I SEMESTER

15LW01 / 15LC01 APPLIED MATHEMATICS

2 2 0 3

VECTOR SPACES: Real vector spaces and subspaces – linear independence - basis and dimension – row space, column space and null space - Rank and nullity. (6+6)

INNER PRODUCT SPACES: Inner products – angle and orthogonality in inner product spaces – Orthonormal bases: Gram-Schmidt process, and QR decomposition – Best approximation: Least squares – change of basis – Orthogonal matrices. (6+6)

LINEAR TRANSFORMATION: Linear transformations – kernel and range – inverse linear transformation – matrices of linear transformation. (3+3)

STOCHASTIC PROCESSES: Introduction – classification of Stochastic processes. Markov chain: Introduction, - transition probability matrices, Chapman Kolmogorov equations, classification of states, limiting probabilities, Poisson Process - continuous Time Markov chain: birth-death processes, transition probability functions, Kolmogorov equations, limiting probabilities. (6+6)

GRAPH THEORY: Graphs - directed and undirected, sub graphs, graph models, degree of a vertex, degree sequence, hand-shaking lemma, walk, trail, path, connectedness, distance, diameter. Common classes of graphs – regular, complete Petersen, cycle, path, tree, k-partite, planar, hypercube, mesh - Isomorphic graphs. Representation of graphs – adjacency list, incidence list, adjacency matrix and incidence matrix, Eulerian graphs – Chinese postman problem and its solution – Hamiltonian graphs – travelling salesman problem – nearest neighbour algorithm. (9+9)

CASE STUDIES: Applications of Vector space, Stochastic processes and Graph theory in communication systems and networks, image processing and information theory.

Total L: 30 + T: 30 = 60

REFERENCES:

1. Howard Anton and Chris Rorres, “Elementary Linear Algebra”, Wiley India, New Delhi, 2011.
2. David C Lay, “Linear Algebra and Its Applications”, Pearson Education, New Delhi, 2013.
3. Sheldon M Ross, “Introduction to Probability Models”, Academic Press, India, 2014.
4. Saeed Ghahramani, “Fundamentals of Probability with Stochastic processes”, Pearson, New Delhi, 2012.
5. Jonathan L Gross and Jay Yellen, “Graph Theory and its Applications”, Chapman & Hall, New York, 2005.

15LW02 BASEBAND DIGITAL COMMUNICATIONS

3 0 0 3

BASEBAND MODULATION: Sampling theorem, Quantization, Baseband Signaling Concepts - Signaling formats - RZ/NRZ, Duobinary Splitphase (Manchester) and high density bipolar coding, PAM, PCM, Delta modulation, Linear Prediction, DPCM, ADPCM, Adaptive delta modulation. (9)

BASEBAND DEMODULATION: Error performance degradation in Communication systems, Signal-to-noise ratio, Probability of error, Detection of Binary signals in Gaussian Noise- matched filter, Maximum Likelihood receiver, error probability performance, ISI, Nyquist’s criterion, pulse shaping, Equalization. (9)

EQUALIZATION: ISI and Channel Capacity , Optimal zero forcing equalization, Generalized Equalization Methods, Fractionally Spaced Equalizer, Transversal Filter Equalizers, Adaptive Equalizers – Adaptive Linear Equalizer, Adaptive DFE. (9)

SYNCHRONISATION OF DIGITAL COMMUNICATION SYSTEM: General problem of synchronization - MAP and ML estimation of signal parameters - Generalization of the estimator equations to multiple symbol intervals and multiple parameters - Data aided and Non data aided synchronization - Carrier recovery circuits - Symbol clock estimation schemes. (9)

ERROR CONTROL CODING: Linear block codes - Optimum soft decision decoding of linear block codes - Hard decision decoding - Polynomial representation of codes - Cyclic codes - Convolutional codes - Viterbi decoding algorithm – Other decoding methods of convolutional codes, Galois fields, BCH codes, Reed Solomon codes, Berlekamp Algorithm, Interleaving and Concatenated codes, Turbo codes, Low- Density Parity-Check codes. (9)

Total L: 45

REFERENCES:

1. Bernard Sklar, "Digital Communications", Pearson Education Asia, 2009.
2. Proakis J G, "Digital Communications", McGraw Hill Inc, 2008.
3. Krzyszbof Wesolowski, "Introduction to Digital Communication Systems", John Willey India, 2012.
4. Barry S, Lee E A and Messershmitt D J, “Digital Communications”, Kluwer Academic Press, 2004.
5. Peter Sweeney, “Error Control Coding from Theory to Practice”, John Wiley and Sons, 2002.

15LW03 WIRELESS NETWORKING

3 0 0 3

WIRELESS PERSONAL AREA NETWORKS: Introduction to Bluetooth, WPAN Device Architecture, Protocol Stack, Network Connection Establishment, Topology Applications, - Low Rate and High Rate WPAN, Wireless Sensor Network, Protocol Stack, IEEE 802.15.3 – Zig bee Technology IEEE 802.15.4- Ultra Wideband, (10)

WIRELESS LOCAL AREA NETWORKS: Introduction to Wireless LANs – WLAN Equipment, Topologies, Technologies, Architecture and Services, Physical Layer- MAC SubLayer –MAC Management Sub Layer, other IEEE 802.11 Standards, Interference between Bluetooth and IEEE 802.11, HIPERLAN, Introduction to IEEE 802.16 WiMAX - General description. (9)

WIRELESS WIDE AREA NETWORKS: Multiple Access techniques FDMA, Second Generation TDMA-GSM (Network Architecture) CDMA-IS 95, GPRS – EDGE. (9)

ADHOC WIRELESS NETWORKS: Characteristics of Adhoc Networks, Classifications of MAC Protocols - Table driven and Source initiated On Demand routing protocols, DSDV, AODV, DSR, Hybrid Protocols, TCP over Ad Hoc Wireless Networks. (8)

SATELLITE COMMUNICATION AND GLOPAL POSITIONING SYSTEM: Introduction to satellite communication, Satellite parameters and Configuration - Different types of Satellite – Design and Principle of Operation of GPS, Satellite Segment, Control Segment, User Segment -Differential GPS. (9)

Total L: 45

REFERENCES:

1. William Stallings, “Wireless Communications and Networks”, Pearson/Prentice Hall of India, 2009.
2. Vijay K Garg, “Wireless Communication and Networking”, Morgan Kaufmann Publishers, 2010.
3. Dharma Prakash Agrawal and Qing-An Zeng, "Introduction to wireless mobile systems" Thomson India, 2007.
4. Siva Ram Murthy C and Manoj B S, “Ad Hoc Wireless Networks: Architectures and Protocols”, Prentice Hall, 2004.
5. Maral G and Bosquet M, “Satellite communications systems Techniques and Technologies, John Wiley & sons, 2009.

15LW04 WIRELESS COMMUNICATION SYSTEMS

3 0 0 3

CELLULAR SYSTEMS AND STANDARDS: Advanced Mobile Phone Systems (AMPS) – Global System for Mobile Communication – Frequency Bands and Channels – International Mobile Telecommunications (IMT-2000) – Spectrum Allocation – Services provided by 3G Cellular Systems – Harmonized 3G Systems – Universal Mobile Telecommunications Systems (UMTS) - 3G UMTS signal processing, WCDMA, HSPA, HSPA+, Towards 4^{th} G, LTE and LTE advanced. (8)

INFRASTRUCTURE-BASED WIRELESS NETWORKS: Cellular System Design, Frequency Reuse in Cellular Systems, Frequency Reuse in Code-Division Systems, Frequency Reuse in Time and Frequency Division Systems, Dynamic Resource Allocation in Cellular Systems, Area Spectral Efficiency. . (9)

PATH LOSS, AND SHADOWING : Free-Space Path Loss, Two-Ray Model, Simplified Path Loss, Shadow Fading, Path Loss and Shadowing, Outage Probability under Path Loss and Shadowing, Cell Coverage Area. (9)

STATISTICAL MULTIPATH CHANNEL MODELS & CHANNEL CAPACITY: Time-Varying Channel Impulse, Narrowband fading models, Autocorrelation, Cross Correlation, and Power Spectral Density, Envelope and Power Distributions, Level Crossing Rate and Average Fade Duration, Markov Channels, Wideband Fading Models, Power Delay Profile, Coherence Bandwidth, Doppler Power Spectrum and Channel Coherence- Capacity in AWGN, Flat Fading, Selective Fading Channels. (10)

BER ANALYSIS OF WIRELESS CHANNELS: BER: Error Probability for BPSK and QPSK in AWGN Channel, BER analysis of Fading Channels – Outage Probability, Average Probability of Error, Moment generating function approach to average error probability, Combined outage and average error probability. (9)

Total L: 45

REFERENCES:

1. Andrea Goldsmith, “Wireless Communications”, Cambridge University Press, 2007.
2. Andreas F Molisch , “Wireless Communications”, John Wiley & Sons, 2010.
3. Dharma Prakash Agarwal and Qing- An zeng, “Introduction to Wireless and Mobile Systems”, Vikas Publishing House, New Delhi, 2004.
4. Singal T L, "Wireless Communications" Tata McGraw Hill, 2010.
5. Theodore S Rappaport, “Wireless Communications”, Pearson Education, Asia , New Delhi, 2009

15LW05/15LC05 RF PASSIVE CIRCUIT DESIGN

3 2 0 4

PASSIVE RF COMPONENTS AND TRANSMISSION LINE ANALYSIS: High frequency Resistors, Capacitor and Inductors – Transmission Line Analysis: Line equation, Micro strip line, Voltage Reflection Co-efficient, propagation constant phase velocity and special termination - Smith Chart-Impedance transformation - Analysis of parallel RL circuit and parallel RC circuit. (9+6)

SINGLE AND MULTI PORT NETWORK THEORY AND RF FILTER DESIGN: Definition - properties - interconnection of networks - ABCD parameters and S parameters - RF Filter Resonator and filter configuration - Butterworth and Chebyshev filters. Design of micro strip filters. (9+6)

DESIGN OF MATCHING NETWORK: Matching by Discrete Components - Design of two-component matching network, Design of T and π matching network- Matching by micro strip line - Design of matching network - Design of stub matching. (9+6)

PASSIVE COMPONENT MODELS: Resistive, self-inductance, and stray capacitance of conductors- frequency response of physical resistors- modeling physical inductors- ferrite beads- via hole models - planar transmission line for RF/ MW applications- dielectric board materials- crystal resonators and models- SAW resonators. (9+6)

FILTERS AND RESONANT CIRCUITS : Introduction- filter specifications-various filter types- LF versus RF/MW filters- filter design outline- transmission line- network transformations- LC resonant circuit in filter design- coupled line filter design using CAD. (9+6)

Total L: 45 + T: 30 = 75

TUTORIAL COMPONENT:

1. Study of Advanced Design System Tool.
2. Design and simulation of transmission line.
3. Design and simulation of impedance matching networks.
4. Design and simulation of directional couplers.
5. Design and simulation of Radio frequency Passive filters.

REFERENCES:

1. Les Besser and Rowan Gilmore, “Practical RF Circuit Design for Modern Wireless Systems”, Vol I, Passive Circuit and Systems, Artech house, London, 2003.
2. David M Pozar, “Microwave Engineering”, John Wiley and Sons, 2005.
3. Reinhold Ludwig and Pavel Bretchko, "RF Circuit Design: Theory and Applications”, Pearson Education, Reprint, 2011.

15LW51 WIRELESS TECHNOLOGY LABORATORY

0 0 2 1

In this course the students will be provided with an orientation program on the following equipment/software for duration of 4 hours. After this orientation each student is expected to formulate a complete an activity of interest which has to be derived from the orientation program under the guidance of a faculty. The details like background, problem definition, state of technology/ knowledge in that area by a good literature review (5 latest papers), objectives, methodology, equipment that can be used from the orientation program, results from the experiments and their interpretation with respect to the assumptions or background and a formal conclusion are expected in the report which is to be submitted at the end of the semester. This work is evaluated for the credit assigned. Expected hours needed for this work is 26 hours.

Topics for orientation program

- Performance evaluation of MAC protocols using discrete event network simulator.
- Performance evaluation of Routing protocols using discrete event network simulator.
- Study the working and routing table formation of Interior Routing Protocols, i.e. Routing Information protocol (RIP) and Open Shortest Path First (OSPF).
- Bit error rate comparison of different digital modulation schemes in presence of AWGN and fading.
- Analysis of combined path loss, shadowing and narrowband fading.
- Flat Channel measurement on capacity versus outage probability.

