THIRD SEMESTER

MA2103: ENGINEERING MATHEMATICS – III [2 1 0 3]

Functions of complex variable. Analytic function, C-R equations, differentiation, Integration of complex function, Cauchy's integral formula. Taylor's and Laurent Series, Singular points, Residues, Cauchy's residue theorem. Periodic function, Fourier Series expansion. even and odd functions, functions with arbitrary periods, Half range expansions Fourier transform, Parseval's identity, PDE-Solution by method of separation of variables and by indicated transformations. One dimensional wave equation, one dimensional heat equation and their solutions. Vector differtial operator, gradient divergence and curl. Line, surface and volume integrals. Green's theorem, Divergence and Stoke's theorem.

References:

1. B.S. Grewal, *Higher Engineering Mathematics*, 43(e), Khanna Publishers, 2014.
2. Eewin Kreyszig, *Advanced Engineering Mathematics*, 7(e), John Wiley & Sons, Inc., 2015.
3. C. F. Gerald and P. O. Wheatley, *Applied Numerical Analysis*, (7e), Pearson Education, 2007
4. R. Spiegel Murray, *Vector Analysis*, 2(e), Schaum Publishing Co., 2009.
5. Ramaniah Narayanan and Manicavachagom Pillay, *Advanced Engineering Mathematics*, Vol 2 and 3, Vishwanthan Publishers Pvt Ltd.1998.

EC2101: Signals and Systems [3 0 0 3]

Introduction to signals and systems: Definitions, Overview of specific systems, Classification of signals, Basic operations on signals, Elementary signals and functions, Systems viewed as interconnections of operations, properties of systems. Time domain representations for Linear time-invariant systems: Introduction, Convolution: Impulse response representation for LTI systems, properties of the impulse response representation for LTI systems, Differential and difference equation representations for LTI systems, Block diagram representations. Fourier representation for signals: The discrete-time Fourier series, continuous-time periodic signals: The Fourier series, Discrete-time non-periodic signals. Applications of Fourier representations: Introduction, Frequency response of LTI systems, Fourier transform representations for periodic signals, convolution and modulation with mixed signal classes. Applications of Laplace transform: Continuous Time System Analysis using Laplace transform, Region of convergence and Stability, Analysis of continuous time signals and systems. Z-Transform: Introduction, the Z-transform, properties of the Region of convergence, Properties of the Z-Transform, Inversion of the Z-Transform, Transform analysis of LTI systems, the unilateral Z-Transform.

References:

1. S. Haykin & B. V. Veen, *Signals and Systems*, (2e), John Wiley &Sons, New Delhi, 2007.
2. A.V. Oppenheim, A. S. Willsky & A. Nawab, *Signals and Systems*, (2e), PHI. /Pearson Education, New Delhi, 1997.
3. H. Hsu, R. Ranjan, *Signals and Systems*, (2e), Schaums's outline, Tata McGraw – Hill, New Delhi, 2008.
4. B. P. Lathi, *Linear systems and Signals*, (2e), Oxford University Press, 2005.
5. Tarun Kumar Rawat, *Signals and Systems*, (1e), Oxford University Press, 2010
6. A. Anand Kumar, *Signals and Systems*, (3e), PHI Learning Pvt. Lit., New Delhi, 2015.

EC 2102: Analog Electronics [3 1 0 4]

Junction Diode Analysis: Built in voltage, Transition and diffusion capacitances. Bipolar Junction Transistor: h-parameter model, Hybrid-π model, analysis of CE, CB, and CC configurations of BJT amplifiers, Miller's theorem. Multistage amplifiers: Distortion in amplifiers, Frequency response of an amplifier, bandwidth of cascaded amplifiers, frequency response of an RC coupled, direct coupled and transformer coupled stages. Power amplifiers: Classification of large signal amplifiers, Analysis and

design with respect to efficiency, linearity and harmonic distortions of classes of Amplifier. Field Effect Transistor: Structure of JFET and MOSFET, device Characteristics, FET biasing, small signal, Analysis of CS, CD and CG amplifiers at low and high frequencies. Feedback amplifiers: Concept of feedback, types of feedback – their advantages and disadvantages, effect of feedback on frequency response & impedances. Oscillators: Barkhausen criterion for sustained oscillation, Nyquist criterion for stability of amplifier, Types of Oscillators: Hartley and Colpitt's oscillator; Wein bridge oscillator; RC phase shift oscillator; crystal oscillator. Introduction to Power Electronic Devices.

References:

1. J. Millman, C. C. Halkias, *Integrated Electronics,* (2e), Tata McGraw Hill, New Delhi, 2011.
2. B.P. Singh and R. Singh, *Electronic Devices an Integrated Circuits*, (2e), Pearson India, 2012.
3. R. L. Boylestad, L. Nashelsky, *Electronic Devices and Circuit Theory,* (10e), Pearson, 2009.
4. S. Salivahanan, N. S. Kumar, *Electronics Devices and circuits,* (2e), McGraw Hill Publication, 2008.
5. A. S. Sedra, K. C. Smith, *Microelectronic Circuits, Technology and System Applications*, (7e), Oxford University Press, 2014.

EC2103: Digital System Design & Computer Architecture [3 1 0 4]

Introduction to Combinational logic circuits. Design of arithmetic circuits: code convertors, multiplexers, demultiplexers, encoders, decoders & comparators, Parity generators and checker. Introduction to Sequential Logic: Binary cell, Latches and flip-flops. RS, JK, Master-Slave JK, D & T flip flops. Sequential circuit design: Registers, Shift Registers, Binary Counters, Finite State Machines, Moore and Mealy Machines. Overview of typical computer architecture: Accumulator based, General Register based and Stack based. Data Path and Control Unit Design: Basic concepts, Types of Bus structures, Control Unit design methods-Hardwired and micro programmed. Computer Arithmetic: Fast adders, subtractors, Multiplication of signed and unsigned integers, Booths Multiplication algorithm, Division, Floating Point Arithmetic Operation. Memory Organization: Memory hierarchies- types of ROMs, Main memory- SRAM and DRAM, Memory Address Map; Cache memory- mapping functions – associative, direct and set-associative. Introduction to Verilog programming.

References:

1. S. Brown and Z. Vranesic, *Fundamentals of Digital logic with Verilog Design*, (3e), McGraw Hill, 2014.
2. M. Mano and M. Ciletti, *Digital Design: With an introduction to Verilog HDL*, (5e), Pearson, 2012.
3. Z. Navabi, *Verilog Digital System Design,* (2e), McGraw Hill, 2008.
4. M. Morris Mano, *Computer System Architecture*, (3e), Pearson, 2008.
5. John P. Hayes, *Computer Architecture and Organization*, (3e), TMH, 1998.
6. C. Hamacher, Z. Vranesic, S. Zaky, Computer Organization, (5e), TMH, 2002.

