal processing to analyze the cardiological signal
CO4: Apply the concept of signal processing to analyze the neurological signal
CO5: Understand mathematical and statistical techniques to analyse biomedical signals
CO6: Understand and evaluate of biomedical signals

Prerequisite: Digital Signal Processing

Unit 1

Generation of Bio-signals, Sources of bio-signals, Bio electric potential/ action potential. Types of bio-signals (ECG, EEG, EMG, EOG), Study of diagnostically significant bio-signal parameters. Acquisition of bio-signals (signal conditioning).

Unit 2

Classification of signals and noise, Digital filtering, Spectral analysis of deterministic, stationary random signals and non-stationary signals, Coherent treatment of various biomedical signal processing methods and applications. Biomedical signal processing by Fourier analysis, wavelet (time-frequency) analysis,

Unit 3

Cardiological signal processing: Basic Electrocardiography, ECG data acquisition, ECG lead system, Power spectrum of the ECG, Bandpass filtering techniques, Differentiation techniques, Template matching techniques, A QRS detection algorithm, Realtime ECG processing algorithm EEG signal.

Unit 4

Neurological signal processing: The brain and its potentials, The electrophysiological origin of brain waves, The EEG signal and its characteristics (EEG rhythms, waves, and transients), Correlation.

Analysis of EEG channels: Detection of EEG rhythms, Template matching for EEG, spike and wave detection

Unit 5

Principal component analysis, Correlation and regression, Analysis of chaotic signals Application areas of Bio–Signals analysis Multiresolution analysis(MRA) and wavelets, Principal component analysis(PCA), Independent component analysis(ICA)

Unit 6

Pattern classification–supervised and unsupervised classification, Neural networks, Support vector Machines, Hidden Markov models. Examples of biomedical signal classification examples.

Text Book:

1. Rangaraj M. Rangayyan, "Biomedical Signal Analysis", IEEE Press, 2001.

References:

1. W. J. Tompkins, "Biomedical Digital Signal Processing", Prentice Hall, 1993.
2. Eugene N Bruce, "Biomedical Signal Processing and Signal Modeling", John Wiley & Son's publication, 2001.
3. Myer Kutz, "Biomedical Engineering and Design Handbook, Volume I", McGraw Hill, 2009.
4. D C Reddy, "Biomedical Signal Processing", McGraw Hill, 2005.
5. Katarzyn J. Blinowska, JaroslawZygierewicz, "Practical Biomedical Signal Analysis Using MATLAB", 1st Edition, CRC Press, 2011

EC6116 Machine Learning and Artificial Intelligence Cr-3

Couse outcomes: After completion of the course the students will be able to

CO-1: Understand different techniques of Supervised and Unsupervised Learning Mechnism
CO-2: Understand the aspects of Machine learning
CO-3: Understand different modelling Techniques of Machine Learning.
CO-4: Apply their knowledge to Extract features that can be used for a particular machine learning approach in various IOT applications.
CO-5: Apply knowledge to compare and contrast pros and cons of various machine learning techniques and to get an insight of when to apply a particular machine learning approach.
CO-6: To mathematically analyse various machine learning approaches and paradigms.

Unit-1

Supervised Learning (Regression/Classification)

Basic methods: Distance-based methods, Nearest-Neighbours, Decision Trees, Naive Bayes, Linear models: Linear Regression, Logistic Regression, Generalized Linear Models, Support Vector Machines, Nonlinearity and Kernel Methods

Unit-2

Unsupervised Learning

Clustering: K-means/Kernel K-means, Dimensionality Reduction: PCA and kernel PCA Matrix Factorization and Matrix Completion, Generative Models (mixture models and latent factor models)

Unit-3
Evaluating Machine Learning algorithms and Model Selection, Introduction to Statistical Learning Theory, Ensemble Methods (Boosting, Bagging, Random Forests)

Unit-4
Sparse Modeling and Estimation, Modeling Sequence/Time-Series Data, Deep Learning and Feature Representation Learning

Unit-5
Scalable Machine Learning (Online and Distributed Learning), A selection from some other advanced topics, e.g., Semi-supervised Learning, Active Learning, Reinforcement Learning, Inference in Graphical Models,
Introduction to Bayesian Learning and Inference

Unit -6
Recent trends in various learning techniques of machine learning and classification methods for IOT applications. Various models for IOT applications.

Text Books:
1. Kevin Murphy, Machine Learning: A Probabilistic Perspective, MIT Press, 2012 2. Trevor Hastie,

Reference Books:
1. Robert Tibshirani, Jerome Friedman, The Elements of Statistical Learning, Springer 2009 (freely available online)
2. Christopher Bishop, Pattern Recognition and Machine Learning, Springer, 2007.

EC6130 Digital Image and Video Processing Cr-3

Couse outcomes: After completion of the course the students will be able to

CO1 : Learn different techniques of image sampling and image transformation.
CO2: Learn different techniques for image enhancement, video and image recovery
CO3 : Understand techniques for image and video segmentation
CO4 : Study techniques for image and video compression.

CO5 : Study techniques for colour image processing and application in video processing.

CO6: Implementation of different techniques for object detection.

Unit 1
Digital Image and Video Fundamentals
Digital image and video fundamentals and formats, 2-D and 3-D sampling and aliasing, 2-D/3-D
filtering, image decimation/interpolation, video sampling and interpolation, Basic image processing operations, Image Transforms
Need for image transforms, DFT, DCT, Walsh, Hadamard transform, Haar transform, Wavelet
transform

Unit 2

Image and Video Enhancement and Restoration
Histogram, Point processing, filtering, image restoration, algorithms for 2-D motion estimation, change detection, motion-compensated filtering, frame rate conversion, deinterlacing, video resolution enhancement, Image and Video restoration (recovery).
Unit 3
Image and Video Segmentation
Discontinuity based segmentation- Line detection, edge detection, thresholding, Region based segmentation, Scene Change Detection, Spatiotemporal Change Detection, Motion Segmentation, Simultaneous Motion Estimation and Segmentation Semantic Video Object Segmentation, Morphological image processing.
Unit 4
Colour image Processing
Colour fundamentals, Colour models, Conversion of colour models, Pseudo colour image processing, Full colour processing
Unit 5
Image and Video Compression
Lossless image compression including entropy coding, lossy image compression, video compression techniques, and international standards for image and video compression (JPEG, JPEG 2000, MPEG-2/4, H.264, SVC), Video Quality Assessment
Unit 6
Object recognition
Image Feature representation and description-boundary representation, boundary descriptors, regional descriptors, feature selection techniques, introduction to classification, supervised and unsupervised learning, Template matching, Bayes classifier.

Books:

1. Ed. Al Bovik ,"Handbook of Image and Video Processing", 2nd Edition, Academic Press, 2000.
2. J. W. Woods, "Multidimensional Signal, Image and Video Processing and Coding",2nd Edition, Academic Press, 2011.
3. Rafael C. Gonzalez and Richard E. Woods," Digital Image Processing", 3rd Edition, Prentice Hall, 2008.
4. M. Tekalp, "Digital Video Processing", 2nd Edition, Prentice Hall, 2015.
5. S. Shridhar, "Digital Image Processing", 2nd Edition, Oxford University Press, 2016.

EC–6122 SATELLITE COMMUNICATION SYSTEMS Cr – 3

Couse outcomes: After completion of the course the students will be able to

CO1: Learn basic parameters for satellite communication.
CO2: Know satellite launching methods and orbital control mechanisms.
CO3: Know the different types of losses in satellite link and satellite link design.
CO4: Learn different types of noises and interferences associated with satellite link.
CO5: Learn about the stability of a satellite in orbit and different satellite sub-systems.
CO6: Learn the different multiple access techniques and its use in satellite communication.

Prerequisite: Physics-I & Physics-II

Introduction:
Frequency spectrum for satellite communication, Types of orbits, Kepler's Laws of planetary motion, Orbital perturbations, Geostationary orbit, Satellite launching, General satellite communication, Block diagram uplink, Downlink frequencies, Types of modulation techniques used orbits, and altitude control Satellite launch vehicles – Arian, SLV space shuttle.

Losses/ Attenuation:
Signal loss on transmission through earth's atmosphere, Atmospheric losses, Ionospheric effects, Rain attenuation. Satellite link budget: Transmission losses, Interference, System noise temperature, Link power budget.

Satellite sub-systems:
Antenna sub-systems, Attitude and orbit control sub-system, Power sub-system, Communication sub-system, TTC&M sub-systems.

Satellite Application:
Satellite application in TV, Internet, Mobile telephony, Receive only home TV, Master Antenna TV, Low earth orbit satellite systems and uses. Multiple access techniques - FDMA, TDMA, SS-TDMA. Interference in FDMA systems.

Text Books:

1. Satellite Communication, T. Pratt & C. W. Bostia, Wiley
2. Satellite Communication, D. Roddy, McGraw Hill

Reference Books:

1. Digital Satellite Communications, T. T. Ha, Tata McGraw Hill

EC6138 Statistical Signal Processing Cr-3

Couse outcomes: After completion of the course the students will be able to

CO1: Understand the mathematical background of signal detection and estimation.
CO2: Understand probability, random variables (RV), functions of RV, random processes and statistics
CO3: Analyze the approaches to solve problems for signal detection.
CO4: Analyze the various methods for parameter estimation from noisy signals
CO5: Development of different filtering methods for parameter estimation
CO6: Extrapolate the Spectral estimation methods for direction of arrival estimation

Unit 1
Review of Vector Spaces: Vectors and matrices: notation and properties, orthogonality and linear independence, bases, distance properties, matrix operations, Eigen values and eigenvectors. Properties of Symmetric Matrices: Diagonalization of symmetric matrices, symmetric positive definite and semi definite matrices, principal component analysis (PCA), singular value decomposition.

Unit 2
Stochastic Processes: Distribution and density functions, Time average and moments, independent, uncorrelated and orthogonal random variables; Vector-space representation of Random variables, Random processes, wide-sense stationary processes, autocorrelation and auto-covariance functions, Spectral representation of random signals, ergodicity, power spectral density, Gaussian Process and White noise process, response of LTI system to random process, cyclo-stationary process, and spectral factorization.

Unit 3

Detection Theory: Detection in white Gaussian noise, correlator and matched filter interpretation, Bayes criterion of signal detection, MAP, LMS, entropy detectors, detection in colored Gaussian noise, Karhunen-Loeve expansions and whitening filters.

Unit 4

Estimation Theory: Principle of estimation and applications, Properties of estimates, unbiased and consistent estimators, Minimum variance estimators, Cramer-Rao lower bound, Efficient estimators; Criteria of estimation: the methods of maximum likelihood and its properties; Baysean estimation examples of linear models, system identification, Markov classification, clustering algorithms.

Unit 5

Topics in Kalman and Weiner Filtering: Discrete time Wiener-Hopf equation, error variance computation, causal discrete time Wiener filter, discrete Kalman filter, continuous-time Kalman filter, extended Kalman filter, examples.