Total P: 30

15LW61 INDUSTRY VISIT & TECHNICAL SEMINAR

0 0 4 2

The student will make atleast two technical presentations on current topics related to the specialization. The same will be assessed by a committee appointed by the department. The students are expected to submit a report at the end of the semester covering the various aspects of his/her presentation together with the observation in industry visits. A quiz covering the above will be held at the end of the semester.

Total P: 60

II SEMESTER

15LW06/15LC07 ADVANCED DIGITAL SIGNAL PROCESSING

3 2 0 4

INTRODUCTION: Classification of **s**ignals and systems – Properties of Systems – LTI Systems – Need for frequency domain analysis - Fourier transform for continuous and discrete time signals – Z-Transform - relationships between system representations - DFT – FFT - recursive and non-recursive filters – Linear phase FIR filters – Realization of FIR filters – finite word length effects in DSP system design (9+6)

MULTIRATE SIGNAL PROCESSING: Representation of discrete time signals – down sampling – up sampling - Noble identities – cascading sampling rate convertors - Decimation with transversal filters – interpolation with transversal filters – decimation with polyphase filters – interpolation with polyphase filters – decimation and interpolation with rational sampling factors - multistage implementation of sampling rate convertors. (9+6)

FILTER BANKS: Two channel filter banks - QMF filter banks - Perfect Reconstruction Filter banks - Filter banks with tree structure and parallel structure - Applications – speech and audio coding – image and video coding. (9+6)

POWER SPECTRUM ESTIMATION: Introduction – Non parametric methods - Periodogram – Modified Periodogram - Bartlett, Welch & Blackman Tukey methods - Performance comparison - Parametric methods - Auto Regressive (AR) spectrum estimation - Relationship between autocorrelation and model parameters – Moving Average and Auto Regressive Moving Average spectrum estimation. (9+6)

ADAPTIVE FILTERS: Introduction – Applications – System identification – Inverse modeling – Prediction - Interference Cancellation - Adaptive linear combiner – Performance function – Gradient and Minimum Mean Square error – Gradient search by the method of steepest descent – LMS algorithm – convergence of LMS algorithm – Learning curve – Misadjustment – RLS algorithm. (9+6)

Total L: 45 + T: 30 = 75

TUTORIAL COMPONENT:

1. Signal operations and verification of system properties.
2. Time and frequency domain analysis of decimators and interpolators.
3. Non parametric method of power spectrum estimation.
4. Parametric method of power spectrum estimation.
5. Implementation of LMS and RLS algorithms.

REFERENCES:

1. Fliege N J, "Multirate Digital Signal Processing", John Wiley and Sons, 2010.
2. Vaidyanathan P P, “Multirate Systems and Filter banks”, Prentice Hall, 2008.
3. Ifeachor E C and Jervis B W, “Digital Signal Processing: A Practical Approach”, Prentice Hall, 2009.
4. Hayes M H, "Statistical Digital Signal Processing and Modeling ", Wiley, New York, 2008.
5. Simon Haykin “Adaptive Filter Theory", Pearson education, 2010.

15LW07/15LC21 RF ACTIVE CIRCUIT DESIGN

3 0 0 3

LINEAR RF AMPLIFER DESIGN GENERAL CONSIDERATIONS- Introduction power gain definitions- neutralization- unilateral transducer gain – RF circuit stability considerations- stabilizing an active two port – bipolar transistor- dc bias techniques- statistical analysis- circuit layout considerations. (9)

LINEAR AND LN RF AMPIFIERS Introduction –bilateral RF amplifier design for maximum small-signal gain – multistage amplifiers- operating gain design for maximum linear output power- noise in RF circuits- available gain design technique- comparison of the various amplifier designs and smith chart based graphical design aids- broadband amplifiers. (9)

ACTIVE RF DEVICES AND THEIR MODELLING- Diode model- two port devices models- Nonlinear circuit simulation techniques- classification of nonlinear circuit simulators- harmonic balance method- harmonic balance analysis of oscillators. (9)

HIGH POWER RF TRANSISTOR AMPLIFIER AND OSCILLATOR DESIGN Nonlinear concept- quasi linear power amplifier design- categories of amplifiers- power amplifier design example- bias considerations- distortion reduction- oscillators – principles of design – oscillator design examples. (9)

MIXER AND FREQUENCY MULTIPLIERS – Overview of mixers and their applications in systems- diode mixers and their topologies- transistor mixer design- frequency multipliers- an overview- doublers- introduction to radio systems applications and software define radio. (9)

Total L: 45

REFERENCES:

1. Rowan Gilmore and Les Besser, “Practical RF Circuit Design for Modern Wireless Systems”, Vol II, Passive Circuit and Systems, Artech house, London, 2003.
2. David M Pozar, “Microwave Engineering”, John Wiley and Sons, 2005.
3. Reinhold Ludwig and Pavel Bretchko, "RF Circuit Design: Theory and Applications”, Pearson Education, 2011.

15LW08/15LC08 RADIATING SYSTEMS

3 0 0 3

ANTENNA FUNDAMENTALS: Antenna fundamental parameters Radiation integrals ,Radiation from surface and line current distributions – dipole, monopole, loop antenna; Mobile phone antenna- base station, hand set antenna; Image; Induction ,reciprocity theorem, Broadband antennas and matching techniques, Balance to unbalance transformer, Introduction to numerical techniques. (9)

RADIATION FROM APERTURES: Field equivalence principle, Radiation from Rectangular and Circular apertures, Uniform aperture distribution on an infinite ground plane; Slot antenna; Horn antenna; Reflector antenna, aperture blockage, and design consideration. (9)

ARRAY ANTENNA: Linear array –uniform array, end fire and broad side array, gain, beam width, side lobe level; Two dimensional uniform array; Phased array, beam scanning, grating lobe, feed network, Linear array synthesis techniques – Binomial and Chebyshev distributions. (9)

MICRO STRIP ANTENNA: Radiation Mechanism and Excitation techniques : Microstrip dipole; Patch ,Rectangular patch, Circular patch, and Ring antenna – radiation analysis from cavity model; input impedance of rectangular and circular patch antenna; Microstrip array and feed network; Applications of microstrip array antenna. (9)

EMC ANTENNA AND ANTENNA MEASUREMENTS: Concept of EMC measuring antenna; Tx and Rx antenna factors; Log periodic dipole, Bi-conical, Ridge guide, Multi turn loop; Antenna measurement and instrumentation – Gain, Impedance and antenna factor measurement; Antenna test range Design. (9)

Total L: 45

REFERENCES:

1. Balanis A, “Antenna Theory Analysis and Design”, John Wiley and Sons, New York, 2009.
2. Krauss J D, “Antennas”, John Wiley and sons, New York, 2009.
3. Bahl I J and Bhartia P, “Microstrip Antennas”, Artech House,Inc.,1980
4. Stutzman W L and Thiele G A, “Antenna Theory and Design”, John Wiley and Sons Inc., 1998.

15LW09 WIRELESS SENSOR NETWORKS

3 2 0 4

INTRODUCTION: Challenges for wireless sensor networks, Comparison of sensor network with ad hoc network, Single node architecture, Hardware components, Energy consumption of sensor nodes, Network architecture, Sensor network scenarios, Design principles. (8+5)

COMMUNICATION PROTOCOLS: Physical layer and transceiver design consideration in wireless sensor networks, MAC protocols –fundamentals of wireless MAC protocols, low duty cycle protocols and wakeup concepts, contention-based protocols, Schedule-based protocols, Gossiping and agent-based uni cast forwarding , Energy-efficient unicast, Broadcast and multicast, geographic routing , mobile nodes, Data centric and content-based networking, Data aggregation. (10+7)

SENSOR LOCALIZATION AND TIME SYNCHRONIZATION: Introduction , Elements of Localization ,Sensor Localization with multidimensional scaling, Localization in wireless sensor networks, On the security of WSN Localization,Time synchronization in wireless sensor network. (9+5)

OPEN ISSUES AND DESIGN CHALLENGES: Internet of Things, Wireless sensor and Actor networks, underwater sensor networks, Video Sensor networks, Wireless Body Area Networks (WBAN) for health-monitoring, indoor surveillance. (9+6)

SENSOR NETWORK PROGRAMMING: Programming Challenges in Wireless Sensor Networks, Tiny Operating System, Contiki OS, Event-Driven Programming, Techniques for Protocol Programming. (9+7)

T**otal L: 45 + T: 30 = 75**

TUTORIAL COMPONENT:

1. Basics of WSN programming using WSN RTOS.
2. Sensing data using WSN motes
3. Simulating WSNs made up of motes running RTOS using the simulation framework
4. Design and implementation of Environmental monitoring using Sensor networks.
5. Design and simulation of MAC protocol for mobile sensor networks
6. Design and simulation of Routing protocol for mobile sensor networks
7. Design and implementation of internet of things.

REFERENCES:

1. Holger Karl and Andreas willig, “Protocol and Architecture for Wireless Sensor Networks”, John Willey Publication, Oct 2007.
2. Fei Hu and Xiaojun Cao, “Wireless Sensor Networks Principles and Practice”, CRC Press, 2010.

3. Feng zhao and Leonidas guibas, “Wireless Sensor Networks: an Information Processing Approach”, Elsevier Publication, 2004.
4. Sitharama Iyengar S, Nandan Parmeshwaran, Balkrishnan N and Chuka D, “Fundaments of Sensor Network Programming, Applications and Technology”, John Wiley & Sons, 2011.
5. Jean Philippe Vasseur and Adam Dunkels, “Interconnecting Smart Objects with IP, The Next Internet”, Morgan Kaufmann, Elsevier, 2010.

15LW10 SPACE TIME WIRELESS COMMUNICATION

3 0 0 3

MULTIPLE ANTENNA PROPAGATION AND ST CHANNEL CHARACTERIZATION: Wireless channel, Scattering model in macrocells, Channel as a ST random field, Scattering functions, Polarization and field diverse channels, Antenna array topology, Degenerate channels, reciprocity and its implications, Channel definitions, Physical scattering model, Extended channel models, Channel measurements, sampled signal model, ST multiuser and ST interference channels, ST channel estimation. (9)

CAPACITY OF MULTIPLE ANTENNA CHANNELS: Capacity of frequency flat deterministic MIMO channel: Channel unknown to the transmitter, Channel known to the transmitter, capacity of random MIMO channels, Influence of ricean fading, fading correlation, XPD and degeneracy on MIMO capacity, Capacity of frequency selective MIMO channels. (9)

SPATIAL DIVERSITY: Diversity gain, Receive antenna diversity, Transmit antenna diversity, Diversity order and channel variability, Diversity performance in extended channels, Combined space and path diversity, Indirect transmit diversity, Diversity of a space-time- frequency selective fading channel. (9)

MULTIPLE ANTENNA CODING AND RECEIVERS: Coding and interleaving architecture, ST coding for frequency flat channels, ST coding for frequency selective channels, Receivers(SISO,SIMO,MIMO),Iterative MIMO receivers, Exploiting channel knowledge at the transmitter: linear pre-filtering, optimal pre-filtering for maximum rate, optimal pre-filtering for error rate minimization, selection at the transmitter, Exploiting imperfect channel knowledge. (9)

ST OFDM, SPREAD SPECTRUM AND MIMO MULTIUSER DETECTION: SISO-OFDM modulation, MIMO-OFDM modulation, Signaling and receivers for MIMO- OFDM,SISO-SS modulation, MIMO-SS modulation, Signaling and receivers for MIMO- S.MIMO-MAC,MIMO-BC, Outage performance for MIMO-MU,MIMO-MU with OFDM,CDMA and multiple antennas. (9)

Total L: 45

REFERENCES:

1. Paulraj A, Rohit Nabar and Dhananjay Gore, “Introduction to Space Time Wireless Communication Systems”, Cambridge University Press, 2003 .
2. David Tse and Pramod Viswanath, “Fundamentals of Wireless Communication”, Cambridge University Press, 2005.
3. Andrea Goldsmith, “Wireless Communications”, Cambridge University Press, 2005.
4. Sergio Verdu, “Multi User Detection”, Cambridge University Press, 2003
5. Andre Viterbi, “Principles of Spread Spectrum Techniques”, Pearson, 1995.

