SEMESTER – I

18LW01/18LC01 APPLIED MATHEMATICS

2 2 0 3

RANDOM VARIABLES: Continuous, Discrete and Mixed random variables, cumulative distribution function - joint distribution-marginal distribution - conditional distribution –statistical independence. (8+7)

EXPECTATION AND ESTIMATION: Moments, central moments – mean, variance, Chebyshev and Schwarz inequatlities, Chernoff bound, auto correlation, cross – correlation, covariance, characteristic functions, central limit theorem. (8+7)

RANDOM PROCESSES: Classification of Random processes, Poisson process, stationary process, wide sense stationary process, cross correlation, White Gaussian process, linear filter. (8+7)

VECTOR SPACES: Real vector spaces and subspaces – linear independence - basis and dimension, inner product space - orthonormal bases - Gram-Schmidt process, linear transformations - change of basis - inverse linear transformation, eigenvalues and eigenvectors. (8+7)

Total L:32 + T:28 = 60

REFERENCES:

1. Howard Anton and Chris Rorres, “Elementary Linear Algebra: Applications Version”, Wiley India, New Delhi, 2018.
2. David C Lay, “Linear Algebra and Its Applications”, Pearson Education, New Delhi, 2017.
3. Saeed Ghahramani, “Fundamentals of Probability with Stochastic Processes”, Pearson, New Delhi, 2016.
4. H. Stark and J.W. Woods, “Probability and Random Process with Applications to Signal Processing”, Pearson Education, 2012.
5. Roy D.Yates and David J Goodman, “Probability and Stochastic Processes - A Friendly Introduction for Electrical and Computer Engineers”, John Wiley & Sons, 2012.

18LW02 ADVANCED DIGITAL COMMUNICATIONS

2 2 0 3

SIGNALING THROUGH AWGN CHANNEL: Review of Signal Representation and Optimum Receivers, Definitions for SER, BER, SNR, average symbol energy, bit energy and Eb/No, decision boundary and decision regions for AWGN model with/without equal prior probability, Exact symbol error probability for several linear modulation schemes (ASK, FSK, PSK and QAM), union bound argument, Chernoff bound. (8+10)

SIGNALING THROUGH BANDLIMITED CHANNELS: Nyquist criterion for zero ISI, Sync and Raised cosine pulse shaping, controlled ISI using duobinary signals. (6+6)

SIGNALING THROUGH DISTORTING CHANNELS: ISI, Zero forcing equalization, Linear MMSE equalizers, Decision Feedback Equalizer, Fractionally Spaced Equalizer – Introduction to Adaptive Equalization. (4+4)

BLOCK MODULATION SCHEMES: single carrier, multicarrier, cyclic prefix in the guard interval, OFDM, OFDMA, MC-CDMA, Introduction to Generalized block modulation schemes – UMC, GFDM, IFDMA, FBMC. (6+6)

TIMING AND FREQUENCY SYNCHRONISATION: synchronization of baseband signals, oversampling, early late gate methods, delay locked loop and squaring loop, carrier synchronization, PLL and Costas loop, pilot aided and decision aided approaches. (6+4)

Total L: 30+T:30=60

TUTORIAL COMPONENT:

- BER Analysis of basic digital modulation schemes – ASK, FSK, BPSK, QPSK and QAM.
- BER Analysis of multicarrier modulation schemes.
- Zero forcing and adaptive equalizer design for signal transmission through distorting channels.

REFERENCES:

1. S Haykin, “Digital Communication Systems”, John Wiley & Sons, 2013.
2. Proakis J.G and Salehi M “Fundamentals of Communication Systems” Pearson, 2011.
3. Lajos L Hanzo and Thomas Keller, “OFDM and MC-CDMA – A primer”, John Wiley and Sons Ltd, 2006.
4. Bernard Sklar, "Digital Communications", Pearson Education Asia, Sixth reprint, 2005.
5. Barry S, Lee E A and Messershmitt D J, “Digital Communications”, Kluwer Academic Press, 2004.