EC2104: Electromagnetic Field Theory [3 1 0 4]

Review of Vector Calculus: Cartesian coordinates, Circular, Cylindrical and Spherical co-ordinates. Electrostatics: Coulomb's law and its applications, Electric field intensity and Electrostatic potential due to point charges, Field due to continuous charge distribution. Electric flux and electric flux density, Gauss's law, Gauss's Law – Maxwell's equation, Electric dipole and flux lines, energy density in electrostatic fields., Electric field in material space: convection and conduction currents, conductors, polarization in dielectrics, continuity equation and relaxation time; Electrostatic boundary condition: dielectric-dielectric, dielectric-conductor. Poisson's and Laplace's equations. Magnetostatics: Magnetic field intensity, Biot-Savart's law, magnetic flux and magnetic flux density, Ampere's law, Maxwell's equation, application of Ampere's law, magnetic flux density- Maxwell's equation, Maxwell's equation for static fields, magnetic scalar and vector potential, magnetic boundary conditions, magnetic energy. Electromagnetic Waves & Applications: Maxwell's equation, Faraday's Law, transformer and motional electromotive forces, displacement current, Maxwell's equation in final form. Maxwell's equations in integral and point form for free space and material media. Electromagnetic wave propagation: Wave propagation in lossy dielectrics, plane waves in lossless dielectrics, plane wave in free space, plane waves in good conductors, power and the pointing vector, reflection of a plain wave in a normal incidence. Introduction to Transmission Lines and waveguides.

References:

1. 1. Jr. Hayt and Bucker, *Engineering Electromagnetics*, (7e), McGraw Hill 2006.
2. 2. M. A. Plonus, *Applied Electromagnetics*, (1e), McGraw Hill 1978.
3. 3. J. D. Kraus, *Electromagnetics,* (4e), McGraw Hill 1992.
4. 4. Cheng, Fields, *Waves and Electromagnetics*, (2e), Addison Wesley, 2004.
5. 5. M. N. O. Sadiku, *Elements of Electromagnetics*, (4e), Oxford University Press, 2006.

EC2130: Analog Electronics Lab [0 0 2 1]

Experiments of this lab are implemented at hardware and software level. Experiments are based on Device characteristics: diodes, BJT and FET, Application of diodes: clippers and clampers, Applications of BJT and FET: amplifiers with and without feedback, RC coupled amplifiers, oscilllators.

EC2131: DSD & HDL Lab [0 0 2 1]

Experiments of this lab are implemented at Hardware as well as software level. List of experiments include: Study of Implementation techniques of combinational circuits, Implementation of Arithmetic circuits using logic gates and MSI chips, Building circuits using MSI chips and their applications, Designing of sequential circuits, Implementation of FSMs, Design of Asynchronous sequential circuits, Design of Combinational & Sequential Circuits using HDL

EC2170: Project Based Lab I [0 0 2 1]

Project-based learning is acquiring practical knowledge through experimental setup, this experimentation induces a desire to learn in newly inducted students and influences their minds to understand the applied content. The projects that may be undertaken in Project Based Lab – I include Thermostat for fridge, LED Based Emergency Lamp, Audio controlled running lights, Digital Modern LED Voltmeter, Digital Memory for Door Bell, Hard Disk Reading and writing process, Faraday Cage, Faraday's Guitar, Traffic Light Controller, 4-bit Arithmetic and Logic Unit, etc.

FOURTH SEMESTER

MA2205: ENGINEERING MATHEMATICS - IV [2 1 0 3]

Finite sample spaces, conditional probability and independence, Baye's theorem, one dimensional random variable, mean, variance, Chebyshev's inequality. Two and higher dimensional random variables, covariance, correlation coefficient, least squares principles of curve fitting. Binomial, Poisson, uniform, normal, gamma, chi-square and exponential distributions. Moment generating function, functions of one and two dimensional random variables, sampling theory, central limit theorem and applications. Stochastic processes. Difference Calculus, difference equations with constant coefficients, solutions. Finite difference expressions for first and second order derivatives. Solution of boundary value problems, numerical solutions of Laplace and Poisson equations by standard five point formula and heat and wave equations by explicit methods.

References:

1. P.L. Meyer, *Introduction to probability and Statistical applications*, 2(e), American Publishing Co., 1979.
2. Erwin Kreyszig, *Advanced Engineering Mathematics*, 7(e), John Wiley & Sons, Inc., 2015.
3. R.V. Hogg and A.T. Craig, *Introduction to Mathematical Statistics* (4e)., MacMillan, 1975
4. S. Narayanan, G. Ramaniah and M Pillay, *Advanced Engineering Mathematics*, Vol 3, S. Viswanathan Printers and Publishers, 1998.

EC2201: Analog Integrated Circuits & Systems [3 0 0 3]

Operational amplifiers: transfer characteristics and frequency response of op-amp, measurement of op-amp parameters. Block level representation of Op-amp; Linear applications of op-amp: voltage to current converter, current to voltage converter, instrumentation amplifier and bridge amplifier. Active filters: Design and analysis of higher order low pass, high pass, band pass (wide and narrow band) and band elimination (wide and narrow band) and all pass active filters. Non-linear applications of operational amplifier: rectifiers, peak detector, sample and hold circuit, comparators, window detector, Schmitt trigger, square wave, triangular wave generators, oscillators. Timer IC: pin details and internal working of 555 IC. Applications: astable multivibrator, monostable multivibrator, Schmitt trigger. Data converters: Principles and specifications of digital to analog converter (DAC) and analog to digital converters (ADC), binary weighted and R-2R DAC, successive approximation type, counter type and servo tracking type and dual slope ADC. Phase-locked loop IC 565 and voltage controlled oscillator IC 566: Analysis and applications. IC based voltage regulators and power amplifiers.

References:

1. R.A. Gayakwad, *Op-Amps and Linear Integrated Circuits*, (4e), Prentice Hall of India, 2002.
2. W. D. Stanley, *Operational Amplifiers with Linear Integrated Circuits*, (4e), Pearson Education, 2007.
3. F. Sergio, *Design with Op amps & Analog Integrated Circuits*, (4e), McGraw Hill, 2014.

EC2202: Microprocessor and Microcontroller [3 1 0 4]

8086 Microprocessor: Introduction and history of microprocessors and microcontrollers, RISC and CISC Architectures. 8086 Architecture: Bus Interface Unit and Execution Unit, Instruction pipeline, Data and Address Bus Configuration, Memory Segmentation, Memory Address generation, I/O Port addressing. 8086 Signals: Functions of all signals, Minimum and Maximum Mode signals, Bus Cycles, Bus Arbitration, Bus driver 8288. 8086 Instruction Set: Types of Instructions and Addressing Modes, assembler and assembler directives, Programming. Basic Peripherals and their interfacing with 8086: Memory interfacing, Types of I/O - Isolated I/O, memory mapped I/O, programmed I/O, Interrupt driven I/O, Interfacing I/O ports, PIO 8255, Programmable Interval Timer 8254, Interrupts, Programmable Interrupt Controller 8259, Keyboard/Display Controller, DMA Controller, DMA transfer and operations, Multiprocessor Systems. 8051 Microcontroller: Architectural features, Programming model, I/O Ports, Special Function Registers, Addressing Modes, Instruction set and Programming.