Unit 6

Spectral Analysis: Estimated autocorrelation function, periodogram, Averaging the periodogram (Bartlett Method), Welch modification, Blackman and Tukey method of smoothing periodogram. Specialized Topics in Estimation: Spectral estimation methods like MUSIC, ESPIRIT, DOA Estimation.

Texts/ References:

1. M. H. Hayes, Statistical Digital Signal Processing and Modeling, John Wiley & Sons, Inc., 2002.
2. S. M. Kay, Fundamentals of Statistical Signal Processing: Estimation Theory, Prentice Hall,1993.
3. J. G. Proakis et. al., Algorithms for Statistical Signal Processing, Pearson Education, 2002.
4. H. V. Poor, An Introduction to Signal Detection and Estimation, 2nd edition, Springer, 1994.
5. H. Stark and J. W. Woods, Probability and Random Processes with Application to Signal Processing, PHI, 2002.
6. S. Haykin, Adaptive Filter Theory, PHI, 2001.

EC-6128 WIRELESS SENSOR NETWORK Cr-3

Course outcome: After completion of the course student will able to

CO1: Analyse the architecture of wireless sensor networks (WSN) and the factors influencing WSN architecture design using Cross Layer Solutions.
CO2: Categorize the various Physical layer issues and developing methods to overcome them.
CO3: Categorize the various MAC layer issues and developing methods to overcome them.
CO4: Analyse the basic principles of Routing Mechanisms for WSN.
CO5: Construct a WSN overcoming the Localization issues.
CO6: Construct a WSN overcoming the Time Synchronization issues.

Prerequisite: Computer & Communication Networks

Introduction: Basic Concepts, Platforms, Standardization, architecture and protocols, Applications in military, environment, healthcare, industry and energy, factors influencing WSN Design. (6)

Physical & MAC Layer: PHY layer standard (IEEE 802.15.4), MAC challenges, MAC protocols for Sensor Network - Contention based (S-MAC, B-MAC, CC-MAC), reservation based-(TRAMA) & Hybrid MAC (Zebra MAC). (9)

Network & Transport layer: Routing challenges, Data Centric and Flat- architecture protocol(SPIN), Hierarchical protocol (LEACH),Geographical routing protocol (MECN), Qos based Protocol(SAR).Challenges of Transport layer ,Transport Layer protocols (PSFQ & CODA). (9)

Cross Layer Solutions: Interlayer Effects, Cross layer Interactions (MAC-Network, MAC-Application, Network and PHY, Transport –PHY), cross layer module. (3)

Localization: Challenges in localization, Ranging Techniques, Range based Localization protocols, Range-Free Localization Protocol. (3)
Time Synchronization: Challenges for Time synchronization, Timing Sync protocol for sensor network (TPSN), Time Diffusion Synchronization protocol (TDP), Rate based diffusion protocol (RDP). (6)

Text Books:

1. Ian F. Akyildiz and Mehmet Can Vuran, "Wireless Sensor Networks," Wiley, 2010
2. WaltenegusDargie and Christian Poellabauer, "Fundamentals of Wireless Sensor Networks: Theory and Practice,"Wiley, 2010.

Reference Books:

1. Jun Zheng and Abbas Jamalipour, "Wireless Sensor Networks: A Networking Perspective," Wiley, 2009
2. C. Raghavendra, K. Sivalingam& T. Znati, "Wireless Sensor Network",
3. Springer, ISBN:1-4020-7883-8, August 2005

EC6114 SPREAD SPECTRUM TECHNIQUES AND MULTIPLE ACCESS Cr-3

Couse outcomes: After completion of the course the students will be able to

CO1: Analyze different spread spectrum Techniques such as DSSS and FHSS.
CO2: Analyze different spreading sequences: correlation functions, Binary linear feedback shift register sequence for spread spectrum.
CO3: Analyze the concept of jamming in spread spectrum communication model.
CO4: Analyze the process of code acquisition and Tracking Loops.
CO5: Differentiate between multiple access such TDMA, FDMA and CDMA.
CO6: Differentiate between various CDMA –SS application like of CDMA digital cellular systems.

Prerequisite: Digital Communication Techniques/ Wireless & Mobile Communication System

Spread Spectrum Techniques: Introduction, Basic communication problems, Pulse noise jamming, Low probability of detection, Signal structure secrecy, Direct sequence spread spectrum, Frequency hopping spread spectrum: Coherent slow frequency hopping spread spectrum, Non Coherent slow frequency hopping spread spectrum, Non coherent fast frequency hopping spread spectrum, Hybrid direct sequence and frequency hopping spread spectrum, Time hopping and Multicarrier Systems.(6)

Spreading Sequences: Correlation functions, Binary linear feedback Shift register sequence for spread spectrum, Definitions, mathematical background and sequence generator fundamentals, Maximal length sequences, Gold Sequences.(5)
Communicating through fading Channels: Performance of spread spectrum system in Jamming environments, Spread spectrum communication model, performance in jamming environment without coding. Fading Channels: statistical model of fading, Characterization of mobile radio channel, Requirement of diversity in fading channel.(7)

Code acquisition and Tracking Loops: Introduction, Optimum tracking of wideband signal, Baseband delay-lock tracking loop, Non coherent delay lock tracking loop, Code tracking loop for frequency hop system.(7)

Multiple Access-multi-user interferences and multi-user Detection: Multiuser systems and multiple access problems, FDMA, TDMA, Code division multiple access, Synchronous CDMA, Asynchronous CDMA, and Asynchronous CDMA in cellular networks.(7)

Applications: Multicarrier CDMA, MC-DS-CDMA, Ultra-Wideband (UWB) systems, Mobile communications and wireless networks: CDMA digital cellular systems, Specific examples of CDMA digital cellular systems.(4)

Text Books:

1. Introduction to Spread Spectrum Communication, by Roger L. Peterson, Rodger E Ziemer and David E. Borth, Prentice hall 1995,ISBN:0024316237
2. Spread Spectrum and CDMA Principle and applications, by Valery P. Ipatov ,John wiley& sons Ltd, ISBN:0470091789

Reference Books:

1. Spread Spectrum Systems by R.C.Dixon**,** John wiley& sons,Ltd,ISBN:0471539427
2. A. J. Viterbi, CDMA: Principle of Spread Spectrum Communication, Addison-Wesley ,1995,ISBN:0201633744

Specialization VLSI Design and Embedded System

EC6209 Digital VLSI Circuits & Systems Cr-3

Couse outcomes: After completion of the course the students will be able to

CO1: Select the most appropriate design methodology and target technology for a specified digital microelectronic system implementation
CO2: Design, at the circuit level, digital library elements, such as gates, flip-flops, etc., to meet a given functional and electrical specification
CO3: Apply a knowledge of layout rules and floor planning guidelines to the physical layout of integrated circuits.
CO4: Design and formulate different dynamic logics and its working principle
CO5: Design and working analysis of Semiconductor memories.
CO6: Design and formulation of timing analysis methodologies

Module-I
Issues of Digital IC Design : General overview of design hierarchy, layers of abstraction, integration density and Moore's law, VLSI design styles, packaging styles, design automation principles; Challenges: power, timing, area, noise, testability reliability and yield.
Basic Circuit Concepts : Introduction to MOS transistor theory, sheet resistance and area capacitances of layers, driving propagation delay models of cascaded pass transistors, wiring capacitances;
Stick diagram and layout design, design rules; transistor scaling: constant field scaling, constant voltage scaling.
Module-II
The CMOS inverter: VTC, switching behavior, noise margins, power dissipation, analytical delay model. Analysis of other inverters: resistive load inverter, saturated load NMOS inverter and others. Design of inverter, large capacitive loads and super-buffers.
Static CMOS Logic: complex CMOS logic gates, transistor sizing in static CMOS logic, ratioed logic-pseudo-nmos; logical effort: delay estimation and delay minimization, pass transistor logic, transmission gates.
Module-III
Dynamic CMOS design: steady-state behavior of dynamic gate circuits, noise considerations in dynamic design, charge leakage, charge sharing, cascading dynamic gates, domino logic, np-CMOS logic, problems in single-phase clocking, two-phase non-overlapping clocking scheme.
Different logic families like CPL, DCVSL etc. Sequential CMOS Logic Circuits.
Dynamic Random Access Memories (DRAM), Static RAM, non-volatile memories, flash memories, low-power memory.

Books:

1. CMOS Digital Integrated Circuits, Sung-Mo Kang and Yusuf Leblebici, 3rd edition, TMH,2003
2. Digital Integrated Circuits: A Design Perspective, J. M. Rabaey, Anantha Chandrakasan and Borivoje Nikolic, 2nd Edition, PHI,2011
3. CMOS VLSI Design: A circuits and Systems Perspective, West, Harris and Banerjee, 3rd edition, Pearson Education, 2012 .

4. Introduction to VLSI Circuit and Systems, John. P. Uyemura, 4th Reprint, Wiley India, 2011.
5. Essentials of VLSI Circuits and Systems, Eshraghian, Puckness and Eshraghian, 2/e, Pearson Education
6. Modern VLSI Design: System-on-Chip Design, Wayne Wolfe, 3rd ed, Pearson Education,2005.
7. Modern VLSI Design: IP-Based Design, Wayne Wolfe, 4/e, 2010, PHI.

EC6217 Digital System Design and its Application Cr-3

Couse outcomes: After completion of the course the students will be able to

CO1: Gain knowledge of different abstract level of digital system design using Verilog.
CO2: Model digital system using Verilog Modeling using dataflow or structural or behavioural style.
CO3: apply, formulate, and solve problems in Digital Systems design.
CO4: analyse and synthesis of design with the use of the necessary technology
CO5: Interpret the specifications of programmable devices and develop an application.
CO6: implement different digital system in PLDs and FPGA to solve complex problems pertaining to society as a whole.

Module-I
From specification to silicon. Abstraction levels in VLSI design, hardware description language, Design flow for HDL-based ASICs and FPGA.

Introduction to Verilog HDL, different levels of modelling, basic concepts, Verilog primitives, keywords, operators, data types, Verilog modules and ports; Structural modelling: gate type, design hierarchy, gate delay, propagation delay, logic simulation, design verification and testing, test bench writing; Dataflow-level modelling: continuous assignments, operators and operands, operator types, examples; Behavioral modelling.

Module-II
Synthesis of combinational and sequential logic: logic synthesis, RTL synthesis, high-level synthesis, synthesis design flow, synthesis of combinational logic example magnitude comparator, etc; synthesis of sequential logic, synthesis of state machine: registers, counters, sequence detector, vending machines, traffic light controller; design partitioning; Basic concepts of high-level synthesis: partitioning, scheduling, allocation and binding. Technology mapping and Static Timing Analysis.

Module-III
Logic Design: switch logic, gate restoring logic, Programmable Logic Array (PLAs), Finite State Machine (FSM), Gate array approach, CPLD, FPGA, standard cell approach. Counter architecture, ALU architecture, latches and flip-flops.
Digital System Verification: Introduction to System Verilog, Language Construct, composite types, system Verilog expressions, Behavioral modeling, structural modeling, Advanced Verification Techniques, Assertions.

Case Study Design Example: instructor may choose any suitable digital system such as UART, A RISC Processor, etc.