18LW03 WIRELESS NETWORKS

3 0 0 3

WIRELESS PAN and LAN: Introduction to Bluetooth, Protocol Stack, Network Connection Establishment, Network topology, Bluetooth applications, Zigbee technology. Introduction to Wireless LANs, WLAN Equipment, Topologies, and Technologies. IEEE802.11 : Architecture and Services, Physical Layer, Data Link Layer, MAC sub layer, IEEE 802.16 WiMAX: Roadmap, physical layer, MAC layer and spectrum allocation. (12)

WIRELESS WIDE AREA NETWORKS: GSM: Evolution for data, 3G wireless systems, UMTS – Network architecture, CODEC, bearer service and QoS. CDMA: CDMA 2000 layering structure, forward link features, reverse link physical channels, WCDMA, evolution of IS 95 to CDMA 2000, IMT 2000, HSPA, HSPA+, LTE and LTE advanced. (12)

ADHOC WIRELESS NETWORKS: Characteristics of Adhoc Networks, Classifications of MAC Protocols - Table driven and Source initiated On Demand routing protocols, DSDV, AODV, DSR and Hybrid Protocols. (11)

FOURTH GENERATION SYSTEMS AND TECHNOLOGIES: 4G vision, features and challenges, applications, 4G technologies: Multicarrier modulation, smart antenna techniques, OFDM – MIMO systems, Adaptive modulation and coding with time slot scheduler, BLAST system, SDR and cognitive radio. (10)

Total L: 45

REFERENCES:

1. Vijay K Garg, "Wireless Communication and Networking", Morgan Kaufmann Publishers, 2010.
2. Dharma Prakash Agrawal and Qing-An Zeng, "Introduction to wireless mobile systems" Thomson India, 2007.
3. Siva Ram Murthy C and Manoj B S, "Ad Hoc Wireless Networks: Architectures and Protocols", Prentice Hall, 2004.

18LW04 WIRELESS COMMUNICATION SYSTEM DESIGN

3 2 0 4

PATH LOSS, SHADOWING AND MULTIPATH CHANNEL MODELS: Free-Space Path Loss, Two-Ray Model, Simplified Path Loss, Shadow Fading, Path Loss and Shadowing, Cell Coverage Area, 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, Wideband Fading Models, Jakes Model, Power Delay Profile, Coherence Bandwidth, Doppler Power Spectrum and Channel Coherence- Capacity in AWGN, Flat Fading, Selective Fading Channels. (12+8)

BER ANALYSIS OF WIRELESS CHANNELS: BER: Error Probability for BPSK, QPSK and QAM 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. (12+8)

ERROR CONTROL CODING: Linear block codes - Polynomial representation of codes - Cyclic codes - Convolutional codes - Viterbi decoding algorithm – Other decoding methods of convolutional codes, Galois fields, BCH codes, Reed Solomon codes, Interleaving and Concatenated codes, Turbo codes, Low- Density Parity-Check codes. (9+6)

WIRELESS SYSTEM DESIGN: Cellular System Design, Frequency Reuse in Cellular Systems, Co-channel Interference and its impacts, Erlang-D formula, Trunking efficiency, MIMO, Receiver Sensitivity, Link Budget, Noise Figure, Radio Planning, Wireless Communication System Design Flow, Design Considerations - High Level View of Wireless Communication Systems, 4G Physical Layer Systems, Case Studies from 4G Communication System. (12+8)

Total L: 45+ T: 30 = 75

TUTORIAL COMPONENT:

- Pathloss with/without Shadowing
- Frequency Reuse
- Flat Fading
- Frequency Selective Fading.

REFERENCES:

1. Haesik Kim, "Wireless Communications System Design", John Wiley & Sons, 2015
2. Andreas F Molisch , "Wireless Communications", John Wiley & Sons, 2012.
3. Andrea Goldsmith, "Wireless Communications", Cambridge University Press, 2007.
4. Theodore S Rappaport, "Wireless Communications", Pearson Education, Asia , New Delhi, 2009
5. David Tse and Pramod Viswanath, "Fundamentals of Wireless Communication", Cambridge University Press, 2005.

18LW05/18LC05 COMMUNICATION ALGORITHMS ON FPGA

3 2 0 4

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 – Timing issues. (11+8)

FIELD PROGRAMMABLE GATE ARRAYS: Introduction – FPGA Technology – DSP Technology Requirement – Design Implementation – FPGA Architectures – Xilinx – Altera Flex – FPGA implementation issues. (11+6)

DSP ALGORITHMS ON FPGA: Fixed and Floating point arithmetic - Design of Binary Adders, Multipliers, Dividers and MAC unit - Design of FIR Filters – Design of IIR Filters – DFT and FFT Algorithms, Approximate DSP algorithms. (11+8)

DIGITAL COMMUNICATION MODULES ON FPGA: Error Control Coders and decoders, encryption, scrambling, LMS Algorithm for channel estimation/equalization, pulse shaping, interpolation, decimation, CORDIC implementations, Numerically controlled oscillator and SDR. (12+8)

Total L: 45+ T: 30 = 75

TUTORIAL COMPONENT:

- Design and implementation of FFT and IFFT algorithm.
- Design and implementation of programmable PN sequence generator.
- Implementation of Universal Modulator and Demodulator using CORDIC
- OFDM Transmitter implementation using model based design.