References:

1. N. Senthil Kumar, M. Saravanan, S. Jeevananthan, *Microprocessors and Microcontrollers,* (1e), Oxford University Press, 2010.
2. K. M . Bhurchandi, A K Ray, *Advanced Microprocessors and Peripheral Devices*, (3e), McGraw Hill Education (India) Private Ltd, 2018.
3. M. A. Mazidi, J. G. Mazidi, R. D. McKinlay, *The 8051 Microcontroller and Embedded Systems using Assembly and C*, (2e), Pearson, 2008.
4. D. V. Hall and S. S. S. P. Rao, *Microprocessors and Interfacing*, (3e), McGraw Hill, 2012.

EC2203: Digital Signal Processing [3 1 0 4]

Review of signals and systems: Time and frequency analysis of signals and systems. Transform Analysis of LTI Systems: The frequency Response of LTI systems, Inverse system, All- Pass system, Minimum Phase system, Linear systems with Generalized Linear Phase. Frequency domain sampling and reconstruction of discrete time signals: Discrete-Time Processing of continuous- Time Signals, Continuous- Time Processing of Discrete-Time Signals, Changing the Sampling Rate Using Discrete-Time Processing. Discrete Fourier transform: Introduction, properties of the DFT, use of DFT in linear filtering, filtering of long data sequences, DFT as linear transformation, Computation of DFT, Decimation-in- Time and Decimation–in–frequency Algorithms. Implementation of discrete time systems: Structures for FIR systems – Direct form, cascade form, Frequency sampling and lattice structures. Structures for IIR systems – Direct form, cascade and parallel form. Design of IIR filters and

digital FIR filters: Classical design by impulse invariance, bilinear transformation and matched Z-transform, characteristics and design of commonly used filters – butterworth. Chebyshev, elliptical.

References:

1. A.V. Oppenheim & R.W. Schafer, *Discrete-Time Signal Processing,* (2e), Pearson education, 2001.
2. S. Salivahanan, C. Gnanpriya, *Digital Signal Processing*, (2e), Tata McGraw-Hill Education, 2011.
3. J.G. Proakis, D.G. Manolakis, D. Mimitris*, Introduction to Digital Signal Processing- Principles, Algorithms and Applications*, (3e), Prentice Hall, India 2007.
4. Sanjit K. Mitra, *Digital Signal Processing A Computer Based Approach*, (4e), Mc Graw Hill Education, 2013.
5. L.R. Rabiner & D.J. Gold, *Theory and applications of digital signal processing*, (3e), Prentice Hall, India, 2007.

EC2230: Electronic Sub-System Design Lab [0 0 2 1]

Experiments of this lab are implemented at Hardware as well as software level. Experiments that will be done in this lab include: Measurement of Op-amp parameters: bias current, offset voltage, CMRR, slew rate, Linear and non-linear applications of OP-AMP: inverting amplifier, non-inverting amplifier, voltage follower, adder, averager, scalar, difference amplifier, comparator, integrator, differentiator, active filters, Schmitt trigger, wave generators, oscillators etc, Applications of Timer IC: multivibrator circuits, Schmitt trigger, Applications of IC voltage regulators, etc.

EC2231: Digital Signal Processing Lab [0 0 2 1]

Experiments of this lab are implemented using MATLAB software and Hardware on DSP Processor Kit. The list of experiments includes: Time domain and Frequency Domain Analysis of signals and systems, Analysis in z-domain, Filter Design, Introduction to Code Composer Studio, Filter Implementation using DSP Kits.

EC2232: Microprocessors & Microcontrollers Lab [0 0 2 1]

Experiments of this lab are related to 8086 Microprocessor and 8051 Microcontroller based system design along with hardware interfacing in assembly language. Module 1 includes familiarization of 8086 microprocessor simulation tool and trainer kits, experiments based on the Intel 8086 microprocessor like data transfer, arithmetic operations, logical instructions, branch instructions, code conversion, packing and unpacking, sorting, searching, recursion, etc. Module 2 includes familiarization of 8051 microcontroller simulation tool and trainer kits, experiments related to timer, serial data communication, etc based on the Intel 8051 microcontroller assembly language programming/embedded C Programming. Module 3 is related to I/O interfacing of LEDs, LCD, keyboard, 7 segment display, stepper motor, etc. to these microprocessors and microcontrollers.

EC2270: Project Based Lab II [0 0 2 1]

Project-based learning is acquiring practical knowledge through experimental setup, this experimentation induces a desire to learn in newly inducted students and influences their minds to understand the applied content. The following projects may be undertaken in Project Based Lab – II: Doorbell cum visitor indicator, Electronic fuse, Geyser timer circuit, Fire sensor, Automatic switch-off battery charger, RF controlled robot, Line Follower, RF based multiple device control, Image enhancement and noise removal using bilateral filter, Image compression using different types of wavelets, Face tracking in real time videos, etc.

FIFTH SEMESTER

EC3101: Antennas [3 1 0 4]

Introduction: Radiation Mechanism, current distribution, Antenna parameters. Vector potentials: Electric and magnetic vector potentials, solutions for wave equations, far-field radiation, Duality theorem, Reciprocity theorem. Linear wire Antennas: Infinitesimal, small and finite dipole Antennas, Region separation, Half wave length dipole. Loop Antennas: Small circular loop Antenna, circular loop with constant current, Ferrite loop. Antenna Arrays and other types of antennas: Two element array, N-element array – uniform, broadside, ordinary end-fire, Non-uniform Amplitude Arrays, planar and circular arrays. Qualitative study of Folded dipole, long wire, V, Rhombic, Helical, Yagi Uda, log-periodic, Aperture antennas, and horn Antennas, Babinet's principle, Huygens's principle, Rectangular and Circular Microstrip Patch antenna, Quality Factor, Bandwidth, Efficiency. Antenna Measurements: Propagation of EM waves: Ground wave Propagation, Space Wave Propagation, Troposphere and ionosphere propagation and its effect on Radio Waves.

References:

1. C. A. Balanis, *Antenna Theory,* (3e), John Wiley & Sons, New Delhi, 2010.
2. J. Kraus, *Antenna and wave Propagation*, (4e), Tata McGraw – Hill, New Delhi, 2010.
3. K. D. Prasad, *Antenna and Wave Propagation*, (3e), Satya Prakashan, New Delhi, 2009.
4. F. E. Termen, *Radio Engineering*, (1e), Tata McGraw – Hill, New Delhi, 1995.