Books:

1. Verilog HDL: A Guide to Digital Design and Synthesis; Samir Palnitkar; 2nd edition, Pearson Education, 2011.
2. Verilog Digital System Design; Zainalabedin Navabi; 2nd edition, TMH,2012.
3. Principles of Digital System Design using VHDL; C. H. Roth; Cengage Learning, 2011.
4. Advanced Digital Design with the Verilog HDL; Michael D. Ciletti; 2009,1st edition, PHI,2010
5. Verilog HDL Synthesis: A Practical Primer; J. Bhasker;, BSP Publishers, 2008.
6. FPGA-Based System Design, Wayne Wolf, 1st edition, Pearson.
7. A System Verilog Primer, J. Bhasker, Star Galaxy Publishing, 2010, ISBN 978-0-9650391-1-6

EC-6207 Analog CMOS VLSI Circuits Cr- 3

Couse outcomes: After completion of the course the students will be able to

CO 1: Apply a knowledge of the operation of MOSFET transistors and circuits to the analysis and design of small signal model of a circuit .
CO 2: Select the most appropriate design configuration for a specified single stage amplifier implementation.
CO 3: Evaluate performance issues and trade-offs based on a knowledge of different current mirror circuits.
CO 4: Choose the most appropriate operational amplifier configuration for a specified analog circuit implementation.
CO 5: Model noiseless analog circuits based on the knowledge of different types of noises and their compensation.
CO 6: Analyze different designs of comparators best suited for a specific analog circuit application.

Prerequisite: VLSI Design (EC3011)

Introduction*:* Analog circuits in VLSI, Overview of circuit performance comparison in Bipolar, BiCMOS and CMOS technologies. Review of MOS transistor theory, large signal and small signal models of MOS transistors, Feedback topologies and Stability theory.

Amplifiers: Basic amplifier topologies and their characteristics, common-source stage amplifier, Cascode amplifiers, Basic differential pair, Differential amplifier with active load; Two-stage differential amplifier: Analysis for different performance parameters, miller effect, types of noise, noise in single-stage amplifiers and differential pairs, Pole-zero compensation and Design.

Biasing circuits: Basic and Cascode current mirrors, Current and Voltage references; bandgap reference, Folded Cascode amplifier.
Operational amplifier: design of CMOS op-amp, one-stage op-amp, two-stage op-amp, cascade op-amp, performance parameters and analysis, compensation of op-amps.
Comparator: Simple comparator, Switch-based comparator, Latch-based comparator.
Oscillator: Ring oscillator, LC oscillator, Voltage control oscillator.

Text Book:
1. Design of Analog CMOS Integrated Circuits; Behad Razavi; 1st edition, TMH, 2007.

Reference Books:
1. CMOS Analog Circuit Design; Allen and Holberg; International 2nd edition, Oxford,2007.

2. VLSI Design Techniques for Analog and Digital Circuits; Geiger, Allen and Strader, 1st edition, TMH,2010.
3. Analog Integrated Circuit Design; D.A. Johns and K. Martin; 2/e, Wiley India,2013.
4. Analysis and Design of Analog Integrated Circuits; Gray and Meyer; 4th edition, Wiley,2010.
5. CMOS Circuit Design, Layout and Simulation; Baker, Li and Boyce; Indian edition, 1st edition, PHI,2002

EC-6203 MOS Device Modelling Cr-3

Couse outcomes: After completion of the course the students will be able to

CO1: Understanding characteristics and operation of of P-N junction, metal semiconductor junctions and MOS transistor.
CO2: Applying acquired knowledge to solve problems related to drain current, threshold voltage of MOSFET
CO3: Analyzing short channel MOSFET and different 2nd order non-ideal effects .
CO4: Identification of different parasitic element present in MOSFET , measurement technique and their effect on device operation.
CO5: Formulation of Small signal modelling of MOS transistor and C-V characteristics.
CO6: Discussion about different MOSFET model such as Level-1,2,3 BSIM and EKV etc.

Module-I

Review of semiconductor fundamentals: P- N junction characteristics and energy band diagram, Built in potential barrier, forward and reverse biased P-N junction. Metal-semiconductor contacts and their properties, Schottky barrier lowering.

Two terminal MOS structure: MOS capacitor at zero bias condition. Energy-band diagram. Flat band voltage. Work function, Oxide charges. MOS structure at non-zero bias condition: Accumulation, depletion and inversion condition. Threshold voltage and its components. Substrate bias effect and temperature dependency of threshold voltage. Quantum effect on threshold voltage.

Module-II

MOSFET Parasitic Elements: Source/ drain resistance. Source/drain junction and sidewall capacitance and their variation with bias voltages. Equivalent junction capacitance. Oxide related capacitances in MOSFET.

MOSFET DC Model: Drain current modelling of long channel MOS transistor- Gradual Channel Approximation. Channel length modulation. Parameter extraction from experimental I-V dataset. Sub-threshold region model and sub-threshold slope.

MOSFET Scaling: Generalized scaling theory for MOSFET, Constant field and constant voltage scaling and their effects on device characteristics and reliability

Module-III

Second order non-ideal effects: Scattering of carriers and mobility degradation due to gate voltage. Velocity saturation effect, velocity overshoot. Effective mobility and its measurement.

Drain-induced barrier lowering (DIBL) and threshold voltage reduction. Gate induced drain leakage (GIDL).

Impact ionization and hot carrier degradation in MOS transistor, punch-through. Tunnelling in MOS transistor-band to band and oxide tunnelling. Narrow-width effect.

Small signal modelling of MOSFET: Small signal equivalent model at low and high frequency. Intrinsic charge and capacitance modelling. Small signal capacitance-voltage characteristics (low and high frequency C-V characteristics). Anomalous C-V characteristics-Polysilicon depletion effect. Unity gain cut-off frequency.

MOSFET Models: SPICE modelling of MOSFET, introduction to LEVEL 1, LEVEL 2, LEVEL 3, BSIM and EKV Models.

Text books:

1. MOSFET Modeling for VLSI Simulation-Theory and Practice, Narain Arora, World Scientific Publishing.
2. Fundamentals of Modern VLSI devices, Y.Taur and T.Ning, 2nd Edition, Cambridge University Press

Reference books:

1. Operation and Modeling of the MOS transistor, Y.Tsividis, 2nd Ed. MGH publishers.
2. CMOS digital integrated circuits, S.M.Kang and Y.Leblebici, 3rd Ed. TMH
3. Solid state Electronic Devices, Streetman and Banerjee, 6th Ed. PHI.

EC6211 VLSI Technology Cr- 3

Couse outcomes: After completion of the course the students will be able to

CO1: to be aware about the trends in semiconductor technology and IC processing
CO2: to understand the process of Silicon crystal growth, wafer preparation, oxidation and doping techniques
CO3: able to know the recent advancement in the area of high – K dielectrics
CO4: able to understand the various steps involved during process of masking and etching during IC fabrication
CO5: able to understand the different process/techniques for thin film deposition
CO6: able to learn layout, process integration and process simulation tools.

Module-I

Semiconductor review and survey of IC processing – Roadmap; Silicon crystal growth and wafer preparation; Unit Processes: Substrate cleaning, Oxidation; High k and low k dielectrics.

Module-II

Doping techniques: Diffusion, Ion implementation; Pattern transfer: mask making & different lithography techniques (optical, x-ray, E-Beam, Ion-Beam and latest techniques); Vacuum science & plasmas; Etching: wet and dry etching techniques, Isotropy, anisotropy, selectivity, wet plasma, RIBE etc.; annealing techniques.
Thin films: Physical deposition, evaporation and sputtering; Chemical Vapor Deposition techniques; Epitaxial growth;

Module-III
Process integration: Device isolation technology (junction, dielectric, LOCOS, trench etc); self-aligned process, Resistors and Capacitors, Advances in Bipolar, MOS and BICMOS process technologies; SOI Devices.
A case study using process simulation tools.

Books:
1. C.Y. Chang and S.M.Sze (Ed), VLSI Technology, McGraw Hill Companies Inc, 1996.
2. S.K. Ghandhi, VLSI Fabrication Principles, John Wiley Inc., New York, 2 nd edition,2012.
3. S.M. Sze (Ed), VLSI Technology, 2nd Edition, McGraw Hill, 2011.
4. D.Nagchoudhari, "Principles of Microelectronics Technology", Wheeler (India), 1998
5. J. D. Plummer, M. D. Deal and P. B. Griffin, Silicon VLSI Technology, 1/e, Pearson Education.
6. Stephan A. Campbell, The Science and Engineering of Microelectronic Fabrication, 2/e, Oxford.

EC6202 Embedded System Design Cr-3

Couse outcomes: After completion of the course the students will be able to
CO1: understand the difference between embedded systems and general-purpose systems.
CO2: understand the various programming methods using different processor.
CO3: optimize hardware designs of custom single-purpose processors.
CO4: introduce different peripheral interfaces to embedded systems.
CO5: understand the design trade-offs made by different models of embedded systems.
CO6: apply knowledge gained in software-hardware integration in team-based projects.

Introduction: Introduction to embedded systems, Design Standards, Characteristics of embedded Systems, Peripherals and interfacing, System-on-Chip paradigm

Modelling Technique: Finite State Machines Model, Petrinets, Event Nets, Dataflow and Control Flow models, Flow Chart based Model, Specification and representation of Embedded Systems, Behavioural and Structural Concurrency, Data driven and control driven concurrency, communication and synchronisation, timing, hardware design languages, Verilog, VHDL, System C, State Charts

Hardware/ Software Co-Design: Hardware software portioning and scheduling, hardware and software estimation models, Co-Simulation, Synthesis and Verification, Architectural Mapping, HW-SW interfaces and Reconfigurable Computing, System level managements, Trade offs

System-on-Chip and IP Cores: Core Based Design, On chip networking

Embedded Processors: ARM, MIPS, PowerPC, along with their programming, FPGA, CPLD, DSP based controllers

Embedded Bus Architecture: Bus Architecture, bus architecture and transactions, serial interconnects, networked embedded systems, bus protocols, CAN bus.

Software for embedded systems: Time critical IO handling, embedded software design under size, performance, and reliability constraints, software timing and functional validation, programming methods and compilation for embeddable software, real time operating systems, device drivers, system level testing, and reliability issues.

Case study: Embedded system design tools and real-world embedded designs

Text Book:

1. Computer as Component: Principle of Embedded Computing System Design by Wayne Wolf, Morgan-Kaufmann, 2012
2. Embedded System Design: A Unified Hardware/Software Introduction by Frank Vahid & Tony Givagis, , John Wiley, 2011.

Reference Book:

1. Embedded System Design, Peter Marwedel, Springer, 2009
2. Embedded Systems, Raj Kamal, 2^{nd} Edn., TMH, 2011.

EC6213 Architectural Design of ICs Cr-3

Couse outcomes: After completion of the course the students will be able to

CO1: review the basics of different processors including architecture and organization
CO2: foster ability of handling and designing different types of pipelining techniques; exception handling corresponding instruction scheduling.
CO3: understand various memory organization and management techniques
CO4: Understand the various advanced architectures.
CO5: achieve the understanding of parallel, shared architectures and important organizational details of superscalar architecture
CO6: Identify different types fault and redesign the IC to remove these.