15LW52 RF SYSTEM DESIGN USING EDA TOOLS LABORATORY

0 0 2 1

In this course the students will be provided with an orientation program on the following equipment/software for duration of 4 hours. After this orientation each student is expected to formulate a complete an activity of interest which has to be derived from the orientation program under the guidance of a faculty. The details like background, problem definition, state of technology/ knowledge in that area by a good literature review (5 latest papers), objectives, methodology, equipment that can be used from the orientation program, results from the experiments and their interpretation with respect to the assumptions or background and a formal conclusion are expected in the report which is to be submitted at the end of the semester. This work is evaluated for the credit assigned. Expected hours needed for this work is 26 hours.

Topics for orientation program

- Design & implementation of Stepped impedance and Open/Short circuited stub Micro strip Filter for RF Applications using ADS
- Design & implementation of micro strip Coupled line/Branch line directional coupler for ISM Band Application using ADS.
- Design & implementation of micro strip Patch Antenna for GSM & ISM Application using ADS.
- Implementation of Stepped impedance and Open/Short circuited stub Micro strip Filter for RF Applications and its Radiation Characteristics & Field distribution Analysis using Electromagnetic Professional.
- Implementation of micro strip Patch Antenna for GSM & ISM Application and its Radiation Pattern & Field distribution Analysis using Electromagnetic Professional.

Total P: 30

SEMESTER III

15LW53 WIRELESS SYSTEM DESIGN LABORATORY

0 0 2 1

In this course the students will be provided with an orientation program on the following equipment/software for duration of 4 hours. After this orientation each student is expected to formulate a complete an activity of interest which has to be derived from the orientation program under the guidance of a faculty. The details like background, problem definition, state of technology/ knowledge in that area by a good literature review (5 latest papers), objectives, methodology, equipment that can be used from the orientation program, results from the experiments and their interpretation with respect to the assumptions or background and a formal conclusion are expected in the report which is to be submitted at the end of the semester. This work is evaluated for the credit assigned. Expected hours needed for this work is 26 hours.

Topics for orientation program

- Bit error rate analysis of Digital modulation Schemes Using System Vue, Vector Signal generator and Vector Signal Analyser.
- Design and analysis of fading techniques for wireless communication Using System Vue and VSA.
- Analysis of diversity schemes for wireless communication system using Base band generator and channel Emulator.
- Design of MIMO wireless communication system using Base band generator and channel Emulator.
- Design and analysis of OFDM modulation receiver using Base band generator and channel Emulator.
- Parallel port programming and interfacing of I/O devices USING ARM MICRO CONTROLLERS
- Serial protocol analyzing : RS 232 / RS 485 / SPI / I^2C / CAN / USB using MSOs

Total P: 30

15LW71 PROJECT WORK- I

0 0 6 3

- Identification of a real life problem in thrust area
- Developing a mathematical model for solving the above problem
- Finalization of system requirements and specification
- Proposing different solutions for the problem based on literature survey
- Future trends in providing alternate solutions
- Consolidated report preparation of the above

Total P: 90

IV SEMESTER
15LW72 PROJECT WORK –II

0 0 28 14

- The project work involves the following:
  Preparing a project- brief proposal including
  - Problem identification
  - A statement of system / process specifications proposed to be developed (Block Diagram/ Concept tree)
  - List of possible solutions including alternatives and constraints
  - Cost benefit analysis
  - Time line of activities

- **A report highlighting the design finalization [based on functional requirements & standards (if any)]**
  A presentation include the following
  - Implementation phase(Hardware / Software / both)
  - Testing and validation of the developed system
  - Learning in the Project
- Consolidated report preparation

Total P: 420

PROFESSIONAL ELECTIVE THEORY COURSES

15LW21 FPGA BASED WIRELESS SYSTEM DESIGN

3 0 0 3

VERILOG HDL: HDL overview - Modules and ports - compiler directives - data types - operands and operators - gate level modeling - data flow modeling - behavioral modeling - structural modeling – primitives-Tasks and functions - Writing test bench. (9)

FIELD PROGRAMMABLE GATE ARRAYS: Introduction – FPGA Technology – DSP Technology Requirement – Design Implementation – FPGA Architectures – Xilinx – Altera Flex – Design Principles using FPGAs – Implementing DSP Functions in FPGA. (9)

DIGITAL SIGNAL PROCESSING WITH FPGAS: Design of Binary Adders, Multipliers and Dividers- Design of FIR Filters – Design of IIR Filters – Multirate Signal Processing – Decimation – Interpolation – Polyphase Decomposition – Multistage Decimator – Filter Banks – DFT and FFT Algorithms – Error Control and Cryptography-FPGA design of LMS Algorithm. (9)

SOFTWARE RADIO: Block Diagram of Software Radio –Numerically controlled oscillator – Digital Up converters – Digital Down Converters and demodulators – Universal Modulator and Demodulator using CORDIC. (9)

APPLICATIONS: Incoherent Demodulation – digital approach for I and Q generation, Special Sampling Schemes. Coherent Demodulation Schemes - Applications of FPGA to Software Radio. (9)

Total L: 45

REFERENCES:

1. Samir Palnitkar, "Verilog HDL: A Guide to Digital Design and Synthesis", Prentice Hall, 2003.
2. Uwe Meyer Baese, "Digital Signal Processing with Field Programmable Gate Arrays", Springer, 2004.
3. Jeffrey H Reed, "Software Radio: A Modern Approach to Radio Engineering", Pearson Education Asia, 2002.
4. James Tsui, "Digital Techniques for Wideband Receivers", Prentice-Hall of India, 2005.
5. Roger Woods, John Mc Allister, Gaye Lightbody and Ying Yi, "FPGA Based Implementation of Signal Processing Systems", Wiley, 2008.

15LW22/15LC36 SOFTWARE RADIO ARCHITECTURE

3 0 0 3

INTRODUCTION: – Software Defined Radio- SDR concepts & history,- Characteristics and Benefits of Software Radio – Design Principles of a Software Radio, Ideal SDR architecture, SDR Based End-to-End Communication. (9)

RF SYSTEM DESIGN – Introduction- Principal Challenge of Receiver Design - Enhanced Flexibility of the RF Chain with Software Radios - Noise and Channel Capacity- Link Budget- Receiver Requirements- Multicarrier Power Amplifiers- Signal Processing Capacity Tradeoff- Baseband Signal Processing-, Analog-to-Digital and Digital-to-Analog Conversion (9)

DIGITAL GENERATION OF SIGNALS: Introduction-Comparison of Direct Digital Synthesis with Analog Signal Synthesis-Approaches to Direct Digital Synthesis-Analysis of Spurious Signals-Spurious Components due to Periodic Jitter-Band pass Signal Generation. (9)

SMART ANTENNAS and SDR PLATFORMS: Introduction – Smart Antenna- Adaptive techniques, Phased array antennas, Applying SDR principles to antenna systems, Smart antenna architectures. Hardware platforms for SDR – Universal Software Radio Peripheral, Wireless open Access Research platform, RTL SDR receiver, comparison of different platforms, Software platforms for SDR- GNU Radio (10)

CASE STUDY: Worldwide frequency band plans , SDR Forum, SDR Applications - Software Communications Architecture, Joint Tactical Radio System, Navigation applications and Cognitive Radio. (8)

Total L: 45

REFERENCES:

1. Jeffrey H Reed, "Software Radio: A Modern Approach to Radio Engineering", PEA Publication, 2002.
2. Paul Burns, "Software Defined Radio for 3G", Bartech House, 2002.
3. Markus Dillinger, "Software Defined Radio: Architectures, Systems and Functions", 2003.
4. Walter Tuttle bee, "Software Defined Radio: Enabling Technologies", Wiley Publications, 2002.
5. Bard, Kovarik, "Software Defined Radio, The Software Communications Architecture", Wiley, 2007.

15LW23/15LC32 WAVELETS AND SUBBAND CODING

3 0 0 3

INTRODUCTION: Signal spaces - concept of Convergence - Hilbert spaces for energy signals. Fourier basis & Fourier Transform – Limitations of standard Fourier analysis – Need for Time-Frequency Analysis, Spectrogram plot – Windowed Fourier transform Tiling of the Time-Frequency Plane for STFT – Heisenberg's Uncertainty principle – Short time Fourier transform (STFT) Analysis- short comings of STFT- Need for Wavelets. (9)

CONTINUOUS WAVELET TRANSFORMS (CWT): Introduction, Continuous Time wavelets, Definition of CWT, The CWT as a correlation, Constant Q-Factor Filtering Interpolation and time frequency resolution, the CWT as an operator, inverse CWT. (9)

DISCRETE WAVELET TRANSFORM (DWT) AND MRA: Introduction,Approximation of vectors in nested linear vector spaces, example of an MRA-Bases for the approximations subspaces and Haar scaling function, Bases for detail subspaces and Haar wavelet, Formal definition of an MRA, Construction of a general orthonormal MRA, A wavelet basis for MRA, Interpreting orthonormal MRAs for Discrete time signals, Daubechies Wavelets, Relationship between Filter banks and wavelet basis, Important wavelets: Haar, Mexican hat, Meyer, Shannon, Daubechies (10)

ADVANCED TOPICS: Wavelet packets, Non - separable multidimensional wavelets, Bi-orthogonal basis-B-Splines, Lifting scheme of wavelet generation, Multiwavelets, Ridgelets, Curvelets. (9)

APPLICATIONS OF WAVELETS: Signal Denoising - Sub-band coding of Speech and music– Image Compression using 2-D DWT- JPEG 2000 standard - Fractal Signal Analysis. (8)

Total L: 45

REFERENCES:

1. Soman K P and Ramachandran K I, "Insight into Wavelets from Theory to Practice", Prentice Hall India, 2010.
2. Jaideva C Goswami and Andrew K Chan, "Fundamentals of Wavelets – Theory, Algorithms and Applications", John Wiley and Sons, Inc., Singapore, 1999.
3. Vetterli M and Kovacevic J, "Wavelets and Subband Coding," Prentice Hall, 1995.
4. Stephane G Mallat, "A Wavelet Tour of Signal Processing", Academic Press, 1999.
5. Wornell G W, "Signal Processing with Fractals: A Wavelet based Approach", Prentice Hall, 1995.

15LW24/15LC41 WIRELESS SECURITY

3 0 0 3

WIRELESS THREATS: Introduction to wireless technologies-Wireless data networks-Personal Area Networks --Kinds of security breaches- Eavesdropping-Communication Jamming - RF interference -Covert wireless channels –DOS attack - Spoofing-Theft of services-Traffic Analysis-Cryptographic threats-Wireless security Standards. (9)

CRYPTOGRAPHY: Encryption and Decryption- Product ciphers-AES (advanced Encryption Standard)-Pseudorandom number Generator-Stream ciphers A5, RC4--Public key cryptography-ECC (Elliptic Curve Cryptography) - Cryptography in Embedded Hardware. (9)

WIRELESS LOCAL AREA NETWORK (WLAN): Introduction to IEEE 802.11 Standard-Security Risks-WEP (wired Equivalence Protocol)- Countermeasures –WPA(Wi- Fi Protected Access)-Bluetooth security. (9)

SECURITY IN WIREELSS DATA NETWORKS: Wireless Device security issues- CDPD security (Cellular Digital Packet Data)-GPRS security (General Packet Radio Service)-GSM (Global System for Mobile Communication) security –IP-security. (9)

WIRELESS TRANSPORT LAYER SECURITY (WTLS): Secure Socket Layer-Wireless Transport Layer Security-WAP Security Architecture-WAP Gateway. (9)

Total L: 45

REFERENCES:

1. Behrouz A Forouzan, "Cryptography and Network Security", McGraw Hill, 2011.
2. William Stallings, "Cryptography and Network Security, Principles and Practices", Prentice Hall of India, 2006.
3. Merritt Maxim and David Pollino, "Wireless Security", Osborne/McGraw Hill, 2002.
4. Nichols and Lekka, "Wireless Security-Models, Threats and Solutions", McGraw – Hill, 2002.