REFERENCES:

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

18LW51 WIRELESS NETWORKS LABORATORY

0 0 4 2

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 56 hours.

- Networking commands (Windows and LINUX)
- Packet and protocol analysis using Wireshark
- Performance analysis of MAC and Routing protocols (RIP and OSPF) using NS2/ NS3
- Study and performance of CSMA / CA using NS2 / NS3
- Performance analysis of Networks with and without packet latency
- Mapping of IP packet with LTE packet

Total P :60

SEMESTER – II

18LW06/18LC30 RADIATING SYSTEMS

3 0 0 3

ANTENNA FUNDAMENTALS: Antenna parameters, Radiation integrals, Radiation from surface and line current distributions, monopole, loop antenna; Mobile phone antenna - hand set antenna - base station antenna-Radiation Hazards. (6)

RADIATION FROM WIRE AND APERTURE ANTENNAS: Radiated fields of infinitesimal and half wave dipole,; Introduction to numerical techniques, 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. (12)

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, 2015.
2. Krauss J D, "Antennas", John Wiley and sons, New York, 2008.
3. Stutzman W L and Thiele G A, "Antenna Theory and Design", John Wiley and Sons Inc., 1998.
4. Bahl I J and Bhartia P, "Microstrip Antennas", Artech House,Inc.,1980

18LW07 RF AND MICROWAVE CIRCUIT DESIGN

3 0 0 3

PASSIVE COMPONENTS AND TRANSMISSION LINE ANALYSIS: High frequency Resistors, Capacitor and Inductors – Transmission Line Analysis and its types –Smith Chart-Impedance transformation- single and multiport networks – network parameters –RF Filter design – definition-RF Filter Resonator and filter- configuration -- properties - Butterworth and Chebyshev filters. Design of microstrip filters. (12)

MATCHING NETWORKS AND PASSIVE DEVICES: Matching with lumped Elements – quarter wave transformer- Design of T and π matching network- Matching by micro strip line -Stub matching. Single stub matching – Double stub matching. Basic properties of dividers and couplers – T Junction Power divider – Wilkinson Power divider – Quadrature Hybrid – Coulped line Directional Coupler.

(9)

LINEAR AND LOW NOISE MICROWAVE AMPLIFER: Introduction power gain definitions- neutralization- unilateral transducer RF circuit stability considerations- bilateral RF amplifier design for maximum small operating gain - design for maximum linear output power . Noise in RF/Microwave circuits- available gain design technique- Smith chart based graphical design aids- broadband amplifiers. (12)

ACTIVE MICROWAVE DEVICES AND THEIR MODELLING: Model- two port devices models-high power amplifiers- Nonlinear circuit simulation techniques- Classification of nonlinear circuit simulators- harmonic - balance method Harmonic balance analysis of oscillators- mixers– Overview of mixers -- frequency multipliers-doublers. (12)

Total L: 45

REFERENCES:

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

18LW08 FILTER DESIGN ON DIGITAL SIGNAL PROCESSOR

3 2 0 4

TMS320C6x PROCESSOR: Evolution of DSP Processor. Architecture of the C6X Processor – Instruction Set – DSP Development System: Introduction-DSP Starter Kit Support Tools- Code Composer studio – Support files – programming – TMS320C6748 DSP Development Kit-Peripheral Information and Electrical Specifications-Multichannel Audio Serial Port –OMAP-L138 Development system-Programming Examples Using C Code. Review of signal processing – Z-Transform - relationships between system representations - FIR and IIR Systems, Application programs for processing real time signals. (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. (12+8)

FILTER BANKS AND MULTICARRIER TECHNOLOGIES: Two channel filter banks - QMF filter banks - Perfect Reconstruction Filter banks - Filter banks with tree structure and parallel structure – Filter Bank based Multicarrier Technologies – Principles of FBMC Transmission –FBMC Transceiver Design – Pulse Design – Orthogonal Multiple carrier Data transmission – Practical FBMC System Design Issues. (12+8)

ADAPTIVE FILTERS: 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. (12+8)

Total L: 45 + T: 30 = 75

TUTORIAL COMPONENT:

- FIR and IIR Filter implementation using digital signal processor.
- Time and frequency domain analysis of decimators and interpolators.
- Implementation of Filter bank systems.
- Implementation of LMS algorithm.
- DSP Processor based multirate systems and filter bank implementation.