Module – I

Introduction: Design flow in digital VLSI- Y-chart a map of digital system, cell libraries, EDA Tools; programmable logic- PLD, CPLD and FPGA; The architectural antipodes-algorithm suitable for a dedicated VLSI architecture, general-purpose and dedicated processing units, Coprocessors, Application-specific instruction set processors, Configurable computing, A transform approach to VLSI architecture design, Equivalence transforms for combinational computations, Equivalence transforms for non-recursive computations, Equivalence transforms for recursive computations

Module-II

Synchronous Design: Introduction-Synchronous clocking, Asynchronous clocking, Self-timed clocking, clocking is essential in VLSI Circuits-pros and cons of synchronous clocking, self timed clocking, Basics, Single-edge-triggered one-phase clocking, Dual-edge-triggered one-phase clocking, Symmetric level-sensitive two-phase clocking, Unsymmetrical level-sensitive two-phase clocking, Single-wire level-sensitive two-phase clocking, Level-sensitive one-phase clocking and wave pipelining, skew and jitters, reduction of clock skew, Input /Output Timing, clock gating

Module-III

Data path element: Data path design philosophies, fast adder, multiplier, driver etc., datapath optimization, application specific combinatorial and sequential circuit design, two operand Adders, multi operand adders, multiplication: Tree multiplier, Radix-2, radix-4 Booth multipliers, Division using Recurrence, CORDIC Algorithm

Control strategies: Finite State Machines- Mealy machine, Moore machine, Relationships between finite state machine models, State reduction, Practical aspects and implementation issues; Switching hazards, Hardware implementation of various control structures, microprogrammed control techniques, VLIW architecture; Testable architecture: Controllability and observability, boundary scan and other such techniques, identifying fault locations, self reconfigurable fault tolerant structures

Books:

1. Digital Integrated Circuit Design From VLSI Architectures to CMOS Fabrication by Hubert Kaeslin, Cambridge University Press, 2008
2. Digital Computer Arithmetic Datapath Design Using Verilog HDL by JAMES E. STINE, Kluwer Academic Publishers.
3. Digital Arithmetic by Miloš D. Ercegovac and Tomás Lang, Morgan Kaufmann Publisher, 2004
4. CMOS VLSI Design : A circuits and systems perspective - A Circuits and Systems Perspective by Neil Waste and David Harris,Pearson Publisher, 2015
5. Digital Integrated Circuits: A Design Perspective by Jan M. Rabaey (Author), Anantha Chandrakasan (Author), Borivoje Nikolic (Author), Pearson Publisher, 2003

EC6224 Low Power VLSI Design Cr-3

Couse outcomes: After completion of the course the students will be able to

CO1: Understand the need for low power in VLSI.
CO2: Understand various dissipation types in CMOS.
CO3: Estimate and analyse the power dissipation in VLSI circuits.
CO4: Derive the architecture of low power architecture.
CO5: Design and analyse the leakage power dissipation in logic level
CO6: Derive the architecture of low power SRAM circuit

Basics of MOS circuits: MOS transistor structure and device modeling, MOS inverters, MOS combinational circuits - different logic families.
Sources of power dissipation in CMOS circuits: static power dissipation - diode leakage power, subthreshold leakage power, gate and other tunnel currents; dynamic power dissipation - short circuit power, switching power, gliching power; degrees of freedom, energy delay product, power delay product.
Supply voltage scaling approaches: technology Level - feature size scaling, threshold voltage scaling; logic level - gate sizing for voltage scaling;

architecture level - parallelism and pipelining; algorithm level - transformations to exploit concurrency; dynamic voltage scaling. Switched capacitance minimization approaches: system level - power down, system partitioning;
algorithm level - concurrency, locality, regularity, data representation; architecture level - concurrency, signal correlation; logic level - gate sizing, logic styles; layout level - layout optimization; technology level - advanced packaging, SOI.
Leakage power minimization techniques: threshold voltage scaling: MTCMOS, VTCMOS and Multiple-Vt CMOS circuits; gate sizing. Low power memory design: ROM, SRAM (4T, 6T), DRAM.

Books

1. CMOS Digital Integrated Circuits, Sung-Mo Kang and Yusuf Leblebici, 3rd edition, TMH,2011
2. Digital Integrated Circuits: A Design Perspective, J. M. Rabaey, Anantha Chandrakasan and Borivoje Nikolic, 2nd Edition, PHI,2001
3. CMOS VLSI Design: A circuits and Systems Perspective, West, Harris and Banerjee, 3rd edition, Pearson Education,.
4. A. Bellamour, and M. I. Elmasri, Low Power VLSI CMOS Circuit Design, Kluwer Academic Press.
5. Anantha P. Chandrakasan and Robert W. Brodersen, Low Power Digital CMOS Design, Kluwer Academic Publishers,2002.
6. Kaushik Roy and Sharat C. Prasad, Low-Power CMOS VLSI Design, Wiley-India,2011.
7. Essentials of VLSI Circuits and Systems, Eshraghian, Puckness and Eshraghian, 2nd edition, Pearson Education

EC6222 Mixed Signal IC Design Cr- 3

Couse outcomes: After completion of the course the students will be able to

CO1: Evaluate performance issues and trade-offs based on a knowledge of different data converters.
CO2: Select the most appropriate design configuration for a specified Nyquist rate DAC implementation.
CO3: Choose the most appropriate operational amplifier configuration for a specified Nyquist rate ADC implementation.
CO4: Model switched capacitor circuits based on the knowledge of different order of noises in oversampling converters.
CO5: Appraise the architecture of Sigma-Delta digital to analog converter.
CO6: Analyze different designs of PLLs best suited for a specific mixed circuit application.

Introduction to Mixed-signal design; Data converters: Introduction and characterization of ADC and DAC.

Block diagram of SAR ADC, Design of SAR ADC, Working principle and architecture of a folding-and-interpolation ADC, Design of sample and hold amplifier, Design of folding amplifier and interpolation network.

Working principle, various architecture and design of different high speed ADCs (e.g. flash ADC, pipeline ADC and others) and high resolution ADCs (e.g. sigma-delta converters), Working principle and various architecture of different high speed and high resolution DAC.

Phase locked loop: Simple PLL, Building blocks in PLL, Locking characteristic of PLL and Design of PLL; non-ideal effects in PLLs, Charge-Pump. PLL based frequency synthesizer, Application and block diagram of a DLL, Design of a multiphase generator.

Switched-Capacitor Circuits: switched-capacitor amplifiers, switched-capacitor integrator. Filters: Continuous time filter, Low pass, high pass and band pass active filter, Design of switched-capacitor filter, Design of Gm-C filter, Design of decimation filter.
Implementation of system on a chip and the associated issue: Precautionary measure for integrating analog and digital modules within an IC, Signal integrity, floor planning and physical design of mixed signal IC design.

Books

1. CMOS mixed-signal circuit design by R. Jacob Baker, Wiley India, IEEE press, 1st edition, 2009.
2. Design of analog CMOS integrated circuits by Behzad Razavi, McGraw-Hill, 1st edition, 2011.
3. CMOS circuit design, layout and simulation by R. Jacob Baker, second edition, IEEE press, Wiley India,2011.
4. CMOS Integrated ADCs and DACs by Rudy V. dePlassche, Springer, Indian edition,2nd edition, 2007.
5. Electronic Filter Design Handbook by Arthur B. Williams, McGraw-Hill, 1981.
6. Design of analog filters by R. Schauman, Oxford university Press, 1st edition, 2010
7. An introduction to mixed-signal IC test and measurement by M. Burns et al., Oxford university press, first Indian edition, 1st edition,2009.

EC-6248 VLSI Signal Processing Cr-3

Couse outcomes: After completion of the course the students will be able to

CO1: To understand the representation of DSP Algorithm
CO2: Apply pipelining and parallel processing to FIR filters for Low Power application
CO3: Know the technique of retiming, folding and unfolding of DSP architecture to reduce critical path delay.
CO4: To know about systolic array design of DSP architecture
CO5: Apply Fast convolution and transform technique for Filtering Application
CO6: Know different arithmetic architecture for addition, subtraction and multiplications technique applicable to DSP

Module-I
Introduction: representation of DSP algorithms: Block Diagram, signal flow graph, data flow graph, dependence graph. loop bound and iteration bound, longest path matrix algorithm, iteration bound of Multirate data flow graphs.
Pipelining and Parallel Processing: Introduction, Pipelining and parallel processing of FIR digital filters, Pipelining and Parallel Processing for Low Power
Module- II
Retiming, Unfolding and Folding: retiming techniques; algorithm for unfolding, Folding transformation
Systolic architecture design: systolic array design methodology, FIR Systolic Arrays, Selection of Scheduling Vectors, 2D Matrix Multiplication Systolic Array Design

Fast Convolution: Cook-Toom algorithm, modified Cook-Toom algorithm, Winograd algorithm, iterated convolution

Module-III

DSP transforms: Discrete Cosine Transform (DCT) and Inverse DCT

Arithmetic Architectures: Parallel Multipliers- Parallel Multiplication with sign extension(Parallel Carry Ripple Array and Parallel Carry Save Multipliers), Bit Serial Multipliers, Redundant Number presentation, Radix-2 and radix-4 Addition and Subtraction, Radix-2 Redundant Multiplier Architecture

Text Book:

1. VLSI Digital Signal Processing Systems, Design and Implementation by Keshab K.Parhi, John Wiley, Indian Reprint, 2007.

Reference Books:

1. VLSI Design Methodologies for Digital Signal Processing Architectures by Magdy A. Bayoumi, Springer/bsp Books; Edition (2005)
2. VLSI and Modern Signal Processing by S.Y.Kuang, H.J. White house, T. Kailath, Prentice Hall, 1995.

EC6246 Memory Design and Testing Cr-3

Couse outcomes: After completion of the course the students will be able to

CO1: Understand the operation of different RAM and ROM architectures
CO2: Analyse and simulate RAM and ROM circuits for varied applications
CO3: Design and implement various fault modeling and testing techniques in memory design
CO4: Learn about various reliability issues faced in memory design
CO5: Understand advanced memory technologies and develop an insight on memory packaging
CO6: Possess knowledge, recognize opportunities and contribute to research in the field of memory design

Introduction to memories, Memory core (RAM, ROM and peripherals), sensing basics, concept of refresh and kickback

SRAM architecture and peripherals, Circuit operation (read, write and hold), 4T, 6T and 8T circuit implementation, low voltage SRAMs, SOI SRAMs, advanced SRAM architectures (multiport, FIFO, CAMs etc.), sense amplifiers, sensing using sigma delta modulation, Floating gate architecture

Introduction to DRAM, DRAM architectures and circuit implementation, bandwidth, latency, cycle time, power, timing circuits, control logic, Gigabit DRAM scaling issues and architectures, multilevel storage DRAMs, EDRAM and CDRAM basics, FLASH memory, ROM circuit operation and implementation, PROM basics, EPROM fundamentals, EEPROM basics

Concept of memory faults, RAM fault modeling, RAM electrical and pseudorandom testing, Functional fault modeling, IDDQ fault modeling and testing, Fault diagnosis and repair algorithms, general design for testability, SRAM DFT and built-in self test, DRAM DFT and built-in self test, Memory error detection and correction techniques, memory fault tolerance techniques

Topics in advanced memory design and testing, Trends in embedded memory testing, Analog memory design, MRAMs, Application specific DRAMs (VRAMs, DDR SGRAMs, RDRAMs, SLDRAMs, 3-D RAM etc.), memory packaging, radiation effects in semiconductor memories, FRAMs and reliability issues, future memory directions with megabytes to terabytes storage capacities using RTDs, single electron memories, etc.