EC3102: Network & Control Theory [3 1 0 4]

Network Analysis: Network Theorems. Transients analysis: Impulse, Step, Ramp and sinusoidal response analysis of first order and second order circuits. Two port Networks; Control system: Classification of control systems, Time domain response of 1st and 2nd order systems, Steady state error for linear Systems , RH criteria, Root Locus technique, Bode plots, Nyquist Plots, Frequency domain based compensator design and their realization through OPAMPS, Design/realization of active P, PI, PID controllers for LTI systems. Lead, Lag and Lead-Lag compensators; State space representation: Stability Analysis, State transition matrix, Eigen values, Controllability and observability;

References:

1. Ghosh & Chakraborty, *Network Analysis and Synthesis*, (1e), Tata McGraw Hill Education Private Ltd, 2009.
2. J. B.C.Kuo, *Automatic Control Systems*,(7e), PHI, 2009.
3. Nagrath & Gopal, *Control System Engineering*, (5e), New Age Publications Ltd., 2006.
4. K.Ogata, *Modern Control Engineering*, (2e), Pearson Education, 2010.

EC3103: Analog & Digital Communication [3 1 0 4]

Introduction to Analog Communication: Amplitude Modulation, Frequency Modulation, Phase Modulation, Representation of Band Pass signals and systems Relationship between PM& FM, Radio Receivers, Superheterodyne Receiver, Noise Theory, Noise Performance of Analog Communication Systems: Introduction to Digital Communication: Line coding, Review of Sampling theorem, uniform and non-uniform quantization, companding, μ-Law and A-Law compressors, Concept and Analysis of PCM, DPCM, DM and ADM modulators and demodulators, M-ary waveforms, S/N ratio for all modulation, probability of error for PCM in AWGN Channel and other modulation techniques, Duo Binary pulse. Digital modulation schemes: Coherent Binary Schemes, Coherent M-ary Schemes, Incoherent Schemes (DPSK and DEPSK), Calculation of average probability of error for different modulation schemes, Power spectra of digitally modulated signals, Performance comparison of different digital modulation schemes.

References:

1. Simon Haykin, *Communication Systems*, (4e), John Wiley, 2009.
2. Taub Schilling, *Principles of Communication Systems*, (3e), McGraw Hill, 2008.
3. G. Kennedy, *Electronic Communication Systems*, (4e), McGraw-Hill, 2008.
4. John G Proakis, M.Salehi and G.Bauch, *Modern Communication System Using MATLAB*, (3e), Cengage Learning, 2013.
5. John G.Proakis, *Digital Communications*, (5e), McGraw Hill, 2008.
6. R.P.Singh & S.D. Sapre, *Communication* System-*Analog and Digital*, (2e), McGraw Hill, 2007.

EC3104: CMOS VLSI DESIGN [3 1 0 4]

Introduction: VLSI technology trends, performance measures and Moore's law. MOS devices and circuits: MOS transistors, Study of depletion and enhancement mode operations, Threshold Voltage. Second order effects in MOSFETs. Fabrication of ICs: Lithographic process of MOS and CMOS fabrication, N-well, P-well and twin tub processes, Latch-up in CMOS, SOI process, VLSI Yield and economics. MOS Circuit design & layouts: Implementation of Boolean functions and combinational circuits using switch logic & gate logic, Pass transistors and transmission gates, Pseudo NMOS inverter, Dynamic and clocked CMOS inverters, Clocking strategies. Basic circuit concepts and performance estimation: Sheet resistance, Standard unit of capacitance, Estimation of delay in NMOS and CMOS inverters. Sub system design: Design strategies, Design issues and structured approach, Design examples such as Adders, ALUs and Shifters, Design of sequential circuits. Memory Arrays: SRAM, DRAM. Current trends: BiCMOS devices and circuits.

References:

1. S. M. Kang & Y. Leblebici, *CMOS digital Integrated circuits design and analysis*,(3e), Tata McGraw Hill, 1996.
2. Jan. M. Rabaey, Anantha Chandrakasan, Borivoje Nikolic, *Digital Integrated Circuits*,(2e),Pearson, 2003.
3. Neil H. E. Weste & Kamran Eshraghian, *Principles of CMOS VLSI Design*,(2e), Addison Wesley, 1993.

EC3130: VLSI Design Lab [0 0 1 1]

The objective of this lab is to impart essential practical knowledge on designing of various circuits using CMOS and various other logic families. The learning objective is to make them familiar with industry standard CAD tools. Students will learn to design, analyse and simulate various combinational and sequential circuits in the Digital VLSI circuits using latest EDA tool and analyse them on the basis of noise margin, delay power. The course emphasizes circuit design and analysis skills that require the student to create digital circuits that meet customer/user specifications as industry professional or entrepreneur. Introduction to Layout design.

EC3131: Analog and Digital Communication Lab [0 0 2 1]

The objective of this lab is to impart essential practical knowledge on analog and digital communication. Hardware Kit/ Matlab/ Labview based practicals on simulation, generation, detection and performance measurement characteristics (S/N and probability of error) of AM, FM, ASK, FSK, PSK, DPSK, QPSK, PCM and DM signal.

EC3170: Project Based Lab III [0 0 2 1]

Project-based learning is acquiring practical knowledge through experimental setup, this experimentation induces a desire to learn in newly inducted students and influences their minds to understand the applied content. The following projects may be undertaken in Project Based Lab – III:

Designing Planar reflector antenna, Coaxial Antenna Design, Designing FM Dipole Antenna, Multiband CW Transmitter, Cell Phone Jammer Circuit, DTMF Based Remote Control System, VLSI Design of Low-Cost FFT Processors, Design of 16-Bit Multiplier, Low Power 4×4 Bit Multiplier Design, etc.

SIXTH SEMESTER

EC3201: Microwave Engineering [3 0 0 3]

Introduction to Transverse Electric, Transverse Magnetic and Transverse Electromagnetic waves in conducting planes, characteristics of TE, TM and TEM waves, wave impedance, attenuation , TE, TM and TEM waves. Transmission line equations & solutions, reflection and transmission coefficient, standing wave and standing wave ratio, line impedance and admittance, impedance matching, using stub line, application of smith chart in solving transmission line problems. Rectangular and circular waveguides-theory and analysis, characteristics of TE and TM mode and excitation of wave guides. Passive components: Resonators, Directional Couplers, E-plane Tee, H-plane Tee and Hybrid Tee, Hybrid ring, Attenuators, Circulator, Faraday rotation principle, Isolators. Microwave active Devices: Limitations of conventional vacuum tube devices. Two cavity klystron: Re-entrant cavities, velocity modulation process, bunching process. Reflex klystron: Velocity modulation, power output and efficiency and electronic admittance. Traveling wave tube: Slow wave structure, amplification process, convection current, axial electric field, wave modes and gain consideration. Magnetron: Mode of oscillation, Types of Magnetron, Strapping and Rising Sun Magnetron. Microwave diodes and transistors: Tunnel diode, Varactor diode, Gunn diode, IMPATT diode, Microwave transistors and FETs.

References:

1. 1. S. Liao, *Microwave Devices and Circuits*, (3e), Prentice Hall, 1990.
2. 2. D. M. Pozar, *Microwave Engineering*, (4e) John Wiley & Sons, 2012.
3. 3. J. Ryder, *Network lines and Fields*, (2e), Prentice Hall, 2015.
4. Jordan & Balmain, *Electromagnetic waves and Radiating System*, (2e), Prentice Hall, 1968.