REFERENCES:

1. Hanna B, Adrian K, and Pawel.K “Advanced Multicarrier Technologies for Future Radio Communication”, Willey, 2017.
2. Simon Haykin “Adaptive Filter Theory", Pearson education, 2013.
3. Vaidyanathan P P, “Multirate Systems and Filter banks”, Prentice Hall, 2008.
4. Hayes M H, "Statistical Digital Signal Processing and Modeling ", Wiley, New York, 2008.
5. Rulph Chassaing, "Digital Signal Processing and Applications with the C6713 and C6416 DSK", Willey, 2005.

18LW09/18LC09 EMBEDDED SYSTEM DESIGN AND IOT

3 2 0 4

COMPONENTS OF EMBEDDED SYSTEMS: Introduction to Embedded Systems, Embedded Design Life Cycle. Overview of ARM Processors. Functional block diagram of ARM Cortex-A, Cortex-R and Cortex-M series controllers and its features. (8+3)

PERIPHERAL INTERFACING TECHNIQUES: Memory Management - Program Memory, Data Memory. AHB and APB Bus Structure. GPIOs, Timer/Counters, Capture/Compare Modules, PWM, QEI, RTC, WDT, DMA, EEPROM and PLL. Serial Peripherals: UART, I2C, SPI, CAN and USB. Hardware and Software Interrupts, Analog Peripherals: ADC, DAC and Analog Comparators. (16+15)

INTERNET OF THINGS: Introduction, IoT protocols: MQTT and AMQP, IoT Security: AES and TLS1.2, FOTA, Consumer Electronics IoT, Automotive IoT, Health Care IoT and Industrial IoT. (11+7)

CLOUD AND APP FACILITIES FOR IoT: Amazon Web Services Cloud (AWS), MS Azure, IBM Bluemix, Carriots and Thing Speak, GE predix. MIT App Inventor and Android App Development tools. (10+5)

Total L: 45 + T: 30 = 75

TUTORIAL COMPONENT:

- Simple problems simulation using IDE
- Smart Sensors Interfacing
- Experimenting Serial Communication Protocols
- Remote Monitoring and Control through Web Browser using WiFi
- Cloud based Data Analysis.

REFERENCES:

1. Arshdeep Bahga and Vijai Madisetti “Internet of Things: A Hands-on Approach”, Bahga & Madisetti, 2014.
2. Jonathan W. Valvano, “Embedded Systems: Real-Time Interfacing to Arm(r) Cortex -M Microcontrollers: Volume 2”, Create Space Independent Publishing Platform, 2012.
3. Jonathan W. Valvano, “Embedded Systems: Real-Time Interfacing to Arm(r) Cortex -M Microcontrollers: Volume 1”, Create Space Independent Publishing Platform, 2011.
4. Steve Furber,” ARM System-on-Chip Architecture”, Prentice Hall of India, New Delhi, 2009.
5. Arnold S. Berger, “Embedded Systems Design: An Introduction to Processes, Tools, and Techniques” CMP Books, 2002.
6. Tiva TM4C123GH6PM Microcontroller Datasheet.

18LW52 RF SYSTEM DESIGN USING EDA TOOLS LABORATORY

0 0 4 2

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 56 hours.

- Design, simulation and analysis of transmission line and impedance matching networks WLAN Application.
- Design, implementation and fabrication of micro strip Filters, coupler and Patch Antenna for GSM /ISM Band Application using ADS.
- Design, simulation and analysis of oscillators/mixers for RF Applications.
- Implementation and analysis of Stepped impedance and Open/Short circuited stub Micro strip Filter for RF Applications and its Field distribution Analysis using 3D structural simulator.
- Implementation and analysis of micro strip Patch Antenna for GSM & ISM Application and its Radiation Pattern & Field distribution Analysis using 3D structural simulator.

Total P :60

18LW61 INDUSTRY VISIT AND TECHNICAL SEMINAR

0 0 4 2

The student will make at least 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

SEMESTER –III

18LW53 WIRELESS SYSTEM DESIGN LABORATORY

0 0 4 2

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 56 hours.

- Design and implementation of subband coding Filter Bank Systems using FPGA.
- Design and implementation of Convolutional Coder Using FPGA.
- Performance analysis of Raised cosine PAM Signal, Multilevel M-ary PAM signal in an optimum receiver using System Vue.
- Generation of M-ary PSK signals and its performance analysis for the optimum Receiver in AWGN environment using System Vue.
- Design and implementation of OFDM and FBMC Systems using SystemVue.
- Single mode Fiber optic Link extension using Fiber Cleaver and Fusion Splicer.
- Fault diagnosis of Fiber optic Cable link using optical Time domain Reflectometer.