15LW25/15LC23 COOPERATIVE COMMUNICATION AND COGNITIVE RADIO

3 0 0 3

INTRODUCTION TO COOPERATIVE COMMUNICATIONS: Cooperation protocols - Hierarchical cooperation; Cooperative communications with single relay; Multi-node cooperative communications; Distributed space–time coding (DSTC) - Distributed space–frequency coding (DSFC); Relay selection (10)

COOPERATIVE NETWORKING: Energy efficiency in cooperative sensor networks; Cognitive multiple access via cooperation; Content-aware cooperative multiple access; Distributed cooperative routing; Source–channel coding with cooperation (10)

INTRODUCTION TO SOFTWARE DEFINED RADIO AND COGNITIVE RADIO: Characteristics and Benefits of Software Radio; Dynamic Spectrum Access; Digital dividend; Types of Cognitive Radio; Spectrum policies and Regulations; Information theoretic perspective on Cognitive Radio networks (8)

COGNITIVE RADIO TASKS: Spectrum sensing and its methods; Cooperative Spectrum sensing; Spectrum sharing; spectrum mobility; spectrum management; spectrum trading (8)

RECENT TRENDS AND CHALLENGES IN COGNITIVE RADIO: OFDM based Cognitive Radio; Security issues in cognitive radio; Game theory in Cognitive radio; applications of cognitive radio; IEEE 802.22 WRAN standard (9)

Total L: 45

REFERENCES:

1. Rayliu K J, Sadek A K, Weifeng Su and Andres Kwasinski, “Cooperative Communications and Networking”, Cambridge University Press, 2009.
2. Jeffrey H Reed, “Software Radio: A Modern Approach to Radio Engineering”, PEA Publication, 2002.
3. Bruce A Fette, “Cognitive Radio Technology”, Elsevier Publication, Burlington, 2009.
4. Joseph Mitola III, “Cognitive Radio Architecture: The Engineering Foundations of Radio XML”, Wiley Interscience Publication, NEW JERSEY, 2006.
5. Kwang-Cheng Chen and Ramjee Prasad, “Cognitive Radio Networks”, John Wiley & Sons, 2009.

15LW26/15LC45 EMBEDDED SYSTEMS

3 0 0 3

EMBEDDED DESIGN CYCLE: Differences between the Desktop PC and typical Embedded System-Examples of Embedded Systems-Major hardware and software modules of an embedded system-Product Specification, Hardware/Software Partitioning, Iteration and Implementation, Detailed Hardware and Software Design, Hardware Software Integration, Product Testing and Release, Maintenance and Upgrading Existing products. (9)

REVIEW OF EMBEDDED ARCHITECTURES: CPU Core**,** Clock and Reset Generator, PLL, RTC, Program Memory, Data Memory, EEPROM, Parallel Ports, Timers/Counters, Watch-dog timers, input-Capture/Output Compare units, PWM unit, Interrupt Structure, Data converters, Serial communication using SCI, SPI, I2C, CAN and USB - Introduction to LIN and MOST - Development and debugging Support: JTAG and BDM. (10)

EMBEDDED SOFTWARE DEVELOPMENT TOOLS: Host and Target Machines, Cross-Compilers, Cross-Assemblers, Linker/Locator for Embedded Software, Locator Maps, Intel hex file format/Motorola s-record format. Introduction to Integrated Development Environment (IDE)- programming concepts and embedded programming in C. Debugging and simulation techniques, Programming the target system. (8)

PERIPHERAL PROGRAMMING: Developing device drivers, Configuring and programming of ports, timer / counter, data converters, interrupts and serial communication. (9)

REAL TIME OPERATING SYSTEMS (RTOS): Survey of software architectures, hard/soft real time systems, Tasks and Task States, Tasks and Data, Semaphores and Shared Data, Message Queues, Mailboxes and Pipes, Timer functions, Events, Memory Management, Interrupt Routines in RTOS Environment. Case study: Programming with RTOS, Application development in ARM micro controllers / Micro controllers / DSP controllers. (9)

Total L: 45

REFERENCES:

1. Rajkamal, “Embedded Systems: Architecture, Programming and Design”, Tata McGraw-Hill, 2006.
2. David E Simon, “An Embedded Software Primer”, Pearson Education Asia, 2006.
3. Arnold Berger, “Embedded System Design: An Introduction to Processes, Tools, and Techniques”, CMP Books, 2001.
4. Wayne Wolf, “Computers as Components: Principles of Embedded Computing System Design”, Morgan Kuafmann Publishers, 2005.

15LW27 ADVANCED PROCESSOR ARCHITECTURE

3 0 0 3

PARALLEL PROCESSING, MEMORY AND INPUT-OUTPUT SUBSYSTEMS: Trends towards Parallel Processing **–** Parallel Computer Structures **–** Architectural Classification Schemes **-** Parallel Processing Applications. Hierarchical Memory Structure - Virtual Memory System **–** Cache Memories – Input-Output Subsystems. (9)

PRINCIPLES OF PIPELINING AND VECTOR PROCESSING: Principles of Linear Pipelining- Classification of Pipeline Processors- General Pipelines and Reservation Tables- Interleaved Memory Organizations- Principles of Designing Pipelined Processors- Characteristics of Vector Processing-Pipelined Vector Processing Methods – Architecture of Cray-I Vector Processor. (9)

STRUCTURES AND ALGORITHMS FOR ARRAY PROCESSORS: SIMD Array Processors: SIMD Computer Organization, Making the data routing mechanism. SIMD Interconnection Networks: Static Vs Dynamic Networks, Mesh-Connected Illiac Network, Cube Interconnection Networks, Barrel Shifter and Data Manipulator- Parallel Algorithms for Array Processors: SIMD Matrix Multiplication, Parallel Storing on Array Processors and SIMD Fast Fourier Transform. (9)

MULTIPROCESSOR ARCHITECTURE, PROGRAMMING: Loosely Coupled Multiprocessors-Tightly Coupled Multiprocessors-Processor Characteristics for Multiprocessing. Interconnection Networks: Time shared or Common Buses- Crossbar Switch and Multiport Memories. (9)

MULTIPROCESSOR, CONTROL AND ALGORITHMS: Inter-process Communication Mechanisms: Process Synchronization Mechanisms, Synchronization with Semaphores, Conditional Critical Sections and Monitors. System Deadlocks and Protection: Deadlock Prevention and Avoidance- Deadlock Detection and Recovery and Protection Schemes. (9)

Total L: 45

REFERENCES:

1. John L Hennessy, "Computer Architecture a Quantitative Approach", Elsevier, 2007.
2. Kai Hwang and Faye A Briggs, “Computer Architecture and Parallel Processing” Mc Graw Hill International Editions, 1985.
3. Seyed Roosta, "Parallel Processing and Parallel Algorithms", Springer Series, 2000.
4. Jurij Silc, ”Processor Architecture : From Data Flow to Superscalar and Beyond “, Springer; 1999.
5. David E Culler, Jaswinder Pal Singh and Anoop Gupta, “Parallel Computer Architecture: A Hardware/Software Approach”, 1998.

15LW28/15LC33 OPTICAL NETWORKS

3 0 0 3

INTRODUCTION: Introduction to WDM and TDM; Wireless Optical Systems; Key Optical Nodes; Evolution of Optical Systems; Key attributes and characteristics of Optical Fiber; The Telecommunications Infrastructure; Timing and Synchronization. (9)

SONET/SDH AND OTN: SONET/SDH – Multiplexing structure, Frame structure, Functional components, problem detection, payloads, Virtual Tributaries, overhead bytes, SONET & SDH concatenation. OTN - Architecture, Digital wrappers, Control Planes, Layered model, Encapsulation and Decapsulation operations, Generic Framing Procedure. (10)

WDM AND OPTICAL NETWORKS: WDM-DWDM-operations, components. Network topologies, protection schemes, robustness, diversity, 1: N protection channel sharing, BLSR, PONs and Metro Optical networking. MPLS and optical networks, Label switching, Lambda switching, Traffic Engineering. (9)

LMP AND OPTICAL ROUTERS: LMP - Link up, LMP messages, connectivity, Fault management. Optical Routers - switching, preferences, OSP, LSP, load increase, technologies, MEMS, Thermo, bubble, Granularity of Labels. (9)

OPTICAL INTERNETS: ATM vs. IP in optical internets: IP over ATM & SONET, OSI internet layered model, Encapsulation & its methods, PPP packet, ATM vs. IP debate. Optical Internets: Evolution to 3G architecture, Migration to IP networking, IP subnets, non-optical nodes, routing tables. (8)

Total L: 45

REFERENCES:

1. Uyless Black, “Optical Networks-Third Generation Transport Systems”, Pearson Education, 2012.
2. Rajiv Ramasami Kumar and Sivarajan N, “Optical Networks : A Practical Perspective”, Morgan Kaufmann Publishers, 2011 .
3. Siva Ram Murthy and Mohan Gurusamy, “WDM Optical Networks-Concept, Design and Algorithms”, Prentice-Hall of India Private Limited, New Delhi, 2011.
4. Vivek Alwayn, “Optical Network Design and Implementation”, Pearson Education, 2004.
5. Stamatious V Kartalopoulos, “Understanding SONET/SDH and ATM-communications Networks for the Next Millennium”, PHI India, 1999.

15LW29 WIRELESS MULTIMEDIA COMMUNICATION

3 0 0 3

INTRODUCTION : Stream characteristics for Continuous media – Temporal Relationship – Object Stream Interactions, Media Levity, Media Synchronization – Models for Temporal Specifications – Streaming of Audio and Video – Jitter – Fixed playout and Adaptive layout – Recovering from packet loss – RTSP –– Multimedia Communication Standards – RTP/RTCP – SIP and H.263. (9)

QOS FOR MULTIMEDIA COMMUNICATION: End to End QoS provisioning in Wireless Multimedia Networks – Adaptive Framework – MAC layer QoS enhancements in Wireless Networks – A Hybrid MAC protocol for Multimedia Traffic – Call Admission Control in Wireless Multimedia Networks – A Global QoS Management for Wireless Networks. (9)

GUARANTEED SERVICE MODEL: Best Effort service model – Scheduling and Dropping policies – Network Performance Parameters – Quality of Service and metrics – WFQ and its variants – Random Early Detection – QoS aware Routing – Admission Control -Resource Reservation – RSVP -Traffic Shaping Algorithms – Caching – Laissez Faire Approach - Possible Architectures – An Overview of QoS Architectures. (9)

MULTIMEDIA DATABASES: Audio Databases - A General Model of Audio Data - Capturing Audio Content through Discrete Transformation - Indexing Audio Data. Video Databases - Organizing Content of a Single Video - Querying Content of Video Libraries – Video Segmentation. (9)

MEDIA ON DEMAND AND APPLICATIONS: Storage and Media servers, Voice and video over IP, MPEG -2 over ATM / IP, indexing, synchronization of requests, recording and control. MIME, Peer – to – Peer Computing, shared application, Video conferencing, centralized and distributed conference control, Distributed virtual reality, Light weight sessions philosophy. (9)

Total L: 45

REFERENCES:

1. Kurose and Ross, "Computer Networks : A Top Down Approach', Pearson Education, 2013
2. Jean Warland and Pravin Vareya, "High Performance Communication Networks", Morgan Kauffman Publishers, 2002
3. Mahbub Hassan and Raj Jain, "High Performance TCP/IP Networking", Pearson Education, 2004.
4. William Stallings, "High Speed Networks and Internets: Performance and Quality of Service", Pearson Education, 2002.
5. Nalin K Sharda, "Multimedia Information Networking", Prentice Hall of India, 1999.