EC3202 EMBEDDED & REAL TIME OPERATING SYSTEMS [3 1 0 4]

Embedded Systems: Introduction, Classification, Elements of Embedded Systems, Hardware units, devices, Software, Embedded SOC (System on Chip), Design Process, Process of Embedded system development. Interrupts, Devices and Device Drivers: Interrupts, Interrupt Handling Mechanism, Interrupt Controllers, Interrupt Latency, Timers, Counters, Device Drivers. Buses and Communication Interfaces and protocols. Operating System: Process Management: Processes, Threads, Process Synchronization, Process Scheduling, Deadlock. Inter-process Communication and synchronization of processes, threads and tasks: Semaphores, Synchronization with semaphores and Mutex, Shared data, Signal function, Message function, Mailbox, Pipe. Real Time Operating Systems (RTOS): Introduction, Classification, Services, Process Management, Timer function, Memory Management, Task Scheduling modules, Interrupt latency.

References:

1. Rajkamal, *Embedded Systems: Architecture, Programming and Design*, (2e), McGraw Hill publication, 2008.
2. Frank Vahid, Tony Givargis, *Embedded System Design: A unified Hardware/Software approach*, (3e), John Wiley and Sons, 2009.
3. Abraham Silberschaltz, Peter Baer Galvin, Greg Gagne, *Operating System Concepts*, (9e), John Wiley and Sons, 2013.

EC3203 OPTICAL COMMUNICATION [3 1 0 4]

Introduction to optical communication: Basic principles of light propagation, Propagation of Light in an Optical Fiber: Ray Model, Numerical aperture, phase-front (wavefront) based study of Total Internal

Reflection, Wave Model and its Analysis, V number of an Optical fiber. Signal distortion on optical fibers: Material Dispersion, Intermodal Dispersion, Intermodal Dispersion, Material Attenuation, Microbending, Macrobending, Analysis of Signal distortion in optical fibers using OTDR, Practical issues in implementation of fiber link. Optical Sources: Introduction of Optical sources. Light Emitting Diode: Quantum Efficiency, material, electrical and spectral characteristics, modulation. Lasers: Introduction to Laser, Spontaneous emission, Absorption, Stimulated emission, Different type of lasers: ruby laser, He-Ni laser, semiconductor laser. Optical Receiver: Photon detector, Photo Diodes, Photo detector and its noise Analysis, Optical Receiver, Digital data transmission in optical domain, SNR, BER analysis, Performance Analysis and the EYE-diagram, Receiver Sensitivity Degradation, Fiber Optic link Design, power penalty.

References:

1. G.P Agrawal, *Fiber optics communication*, (3e), John Wiley & sons, 2002.
2. G. Keiser, *Optical Fiber Communication*, (4e), Mc Graw Hill, 2017.
3. M.N. Islam (Ed), *Raman Amplifiers for communications*, (1e), Springer-verlag, New York, 2004.
4. J. M. Senior, *Optical Fiber Communications*, (3e), Prentice Hall of India, 2009
5. J. C. Palais, *Fiber Optic Communications*, (5e), Pearson, 2005.
6. R.W. Waynant & M.N. Ediger, *Electro-Optics Handbook*, (2e), McGraw Hill, 2000.

EC3230 Embedded & RTOS Lab [0 0 2 1]

Experiments of this lab are related to embedded system design using Keil/Arduino software and its implementation on Hardware Kit. Experiments embedded C/Arduino programming for hardware interfacing to various sensors and actuators and implementation of communication protocols like RS 232 communication, SPI, I2C, etc. for embedded systems. Lab also introduces to Linux commands, Shell programming, etc. with introduction to basic concepts of Real Time Operating Systems like Process, Thread, Semaphores, Mutex, IPC, scheduling, etc. Embedded & IoT based system design as a mini project

EC3231 Antenna & Microwave Lab [0 0 2 1]

Experiments of this lab are divided into three modules. In modules 1 experiments are related to Microwave Communication which includes: Setting up of a microwave link using klystron and gunn based microwave test bench and verifying the functions of waveguides, E plane Tee, H plane Tee, magic Tee, directional coupler, circulator and isolator. Measurement of resonant frequencies and obtaining VI characteristics of Gunn Diode etc. Module 2 focuses on Transmission Line: Measurement of transmission line parameters, attenuation, phase and fault localization of the line. Experiments in module 3 are related to Antenna Systems: Measurement of the radiation pattern of various types of antennas, half power points, gain, beam width and bandwidth etc. and understand its significance in EM wave propagation.

EC3232 Optical Communication Lab [0 0 2 1]

Optical Fiber: Study various types of Optical fibers, optical sources and their radiation patterns, understand use of OTDR for various optical measurements and link analysis, study transmission and reception of analog and digital signals on an optical fiber link, determine the numerical aperture and attenuation constant of fibers. Study of Optical Laser Source, Optical Power Meter, Variable Optical Attenuator, Optical connector certification system, attenuation in optical fiber through, Splice & Connector joints and their losses, Identification of fault location (distance) in the optical fiber, Measurement of fibre losses of single mode fibre due to bending, study the operation of optical fusion splicer, wavelength separation properties of a WDM coupler, study the isolation properties of optical isolators, circulators.

EC3270 Minor Project [0 0 2 1]

To design and present a project related to Electronics and Communication engineering with substantial multidisciplinary component.

PROGRAM ELECTIVES – I & II

EC3243 VLSI/ULSI Process Technology [3 0 0 3]

Introduction of semiconductor and process technology, Materials for VLSI/ULSI process technology. Crystal growth & Silicon Oxidation: Silicon Crystal Growth - Czochralski and Float Zone Technique, Distribution of dopants, Segregation/Distribution coefficient. Material properties: Physical properties, Crystal structure, Packing Density, Defects, Dislocation; Silicon oxidation: Thermal Oxidation process-Kinetics of oxide Growth. Photolithography: Photo resists, Lift Off technique, Optical Lithography, masks, photo resists, Pattern transfer, Resolution enhancement techniques, Next generation lithography- electron beam lithography. Diffusion & Ion implantation: Basic diffusion process, Fick's law, Pre-deposition and drive-in diffusion, Diffusion profile for various dopants, Lateral Diffusion, Range of Implanted Ions, straggle, ion stopping, ion Channeling, Annealing, Rapid Thermal Annealing. Etching: Wet chemical etching of Silicon, Silicon dioxide, Silicon Nitride and Aluminum. Dry etching, Plasma fundamentals and etch mechanism. Epitaxy: Epitaxial growth technique, Molecular beam epitaxy; Metallization: evaporation and sputtering, Realizing resistor; Single and double damascene process. Overview of MOS and CMOS process technology, Fundamental considerations for optimizing the process technology with latest technology nodes.

References:

1. S. M. Sze, *VLSI Technology*, (2e), McGraw Hill, 1988.
2. S.K. Gandhi, *VLSI Fabrication Principles*, (2e), John Wiley & Sons, 1983.
3. S. A. Campbell, *The Science & Engineering of Microelectronic Fabrication*, (2e), Oxford University Press, 2005.
4. G.S. May & S. M. Sze, *Fundamentals of Semiconductor Fabrication*, (1e), Wiley, 2004.