Total P: 60

18LW71 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

18LW72 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

18LW21 WIRELESS SENSOR NETWORKS

2 2 0 3

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+6)

SENSOR LOCALIZATION AND TIME SYNCHRONIZATION: Localization and positioning: Possible approaches, single hop localization, positioning in multihop environments. Time synchronization: Time synchronization problem, protocols based on sender to receiver and receiver to receiver synchronization in WSN. (8+6)

MAC AND ROUTING PROTOCOLS: Fundamentals of wireless MAC protocols, low duty cycle protocols and wakeup concepts, contention-based protocols, Schedule-based protocols. ROUTING PROTOCOLS - Gossiping and agent-based unicast forwarding, Energy-efficient unicast, Broadcast and multicast, geographic routing, Data centric routing, Data aggregation. (8+10)

SENSOR NETWORK PROGRAMMING: Programming Challenges in Wireless Sensor Networks, Tiny Operating System, Contiki OS, Event-Driven Programming, Techniques for Protocol Programming. Simulators: GloMosim, Sensor Sim, ToSSIM and Power TOSSIM.

(6+8)

T**OTAL L: 30 + T: 30 = 60**

TUTORIAL COMPONENT:

- Basics of WSN programming
- Sensing data using WSN motes
- Simulation with RTOS (TOSSIM)
- Dissemination and over the air programming

REFERENCES:

1. Sitharama Iyengar S, Nandan Parmeshwaran, Balkrishnan N and Chuka D, “Fundaments of Sensor Network Programming, Applications and Technology”, John Wiley & Sons, 2011.
2. Fei Hu and Xiaojun Cao, “Wireless Sensor Networks Principles and Practice”, CRC Press, 2010.
3. Jean Philippe Vasseur and Adam Dunkels, “Interconnecting Smart Objects with IP, The Next Internet”, Morgan Kaufmann, Elsevier, 2010.
4. Holger Karl and Andreas willig, “Protocol and Architecture for Wireless Sensor Networks”, John Willey Publication, Oct 2007.
5. Feng zhao and Leonidas guibas, “Wireless Sensor Networks: an Information Processing Approach”, Elsevier Publication, 2004.

18LW22 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. (7)

OTN AND MPLS: OTN - Architecture, Digital wrappers, Control Planes, Layered model, Encapsulation and Decapsulation operations, Generic Framing Procedure, MPLs – Labels and forwarding, QoS, signaling and routing and carrier transport (11)

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. (9)

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.

18LW23 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) - Stream ciphers ,Pseudorandom number Generator, 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)- IEEE 802.11x-Standards-Bluetooth security. (9)

SECURITY IN WIREELSS DATA NETWORKS: Wireless Device security issues- 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. Wolfgang Osterhage ,Wireless security, CRC press ,2016.
2. William Stallings, “Cryptography and Network Security, Principles and Practices”, Pearson; 7th edition, 2016.
3. Behrouz A Forouzan, “Hill Cryptography and Network Security“, McGraw, 2011.
4. Hakima Chaouchi, Maryline Laurent, Maknavicius,” Wireless and Mobile Network security”, 2010.
5. Merritt Maxim and David Pollino, “Wireless Security”,RSA press series Osborne/McGraw Hill, 2002.
6. Nichols and Lekka, “Wireless Security-Models, Threats and Solutions”, McGraw – Hill, 2002.

18LW24 DIGITAL SIGNAL PROCESSOR ARCHITECTURES

3 0 0 3

PROGRAMMABLE DSP HARDWARE: Processing Architectures (von Neumann, Harvard), DSP core algorithms (FIR, IIR, Convolution, Correlation, FFT), IEEE standard for Fixed and Floating Point Computations, Special Architectures Modules used in Digital Signal Processors (like MAC unit,Barrel shifters), On-Chip peripherals, DSP benchmarking. (11)

STRUCTURAL AND ARCHITECTURAL CONSIDERATIONS: Parallelism in DSP processing, Texas Instruments TMS320 Digital Signal Processor Families, Fixed Point TI DSP Processors: TMS320C1X and TMS320C2X Family,TMS320C25 –Internal Architecture, Arithmetic and Logic Unit, Auxiliary Registers, Addressing Modes (Immediate, Direct and Indirect, Bit-reverse Addressing), Basics of TMS320C54x and C55x Families in respect of Architecture improvements and new applications fields, TMS320C5416 DSP Architecture, Memory Map, Interrupt System, Peripheral Devices, Illustrative Examples for assembly coding. (12)

VLIW ARCHITECTURE: Current DSP Architectures, GPUs as an alternative to DSP Processors, TMS320C6X Family, Addressing Modes, Replacement of MAC unit by ILP, Detailed study of ISA, Assembly Language Programming, Code Composer Studio, Mixed Cand Assembly Language programming, On-chip peripherals, Simple applications developments as an embedded environment. (11)