Text Books:

1. Betty Prince, "Semiconductor Memories: A Handbook of Design, Manufacture and Application", Wiley, Second Edition, 1996.
2. Keeth, Baker, Johnson, and Lin, "DRAM Circuit Design: Fundamental and High-Speed Topics", Wiley IEEE, 2007.

Reference Books:

1. Jacob Baker, "CMOS Circuit Design, Layout and Simulation", Wiley IEEE, 3rd Edition, 2010.
2. Ashok K. Sharma, "Semiconductor Memories: Technology, Testing and Reliability", Wiley-IEEE, 2013.
3. Luecke Mize Care, "Semiconductor Memory design and application", 1st Edition, McGraw Hill, 1999.

EC6219 ASIC and SOC DESIGN Cr-3

Couse outcomes: After completion of the course the students will be able to

CO1: demonstrate VLSI tool-flow and appreciate FPGA architecture for ASIC and SoC design.
CO2: understand the issues involved in ASIC & SoC design, including technology choice, design management, tool-flow, verification, debug and test, as well as the impact of technology scaling on ASIC design.
CO3: understand the algorithms used for ASIC & SoC construction
CO4: understand the basics of System on Chip, On chip communication architectures like AMBA,AXI and utilizing Platform based design.
CO5: appreciate high performance algorithms available for ASIC & SoC
CO6: Design PLL for different application need for SIC & SoC

MODULE – I

Introduction: Voice over IP SOC, Intellectual Property, SOC Design Challenges, Design Methodology. Overview of ASICs: Introduction, Methodology and Design Flow, FPGA to ASIC Conversion, Verification.

MODULE – II

SOC Design and Verification: Introduction, Design for Integration, SOC Verification, Set-Top-Box SOC, Set-Top-Box SOC Example. Summary. References. Physical Design: Introduction, Overview of Physical Design Flow, Some Tips and Guidelines for Physical Design, Modern Physical Design Techniques.

MODULE – III
Low-Power Design: Introduction, Power Dissipation, Low-Power Design Techniques and Methodologies, Low-Power Design Tools, Tips and Guidelines for Low-Power Design. Low-Power Design Tools: PowerTheater, PowerTheater Analyst, PowerTheater Designer.
MODULE – IV
Open Core Protocol (OCP): Highlights, Capabilities, Advantages, Key Features. Phase-Locked Loops (PLLs): PLL Basics, PLL Ideal Behavior, PLL Errors.

Text Books:

1. FarzadNekoogar and FaranakNekoogar, From ASICs to SOCs: A Practical Approach, Pearson Education, 2003, ISBN-10: 0-13-033857-5, ISBN-13: 978-0- 13-033857-0

Reference Books:

3. Michael Smith, Application Specific Integrated Circuit, Addison-Wesley, 1997, ISBN: 0201500221
2. Jari Nurmi, Processor Design: System-On-Chip Computing for ASICs and FPGAs, Springer, 1st edition, 2007, ISBN: 1402055293
3. Douglas J. Smith, HDL Chip Design – a practical guide for designing, synthesizing and simulating ASICs and FPGAs using VHDL or Verilog, Doone Publications, 2000, ISBN: 0965193438

EC6236 MEMS Design Cr-3

Couse outcomes: After completion of the course the students will be able to

CO1: Understand about different MEMS Sensors and Actuators used in different real world applications
CO2: Explain about the material properties of different materials used in MEMS design.
CO3: Elaborate on various MEMS fabrication technologies and able to differentiate between different micromachining processes used in designing MEMS structures and different parameters involved in the process.
CO4: Develop different concepts of micro system **sensors** for real-world applications.
CO5: Develop different concepts of micro system **actuators** for real-world applications.
CO6: Design micro-sensors for different MEMS applications like RF MEMS, Bio-MEMS, microfluidics etc. and able to analyse different parameters involved in the MEMS packaging.

Introduction:

Introduction to MEMS & Real world Sensor/Actuator examples: DMD, Air-bag, pressure sensors: MEMS Sensors in Internet of Things (IoT), MEMS sensors in Bio-Medical Applications

MEMS Materials:
MEMS Materials, Silicon, Crystal Defects, Mechanical Properties of Materials, Beams and structures, Piezoelectric Materials, Piezoresistive Materials

MEMS Fabrication Processes:
Review of VLSI Processing, Micro machining, Bulk Micro machining, Surface Micro machining, Deep RIE, Advanced Lithography, LIGA Process

MEMS Sensor:
Resistive and Capacitive methods, Strain gauges, Piezoresistivity, MEMS Capacitive Sensors, MEMS Pressure sensor, MEMS Accelerometer, MEMS Gyroscope, MEMS Gas Sensors, Cantilever Sensors

MEMS Actuator:
Electrostatic MEMS actuators, Comb drives, MEMS RF resonator, Scratch drive, Piezoelectric MEMS actuators, Thermal MEMS actuators, Magnetic MEMS actuators, Optical MEMS

MEMS Applications - Micro-fluidics, Bio MEMS, RF MEMS:
Microfluidics: Fluid flow, Electro-osmotic flow, Electrophoresis, Micropumps, Microvalves, microneedles, Lab-on-a-Chip, µTAS, RF MEMS switches, RF MEMS switched capacitors and varactors

MEMS Packaging:
MEMS Packaging Issues, Die Level Packaging, Wafer Level Packaging, Micro assembled caps, Sealing

Text Books:

1. MEMS, Mahalik N P, Tata McGraw-Hill Education, 07-Feb-2008
2. MEMS & Microsystem Design and Manufacture by Tai-Ran Hsu, Tata McGraw-Hill Education, 2002

Reference Books:

1. MEMS Design, Stephen D. Senturia, 2001
2. VLSI Technology, S. M. Sze, 2^{nd} ed., McGraw-Hill Education, NY, 1988

EC6234 CMOS RFIC Design Cr-3

Couse outcomes: After completion of the course the students will be able to

CO1: Understanding RF basics
CO2: Understanding of Design of Receiver by designing of LNAs, Oscillators and Mixers
CO3: Understanding of Design of Transmitter by designing of Power Amplifiers
CO4: Hands-on training of Receiver and Transmitter circuit components in Cadence Simulator
CO5: Understanding RF Phase Locked Loop (PLL)
CO5: Course Project on 60 GHz 5G Receiver/Doherty Power Amplifier design and development in Lab

Module-I

Small Signal RF Model of MOSFET to be used in IC Design, Noise in MOSFET and in circuit, Non-linearity - 1-dB Gain compression point, Intermodulation and IIP3/OIP3, Dynamic Range, Sensitivity, Spurious Free Dynamic Range, RF Transmitter and Receiver Architectures with Hartley Architecture of Receiver IF Down-conversion and Image Rejection, Impedance Matching, RF Low Noise Amplifier – Design of Common Source; Common Gate; Cascode and Differential configurations with implementations by Inductors

Module-II

Microstrip and CPW transmission lines, Broadband Monolithic Distributed Amplifier with CPW inductive transmission lines, Oscillation Condition, RF Oscillators, Configurations/Designs of Ring oscillator, LC Cross-Coupled/negative-resistance Oscillator, Distributed Oscillator and Voltage Controlled Oscillator (VCO), Use of MOSFET as MOS-Varactors in VCO, Quadrature VCO, Phase Noise in Oscillators, RF Mixers basics like Conversion Gain, Noise Figure and other performance parameters,

Module-III

Active Down-conversion Mixers such as Single-Balanced, Double-Balanced/Gilbert Cell Mixers, Phase lock Loop (PLL), Phase Frequency Detector (PFD) and Charge Pump (CP), CP-PLL, PLL Integer-N Frequency Synthesizer, PLL Divider Chain with Injection-Locked Frequency Divider; Divide by 2 Circuit and other Dividers, Class E (stacked FET and others) Power Amplifiers for 60/77 GHz bands, Doherty Power Amplifier.

Text Book:

B Razavi, "RF Microelectronics", Second Edition, Pearson, 2012 (Indian Edition 2013 by Dorling Kindersley).

References:

1. Sorin Voinigescu, "High-Frequency Integrated Circuits", Cambridge University Press, 2013, South Asian Paperback edition of 2016.
2. Michael Steer, "Microwave and RF Design - A Systems Approach", SciTech Publishing, 2010, Indian Reprint of 2012 by Yesdee Publishing.

Specialization in RF and MICROWAVE ENGINEERING

EC6319 Advanced Electromagnetics Cr - 3

Couse outcomes: After completion of the course the students will be able to

CO1: Memorize basic parameters, conditions and equations of electromagnetic.
CO2: Understand the propagation of electromagnetic wave.
CO3: Solve design problems of transmission lines.
CO4: Compare the propagation of signal through transmission line and waveguide.
CO5: Evaluate the design problem of rectangular and circular cavity resonators.
CO6: Investigate the EM wave propagation through anisotropic materials.

Prerequisite: Electromagnetic Theory

Time-varying Electromagnetic Fields: Maxwell's equations, potential functions, retarded vector potential, Lorentz gauge condition. Electromagnetic boundary conditions, interface between a dielectric and a perfect conductor, Homogeneous and non-homogeneous Helmholtz's wave equations, principle of duality, plane waves in lossless and lossy media, Propagation of plane wave through ionized gases, plasma frequency, Phase velocity and group velocity, Flow of electromagnetic power and Poynting vector.

Transmission Lines: Origins of primary transmission line parameters (R, L, C, G), characteristic impedance, phase constant, attenuation constant, distortionless line. Input impedance for a finite transmission line, transmission lines as circuit elements, transients on transmission lines, initially charged line, quarter-wave transformer, SWR. Smith chart, single-stub and double-stub matching.

Waveguides and Cavity Resonators: Waveguide structures and excitation of waveguides, TE and TM modes of propagation through rectangular waveguide and circular waveguide, power losses through waveguide, wave impedance, transmission line analogy of waveguide and circuit representation of waveguide, Rectangular and circular cavity resonators.

Propagation of Electromagnetic Waves through Anisotropic Media: Index ellipsoid, Plane-wave propagation through anisotropic crystals, Fresnel's equation of wave normal, plane-wave propagation through uniaxial crystals, double refraction. Permeability matrix for ferrites, TEM wave propagation through d. c. magnetized ferrites, Faraday effect.