15LW30/15LC26 RADAR COMMUNICATION

3 0 0 3

INTRODUCTION TO RADAR: Basics of radar, EM Waves & properties- applications of radar, radar frequencies-radar block diagram, Radar Coordinates, Radar equation for hard targets and the SNR-radar cross section of targets, Radar Resolution Elements, Pulse, CW and FMCW Radars–configurations, transmitter power- pulse repetition frequency, Duty Ratio, Pulse Compression, Coding. (9)

DETECTION OF SIGNALS IN NOISE AND RADAR SIGNALS: Introduction to Noise in detail, probability density functions – probabilities of detection and false alarm-matched filter receiver-detection criteria – integration of radar pulses - constant-false alarm rate receivers - Radar Wave forms, Pulse Compression, Ambiguity Diagram. (9)

RADAR TRANMIMTTER AND RECEIVER: Introduction- Types of Transmitters - linear-beam power tubes- solid-state RF power sources- magnetron- Klystron, crossed-filed amplifier- radar receiver- receiver noise figure- super heterodyne receiver, Digital Receivers, duplexers and receiver protectors- radar displays-Human Machine Interface (HMI). (9)

RADAR ANTENNA: Functions of radar antenna- antenna parameters- antenna radiation pattern and aperture illumination - reflector antennas- electronically steered phased array antennas- phase shifters – frequency - scan arrays-- architectures for phased arrays , radiators for phased arrays- mechanically steered planar array antennas- radiation pattern synthesis -effect of errors on radiation patterns - low side lobes antennas. (9)

MTI AND PULSE DOPPLER RADAR: Introduction to Doppler and MTI radar- delay –line cancellers- staggered pulse repetition frequencies- doppler filter banks- digital MTI processing - Moving target detector- limitations to MTI performance- pulse Doppler radar-MTD, Tracking radar- monopulse tracking- conical scan and sequential lobing- comparison of trackers. tracking accuracy-low-angle tracking- Atmospheric & Weather Radars: Precipitation Radars, Doppler Weather Radar, Polarimetric Radar, Clear Air Radars. (9)

Total L: 45

REFERENCES:

1. Merril I Skolnik "Introduction to Radar Systems", Mc Graw-Hill, 2008.
2. Richard J Doviak and Dusan S Zrnic, "Doppler Radar and Weather Observations", Dover Publications, 1993.
3. Bringi V N and Chandrasekar V, "Polarimetric Doppler Weather Radar ", Cambridge University Press,2001.
4. Richards M A, Scheer J A and Holm W A, "Principles of Modern Radar", Yes Dee Publishing Pvt. Ltd., 2012.

15LW31 FREE SPACE OPTICS

3 0 0 3

FUNDAMENTALS OF FSO TECHNOLOGY: Introduction – Maxwell's equations- Electromagnetic Wave Propagation in free space - Alternate Bandwidth technologies - fiber Vs FSO- fiber access - Overview of FSO optical transmitters- receivers-subsystems-pointing, acquisition and tracking – line of sight analysis. (9)

FSO NETWORKS: The role of FSO in the network- factors affecting FSO line of sight- selecting transmission wave integration of FSO in optical networks- installation of FSO systems- Moving towards edge and residential areas. (9)

LONG DISTANCE FSO COMMUNICATION: The FSO model - applications- system descriptions and design- introduction to laser satellite communications- characteristics, modulation techniques and radiation effects – laser sources. (9)

OPTICAL COMPONENTS FOR FSO: Optical waveguides- optical filters, couplers, amplifiers, switches, antennas, interconnecting equipments- optical integrated circuits- semiconductor integrated optic devices. (9)

OPTICAL SIGNAL PROCESING : Analog and Discrete systems- noise and stochastic processes- filters- power spectra estimation – The ambiguity function, Wigner distribution function and triple correlation. (9)

Total L: 45

REFERENCES:
1. Heinz and Willebrand, “Free Space Optics”, Sams, 2002.
2. William H Mott and Robert B Sheldo, “Laser Satellite Communication- The Third Generation”, Green Wood Publishing, 2000.
3. Hiroshi Nishihara, “Optical Integrated Circuits”, McGraw Hill, New York, 1989.
4. Pankaj K Das, “Optical Signal Processing”, Narosa Publishing House, 1993.

15LW32/15LC39 RADIO FREQUENCY INTEGRATED CIRCUIT DESIGN

3 0 0 3

ISSUES IN RFIC DESIGN, NOISE, LINEARITY, and FILTERING: Lower frequency analog design and microwave design versus radio frequency integrated circuit design - Impedance levels for microwave and low-frequency analog design- noise - linearity and distortion in RF Circuits - dynamic range - filtering issue. (9)

REVIEW OF TECHNOLOGY: Small -signal model of bipolar transistor **-** high frequency effects - noise in bipolar transistors - base shot noise-noise sources in the transistor model - bipolar transistor design considerations-CMOS transistor.- impedance matching - tapped capacitors and inductors - the concept of mutual inductance - tuning a transformer - bandwidth of an impedance transformation network-quality factor of an LC resonator. (8)

DESIGN OF PASSIVE CIRCUIT ELEMENTS IN IC TECHNOLOGIES: Technology backend and metallization in IC technologies - sheet resistance and skin effect -parasitic capacitance and inductance -current handling in metal lines-design of inductors and transformers - characterization of inductor-layout of spiral inductors - on-chip transmission lines - high frequency measurements of on-chip passives and common De-Embedding techniques-packaging. (9)

LNA AND POWER AMPLIFIER: Basic amplifiers - amplifiers with feed back - noise in amplifiers - linearity in amplifiers - differential pair and other differential amplifiers-low-voltage topologies for LNAs and the use of on-chip transformers - DC bias networks - temperature effects - broad band LNA design. Power amplifier: power capability - efficiency calculations - matching considerations - Class A,B,C.D.E.F,G,H and S amplifiers -summary of amplifier classes for RF Integrated circuits - AC load line - matching to achieve desired power - packaging -effects and implications of non linearity - linearization techniques - CMOS power amplifier example. (10)

MIXERS: Mixing with nonlinearity - basic mixer operation – controlled transconductance mixer - double- balanced mixer - mixer with switching of upper quad - analysis of switching modulator-mixer noise - linearity - improving isolation - image reject and single - sideband mixers-alternative mixer designs - general design comments-CMOS mixers. (9)

Total L: 45

REFERENCES:
1. John Rogers and Calvin Plett, “Radio Frequency Integrated Circuit Design”, Artech House, 2002.
2. Stephan A Mass, “Non-Linear Microwave and RF circuits”, Artech House.
3. Ferri Losee, “RF Systems, Components and Circuits Handbook”, Artech house, 2002.
4. Larson L E, “RF and Microwave Circuit for Wireless Applications”, Artech House, 1997.

15LW33/15LC24 RF MEMS

3 0 0 3

MICROELECTROMECHANICAL SYSTEMS(MEMS) AND RADIO FREQUENCY MEMS: Introduction –Microfabrication for MEMS – Electromechanical transducers – Microsensing for MEMS – Materials for MEMS.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 micromaching – Microstereolithography for polymer MEMS. (10)

RF MEMS SWITCHES: Introduction – Switch parameters – Basics of switching – Switches for RF and microwave applications – Electrostatic switching – Approaches for low-actuation –voltage switches – thermal switching –MEMS switch design, modeling and evaluation –MEMS switch design considerations. MEMS Inductors and Capacitors: Introduction – MEMS inductors –MEMS capacitors. (10)

MICROMACHINED RF FILTERS AND PHASE SHIFTERS: Introduction – Modeling of mechanical filters - Micromechanical filters – Micromachined phase shifters: Introduction – Types of phase shifters and their limitations – MEMS phase shifters. (9)

MICROMACHINED TRANSMISSION LINES AND COMPONENTS: Introduction – Micromachined transmission lines and components – Design, fabrication and measurements. (8)

MICROMACHINED ANTENNA: Introduction - Overview of microstrip antenna – Micromachining techniques to improve antenna performance – Micromaching as a fabrication process for small antenna – Micromachined reconfigurable antenna. (8)

Total L: 45

REFERENCES:
1. Vijay K Varadan, Vinoy K J and Jose K A, "RF MEMS and Their Applications“, John Wiley & Sons Ltd, England, 2003.
2. Gabriel M Rebeiz, “RF MEMS Theory, Design and Technology “, John Wiley & Sons Ltd, New Jersey, 2004.
3. Hector J De Los Santos, “RF MEMS Circuit Design for Wireless communications”, Artech House, 2002.
4. http://public.ccsds.org/publications/default.aspx.

15LW34/15LC30 MULTI USER DETECTION

3 0 0 3

SINGLE-USER MATCHED FILTER: Hypothesis testing – Optimal receiver for the single user channel – The Q function – The matched filter in the CDMA system – Asymptotic Multiuser efficiency and related measures – Coherent single user matched filter in Rayleigh fading – Differentially coherent demodulation – Noncoherent modulation. (9)

OPTIMUM MULTIUSER DETECTION: Optimum detector for synchronous channels – Optimum detector for asynchronous channels – Minimum error probability in synchronous channel – K user optimum asymptotic efficiency and Near – far resistance – Minimum error probability in the asynchronous channel – Performance analysis in Rayleigh fading – Optimum noncoherent multiuser detection. (9)

DECORRELATING DETECTOR: Decorrelating Detector in the synchronous Channel – Decorrelating Detector in the Asynchronous Channel – Truncated Window Decorrelating Detector – Approximate Decorrelator – Performance Analysis in Synchronous and Asynchronous case – Coherent Decorrelator in presence of fading – Differentially Coherent Decorrelation- Decorrelation for Nonlinear Modulation. (9)

NON - DECORRELATING DETECTOR: Optimum linear multiuser detection – Minimum Mean Square Error (MMSE) linear multiuser detection – Performance of MMSE linear multiuser detection – Adaptive MMSE linear multiuser detection – Canonical representation of linear multiuser detectors – Blind MMSE multiuser detector. (9)

DECISION-DRIVEN MULTIUSER DETECTORS: Successive Cancellation – Performance Analysis of Successive Cancellation – Synchronous Decorrelating Decision-Feedback – Synchronous MMSE Decision-Feedback – Asynchronous Decision-Feedback. (9)

Total L: 45

REFERENCES:

1. Sergio Verdu, “Multiuser Detection”, Cambridge University Press, 2011.
2. Sergio Verdu, “Recent Progress in Multiuser Detection Advances in Communication and Control Systems”, IEEE Press, 1993.
3. Michael L Honig, “Advances in Multiuser Detection”, Wiley-IEEE Press, 2009.

15LW35/15LC29 DETECTION AND ESTIMATION

3 0 0 3

STATISTICAL DECISION THEORY: Bayesian Hypothesis Testing - Likelihood Ratio Tests - Minimax Hypothesis Testing - Neyman Pearson Hypothesis Testing - Composite Hypothesis Testing - M’ary Hypothesis Testing. (8)

SIGNAL DETECTION IN DISCRETE TIME: Deterministic Signals - Stochastic Signals – Models and Detector Structures – Performance Evaluation - Chernoff Bounds - Applications of Detection in Signal Processing. (8)

PARAMETER ESTIMATION: Fundamentals of Estimation Theory - Minimum Variance Unbiased Estimation – Cramer Rao Lower bound – Best Linear Unbiased Estimators - Linear Least Squares Estimation – Nonlinear Least Squares Estimation - Maximum Likelihood Estimation. (10)

BAYESIAN ESTIMATION: Bayesian philosophy – General Bayesian Estimators - Minimum Mean Square Error Estimators – Maximum A Posteriori Estimators – Linear MMSE Estimation. (9)

DISTRIBUTION-FREE ESTIMATION: Orthogonality Principle – Autoregressive Techniques - Discrete Wiener Filter, Continuous Wiener Filter, Generalization of Discrete and Continuous Filter Representations, Kalman Filter, Extended Kalman Filter - Applications of Estimation in Signal Processing. (10)

Total L: 45

REFERENCES:

1. Thomas Schonhoff and Arthur A Giordano, “Detection and Estimation Theory", Prentice Hall, 2007.
2. Kay S M, “Fundamentals of Statistical Signal Processing, Volume 1: Estimation Theory”, Prentice Hall, 1993.
3. Kay S M, “Fundamentals of Statistical Signal Processing, Volume 2: Detection Theory”, Prentice Hall, 1998.
4. Poor H V, “An Introduction to Signal Detection and Estimation”, Springer-Verlang, 1994.
5. Scharf L L, “Statistical Signal Processing”, Addison Wesley, 1991.