EC3244 Data Communication & Network Security [3 0 0 3]

Data communication, communication system, Networking: Needs and Advantages, Network, Types-Client, Server and Peers, introduction to various types of servers, client/server architecture. Transmission Media types: Wired & Wireless transmission. Classification of Networks, Network Topologies. Transmission Modes, Asynchronous & synchronous Transmission, Parallel and Serial Transmission. Connectivity Devices. Real World Networks. IEEE 802 standards. Addressing: physical, port, logical Addresses (IPv4), subnetting, NAT, IPv6. Standards Organizations, OSI reference model TCP/IP suite. TCP/IP protocols: IP, ARP, RARP, ICMP, TCP, UDP TCP/IP Services Protocols: DHCP, DNS, FTP, TFTP, SMTP, TELNET, and NFS. WWW, URL, e-mail, HTTP. Network Security: Network security issues, approaches to network security, hacking. Virus, Worms, Different networking attacks and prevention. Firewalls: types of firewall technology- network level and application level, IP packets filter screening routers, limitations of firewalls. Encryption and Decryption – Cryptography, Public/Private key encryption. Overview of Digital Signature and Digital Certificates Technology Network building blocks required for setting up a small LAN using Windows in an office, Hardware & software required.

References:

1. Fourauzan B., *Data Communications and Networking*, (3e), Tata McGraw-Hill Publications, 2004.
2. Tanenbaum A., *Computer Networks*, (5e), PHI, 2011.
3. Comer D., *Computer Networks and Internet*, (2e), Pearson Education, 1999.
4. S.K.Basandra & S. Jaiswal, *Local Area Networks*, (5e), Galgotia Publications,2009.
5. S. Bose, P. Vijaykumar, *Cryptography and Network Security,* (1e), Pearson Publication, 2016.

EC3245 MIMO Wireless Communication Fundamentals [3 0 0 3]

Introduction to wireless communication systems and wireless channels (evolution from 1G-5G, elements of a communication system, layered view of transmitter and receiver). Wireless channel

models (Large scale propagation models, Path Loss, Shadowing , Small Scale Propagation Model, Small scale propagation frequency flat fading, Received signal correlation. MIMO channel model Coherence Time, Doppler Shift, Frequency Selective Fading, Coherence Bandwidth, Delay Doppler Characteristics, Spatial Channel Characteristics).Information Theory basics for MIMO communication. Capacity of MIMO Communication systems. (Capacity of deterministic MIMO channels (known and unknown to transmitter), Capacity of Random Channel. Diversity performance of MIMO channels (spatial diversity, Diversity Gain, Transmit Diversity, MIMO Diversity). Space Time Coding schemes, Multi-user MIMO communications.

References:

1. G. Stuber, *Principles of Mobile Communications*, (2e), Springer, 2002.
2. A. Goldsmith, *Wireless Communications*, (2e), Cambridge,2011.
3. A. Paulraj, Nabar and Gore, *Introduction to Space Time Wireless Communications*, (1e), Cambridge University Press, 2003.
4. Bolskei, Gesbert, et al., *Space Time Wireless Communication Systems*, (1e), Cambridge University Press, 2006.
5. Biligeri, et al., *MIMO wireless communications*, (1e), Cambridge University Press, 2010.
6. R. Prasad, Rahman and S. S. Das, *Single and Multi Carrier MIMO Transmission for Broadband Wireless Systems*, (1e), River Publishers Series in Communications, 2009.

EC3246 Digital System Design using FPGAs [3 0 0 3]

Introduction: Digital System implementation using MSI/LSI circuits like PLDs, PLAs and PALs. Full-custom, semi-custom, standard cell based, Programmable ASICs – CPLDs, MPGAs and FPGAs, FPGA Design flow. Sequential Logic Design. Introduction, Basic Bi-stable Memory Devices, additional bi-stable devices, reduced characteristics and excitation table for bi-stable devices. Synchronous Sequential Logic Circuit Design: Introduction, Moore, Mealy and Mixed type, Synchronous State Machines. Synchronous sequential design of Moore, Melay Machines. Algorithmic State Machine. An Algorithm with inputs, digital solution, Implementation of traffic light controller, ASM charts, Design Procedure for ASMs. Digital System Design: Top down and Bottom up approach, Data Path, Control Path, Controller behaviour and Design, Timing of sequential circuits, Pipelining, Resource sharing. FSM issues: State diagram optimization, State Assignment, Asynchronous Inputs, Output Races, Fault Tolerance. Data path and Control design using VHDL/Verilog HDL and it's mapping on FPGA.

References:

1. Zvi Kohavi, *Switching and Finite Automata Theory*, (2e), Tata McGraw-Hill, 2008.
2. Navabi, *Analysis and modeling of digital systems*, (2e) McGraw Hill, 1998.
3. Douglas Perry, *Modeling with VHDL*, (3e), McGraw Hill, 1994.
4. Navabi, *Verilog Digital Design*, (2e), McGraw Hill, 2007.

EC3247 Internet of Things [3 0 0 3] (redesign)

Introduction to IoT: Architecture and Functional blocks of IoT, IoT communication and Technologies, Communication models, supporting protocols & APIs, IoT protocols, IoT levels and Deployment templates. IoT Applications: Home Automation, Health monitoring system, Smart Transportation, Smart City, etc. Machine to Machine: Difference between IoT and M2M, introduction to SDN and NFV for IoT. IoT Platform Design methodology: IoT design process flow, logical design using python. IoT Cloud Platform: Cloud using Web Services, Cloud Computing Services for Sensor Management. Data Analytics: Mongo DB, Map Reduce, Using cloud APIs for analytics, Visualization, NVD3, Mobile interfacing.

References:

1. Vijay Madisetti, Arshdeep Bahga, *Internet of Things: A Hands-On Approach, (1e),* Orient Blackswan Private Limited, 2015.
2. R. Kamal, *Internet of Things – Architecture and Design Principles*, (1e), McGraw Hill, 2017.
3. R. Buyya A. V. Dastjerdi, *Internet of Things: Principles and Paradigms*, (1e), Book ISBN: 9780128093474, Paperback ISBN: 9780128053959, Morgan Kaufmann,2016.

EC3248 ARM System Development [3 0 0 3]

Introduction to microcontroller: Review of History of different types of microprocessors and microcontrollers.ARM Processor Fundamentals: The ARM Design Philosophy, Architecture, ARM Processor Families. Introduction to the ARM Instruction Set: Data Processing Instructions, Branch Instructions, Load-Store Instructions, Software Interrupt Instruction, Program Status Register Instructions. Introduction to the Thumb Instruction Set: Thumb Register Usage, ARM-Thumb Interworking, Other Branch Instructions, Data Processing Instructions, Single-Register Load-Store Instructions, Multiple-Register Load-Store Instructions, Stack Instructions, Software Interrupt Instruction. ARM Organization and Implementation: 3-stage pipeline ARM organization, 5-stage pipeline ARM organization. Memory Hierarchy: Memory management, On-chip memory, Cache design - an example. Programming with ARM: Programming loops, Character coded data, Code conversion, and Arithmetic examples. Project development.