Text Books:
1. *Field and Wave Electromagnetics – D. K. Cheng, Pearson Education, 2nd Ed., 2004.*
2. *Electromagnetic Waves and Radiating Systems – E. C. Jordan and K. G. Balmain, Pearson Education/PHI, 4th Ed., 2006.*

Reference Books:
1. *Field & Waves in Communication Electronics – S. Ramo, J. R. Whinnery and T. Van Duzer, John Wiley & Sons, 3rd Ed., 1994.*
2. *Microwave Engineering- D. M. Pozar, John Wiley & Sons, 3rd Ed., 2005.*

EC6307 Microwave Devices Cr – 3

Couse outcomes: After completion of the course the students will be able to

CO1: Recall the basic concepts of microwave diodes, BJT and FET.
CO2: Describe amplification and oscillation of solid state microwave devices.
CO3: Demonstrate mechanisms of Reflex Klystron oscillator.
CO4: Analyze microwave M-type sources like, BWO, Magnetron.
CO5: Evaluate and analyze microwave periodic structures.
CO6: Design microwave filters.

Prerequisite: Microwave Engineering

Microwave Solid State Devices: Basics of microwave BJT, microwave FET and microwave tunnel diode. Gunn effect, Gunn diode, Two-valley model theory, modes of operation (Gunn oscillation mode, LSA mode, SA mode), microwave generation and amplification using Gunn. READ diode, carrier current and external current in a READ diode resonant circuit, Working principle of IMPATT diode, Power output and efficiency of IMPATT circuit, TRAPATT diode and BARITT diode.

Microwave Sources: Reflex Klystron (velocity modulation, bunching process, power output, efficiency, electronic admittance spiral), BWO, Magnetron oscillator (Hull cut-off equations, strapping, frequency pulling & pushing, power output, efficiency).

Microwave Filters: Periodic structures and their analysis, filter design by image parameter method, constant k-filter and m-derived filter sections, filter design using insertion loss, filter transformations, design of stepped-impedance filters, coupled-line filters. **12Hrs**

Text Book:

1. Microwave Devices and Circuits- S. Y. Liao, Pearson Education, 3rd Ed., 2013.
2. Microwave Engineering- D. M. Pozar, John Wiley & Sons, 3rd Ed., 2005.

Reference Books:

1. Microwave Engineering – G. S. Raghuvanshi, CENGAGE Learning, 1st Ed., 2012.
2. Microwaves-Introduction to Circuits, Devices & Antennas–M. L. Sisodia & V. L. Gupta, New Age International, 1st Ed., 2004**.**

EC6309 RF and Antenna Engineering Cr – 4

Couse outcomes: After completion of the course the students will be able to

CO1: Memorize and learn microwave vacuum tubes and principle of microwave components.
CO2: Understand antenna basics and operation commonly used antennas.
CO3: Solve the design problems of broadband antennas.
CO4: Analyze and synthesize antenna arrays.
CO5: Judge the design principle of reflector antenna and microstrip antenna.
CO6: Investigate the antenna techniques for cellular communication.

Prerequisite: Electromagnetic Theory

Microwave Tubes: Limitations of conventional vacuum tubes, Reentrant cavities, Klystron amplifier (velocity modulation, bunching process, power output, efficiency), Slow wave structure, helix TWT.

Microwave Components: Scattering matrix formulation of microwave network, Tees, waveguide directional couplers (two-hole and Bathe-hole), rat-race ring, precision variable attenuator, coaxial attenuator, microwave phase shifters, waveguide slotted section, circulator, isolator, crystal detector.

Antenna Basics: Radiation mechanism, far field & near field, radiation pattern, E-plane & H-plane, radiation resistance, efficiency, effective aperture area, directivity, gain, beamwidth, bandwidth, linear & elliptic polarizations, cross polarization, antenna factor, antenna-noise temperature, equivalence theorem, Friis transmission formula.

Antennas: Dipole & monopole antennas, sleeve antenna. Waveguide antenna, pyramidal and conical horns, sectoral horns, Helical antenna and dielectric resonator antenna, Discone antenna, turnstile antenna, plasma antenna, Vivaldi antenna, electrically small antennas and their fundamental limits.

Broadband and Frequency-independent Antennas: Rumsay's principle, planar log-spiral antenna, log-periodic antenna, Yagi-Uda array.

Antenna Arrays: Uniform n-element linear array, grating lobes, planar antenna array, phased array antenna, adaptive antennas, Dolph-Tchebyscheff array, basic concept of thinned array antennas and methods of array thinning.

Reflector Antennas: Corner reflectors, parabolic reflector, losses in parabolic reflector, tilted and offset-fed parabolic reflector, Cassegrain antenna.

Microstrip Antennas: Advantages and disadvantages of microstrip patch antennas, radiation from microstrip antenna, field configurations, design equations for rectangular and circular microstrip patches. Analysis of microstrip antennas using transmission line model and cavity method, Stacked, proximity-coupled and aperture-coupled microstrip antennas, ceramic antenna, PIFA.

Special Antenna Techniques for Wireless Communications: Antenna Diversity Techniques, base station and mobile station antennas, Sector Antennas, Smart Antennas, MIMO antennas, SDMA Antennas, concept of UWB antennas.

Text Books:

1. Antennas for All Applications-J. D. Kraus & R. J. Marhefka, Tata McGraw Hill, 3rd Ed., 2007.
2. Antenna Theory – Analysis and Design-C. A. Balanis, Harper & Row, 3rd Ed., 2005.

Reference Books:

1. Antennas and Radio Wave Propagation-R. E. Collin, McGraw Hill, 1st Ed., 1985.

EC6302 RF Circuit Design Cr – 4

Couse outcomes: After completion of the course the students will be able to

CO1: Memorize RF passive components.
CO2: Describe RF filter design.
CO3: Demonstrate design principles of matching and biasing networks.
CO4: Analyze and design RF transistor amplifiers.

CO5: Design principles of RF oscillators.
CO6: Design RF mixers.

Prerequisite: **Advanced Electromagnetics**

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

An Overview of RF Filter Design: Introduction to Periodic Structures, Basic Resonator and Filter Configurations, Insertion Loss, Special Filter Realizations: Butterworth –Type, Chebyshev and Denormalization of Standard Low-Pass Design. Filter Implementations: Kuroda's identities and examples of microstrip filter design, Coupled filter design.
.
Matching and Biasing Network: Impedance matching using discrete components: two component matching networks. Microstrip line matching networks: from discrete components to microstrip lines, single-stub matching networks, double-stub matching networks, Amplifier Classes of Operation and Biasing Network, Field effect transistor biasing networks.

RF Transistor Amplifier Design: Amplifier Power Relations: RF source, Transducer Power Gain, Additional Power Relations, Stability Considerations: Stability Circles, Unconditional Stability, Stabilization Methods. Constant Gain: Unilateral Design, Unilateral Figure of Merit, Bilateral Design, Broadband, High Power and Multistage Amplifiers.

RF Oscillators and Mixers: Basic Oscillator Model: Negative resistance oscillator, Feedback oscillator design, Design steps, Quartz oscillators. High frequency oscillator Configuration: Fixed frequency oscillators, Dielectric resonator oscillators, YIG-Tuned oscillators, Voltage-controlled oscillators, Gunn oscillator, Characteristics of different types of Mixers.

Text Books:

RF Circuit Design Theory and Application- R. Ludwig and P. Bretchko, Pearson Education, 1st Ed., 2009.

Reference Books:

Radio Frequency & Microwave Electronics Illustrated, M. Radmanesh, Pearson Education, 1st Ed., 2004.

EC6316 Microwave Integrated Circuits Cr – 3

Couse outcomes: After completion of the course the students will be able to

CO1: Define basics if microwave integrated circuits.
CO2: Classify Planar Transmission Lines-I.
CO3: Demonstrate Planar Transmission Lines-II.
CO4: Analyze Parallel-coupled Microstrip Lines.
CO5: Evaluate the design methods of planar Power Dividers.
CO6: Design, measure and testing of microwave integrated circuits.

Prerequisite: **Advanced Electromagnetics**

Introduction: Introduction to Microwave Integrated Circuits (MIC) and Monolithic Microwave Integrated Circuits (MMICs), their advantages over discrete circuits, MMIC fabrication techniques, Thick and Thin film technologies and materials, encapsulation and mounting of active devices in MIC and MMIC.

Planar Transmission Lines-I: Strip line & microstrip line, field configurations, quasi-TEM mode in microstrip line, analysis of microstrip transmission line, concept of effective dielectric constant, impedance of Strip line & microstrip line, dispersion and losses in microstrip line, discontinuities in microstrip.

Planar Transmission Lines-II: Slot Line, approximate analysis and field distribution of slot line, transverse resonance method and evaluation of slot line impedance, comparison with microstrip line. Fin lines & Coplanar Lines, analysis of Fin lines by transverse resonance method, conductor loss in Fin lines, coplanar wave guide (CPW).

Parallel-coupled Microstrip Lines and Power Dividers: Coupled microstrip lines, even mode and odd mode characteristic impedances, semi-empirical formulae for coupled line parameters, coupled-region length, coupler directivity, crosstalk between microstrip lines, design of microstrip branch-line power divider and rat-race ring power divider.

MIC Measurement, Testing and Applications: MIC measurement system, microwave test fixtures and probes, measurement techniques of S- parameters, noise measurement.

Text Books:

1. *Microstrip Lines and Slot Lines - K.C. Gupta, R. Garg. , I. Bahl, P. Bhartia, Artech House, 2nd Ed., 1996.*
2. *Foundation for Microstrip Circuit Design-T. C. Edwards, John Wiley & Sons Ltd, 2nd Ed., 1992.*

Reference Books:

1. *Stripline-like Transmission lines for Microwave Integrated Circuits, B. Bhat, S. K. Koul, Wiley Eastern Ltd, 1st Ed., 1989.*
2. *Microwave Integrated Circuits, K.C. Gupta and A. Singh, Wiley Eastern Limited, 1st Ed., 1975.*

EC-6322 Planar and Small Antennas Cr-3

Couse outcomes: After completion of the course the students will be able to

CO1: Remember the antenna basics and planar antennas.
CO2: Describe and discuss characteristics and principles of microstrip antennas.
CO3: Demonstrate and implement the CP patch antennas and microstrip antenna arrays.
CO4: Analyze planar slot antennas and planar monopole antennas.
CO5: Evaluate characteristics and design aspects of electrically small antennas.
CO6: Investigate planar antennas for special applications for wireless access.

Prerequisite: RF and Antenna Engineering

Planar Radiators: Introduction to antennas (radiation pattern, directivity, efficiency, gain, impedance, axial ratio etc.), different types of planar antennas, applications of planar antennas, Brief description of fabrication process of planar antennas.

Microstrip Patch Antennas-I: Characteristics of microstrip patch antennas, radiation from microstrip antenna, field configurations, different types of feeding techniques. Design equations for rectangular and circular microstrip patches, analysis of microstrip antennas using transmission line model and cavity method. Broadband techniques using stacked patch antennas, proximity-coupled and aperture-coupled microstrip antennas, slot-loaded and slit-loaded microstrip antennas, microstrip antennas with shorted pin, effect of finite ground plane on the performance of microstrip antennas, principle of planar fractal antennas.