15LW36/15LC34 SMART ANTENNAS

3 0 0 3

INTRODUCTION: Antenna gain, Phased array antenna, power pattern, beam steering, degree of freedom, optimal antenna, adaptive antennas, smart antenna - key benefits of smart antenna technology, wide band smart antennas, Digital radio receiver techniques and software radio for smart antennas. (9)

NARROW BAND PROCESSING: Signal model conventional beamformer, null steering beamformer, optimal beamformer, Optimization using reference signal, beam space processing. (8)

ADAPTIVE PROCESSING: Sample matrix inversion algorithm, unconstrained LMS algorithm, normalized LMS algorithm, Constrained LMS algorithm, Perturbation algorithms, Neural network approach, Adaptive beam space processing, Implementation issues. (9)

BROADBAND PROCESSING: Tapped delay line structure, Partitioned realization, Derivative constrained processor, Digital beam forming, Broad band processing using DFT method. (9)

DIRECTION OF ARRIVAL ESTIMATION METHODS: Spectral estimation methods, linear prediction method, Maximum entropy method, Maximum likelihood method, Eigen structure methods, Music algorithm – root music and cyclic music algorithm, the ESPRIT algorithm. DIVERSITY COMBINING: Spatial diversity selection combiner, switched diversity combiner, equal gain combiner, maximum ratio combiner, optical combiner. (10)

Total L: 45

REFERENCES:

1. Lal Chand Godara, “Smart Antennas” CRC press, 2004.
2. Balanis, “Antenna Theory: Analysis and Design”, John Wiley and Sons, 2005.
3. Joseph C Liberti.Jr and Theodore S Rappaport, “Smart Antennas for Wireless Communication: IS-95 and Third Generation CDMA Applications”, Prentice Hall, 1999.
4. Robert A Monzingo, Haupt R L and Miller T W, “Introduction to Adaptive Arrays”, Yesdee Publishing Pvt. Ltd., 2012.

15LW37/15LC35 ADAPTIVE SIGNAL PROCESSING

3 0 0 3

INTRODUCTION: The Filtering problem – Linear optimum filters - Adaptive filters – Approaches to the development of linear adaptive filters – Applications: System identification – Inverse modeling – Prediction - Interference Cancellation – Adaptive linear combiner – Performance function – Gradient and Minimum Mean Square error - Properties of the Quadratic Performance surface. (9)

SEARCH METHODS: Basic ideas of gradient search methods - Gradient Search Methods: Newton’s method, Steepest Descent Method – Comparison - Least-Mean-Square (LMS) algorithm. (9)

ADAPTIVE ALGORITHMS: Convergence – Learning Curve - Misadjustment – Excess MSE - LMS Variants - Recursive Least Squares (RLS) Algorithm – Matrix inversion lemma - Exponentially Weighted RLS – Sliding Window RLS – convergence - Kalman Filter – Innovation process – Extended Kalman Filter. (9)

FILTERING APPLICATIONS: Adaptive Modeling & System Identification - Inverse Adaptive Modeling – Deconvolution – Equalization - Adaptive self tuning filter - Adaptive Line enhancer. - Harmonic cancellation with adaptive prediction. (9)

NOISE AND INTERFERENCE REMOVAL: Adaptive Interference Canceling - Adaptive noise canceling - Canceling power supply interference in ECG – canceling maternal ECG interference in fetal ECG - Adaptive echo cancellation in Telephone channels. (9)

Total L: 45

REFERENCES:

1. Haykin S, “Adaptive Filter Theory", Prentice Hall Inc, 2012.
2. Widrow B and Stearns S D, "Adaptive Signal Processing", Prentice Hall inc., 2011.
3. Cowan C F N and Grant P M, "Adaptive Filters", Prentice Hall inc., 2010.
4. Farhang - Boroujeny, “Adaptive Filters Theory and Applications”, John Wiley & Sons, 2010.
5. Alexander S T, "Adaptive Signal Processing: Theory and Applications ", Springer – Verlag, 2010.

15LW38 3G AND 4G WIRELESS COMMUNICATIONS

3 0 0 3

BROAD BAND WIRELESS CHANNEL MODELING : Wide-Sense Stationary Uncorrelated Scattering Channel Modeling – RMS Delay Spread – Doppler Fading –Jakes Model, Autocorrelation – Jakes Spectrum – Impact of Doppler Fading . (9)

CODE DIVISION MULTIPLE ACCESS: Introduction to CDMA – Walsh codes – Variable tree OVSF – Multipath diversity- RAKE Receiver – CDMA Receiver Synchronization. (7)

ORTHOGONAL FREQUENCY DIVISION MULTIPLEXING : Introduction to OFDM – Multicarrier Modulation and Cyclic Prefix – Channel model and SNR – Performance – OFDM issues – Peak to Average Power Ratio – Frequency & Timing offset issues. (10)

MULTIPLE INPUT MULTIPLE OUTPUT SYSTEMS : Introduction to MIMO, MIMO Channel – Singular value Decomposition and Eigen Modes of the MIMO Channel – MIMO Spatial Multiplexing – BLAST – MIMO Diversity techniques –Alamouti Coding , OSTBC, MRT – MIMO and OFDM. (10)

ULTRAWIDE BAND 3G AND 4G WIRELESS STANDARDS: UWB Definition and Features – UWB Wireless channels – UWB Data Modulation – Uniform Pulse Train – Bit Error Rate Performance of UWB. Standards of GPRS, WCDMA , LTE and WiMax Technologies. (9)

Total L: 45

REFERENCES:

1. Martin Sauter, "From GSM to LTE-Advanced: An Introduction to Mobile Networks and Mobile Broadband" John Willey & Sons Ltd., 2014.
2. Jiangzhou Wang, “High-Speed Wireless Communications: Ultra-wideband, 3G Long Term Evolution, and 4G Mobile Systems” Cambridge University Press, 2008.
3. Ezio Biglieri and Robert Calderbank “MIMO Wireless Communications”, Cambridge University Press, 2007.
4. David Tse and Pramod Viswanath, “Fundamentals of Wireless Communication”, Prentice Hall, 2003.

15LW39 LONG TERM EVOLUTION DESIGN

3 0 0 3

LTE INTRODUCTION AND NETWORK ARCHITECTURE: Motivation to LTE - Evolution of Architecture – Standardization process in 3GPP – Technologies for LTE The Core Network – The Access Network – Roaming Architecture – Protocol Architecture – S1 and X2 E-UTRAN Network Interfaces. (9)

CONTROL PLANE AND USER PLANE PROTOCOLS: Radio Resource Control – PLMN and Cell Selection – Paging – User Plane Protocol Stack – Packet Data Convergence Protocol – Radio Link Control – Medium Access Control. (8)

PHYSICAL LAYER FOR DOWNLINK: OFDMA – Parameter dimensioning – Downlink physical layer design – Synchronization and Cell Search – Reference Signals and Channel Estimation – Downlink Physical Data and Control Channels – Link Adaptation and Channel Coding. (10)

PHYSICAL LAYER FOR UPLINK: Uplink Physical Layer Design – Uplink reference signals – Uplink Physical channel structure – Random Access – Uplink transmission procedures. (9)

LTE ADVANCE TOPICS: Self Optimizing Networks – LTE- Advanced - Carrier Aggregation- Multiple Antenna Techniques for LTE Advanced - Voice Over LTE. (9)

Total L: 45

REFERENCES:

1. Stefania Sesia, Issam Toufik and Matthew Baker, “LTE – The UMTS Long Term Evolution: From Theory to Practice”, John Wiley & Sons, 2011.
2. Christopher Cox, “An introduction to LTE – LTE, LTE-Advanced, SAE and 4G Mobile Communications”, John Wiley & Sons, 2012.

15LW40 SPREAD SPECTRUM COMMUNICATION

3 0 0 3

INTRODUCTION TO SPREAD SPECTRUM SYSTEMS: Communication in the presence of pulse noise jamming - Low probability detection scheme -Direct sequence spread spectrum methods - Frequency Hop spread spectrum methods - Hybrid DS/FH spread spectrum - Complex envelope representation of spread spectrum systems - examples of Spread Spectrum Systems (9)

MULTICARRIER SPREAD SPECTRUM SYSTEMS: Amalgamating DS-CDMA and OFDM - Multi-Carrier CDMA techniques – MC CDMA – MC DS CDMA – MT CDMA (8)

BINARY SHIFT REGISTER SEQUENCES FOR SPREAD SPECTRUM SYSTEMS: Definition - PN sequence generator fundamentals - Maximal length sequences - Properties, Power spectrum and Polynomial tables for maximal length sequences - Gold codes - Rapid Acquisition systems - Non-linear code generators. (9)

SYNCHRONIZATION OF SPREAD SPECTRUM SYSTEMS: Optimal tracking of wideband signals - Early-late tracking loops - Code tracking loops for FHSS - Optimum synchronization techniques - Multiple dwell and sequential detectors - Synchronization using a matched filter - Synchronization by estimating the received spreading code. (10)

PERFORMANCE OF SPREAD SPECTRUM SYSTEM: SS Systems communications models - Performance without coding under AWGN and different jamming environments - spread spectrum systems performances with forward error correction - Block coding - Convolutional coding and specific error correcting codes - Inter leaving - Random coding bounds. (9)

Total L: 45

REFERENCES:

1. Ziemer R E and Peterson R L, "Digital Communication and Spread Spectrum Systems", Macmillan Publishing Co., 1985.
2. Hanzo L and Keller T, “OFDM and MC-CDMA: A Primer”, John Wiley and sons Ltd., 2006.
3. Holms J K, "Coherent Spread Spectrum Systems", Wiley Interscience, 1982.
4. Peterson R L, Ziemer R E and Borth D E, “Introduction to Spread Spectrum Communications”, Prentice Hall, 1995.
5. Dixon R C, “Spread Spectrum Systems with Commercial Applications”, John Wiley & Sons, 1994.

15LW41/15LC40 WIRELESS AD HOC NETWORKS

3 0 0 3

INTRODUCTION AND MAC PROTOCOLS: Fundamentals of Wireless Communication Technology, Characteristics of the Wireless Channel, Modulation Techniques, Multiple Access Techniques, Networking Standards, Wireless Networks, Mobile IP, Ad Hoc Wireless Networks Designing a MAC Protocol for Ad Hoc Wireless Networks, Classifications of MAC Protocols - Contention-Based, Contention-Based with Reservation Mechanisms, Contention-Based with Scheduling Mechanisms, MAC Protocols that Use Directional Antennas. (9)

ROUTING AND MULTICAST ROUTING PROTOCOLS: Designing a Routing Protocol for Ad Hoc Wireless Networks, Classifications of Routing Protocols -Table-Driven, On-Demand, Hybrid, Routing Protocols with Efficient Flooding Mechanisms, Hierarchical, Power-Aware Routing Protocols. Designing a Multicast Routing Protocol, Operation of Multicast Routing Protocols, Classifications of Multicast Routing Protocols - Tree-Based, Mesh-Based, Energy-Efficient, Multicasting with Quality of Service Guarantees. (10)

TRANSPORT LAYER AND SECURITY PROTOCOLS: Designing a Transport Layer Protocol for Ad Hoc Wireless Networks, Classification of Transport Layer Solution, TCP over Ad Hoc Wireless Networks, Security in Ad Hoc Wireless Networks, Network Security Requirements. Issues and Challenges in Security Provisioning, Network Security Attacks, Key Management, Secure Routing in Ad Hoc Wireless Network (8)

QUALITY OF SERVICE AND ENERGY MANAGEMENT: QoS in Ad Hoc Wireless Networks, Classifications of QoS Solutions, MAC Layer Solutions, Network Layer Solutions, QoS Frameworks for Ad Hoc Wireless Networks. Energy Management in Ad Hoc Wireless Networks, Classification of Energy Management Schemes - Battery Management Schemes, Transmission Power Management Schemes, System Power Management Schemes. (10)

ADVANCES IN WIRELESS NETWORKS: Ultra-wide-band radio communication, Wireless fidelity systems, Optical wireless networks, Multimode 802.11 - IEEE 802.11a/b/g, wireless AD Hoc sensor Networks. (8)

Total L: 45

REFERENCES:

1. Siva Ram Murthy C and Manoj B S, “Ad Hoc Wireless Networks: Architectures and Protocols”, Prentice Hall, 2004.
2. Charles E Perkins, “Ad Hoc Networking”, Addison-Wesley, 2001.
3. Toh C K, “Ad Hoc Mobile Wireless Networks: Protocols and Systems”, Prentice Hall, 2001.
4. Mohammad Ilyas, “The Handbook of Ad Hoc Wireless Networks”, CRC Press, 2002.
5. Basagni S, Marco Conti, Silvia Giordano, Ivan Stojmenovi and Cacute, “Mobile Ad Hoc Networking”, John Wiley and Sons, 2004.