MULTI-CORE DSPS & P-DSP: Introduction to Multi-core computing and applicability for DSP hardware, Concept of threads, introduction to P-thread, mutex and similar concepts, heterogeneous and homogenous multi-core systems, Shared Memory parallel programming –OpenMP approach of parallel programming, PRAGMA directives, OpenMP Constructs for work sharing like for loop, sections, TI TMS320C6678 (Eight Core subsystem). Preliminaries of HPC, MPI, OpenMP, multicore DSP as HPC infrastructure. (11)

Total L: 45

REFERENCES:

1. Fayez Gebali, "Algorithms and Parallel Computing",1st Edition, John Wiley & Sons, 2011
2. Ann Melnichuk,Long Talk, "Multicore Embedded systems", 1st Edition, CRC Press, 2010.
3. M. Sasikumar, D. Shikhare, Ravi Prakash, "Introduction to Parallel Processing", 1st Edition, PHI, 2006.
4. Wayne Wolf, "High Performance Embedded Computing: Architectures, Applications and Methodologies", 1st Edition, Morgan Kaufman, 2006.
5. Rohit Chandra, Ramesh Menon, Leo Dagum, David Kohr, DrorMaydan, Jeff McDonald,"Parallel Programming in OpenMP", 1st Edition, Morgan Kaufman, 2000.

18LW25 SOFTWARE DEFINED RADIO ARCHITECTURE

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)

ARCHITECTURE AND STANDARDISATION OF SDR: Signal Processing Architectures - GPP-Based SDR, FPGA-Based SDR, Architecture for FPGA-Based SDR, Hybrid and Multi-FPGA Architectures, Hardware Acceleration, Multi-Channel SDR; SDR Standardization - Software Communications Architecture – JTRS, STRS, Physical Layer Description and Data Formats. (10)

RF SYSTEM DESIGN: Introduction- Principal Challenge of Receiver Design - Enhanced Flexibility of the RF Chain with Software Radios - Noise and Channel Capacity, Transmitter RF Architectures - Receiver RF Front End Architectures, State-of-the-Art SDR Components - SDR Using Test Equipment, SDR Using COTS Components. (9)

HARDWARE AND SOFTWARE CENTRIC SDR PLATFORMS: Hardware platforms for SDR – Universal Software Radio Peripheral, Wireless open Access Research platform, RTL SDR receiver. Software platforms for SDR- GNU Radio, Open-Source SCA Implementation: Embedded, Other All-Software Radio Frameworks and Front End for Software Radio. (9)

APPLICATIONS OF SDR: Cognitive Radio and Intelligent Wireless Adaptation – Wireless Device Parameters, Vehicular Communication Networks – VDSA overview, Transmitter and Receiver design, VDSA Test bed Implementation, Satellite Communication. (8)

Total L: 45

REFERENCES:

1. Eugene Grayver, "Implementing Software Defined Radio", Springer, 2013.
2. Alexander M. Wyglinski, Di Pu, "Digital Communication Systems Engineering with Software-Defined Radio", Artech House, 2013.
3. Jeffrey H Reed, "Software Radio: A Modern Approach to Radio Engineering", PEA Publication, 2002.
4. Walter Tuttle bee, "Software Defined Radio: Enabling Technologies", Wiley Publications, 2002.

18LW26 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. Mahbub Hassan and Raj Jain, "High Performance TCP/IP Networking", Pearson Education, 2004.
3. Jean Warland and Pravin Vareya, "High Performance Communication Networks", Morgan Kauffman Publishers, 2002
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.

18LW27 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. Richards M A, Scheer J A and Holm W A, "Principles of Modern Radar", Yes Dee Publishing Pvt. Ltd., 2012.
2. Merril I Skolnik, "Introduction to Radar Systems", Mc Graw-Hill, 2008.
3. Bringi V N and Chandrasekar V, "Polarimetric Doppler Weather Radar ", Cambridge University Press, 2001.
4. Richard J Doviak and Dusan S Zrnic, "Doppler Radar and Weather Observations", Dover Publications, 1993.

18LW28 SPACE TIME WIRELESS COMMUNICATION

3 0 0 3

MULTIPLE ANTENNA PROPAGATION AND ST CHANNEL CHARACTERIZATION: Wireless channel: free space, fixed transmitting and receive antennas - free space, moving antenna - reflecting wall, fixed antenna - reflecting wall, moving antenna - reflection from a ground Plane, 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. David Tse and Pramod Viswanath, “Fundamentals of Wireless Communication”, Cambridge University Press, 2005.
2. Andrea Goldsmith, “Wireless Communications”, Cambridge University Press, 2005.
3. Paulraj A, Rohit Nabar and Dhananjay Gore, “Introduction to Space Time Wireless Communication Systems”, Cambridge University Press, 2003.
4. Sergio Verdu, “Multi User Detection”, Cambridge University Press, 2003
5. Andre Viterbi, “Principles of Spread Spectrum Techniques”, Pearson, 1995.