References:

1. Muhammad Ali Mazidi, *ARM Assembly Language Programming Architecture: Volume (ARM books)*, (2e), MicroDigitalEd.com, 2016.
2. Yifeng Zhu, *Embedded Systems with Arm Cortex-M Microcontrollers in Assembly Language and C*, (2e), E-Man Press LLC, 2015.
3. S. Furber, *ARM System-on- Chip Architecture*, (2e), Pearson Education, 2000.
4. J. R. Gibson, *ARM Assembly Language-an Introduction*, (2e), Dept. of Electrical Engineering and Electronics, The University of Liverpool, 2007.
5. A. N. Sloss, Dominic Symes, Chris Wright, *ARM System Developer's Guide*, (1e), Elsevier, 2004.

EC3249 Medical Electronics [3 0 0 3]

Brief introduction to human physiology. Biomedical transducers: displacement, velocity, force, acceleration, flow, temperature, potential, dissolved ions and gases. Bio-electrodes and bio-potential amplifiers for ECG, EMG, EEG, etc. Measurement of blood temperature, pressure and flow. Impedance plethysmography. Ultrasonic, X-ray and nuclear imaging. Prostheses and aids: pacemakers, defibrillators, heart-lung machine, artificial kidney, aids for the handicapped. Safety aspects.

References:

1. W.F. Ganong, *Review of Medical Physiology*, (8e), Medical Publishers, 1977.
2. J.G. Websster, ed., *Medical Instrumentation-Application and design*, (4e), Houghton Mifflin, 2010.
3. A.M. Cook and J.G. Webster, eds., *Therapeutic Medical Devices-application and design*, (1e), Englewood Cliffs, N.J., Prentice-Hall, 1982.

EC3250 Defence Information System & Electronic Warfare [3 0 0 3]

Electronic Warfare Principles and Overview**:** Electronic Warfare taxonomy, Mission and scenarios, Components of EW and SIGINT, Electronic Support Measures (ESM) fundamentals, Operational use of EW in air, land and maritime domains. Intelligence Surveillance Target Acquisition and Reconnaissance (ISTAR), Force protection. Anti-Submarine Warfare Fundamentals: Interpreting and exploiting the underwater environment, Pre-mission threat assessments and awareness of evolving

technologies, Prediction of target detection ranges and sensor deployment. Detection and tracking using SONAR and non-acoustic methods. Air and Maritime Platform Protection**:** Threat systems, Platform vulnerability, Stealth technology overview, Threat avoidance and detection, Countering the threat through jamming, Introduction to Suppression of Enemy Air Defence (SEAD), Radio Controlled Improvised Explosive Device (RCIED), Introduction to EW planning, Electronic Orders of Battle (EOB) production.

References:

1. Curtis Schleher. D., *Introduction to Electronic Warfare*, (1e), Artech House Inc.1986.
2. Sergei A. Vakin, Lev N. Shustov, Robert H. Dunwell, *Fundamentals of Electronic Warfare*, (1e), Artech House Inc., 2001.
3. Richard Poisel, *Introduction to Communication Electronic Warfare Systems*, (2e), Artech House Inc., 2008.

EC3252 ANTENNA DESIGN FOR WIRELESS APPLICATIONS [3 0 0 3]

Antenna parameters (gain, efficiency, bandwidth, polarization etc.) – theory, comparison with simulators, and measured data for simple antennas. **Antennas:** radiation concepts, dipoles, monopoles, other printed antennas. **Mathematical Model of Microwave Transmission**-Concept of Mode, Features of TEM, TE and TM Modes, Losses associated with microwave transmission, Concept of Impedance in Microwave transmission. M**icrostrip antennas:** Basic characteristics of micro strip antennas, feeding methods, methods of analysis, design of rectangular and circular patch antennas. Broadband printed antennas, Circular polarized antennas, broadband Circular polarized Antennas, MIMO antennas, Recent Trends. Introduction to CST Microwave studio, Implementation of Antenna designs using CST Microwave studio.

Reference Books:

1. C. A. Balanis, *Antenna Theory – Analysis and Design,* 3rd Edition, John Wiley & Sons, 2005.
2. Girish Kumar and K. P. Ray, *Broadband Microstrip Antennas,* Artech house; 2003.
3. Guha, Debatosh, and Yahia MM Antar, eds. *Microstrip and printed antennas: new trends, techniques and applications*, John Wiley & Sons, 2011.
4. R. A. Sainati, *CAD of Microstrip Antennas for Wireless Applications,* Artech, 1996.
5. Warren L. Stutzman, Gary A. Thiele, *Antenna Theory and Design,* John Wiley & Sons; 3rd edition, 2012
6. CST Microwave studio Users Manual.

EC3253 BIOMETRICS [3 0 0 3]

Biometric fundamentals: comparison with traditional authentication systems, Applications of Biometric Systems, Security and Privacy Issues. Biometric standards and databases. Physiological Biometrics and Behavioral Biometrics. Biometric systems: Architecture, Biometric processes- verification, identification and matching, Performance measures in biometric systems. Basic image processing for biometrics: acquisition, enhancement, interpolation and registration. Face biometrics: Introduction, face recognition methods, challenges in face recognition. Retina and Iris biometrics. Fingerprint and hand geometry biometrics: fingerprint feature extraction methods, hand geometry and characteristics. Voice biometrics: speaker identification and verification. Multibiometric systems. Biometric cryptography and watermarking.

References:

1. G. R. Sinha, Sandeep B. Patil, *Biometrics: concepts and applications*, Wiley, 2013.
2. Anil K. Jain, Arun A. Ross, Patrick Flynn, *Handbook of Biometrics*, Springer, 2008.

3. Rafael C. Gonzalez, Richard E. Woods, *Digital Image Processing*, (4e) Pearson Education, , 2018.
4. J. L. Wayman, A. K. Jain, D. Maltoni, D. Maio, *Handbook of Biometrics- Technology, Design and Performance Evaluation*, Springer 2005.
5. Ruud M. Bolle, Sharath Pankanti, Nalini K. Ratha, Andrew W. Senior, Jonathan H. Connell, *Guide to Biometrics*, Springer 2009.

PROGRAM ELECTIVES –III, IV, V, VI AND VII

EC4142 **Analog VLSI Design** **[3 0 0 3]**

Review of MOS Transistor operation models and equivalent circuits for low and high frequency. Single-Stage Amplifiers: CS, CG, CD, Cascode amplifiers, Differential Amplifiers: Common mode, differential mode response analysis and gain calculation. Passive and Active Current Mirrors: Cascode current mirror, current mirror as an active device, Miller effect for frequency response of amplifiers, Feedback amplifiers, Theory and design of MOS Operational Amplifier, Stability and Frequency compensation of operational amplifiers. Comparators and Voltage Reference Sources. Switched Capacitor Circuits: Principles of operation of Switched Capacitor Circuits, Switched Capacitor Filters.