15LW42/15LC42 COMPUTATIONAL ELECTROMAGNETICS

3 0 0 3

EM REVIEW: E-field, permittivity, Coulombs Law, Flux of a vector field, Gausss Law for E fields (Integral), divergence, Gausss Law for E fields (Differential) B-field, permeability, Biot-Savart law, Gausss law for B fields (integral and differential), Divergence Theorem, circulation of a vector field, curl, Stokes Theorem. Gradient. Laplacian. Poisson and Laplace equations. Ampere-Maxwell Law, Faraday-Maxwell Law. Continuity equation. Constitutive equations. (9)

NUMERICAL DIFFERENTIATION: Forward difference, backward difference, central difference. Higher order derivatives. Partial derivatives. Solution of Linear Systems: Matrix equivalent. Solution sets. Direct *vs* iterative methods. Sparse matrices. Libraries. Gaussian Elimination. Gauss-Seidel method. Numerical Integration Riemann Sums Left/right-point rules Midpoint, trapezoid, Simpsons rules Error bounds-Numerical Integration Examples (9)

METHOD OF MOMENTS: Greens Functions; Surface equivalence principle; Electrostatic formulation; Magnetostatic formulation; Electric Field Integral Equation; Magnetic Field Integral Equation; Direct and Iterative Solvers; (9)

FINITE DIFFERENCE TIME DOMAIN METHODS: 1D wave propagation, yee Algorithm, Numerical dispersion and stability, perfectly matched absorbing boundary conditions, Dispersive materials. Antenna and scattering problems with FDTD, non-uniform grids, conformal grids, periodic structures. (10)

APPLICATIONS OF CEM: Antennas, biological electromagnetic effects, electronic packing and high speed circuits, microwave devices and circuits, environmental issues. surveillance and intelligence gathering, homeland security, signal integrity. (8)

Total L: 45

REFERENCES:

1. Walton C Gibson, “The Method of Moments in Electromagnetics” , CRC Press,2014.
2. Andrew F Peterson, Scott L Ray and Raj Mittra, “Computational Methods for Electromagnetics”, IEEE Press Series on Electromagnetic Wave Theory,1998.
3. Roger F Harrington, “Field Computation by Moment Methods”, IEEE Press, 1993.
4. Taflove A and Hagness S C, “Computational Electrodynamics: The Finite Difference Time Domain Method”, Artech ouse,2004.

15LW43/15LC31 DATA COMPRESSION

3 0 0 3

INTRODUCTION: Compression Techniques - Overview of information theory - lossless and lossy coding– Modeling and Coding - Taxonomy of compression techniques – Rate distortion theory - Huffman coding – Non-Binary Huffman codes – adaptive Huffman coding – Application of Huffman coding. (8)

ARITHMETIC CODING AND DICTIONARY TECHNIQUES: Introduction- coding a sequence – generating deciphering the tag – Generating a binary code – Uniqueness of arithmetic code – Algorithm, integer implementation – comparison of Huffman and arithmetic coding – Applications -Static and Adaptive dictionary – LZ77, LZ78, LZW approach – Applications - Facsimile encoding – run length coding – comparison of MH, MR, MMR and JBIG. Scalar and Vector Quantization (10)

AUDIO COMPRESSION: Audio compression techniques - frequency domain and filtering - basic sub-band coding -application to speech coding - G.722 - application to audio coding - MPEG audio - silence suppression - speech compression techniques – Vocoders. (10)

IMAGE COMPRESION: Predictive techniques - DPCM, DM - KL transform – discrete cosine, Walsh- Hadamard transform - JPEG, Wavelet based compression: quad-trees, EZW, SPIHT, JPEG-2000. (9)

VIDEO COMPRESSION: Video signal representation – Motion compensation – MPEG standards - Motion estimation techniques - H.261 family of standards - Motion video compression. (8)

Total L: 45

REFERENCES:

1. Khalid Sayood, “Introduction to Data Compression”, Morgan Kaufman, 2012.
2. Salomon D,”Data Compression The Complete Reference”, Springer, 2007.
3. Salomon D, “A Guide to Data Compression Methods”, Springer, 2002.
4. Jan Vozer, “Video Compression for Multimedia”, AP Press, New York, 1995.
5. Alistar Moffat, “Compression and Coding Algorithms”, Kluwer Academic Publishers, 2002.

15LW44/15LN34/15LC50 DATA STRUCTURES AND ALGORITHMS

2 2 0 3

INTRODUCTION: Software Development process – Data structures - Abstract Data Types - Analysis of algorithms - Best, worst and average case time complexities - notations. (4+4)

ARRAYS: Operations - Implementation of one, two, three and multi dimensioned arrays – Sparse and dense matrices - Applications. (4+6)

STACK AND QUEUE: Stack operations - implementations - Applications: Function handling - Recursion – Expression Evaluation. Queue - operations - implementations - Priority Queues - Dequeues - Applications: Job scheduling. (6+4)

LISTS : Operations - Singly linked lists, doubly linked lists, Circular lists - Applications – Linked Stacks - Linked queues. (6+4)

TREES AND GRAPHS: Tree Terminologies - Implementation - Binary Tree: Properties –representation of trees, operations-Traversals- Expression trees - Infix, Postfix and Prefix expressions – Dijkstra’s Algorithms-Floyd’s Algorithm. Graph Terminologies-representations-graph search methods: Breadth first search, Depth first search, Minimum spanning trees-Multistage graph. (6+6)

SORTING: Insertion sort - Selection sort - Bubble sort - Radix sort - Algorithms and their time complexities. (4+6)

TUTORIAL COMPONENT:

1. Analysis of algorithms
2. Implementation of stack and queue
3. Evaluation of expressions
4. Singly and doubly linked lists implementation
5. Binary tree traversal.
6. Single source shortest path algorithm – Dijkstra’s algorithm

7. All pairs shortest path problem- Floyd's Algorithm
8. Graph search method implementation

Total L: 30+ T: 30 = 60

REFERENCES:

1. Sahni Sartaj, "Data Structures, Algorithms and Applications in C++", Universities Press, Hyderabad, 2005.
2. Mark Allen Weiss, "Data Structures and Algorithm Analysis in C", Pearson Education, New Delhi, 2007.
3. Robert L Kruse, Bruce P Leung and Clovin L Tondo, "Data Structures and Program Design in C", Pearson Education, New Delhi, 2009.
4. Vijayalakshmi Pai G A, "Data Structures and Algorithms: Concepts Techniques and Applications", McGraw-Hill, 2009.
5. Chitra A, Rajan P T "Data Structures", Tata Mc Graw Hill Education, 2008.
6. Ellis Horowitz , Sartaj Sahni and Sanguthevar Rajasekaran, "Computer Algorithms/C++", Orient Black Swan, 2008.

15LW49/15LC81 INTERNET OF THINGS

3 0 0 3

INTRODUCTION : History of IoT , Enabling technologies of IoT , Sensing and actuating technology , Connected objects' communication. (7)

WIRELESS SENSOR NETWORKS TECHNOLOGY: From smart dust to smart plants , Application requirements in modern WSNs ,The node ,Connecting nodes , Radio basics, Reliable communication, Networking nodes , IEEE 802.15.4,The IEEE 802 Committee Family of Protocols, The Physical Layer, The Media-Access Control Layer, Uses of 802.15.4. (9)

POWER LINE COMMUNICATION TECHNOLOGY: Overview of existing PLC technologies and standards , Different types of in-home PLC technologies ,Security ,Performances of PLC technologies , Architectures for home network applications , Internet of things using PLC technology , Power line Communication: A Constrained Media ,The Ideal PLC System for M2M. (9)

RADIO FREQUENCY IDENTIFICATION TECHNOLOGY: Principle of RFID , Components of an RFID system Reader, RFID Tag, RFID middleware, RFID Applications and Related Research Issues , Concepts and terminology , RFID system architecture ,RFID Applications

(9)

PROTOCOLS AND APPLICATIONS: Legacy M2M protocols, Zwave , Co-AP , RPL and 6LoWPAN, Implementation Examples, Smart Grid , Industrial Automation and Building automation ,Connected car, Connected Home, Digital Health , Smart city , environmental (Scenario1 : Shopping , Scenario2 : Monitoring).

(11)

Total : 45

REFERENCES:

1. Hakima Chaouchi , "The Internet of Things Connecting Objects to the Web" ISTE Ltd , John Wiley & Sons, Inc ,2010.
2. Olivier Hersent, David Boswarthick, Omar Elloumi , "The Internet of Things: Key Applications and Protocols", 2nd Edition John Wiley & Sons Ltd 2012.
3. Jan Holler, Vlasios Tsiatsis, Catherine Mulligan, Stamatis Karnouskos, Stefan Avesand, David Boyle "From Machine-to-Machine to the Internet of Things" Introduction to a New Age of Intelligence , Academic Press 2014
4. Claire Rowland, Elizabeth Goodman, Martin Charlier, Ann Light, and Alfred Lui , "Designing Connected Products" O'Reilly Media, Inc.,2015.
5. Peter Waher "Learning Internet of Things" 2015 Packt Publishing.
6. www.ti.com/product/CC3200.
7. Adrian McEwen,Hakim Cassimally "Designing the Internet of Things" John Wiley and Sons, Ltd , 2014.

15LW50/15LC82 OBJECT BASED IMAGE ANALYSIS FOR REMOTE SENSING

3 0 0 3

INTRODUCTION AND BASIC CONCEPTS OF REMOTE SENSING SYSTEMS: Introduction, Basic concepts of remote sensing, Airborne and space born sensors, Passive and active remote sensing, EMR Spectrum, Energy sources and radiation principles, Energy interactions in the atmosphere, with earth surfaces, Satellites and orbits, Polar orbiting satellites, Multispectral, thermal and hyperspectral sensing, Some remote sensing satellites and their features. (9)

IMAGE PROCESSING SYSTEM AND DISPLAY: Image Processing System Characteristics, The Histogram and Its Significance, Univariate, Multivariate Image Statistics, Black-and-White Hard-Copy Image Display, Temporary Video Image Display, Merging Different Types of Remotely Sensed Data , Transforming Video Displays to Hard-Copy Displays. (8)

IMAGE PREPROCESSING: CORRECTION AND ENHANCEMENT: Radiometric Correction, Geometric Correction of Remote Sensor Data, Image Reduction and Magnification, Contrast Enhancement, Band Rationing, Spatial Filtering to Enhance Low- and High-Frequency Detail and Edges, Special Transformations. (8)

THEMATIC INFORMATION EXTRACTION AND DIGITAL IMAGE CLASSIFICATION: Image Classification, Supervised Classification, The Classification Stage, The Training Stage, Unsupervised Classification, Hybrid Classification of Mixed Pixels, The Output Stage and Post classification, Object-Based Classification, Neural Network Classification, Classification Accuracy, Assessment Change Detection, Image Time Series Analysis, Data Fusion and GIS. (10)

CASE STUDY: APPLICATIONS OF REMOTE SENSING: Introduction, Land Use/Land Cover Mapping, Geologic and Soil Mapping Agricultural Applications, Forestry Applications, Rangeland Applications, Water Resource Applications, Snow and Ice Applications, Urban and Regional Planning Applications, Wetland Mapping, Wildlife Ecology Applications Archaeological Application. (10)

Total : 45

REFERENCES:

1. John R. Jensen, "Introductory Digital Image Processing: A Remote Sensing Perspective'", Pearson, 2015.
2. Thomas Lillesand, Ralph W. Kiefer**,** Jonathan Chipman,"Remote Sensing and Image Interpretation" , Wiley, 2015.
3. Richards John A& Xiuping Xia, "Remote Sensing Digital Image Analysis: An Introduction", Springer-Verlag, 2013
4. Gonzalez Rafael C and Woods Richard E," Digital Image Processing Addison Wesley, New York , Pearson, 2007.
5. Robert Grier Reeves,"Manual of Remote Sensing: American Society of Remote Sensing and Photogrammetry", American Society of Photogrammetry , 2007.