18LW29 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. Hanzo L and Keller T, “OFDM and MC-CDMA: A Primer”, John Wiley and sons Ltd., 2006.
2. Peterson R L, Ziemer R E and Borth D E, “Introduction to Spread Spectrum Communications”, Prentice Hall, 2005.
3. Dixon R C, “Spread Spectrum Systems with Commercial Applications”, John Wiley & Sons, 1994.
4. Ziemer R E and Peterson R L, "Digital Communication and Spread Spectrum Systems", Macmillan Publishing Co., 1985.
5. Holms J K, "Coherent Spread Spectrum Systems", Wiley Interscience, 1982.

18LW30 5G WIRELESS TECHNOLOGIES

3 0 0 3

INTRODUCTION AND ROADMAP TO 5G: Historical trend and evolution of LTE technology to beyond 4G – Key building blocks of 5G – 5G use cases and System Concepts – The 5G Architecture – IoT: relation to 5G. (8)

RF FRONT END FOR 5G: Millimeter Wave Communications: Hardware technologies for mmW systems – Architecture and Mobility – Massive MIMO: Resource allocation and transceiver algorithms for massive MIMO - Fundamentals of baseband and RF implementations in massive MIMO - Beamforming. (9)

5G WAVEFORMS AND CHANNEL MODELS: 5G Radio Access Technologies: Design principles - Multi-carrier with filtering - Non-orthogonal Multiple Access - Radio access for dense deployments – Radio Access for V2X Communication - Radio access for massive machine-type communication - 5G wireless propagation channel models: Modelling requirements and scenarios - The METIS channel models. (10)

NETWORKING IN 5G: Coordinated multi-point transmission in 5G: Joint Transmission CoMP enablers - Distributed cooperative transmission - JT CoMP with advanced receivers - Relaying and network coding in 5G: Multi-flow wireless backhauling - Buffer-aided relaying. (9)

EVALUATION OF 5G AND 5G APPLICATIONS: Machine-type communications: Fundamental techniques for MTC - Massive MTC - Ultra-reliable low-latency MTC - Device-to-device (D2D) communications - Multi-hop D2D communications - Multi-operator D2D communication - Simulation methodology: Evaluation methodology – Calibration - New challenges in the 5G modelling. (9)

Total L: 45

REFERENCES:
1. Wei Xiang, Kan Zheng, Xuemin (Sherman) Shen, - 5G Mobile Communications, Springer, 2017.
2. Afif Osseiran, Jose F. Monserrat and Patrick Marsch, - 5G Mobile and Wireless Communications Technology, Cambridge University Press, 2016.
3. Jonathan rodriguez, - Fundamentals of 5G mobile networks, John Wiley & Sons, Ltd, 2015.

18LW31 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. (12)

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. (10)

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. (11)

OPTICAL COMPONENTS AND SIGNAL PROCESSING: Optical waveguides- optical filters, couplers, amplifiers, switches, antennas, interconnecting equipments- optical integrated circuits- semiconductor integrated optic devices. Analog and Discrete systems- noise and stochastic processes- filters- power spectra estimation – The ambiguity function, Wigner distribution function and triple correlation. (12)

Total L: 45

REFERENCES:

1. Pankaj K Das, "Optical Signal Processing", Narosa Publishing House, 2012
2. Olivier Bouchet, ,Herve Sizun ChristianBoisrobert, "Free-Space Optics" ISTE USA, 2010.
3. Heinz and Willebrand, "Free Space Optics", Sams, 2002.
4. William H Mott and Robert B Sheldo, "Laser Satellite Communication- The Third Generation", Green Wood Publishing, 2000.
5. Hiroshi Nishihara, "Optical Integrated Circuits", McGraw Hill, New York, 1989.

18LW32 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. Robert A Monzingo, Haupt R L and Miller T W, "Introduction to Adaptive Arrays", Yesdee Publishing Pvt. Ltd., 2012.
2. Balanis, "Antenna Theory: Analysis and Design", John Wiley and Sons, 2005.
3. Lal Chand Godara, "Smart Antennas" CRC press, 2004.
4. Joseph C Liberti.Jr and Theodore S Rappaport, "Smart Antennas for Wireless Communication: IS-95 and Third Generation CDMA Applications", Prentice Hall, 1999.