Microstrip Patch Antennas-II: Methods of generating circular polarization in microstrip antennas using single feed and double feed, methods of generating multiple frequencies using microstrip antennas, miniaturization techniques for mcirostrip antennas. Design techniques of microstrip antenna arrays with feed network, effect of mutual coupling, microstrip phased array antenna design.

Planar Slot Antennas: Geometry and design of microstrip slot antenna, radiation pattern, CPW-fed slot antennas, design of folded slot antenna, annular slot antenna.

Planar Monopole Antennas: Feeding methods and characteristics of planar triangle monopole, Sierpinski monopole, planar bi-conical monopole antenna and roll monopole antenna.

Electrically Small Antennas: Electrically small antennas and their limitations, planar inverted F antenna (PIFA), PIFA for wireless potable sets, ground-plane effects on PIFA performance, different types of PIFA, multi-frequency PIFA, Printed notch antennas, small fractal antennas, dielectric resonator antennas, small Tera Hertz antennas.

Planar Antennas for Special Applications: Planar mobile handset antennas, planar laptop computer antennas, planar antennas for USB modem, planar antennas for WLAN and UWB communication.

Text Books:

1. R. Garg, P. Bhartia, I. Bahl and A. Ittipiboon, Microstrip Antenna Design Handbook, Artech House, 1st Ed., 2001.
2. Broadband Planar Antennas-Design & Applications- Z. N. Chen & M. Y. W. Chia, John Wiley & Sons, 1st Ed., 2006.

Reference Book:

1. Compact and Broadband Microstrip Antennas-K-L. Wong, John Wiley & Sons, 1st Ed., 2002.

EC6315 Computational Electromagnetics Cr – 3

Couse outcomes: After completion of the course the students will be able to

CO1: Define numerical problems and their solutions in electromagnetic problems.
CO2: Classify integral equation and Green's function.
CO3: Solve numerical problems for dipoles using method of moment.
CO4: Analyze and solve finite difference method for electromagnetic problems.
CO5: Evaluate numerical problems using Finite Element method.
CO6: Formulate electromagnetic diffraction problem using GTD & UTD.

Prerequisite: Advanced Electromagnetics

Introduction: Need for numerical solution of electromagnetic problems, selection of a numerical method, classification of electromagnetic problems, classification of solution region, classification of boundary conditions.

Integral Equation and Green's Function: Classification of integral equations, relation between differential and integral equations, overview of Green's function, Green's function for free space, Green's function with conducting boundaries (method of Images & Eigen function expansion).

Method of Moments: Overview, application to quasi-static problems (thin conducting wire, parallel plate capacitor), application of scattering from a short dipole, mutual impedance of two short dipoles, etc.

Finite Difference Methods: Overview, finite difference schemes, finite differencing of parabolic, hyperbolic & elliptical partial differential equation, practical applications of FD technique (guided structures). Finite Difference Time Domain Methods: Yee's FD algorithms, accuracy & stability, lattice truncation condition, initial fields, absorbing boundary conditions for FDTD, finite differencing for nonrectangular systems.

Finite Element Method: Finite element discretization, element governing equations, assembling of all elements, solving the resulting equations, typical applications.

Electromagnetic Diffraction: Geometrical theory of diffraction & its uniform theory of diffraction (UTD).

Text Books:

1. Numerical Techniques in Electromagnetics- M. N. O. Sadiku, CRC Press, 2nd Ed., 2001.
2. Analytical and Computational Methods in Electromagnetics–R. Garg, Artech House, 1st Ed., 2008.

Reference Book:

1. Numerical Techniques in Microwave and Millimeter wave Passive Structures - T. Itoh (Ed.), John Wiley & Sons, 1st Ed., 1989.

EC6311 Microwave Remote Sensing Cr-3

Couse outcomes: After completion of the course the students will be able to

CO1: Define physical parameters of microwave remote sensing.
CO2: Classify passive and active polarimetry.
CO3: Describe microwave scattering, emission and microwave radiometer.
CO4: Analyze passive imaging.
CO5: Evaluate principle of active imaging.
CO6: Design and analyze interferometer.

Prerequisite: Advanced Electromagnetics

Microwave Remote Sensing and Physical Fundamentals: Electromagnetic spectrum and penetration capabilities of electromagnetic wave through vegetarian, soil, moisture etc. energy and power of wave. Introduction to microwave remote sensing, microwave remote sensing from space, radios, death rays, principles of radar, phase as a distance measure, passive remote sensing and active remote sensing.

Polarimetry: Polarized wave and partially polarized wave, scattering matrix, passive polarimetry and Radar polarimetry, polarimetric ratio, coherent parameters and polarimetric decomposition.

Microwave in Remote Sensing: Microwave brightness temperature, interaction with discrete objects, radar cross-section, microwave scattering and emission from oceans, lakes, ice, snow, glacier, soil, vegetarian, rocks, deserts etc, detection of microwaves, microwave radiometer, antenna properties for microwave remote sensing, Dielectric properties of earth materials at microwave frequencies, atmospheric sounding.

Passive and Active Imaging: Principles of passive imaging, practical radiometers, measurement of parameters related to ocean, sea, ice, land. Principles of active imaging using Radar, altimeter measurement, scanning altimeters, echo shape analysis, synthetic aperture altimeters, rain Radar, wind scatterometers, imaging Radar, principles of synthetic aperture radar (SAR), SAR focusing, scanSAR operation, spotlight mode, SAR images, speckle statistics and speckle filtering.

Interferometry: Principles of interferometry, phase measurements, interferometry for resolving direction, passive imaging interferometry, Radar interferometry, interferometric altimetry, interferometric SAR, vegetation height estimation.

Text Books:

1. Introduction to Microwave Remote Sensing – I. H. Woodhouse, CRC Press/Taylor & Francis, 2006.

Reference Books

1. Remote Sensing of Snow and Ice- G. Rees, CRC Press, Taylor & Francis, 2006
2. Fundamentals of Remote Sensing and Airphoto Interpretation - G. L.L. Berlin and T. E. Avery, Prentice Hall, NJ, USA, 2003.

ECxxxx ARTIFICIAL NEURAL NETWORK AND FUZZY SYSTEMS Cr-3

Couse outcomes: After completion of the course the students will be able to

CO1. understand the fundamentals of neural networks and a develop an overview of broad learning strategies.

CO2. understand fundamental neural models, their learning strategies and apply them for simple modeling problems.

CO3. understand the architecture and need for multi-layer feed forward neural networks, Recurrent neural networks, radial basis function networks and apply them for simple modeling problems.

CO4. comprehend the concepts, architecture, training and testing algorithms corresponding to auto-associative, hetero-associative and bidirectional associative memory networks.

CO5. comprehend and apply knowledge of Fuzzy Logic to develop fuzzy system.

CO6. develop a comprehensive idea on unsupervised learning networks and advanced neural networks with application of fuzzy logic..

Introduction: Neural network, models of neuron, network architecture, artificial intelligence versus neural networks.

Learning Processes and Perceptrons: Error-correction and memory-based learning, Hebbian learning, competitive and other types of learning. Learning curves and learning rate annealing techniques, single-layer perceptron, perceptron convergence theorem. Multilayer perceptron, back-propagation algorithm, heuristics for making back-propagation algorithm perform better, output representation and decision rule.

Artificial Neural Networks and Neurodynamics: Radial-basis function networks, interpolation problem, regularization network, generalized radial-basis function networks.

Support vector mechanics. Neurodynamical systems, stability, neurodynamical models, Hopfield and related models.

Fuzzy Sets and Fuzzy Rules: Introduction to fuzzy logic, various parameters, set-theoretic operations, MF formulation, fuzzy union, intersection and complement. Extension principle and fuzzy relations, uzzy rules, fuzzy reasoning.

Fuzzy Models and Fuzzy Systems: Mamdani fuzzy models, Sugeno fuzzy models, Tsukamoto fuzzy models, example of various fuzzy systems, neuro-fuzzy system, adaptive neuro-fuzzy system.

Text Books:

1. Neural Networks -A Comprehensive Foundation- S. Haykin, 2^{nd} Ed., Pearson Education Asia, 1999.
2. Neural Network Design-M.T. Hagan, H. B. Demuth and M. Beale, Cengage Learning, 2011.

Reference Books:

1. Neuro-Fuzzy and Soft Computing - J. S. R. Jang, C. T. Sun and E. Mizutani, PHI/Pearson, 2004.
2. Fuzzy Logic with Engineering Applications- T. J. Ross, Wiley, 2004.

EC-6312	Electromagnetic Interference and Electromagnetic Compatibility	Cr-3

Couse outcomes: After completion of the course the students will be able to

CO1: Define electromagnetic interference and electromagnetic compatibility.
CO2: Explain EMC requirements in electronics systems.
CO3: Solve the problems of conducted emission and susceptibility.
CO4: Analyze cross talk between open transmission lines and shielded cables/lines.
CO5: Evaluate the shielding problem in EMI/EMC.
CO6: Design EMI/EMC systems.

Prerequisite: Advanced Electromagnetics

Introduction to Electromagnetic Interference and Electromagnetic Compatibility: Electromagnetic interference & its analysis, types of noise & interference, electromagnetic compatibility, radiated emission & susceptibility, conducted emission & susceptibility, benefits of good EMC design, EMI/EMC standards and regulations.

EMC Requirements for Electronic Systems: Requirement for commercial products and military products, radiated emission limits for class A, class B, FCC and CISPR, measurement of emissions for verification of compliance: Radiated Emission and conducted emissions, product requirements, design constraints for products, advantages of EMC design.

Conducted Emission and Susceptibility: Measurement of conducted emission: LISN, common and differential mode currents, power supply filters: basic properties of filters, a generic power supply filter topology, effect of filter elements on common and differential mode currents, separation of conducted emissions into common and differential mode components for diagnostic purpose, power supplies: Linear and SMPS, effect of power supply components on conducted emissions, power supply and filter placement, conducted susceptibility.

Radiated Emission and Susceptibility: Simple emission models for wires and PCB lands: Differential mode versus common mode currents, differential mode current emission model, common mode current emission model, current probes, simple susceptibility models for wires and PCB lands: Shielded cables and surface transfer impedance, EMI measurement and EMI sensor.

Cross Talk: Three conductor transmission lines and crosstalk, Transmission line equations for lossless lines, line parameters, inductive-capacitive coupling approximation model: Frequency domain inductive-capacitive coupling model, time domain inductive-capacitive coupling model, lumped circuit approximate models. Shielded wires: Per unit length parameters, inductive and capacitive coupling, effect of shield grounding, effect of pigtails, effects of multiple shields, MTL model predictions, Twisted wires: Per unit length parameters, inductive and capacitive coupling, effects of twist, effects of balancing.

Shielding: Shielding effectiveness, far field sources: Exact solution, approximate solution, near field sources: near field versus far field, electric sources, magnetic sources, low frequency, magnetic fielding shielding, effect of apertures.

System Design for EMI/EMC and Other Related Issues: Shielding and grounding, PCB Design, electrostatic discharge, diagnostic tools. Signal integrity and its effect in PCB design. Annoying effect, distributing effect, biological effect of EMI.