15LW81/15LC83 GREEN COMMUNICATION

3 0 0 3

COOPERATIVE COMMUNICATIONS AND GREEN CONCEPTS :

Network architectures and research issues in cooperative cellular wireless networks; Cooperative communications in OFDM and MIMO cellular relay networks: issues and approaches; Fundamental trade-offs on the design of green radio networks, Green modulation and coding schemes. (9)

COOPERATIVE TECHNIQUES

Cooperative techniques for energy efficiency, Cooperative base station techniques for cellular wireless networks; Turbo base stations ; Antenna architectures for cooperation; Cooperative communications in 3GPP LTE-Advanced, Partial information relaying and Coordinated multi-point transmission in LTE-Advanced. (9)

RELAY-BASED COOPERATIVE CELLULAR NETWORKS

Distributed space-time block codes ; Collaborative relaying in downlink cellular systems ; Radio resource optimization; Adaptive resource allocation ; Cross-layer scheduling design for cooperative wireless two-way relay networks ; Network coding in relay-based networks. (9)

GREEN RADIO NETWORKS

Base Station Power-Management Techniques- Opportunistic spectrum and load management, Energy-saving techniques in cellular wireless base stations , Power-management for base stations in smart grid environment , Cooperative multicell processing techniques for energy-efficient cellular wireless communications. (9)

ACCESS TECHNIQUES FOR GREEN RADIO NETWORKS

Cross-layer design of adaptive packet scheduling for green radio networks; Energy-efficient relaying for cooperative cellular wireless networks ; Energy performance in TDD-CDMA multihop cellular networks ; Resource allocation for green communication in relay-based cellular networks ; Green Radio Test-Beds and Standardization Activities. (9)

Total : 45

REFERENCES:

1. Ekram Hossain, Dong In Kim, Vijay K. Bhargava , "Cooperative Cellular Wireless Networks", Cambridge University Press, 2011.
2. Ekram Hossain, Vijay K. Bhargava (Editor), Gerhard P. Fettweis (Editor), "Green Radio Communication Networks", Cambridge University Press, 2012.
3. F. Richard Yu, Yu, Zhang and Victor C. M. Leung "Green Communications and Networking", CRC press, 2012.
4. Mazin Al Noor, "Green Radio Communication Networks Applying Radio-Over-Fibre Technology for Wireless Access, GRIN Verlag, 2012.
5. Mohammad S. Obaidat, Alagan Anpalagan and Isaac Woungang, "Handbook of Green Information and Communication Systems", Academic Press, 2012.

15LW45/15LC47/15LV42 WIRELESS TECHNOLOGIES AND MEASURING TOOLS

3 2 0 4

MODERN WIRELESS COMMUNICATION SYSTEMS: Second Generation, Third Generation mobile Cellular networks – 4G, 5G, LTE, LTE A- Cognitive Radio Technology. (9+6)

RF SIGNAL AND SYSTEM FUNDAMENTALS: Basics of RF and Microwaves - Scattering parameters – Distribution of power – Deterministic & Random signal Power spectral densities – Microwave passive devices –Mixers – Switches – Attenuators – Connectors & adaptors. (9+6)

RF SIGNAL GENERATION: Oscillator Circuits – Direct Digital synthesis – PLL Based Synthesizers – Arbitrary waveform generator – Vector Signal Generator - Phase frequency detector. (9+6)

POWER AND SCATTERING MEASUREMENTS: Power detectors and instrumentation – Primary power standards – power measurement techniques – History of vector network analyzers – Measurement types in VNA – Two port network analyzer calibration. (9+6)

RF MODULAR INSTRUMENTS: Introduction – Understanding software designed systems – Multichannel measurements – Customized measurement systems – Instruments: Spectrum/Signal Analyser – Digital storage Oscilloscope - Mixed signal Oscilloscopes. (9+6)

Total L: 45 + T: 30=75

TUTORIAL COMPONENT:

1. Study of Vector Signal analysis software.
2. Analysis of BER, EVM and constellation for Digital modulation techniques.
3. Wave form generation and play back operation using vector signal generator and VSA hardware.
4. Frequency domain measurements using Signal analyser.
5. Time domain measurements using Mixed signal oscilloscope.

REFERENCES:

1. Gordon L Stuber, “Principles of Mobile Communication”, Artech House, 2011.
2. Valeria Teppati, ,Andrea FerreroMohamed Sayed “Modern RF and Microwave Measurement Techniques”, Cambridge University Press, 2013.
3. Ananjan Basu “An Introduction to Microwave Measurements”, CRC Press, 2015.
4. Matthew M Radmanesh “RF & Microwave Design Essentials”, Author house, 2007.
5. Hsiao-Hwa Chen and Mohsen Guizani, "Next Generation Wireless Systems and Networks”, John Wiley & Sons, 2006.

15LW46/15LC46/15LV41 RF CIRCUITS AND MEASUREMENTS

3 2 0 4

PASSIVE RF COMPONENTS AND TRANSMISSION LINE ANALYSIS: High frequency Resistors, Capacitor and Inductors – Transmission Line Analysis: Line equation, Micro strip line, Voltage Reflection Co-efficient, propagation constant phase velocity and special termination - Smith Chart-Impedance transformation - Analysis of parallel RL circuit and parallel RC circuit. (9+6)

SINGLE AND MULTI PORT NETWORK THEORY AND RF FILTER DESIGN: Definition - properties - interconnection of networks - ABCD parameters and S parameters - RF Filter Resonator and filter configuration - Butterworth and chebyshev filters. Design of micro strip filters. (9+6)

DESIGN OF MATCHING NETWORK: Matching by Discrete Components - Design of two-component matching network, Design of T and π matching network- Matching by micro strip line - Design of matching network - Design of stub matching. (9+6)

MEASUREMENTS USING VECTOR NETWORK ANALYZER: Operating principles of VNA-Calibration of VNA- Specification of N and SMA connectors-Inferences of VNA Measurements. (9+6)

MEASUREMENTS USING SPECTRUM ANALYZER: Operating principles of spectrum analyzer- measurement categories-Characteristics of Spectrum analyzer-applications of spectrum analyzer. (9+6)

Total L: 45+T: 30=75

TUTORIAL COMPONENT:

1. Design, simulation and testing of branch-line coupler.
2. Design, simulation and testing of Rat-race coupler.
3. Design, simulation and testing of stepped impedance filter.
4. Design, simulation and testing of microstrip filter.

REFERENCES:

1. Reinhold Ludwig and Pavel Bretchko, “RF Circuit Design”, Pearson Education Asia Publication, 2011.
2. Matthew M Radmanesh, “Radio Frequency and Microwave Electronics Illustrated”, Pearson Education ,Asia Publication, 2001.

3. David M Pozar, “Microwave Engineering”, John Wiley and Sons, Inc., 2011.
4. Les Besser and Rowan Gilmore, “Practical RF Circuit Design for Modern Wireless Systems Vol I Passive Circuit and Systems, Artech house”, London, 2003.

15LW47/15LC48/15LV43 EMBEDDED SYSTEM DESIGN

3 2 0 4

EMBEDDED DESIGN CYCLE: Differences between the Desktop PC and typical Embedded System-Examples of Embedded Systems-Major hardware and software modules of an embedded system-Product Specification, Hardware/Software Partitioning, Iteration and Implementation, Detailed Hardware and Software Design, Hardware Software Integration, Product Testing and Release, Maintenance and Upgrading Existing products. (4)

REVIEW OF EMBEDDED ARCHITECTURES: CPU Core**,** Clock and Reset Generator, PLL, RTC, Program Memory, Data Memory, EEPROM, Parallel Ports, Timers/Counters, Watch-dog timers, input-Capture/Output Compare units, PWM unit, Interrupt Structure, Data converters, Serial communication using SCI, SPI, I2C, CAN and USB - Introduction to LIN and MOST - Development and debugging Support: JTAG and BDM. (12+6)

EMBEDDED SOFTWARE DEVELOPMENT TOOLS: Host and Target Machines, Cross-Compilers, Cross-Assemblers, Linker/Locator for Embedded Software, Locator Maps, Intel hex file format/Motorola s-record format. Introduction to Integrated Development Environment (IDE)- programming concepts and embedded programming in C. Debugging and simulation techniques, Programming the target system. (8+3)

PERIPHERAL PROGRAMMING: Developing device drivers, Configuring and programming of ports, timer / counter, data converters, interrupts and serial communication. (6+6)

REAL TIME OPERATING SYSTEMS (RTOS): Survey of software architectures, hard/soft real time systems, Tasks and Task States, Tasks and Data, Semaphores and Shared Data, Message Queues, Mailboxes and Pipes, Timer functions, Events, Memory Management, Interrupt Routines in RTOS Environment. (8+6)

CASE STUDY: Study and analysis of generating low frequency bio signals, High power signal analysis using Mixed Signal oscilloscopes, FPGA Debugs and host of serial protocols like CAN/LIN,USB, RS232/UART, I²C/SPI, MIL-STD 1553/ARINC 429, I²S, Application development in ARM micro controllers / Micro controllers / DSP controllers, Programming with RTOS.

(7+9)

Total L: 45+T:30=75

TUTORIAL COMPONENT:

1. Parallel Port programming and interfacing of I/O devices.
2. Interrupt programming: Timer interfacing and analyzing capture compare module.
3. Serial port interfacing.
4. Serial protocol analyzing: RS232 / RS485 / SPI / SCI / I2C / CAN / USB.
5. Programming and Interfacing of data converters.

REFERENCES:

1. Rajkamal, “Embedded Systems: Architecture, Programming and Design”, Tata McGraw-Hill, 2006.
2. David E Simon, “An Embedded Software Primer”, Pearson Education Asia, 2006.
3. Arnold Berger, “Embedded System Design: An Introduction to Processes, Tools, and Techniques”, CMP Books, 2001.
4. Wayne Wolf, “Computers as Components: Principles of Embedded Computing System Design”, Morgan Kuafmann Publishers, 2005.

15LW48/15LC49/15LV40 FPGA BASED IMPLEMENTATION OF SIGNAL PROCESSING SYSTEMS

3 2 0 4

FUNDAMENTALS OF FPGAs and DSP: Introduction to Field-programmable Gate Arrays, A Short History of the Microchip, Influence of Programmability, Challenges of FPGAs, DSP System Basics, DSP System Definitions, DSP Transforms, Filter Structures, Adaptive Filtering, Basics of Adaptive Filtering, Number Systems, Fixed-point and Floating-point, Arithmetic Operations, Fixed-point versus Floating-point. (9+6)

FPGA TECHNOLOGIES AND IMPLEMENTATION ISSUES: Xilinx FPGA Technologies, Altera FPGA Technologies, Various Forms of the LUT, Memory Availability Fixed Coefficient Design Techniques, Distributed Arithmetic, Reduced Coefficient Multiplier. (9+6)

ARCHITECTURES AND TOOLS FOR FPGA BASED DSP SYSTEMS: The Evolution of FPGA System Design, Design Methodology Requirements for FPGA DSP, System Specification, IP Core Generation Tools for FPGA, System-level Design Tools for FPGA, DSP Algorithm Characteristics, DSP Algorithm Representations, Basics of Mapping DSP Systems onto FPGAs, Parallel Operation, Hardware Sharing, Application to FPGA. (9+6)

COMPLEX DSP SYSTEMS: Motivation for Design for Reuse, Intellectual Property (IP) Cores, Evolution of IP Cores, Parameterizable (Soft) IP Cores, IP Core Integration, IP Core Example, Current FPGA-based IP Cores, Dataflow Modelling and Rapid Implementation for FPGA DSP Systems, System-level Design and Exploration of Dedicated Hardware. (9+6)

LOW POWER FPGA IMPLEMENTATION: Sources of Power Consumption, Power Consumption Reduction Techniques, Voltage Scaling in FPGAs, Reduction in Switched Capacitance, Data Reordering, Fixed Coefficient Operation, Pipelining, Locality, Application to an FFT Implementation, Reconfigurable Systems, Memory Architectures, Support for Floating-point Arithmetic. (9+6)

Total L: 45+T: 30=75

TUTORIAL COMPONENT:

1. FPGA implementation of Digital Filters.
2. FPGA implementation Adaptive Filters.
3. FPGA implementation of Fixed point and Floating point Architectures.
4. FPGA implementation of Distributed Arithmetic Architecture.
5. IP Core Generation for System Level Design.
6. FPGA based DSP System implementation.
7. FPGA implantation of Reconfigurable systems.

REFERENCES:

1. Roger Woods, John McAllister, Gaye Lightbody and Ying Yi, “FPGA-based Implementation of Signal Processing Systems”, John Wiley and Sons, 2008.
2. Uwe Meyer Baese, “Digital Signal Processing with Field Programmable Gate Arrays”, Springer, 2004.
3. Wayne Wolf, “FPGA-Based System Design”, Prentice Hall, New Delhi, 2012.

ONE CREDIT COURSES

For the detailed Syllabi of all the one credit courses offered by Electronics and Communication Engineering department which are listed in this programme scheme refer to the syllabi of M.E Communication Systems programme.

For the detailed syllabi of the electives and one credit courses offered by other departments refer to the syllabi of M.E- Automotive Engineering offered by Automobile Engineering Department.