18LW33 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, 2010.
2. Ferri Losee, “RF Systems, Components and Circuits Handbook”, Artech house, 2005.
3. Stephan A Mass, “Non-Linear Microwave and RF circuits”, Artech House, 2003.
4. Larson L E, “RF and Microwave Circuit for Wireless Applications”, Artech House, 1997.

18LW34 WIRELESS TECHNOLOGIES AND MEASURING TOOLS

3 0 0 3

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

RF SIGNAL GENERATION: Oscillator Circuits – Direct Digital synthesis – PLL Based Synthesizers – Arbitrary waveform generator – Vector Signal Generator - Phase frequency detector. (10)

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. (10)

RF MODULAR INSTRUMENTS: Introduction – Understanding software designed systems – Multichannel measurements – Customized measurement systems – Instruments: Spectrum/Signal Analyser – Digital storage Oscilloscope - Mixed signal Oscilloscopes. (10)

Total L: 45

REFERENCES:

1. Ananjan Basu “An Introduction to Microwave Measurements”, CRC Press, 2015.
2. Valeria Teppati, Andrea Ferrero, Mohamed Sayed “Modern RF and Microwave Measurement Techniques”, Cambridge .University Press, 2013
3. Gordon L Stuber, “Principles of Mobile Communication”, Artech House, 2011.
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.

18LW35 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. Gabriel M Rebeiz, “RF MEMS Theory, Design and Technology “, John Wiley & Sons Ltd, New Jersey, 2004.
2. Vijay K Varadan, Vinoy K J and Jose K A, "RF MEMS and Their Applications“, John Wiley & Sons Ltd, England, 2003.
3. Hector J De Los Santos, “RF MEMS Circuit Design for Wireless communications”, Artech House, 2002.

18LW36 COMPUTATIONAL ELECTROMAGNETICS

3 0 0 3

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

18LW37 EMC TESTING AND MEASUREMENTS

2 2 0 3

NATURE AND ORIGINS OF ELECTROMAGNETIC COMPATIBILITY: Introduction – Visualising the EMI problem – Source of EMI – EMI coupling to victim equipments – Intersystem and Intrasystem EMI – Historical background –Technical disciplines and Knowledge areas within EMC – Electrical engineering – Physics –Mathematical modeling – Limited chemical knowledge – System engineering – Legal aspects of EMC. (8+6)

EMC STANDARDS AND SPECIFICATIONS: The need for standards and specifications – The need to meet EMC standards – Derivation of military standards – Derivation of commercial standards– Outline of EMC testing – Types of EMC testing – Preconformance test measurements – Implication of repeatability of EMC measurements – Introduction to EMC test sensor – Conduction and Induction couplers – Radiative coupling – EMC antennas. (7+6)

MEASUREMENT DEVICES FOR CONDUCTED EMI: Introduction – Measurement by direct connection –Inductively coupled devices – EMC antennas – Basic antenna parameters – Antennas for radiated emission testing –Wideband antennas – Magnetic field antennas – Use of antennas for radiated susceptibility testing – Type of antennas used in susceptibility testing – Standards requiring immunity tests. (5+6)

RECEIVERS, ANALYSERS AND MEASUREMENT EQUIPMENT: Introduction – EMI receiver – Spectrum Analyzers – RF power meter – Frequency meters – Instrumentation for susceptibility testing – Automatic EMC tests – Electromagnetic transient testing – Transient types – Continuous and transient signal – ESD-electrostatic discharge. (5+6)

DESIGNING TO AVOID EMC PROBLEMS: Intrasystem and Intrasystem EMC – Design for formal EMC compliance – Achieving product EMC :checklists for product development and testing – Introduction – Developing an approach to EMC design – Process flow chart, EMC strategy – Self certification. (5+6)

Total L: 30 + T: 30=60

TUTORIAL COMPONENT:
- Design of Mathematical Modeling for EMC.
- Measurement & Implementation of EMC testing.
- Design of conduction & induction couplers.
- Design of EMC antennas & analysis.
- Measurement of power using RF power meter.
- Design of EMC compliance.

REFERENCES:
1. Tim Williams, “EMC for Product Designers”, 5th Edition, Newnes Elsevier, 2017.
2. Clayton R. Paul “Introduction to Electromagnetic Compatibility”, Wiley Press, 2014.
3. David Morgan, “A Handbook for EMC Testing and Measurement”, IET Electrical Measurement, 2012.

AUDIT COURSES

18LW81 ENGLISH FOR RESEARCH PAPER WRITING

vide Automotive Engineering 18AE81

18LW82 RESEARCH METHODOLOGY AND IPR

vide Automotive Engineering 18AE82