Text Books:

1. Introduction to Electromagnetic Compatibility-C. Paul, John Wiley & Sons, 2nd Ed., 2006.
2. Electromagnetic Compatibility Handbook – K. L. Kaiser, CRC Press Inc., 2nd Ed., 2005.

Reference Books:

1. Electronic Communications Systems- G. Kennedy, McGraw-Hill, 4th Ed., 2003.
2. Noise Reduction Techniques in Electronic Systems- H. W. Ott, John Wiley & Sons, 2nd Ed., 1976.

EC6318 RF Micro-Electromechanical Systems Cr -3

Couse outcomes: After completion of the course the students will be able to

CO1: Define MEMS system and learn MEMS fabrication.
CO2: Explain MEMS Actuators and Sensors.
CO3: Demonstrate MEMS Materials and Fabrication Techniques.
CO4: Analyze MEMS Switches and Micro Relays.
CO5: Evaluate the design principles of MEMS Inductors and Capacitors.
CO6: Design MEMS Packaging and MEMS Applications.

Prerequisite: RF Circuit Design

MEMS Fabrication Processes: Introduction**,** MEMS Overview, Microfabrication of MEMS: Surface Micromachining, Bulk Micromachining, LIGA, micromachining of polymeric MEMS devices, Three dimensional microfabrications.

MEMS Actuators and Sensors: Electromechanical transducers: Piezoelectric transducers, Electrostrictive transducers, Magnetostrictive transducers, Electrostatic actuators, Electromagnetic transducers, Electrodynamic transducers, Electrothermal actuators, comparison of electrothermal actuation process, Microsensing for MEMS: Piezoresistive sensing, Capacitive sensing, Piezoelectric sensing, Resonant sensing, Surface Acoustic Wave sensors.

MEMS Materials and Fabrication Techniques: Metals, semiconductors, thin films for MEMS and their deposition techniques, materials for polymer MEMS, Bulk micromachining for silicon based MEMS, Silicon surface micromachining, Microstereolithography for polymer MEMS.

MEMS Switches and Micro Relays: Switch parameters, basics of switching, Switches for RF and microwave applications, actuation mechanisms for MEMS devices, bistable micro relays and microactuators, dynamics of switch operation, MEMS switch design considerations, modeling and evaluation.

MEMS Inductors and Capacitors: MEMS Micromachined passive elements: pros and cons, MEMS Inductors: self and mutual inductance, micromachined inductors, reduction of stray capacitance, improvement of quality factor, folded inductors, modeling and design issues of planar inductors, variable inductor and polymer based inductor. MEMS Capacitors: MEMS gap tuning capacitor, MEMS area tuning capacitor, Dielectric Tunable capacitors.

MEMS Packaging and MEMS Applications: MEMS packaging: Role of MEMS packaging, Types of MEMS packaging, flip-chip and multichip module packaging, RF MEMS packaging issues, Micromachined transmission line and components, micromachied RF Filters, Micromachined Phase shifters & Micromachined antenna, Gyros and Bio-MEMS.

Text Books:

1. RF MEMS: Theory, Design, and Technology-Gabriel M. Rebeiz, John Wiley & Sons, 1st Ed., 2003.
2. RF MEMS & Their Applications-V. K. Varadan, K. J. Vinoy and K. A. Jose, John Wiley & Sons, 1st Ed., 2003.

Reference Books:

1. MEMS and Microsystems: Design and Manufacture-Tai-Ran Hsu, Tata McGraw-Hill, 1st Ed., 2002.

EC6314 RADAR and Navigation Engineering Cr – 3

Couse outcomes: After completion of the course the students will be able to

CO1: Define basics of RADAR.
CO2: Describe RADAR Transmitters and Receivers.
CO3: Demonstrate different types of RADAR.
CO4: Distinguish and classify methods of Navigation.
CO5: Evaluate the principles of Aircraft Homing System.
CO6: Construct Aircraft Landing System.

Prerequisite: RF & Antenna Engineering

Introduction to RADAR: Radar principle, Radar system losses & propagation losses, antennas, Radar cross section, Rayleigh region, Mie region, Optical region, Scanning & Tracking Radars, Radar clutter, SONAR & LIDAR, Synthetic aperture Radar (SAR).

RADAR Transmitters and Receivers: Principles of microwave power sources (qualitative) Radar modulators & Radar transmitters, Types of Radar receivers, receiver noise and noise figure, receiver protectors.

Types of RADAR: Basic principles of CW Radar, FMCW & Gated CW Radars, Pulse Doppler Radar, MTI Radar.

Navigation Engineering: Methods of navigation (celestial navigation, pilotage and dead reckoning, radio navigation). Classes of radio direction finders, direction finding using loop antennas and errors in

this method, Adcock direction finders, Goniometer, automatic direction finders, Radar Beacons, Hyperbolic electronic navigational systems (Decca, Consol, Omega & LORAN systems), Principles of distance measuring equipment (DME) and tactical air navigation (TACAN).
10Hrs

Aircraft Homing System and Landing System: Switched cardiod homing system, four course radio range, omnidirectional range, VHF omnirange (VOR), electrical pattern rotation, recovery of reference phase and measurement of bearing, Doppler VOR, Instrument landing system, elevation and azimuth guidance, localizer, Ground control approach, Radar altimeter, principle of precision approach radar (PAR) landing system, jamming & anti-jamming techniques.

Text Books:

1. Introduction to Radar Systems - M.I. Skolnik, Tata McGraw Hill, 3rd Ed., 2003.
2. Radar Systems and Radio Aids to Navigation- A. K. Sen and A. B. Bhattacharya, Khanna Publishers, 1988.

Reference Books:

1. Fundamentals of RADAR, SONAR and Navigation Engineering (with Guidance) – K. K. Sharma, S. K. Kataria & Sons Publication, 1st Ed., 2012.

EC6324 Adaptive Antennas and Smart Antennas Cr – 3

Couse outcomes: After completion of the course the students will be able to

CO1: Memorize the basics of antennas and antenna arrays.
CO2: Classify Adaptive Processing.
CO3: Demonstrate Mutual Coupling in Adaptive Antennas.
CO4: Analyze and formulate Direction of Arrival (DOA) Estimation.
CO5: Differentiate between Adaptive Signal Processing for Smart and phased array antennas.
CO6: Formulate Space-Time Adaptive Processing.

Prerequisite: RF and Antenna Engineering

Introduction: Basics of linear antenna arrays, circular antenna arrays and phased antenna arrays. Concept of adaptive antennas and smart antennas, adaptive processing using minimum variance distortionless technique, application of smart antennas.

Direct Data Domain Least Square Approaches to Adaptive Processing: Direct data domain least square procedures, eigenvalue method, forward method, backward method, forward-backward method, main beam construction for prevention of signal cancellation.

Mutual Coupling in Adaptive Antennas: Mutual coupling among an array of dipoles, compensation using open-circuit voltages and minimum norm formulation, effect of mutual coupling for constant jammers and constant signals, compensation for mutual coupling for constant jammers and constant signals, effect of thermal noise on the adaptive algorithm.

Direction of Arrival (DOA) Estimation and Adaptive Signal Processing for Smart Antennas: Problem formulation, transformation matrix to compensate undesired electromagnetic effects, DOA estimation for a semicircular array, adaptive processing using a single snapshot from a non-uniformly spaced array in presence of mutual coupling and near-field scatterers, DOA estimation using a phased array on a conformal hemispherical surface, DOA estimation using cyclostationarity, DOA estimation in a multipath environment.

Direct Data Domain Least Squares Space-Time Adaptive Processing (STAP): Signals and information, signal processing method, direct data domain space-time approach, least squares forward processor, least squares backward processor, direct data domain least squares STAP for circular arrays, knowledge-based STAP processing.

Text Books:

1. Smart Antennas – T. K. Sarkar, M. C. Wicks, M. Salazar-Palma and R. J. Bonneau, Wiley-Interscience, 1st Ed., 2003.
2. Smart Antennas for Wireless Communication: With MATLAB- F. Gross, McGraw Hill, 1st Ed., 2005.

Reference Books:

1. Smart Antennas for Wireless Communications: IS-95 and Third-Generation CDMA - J. C. Liberti and T. S. Rappaport, Prentice Hall, 1st Ed., 1999.
2. Smart Antenna Engineering - Ahmed El-Zooghby, Artech House, 1st Ed., 2005.

EC-6326 Millimetre Wave Communication Systems Cr – 3

Couse outcomes: After completion of the course the students will be able to

CO1: Define Millimeter Wave Characteristics.
CO2: Understand Modulation Techniques for Millimeter Wave Communications.
CO3: Solve design problems of Millimeter Wave Transceivers.
CO4: Analyze different types of Millimeter Wave Antennas.
CO5: Evaluate the design aspects of Millimeter Wave MIMO Systems.
CO6: Design and construct Millimeter Wave Application Systems.

Prerequisite: RF & Antenna Engineering

Millimeter Wave Characteristics: History of millimeter wave development, propagation characteristics of millimeter wave, attenuation of millimeter wave by atmosphere, rain and foliage loss, channel performance at 60 GHz, Gigabit wireless communications, short range communication and enhanced security, development of millimeter wave standards, coexistence with wireless backhaul.

Modulation Techniques for Millimeter Wave Communications: On/Off Keying (OOK), Phase Shift Keying (PSK), Frequency Shift Keying (FSK), Quadrature Amplitude Modulation (QAM), Orthogonal Frequency Division Multiplexing (OFDM).

Millimeter Wave Transceivers: Millimeter wave link budget, transceiver architecture, transceiver without mixer, receiver without local oscillator, millimeter wave calibration.

Millimeter Wave Antennas: Path loss and antenna directivity, antenna beamwidth, maximum possible Gain-to-Q, polarization, beam steering antenna, millimeter wave design consideration, antennas for millimeter wave communication.

Millimeter Wave MIMO Systems: Spatial diversity of antenna arrays, multiple antennas, multiple transceivers, noise coupling in a MIMO system, potential benefits for millimeter wave systems, spatial diversity, frequency diversity and temporal diversity, advantages of single carrier frequency domain equalization (SC-FDE) over OFDM for millimeter wave systems.

Millimeter Wave Application Systems: Radio stations at 50 GHz, wireless LAN systems, WPAN and broadband wireless access systems at millimeter wave band, wireless train communication systems, intelligent transport systems (ITS) using millimeter wave technology, satellite broadcasting systems in millimeter wave band, millimeter wave technology for broadband wireless communication using high altitude platform (HAP).

Text Books:

1. Millimeter Wave Communication Systems-K-C. Huang, Z. Wang, Wiley-IEEE Press, 2011.
2. Modern Millimeter Wave Technologies-T. Teshirogi & T. Yoneyama (Ed), IOS Press, 2000.

Reference Books:

1. E. Carey and S. Lidholm, Millimeter-wave Integrated Circuits, Springer, 2005.
2. Millimeter Wave Technology in Wireless PAN, LAN, and MAN - S-Q. Xiao, M-T. Zhou (Ed), CRC Press, 2008.