References:

1. Behzad, Razavi, *Design of Analog CMOS Integrated Circuits*, (2e), McGraw Hill, 2001.
2. Allen Holberg, *CMOS Analog Integrated Circuit Design*, (3e), Oxford University Press, 2012.
3. P. R.Gray, Hurst, Lewis and R. G. Meyer, *Analysis and Design of Analog Integrated Circuits*, (4e), John Wiley, 2001.

EC4144 **Wireless & Adhoc Networks** **[3 0 0 3]**

Introduction and Issues in Ad-Hoc Wireless Networks. MAC Protocols, Issues, Classifications of MAC protocols, Multi-channel MAC & Power control MAC protocol. Issues – Classifications of routing protocols – Hierarchical and Power aware. Multicast routing –Classifications, Tree based, Mesh based. Ad Hoc Transport Layer Issues. TCP Over Ad Hoc –Feedback based, TCP with explicit link, TCP-BuS, Ad Hoc TCP, and Split TCP. Introduction – Sensor Network Architecture, Data dissemination, Gathering. MAC Protocols, self-organizing, Hybrid TDMA/FDMA and CSMA based MAC, WSN routing, OLSR, AODV. Localization Indoor and Sensor Network Localization. QoS in WSN, Self-configuration and Auto configuration, Capacity Models, Fairness, Heterogeneous Mesh Networks, Vehicular Mesh Networks.

References:

1. C. Siva Ram Murthy and B. S Manoj, *Ad Hoc Wireless Networks – Architectures and Protocols*, (1e), Pearson Education, 2004.
2. Feng Zhao and Leonidas Guibas, *Wireless Sensor Networks,* (1e), Morgan Kaufman Publishers, 2004.
3. C. K. Toh, *Ad Hoc Mobile Wireless Networks,* (1e), Pearson Education, 2002.

EC4145 **Adaptive Signal Processing** **[3 0 0 3]**

Complex-Valued Adaptive Signal Processing: Optimization in the Complex Domain, Widely Linear Adaptive Filtering, Nonlinear Adaptive Filtering with Multilayer Perceptrons, Complex Independent Component Analysis. Robust Estimation Techniques for Complex-Valued Random Vectors: Statistical Characterization of Complex Random Vectors, Complex Elliptically Symmetric (CES) Distributions, Tools to Compare Estimators, Scatter and PseudoScatter Matrices Array Processing Examples, MVDR Beamformers Based on M-Estimators, Turbo Equalization: Communication Chain. Turbo Decoder:

Overview, Forward-Backward Algorithm, Simplified Algorithm: Interference Canceler, Capacity Analysis, Blind Turbo Equalization, Convergence, Multichannel and Multiuser Settings. Subspace Tracking for Signal Processing: Linear Algebra Review, Observation Model and Problem Statement, Preliminary Example: Oja's Neuron, Subspace Tracking, Eigenvectors Tracking, Convergence and Performance Analysis Issues. Particle Filtering: The Basic Idea, The Choice of Proposal Distribution and Resampling, Some Particle Filtering Methods, Handling Constant Parameters, Rao–Blackwellization, Prediction, Smoothing.

References:

1. Tulay Adalı, Simon Haykin, *Adaptive Signal Processing-Next Generation Solutions*, (1e), John Wiley & Sons, 2010.
2. Dimitris G. Manolakis, Dimitris Manolakis, Vinay K. Ingle, Stephen M. Kogon, *Statistical and Adaptive Signal Processing: Spectral Estimation, Signal Modeling, Adaptive Filtering and Array Processing*, (1e), Artech House, 2005.
3. Ali H. Sayed, *Fundamentals of Adaptive Filtering*, (1e), John Wiley, 2003.

EC4146 Information Theory & Coding [3 0 0 3]

Random Signal Theory: Introduction to random variables and random processes, probability distribution- Binomial, Poisson and Normal distributions, Cumulative Distribution Function, Joint Distribution, Independent random variable and conditional distribution, Characteristics of random variable-Mean, variance and standard deviation. Information Theory: Introduction to information theory and probability, entropy, rate of information, Joint and conditional entropy. Mutual information: noise free channel, channel with independent input and output. Channel capacity: Binary symmetric channel, binary erasure channel, noise free channel, cascaded channels, and binary channel. Coding: Introduction, code efficiency, Shannon theorem, capacity of Gaussian channel, Bandwidth and S/N trade off Shannon-Fano coding, Huffman coding, LZ coding, Error control coding, Automatic Repeat Request and Forward error correction codes, Block codes and parity check codes, Hamming Weight, Hamming Distance, Minimum distance decoding, Single Parity codes, Repetition Codes, Hamming Codes, Linear block codes, Cyclic code, Convolution code, Turbo Codes.

References:

1. M. Kulkarni & K. S. Shivaprakasha, *Information Theory and Coding,* (1e), Wiley India Pvt. Ltd, First edition,2014.
2. A. Saha, N. Manna and S. Mandal, *Information Theory and Coding*, (1e), Pearson Education, First edition,2013.
3. P.Z. Peebles, *Probability, Random Variables and Random Signal Principles*, (4e), Mc-Graw Hill, 2000.
4. F.M. Reza, *Information Theory,* (1e), Tata McGraw Hill, 1961.
5. R D Singh and S D Sapre, *Communication Systems*, (2e), Tata McGraw Hill, 1995.
6. R. Bose, *Information Theory, Coding and Cryptography,* (2e), Tata McGraw Hill, 2001.

EC4147 Photonics & Optoelectronics [3 0 0 3]

Nature of light, light sources, black body, colour temperature, units of light, radio metric and photometric units, basic semiconductors, PN junction, carrier recombination and diffusion, injection efficiency, heterojunction, internal quantum efficiency, External quantum efficiency, double hetero junction, fabrication of heterojunction, quantum wells and super lattices. Opto-electronic devices, Optical modulators, modulation methods and modulators, transmitters, optical transmitter circuits, LED and laser drive circuits, LED-Power and efficiency, double hereostructure LED, LED structures, LED characteristics, laser modes, strip geometry, gain guided lasers, index guided lasers. Modulation of light, birefringence, electrooptic effect, EO materials, Kerr modulators, scanning and switching, self electro optic devices, MO devices, AO devices, AO modulators. Display devices, Photoluminescence,

cathodo luminescence, EL display, LED display, drive circuitry, plasma panel display, liquid crystals, properties, LCD displays, numeric displays. Photo detectors, thermal detectors, photoconductors, detectors, photon devices, PMT, photodiodes, photo transistors, noise characteristics of photo-detectors, PIN diode, APD characteristics, APD Design of detector arrays, CCD, Solar cells.

References:

1. J Wilson and J F B J iS Hawkers, *Opto electronics - An introduction*, (2e), Prentice-Hall India, 1993.
2. J M Senior, *Optical fibre communication*, (3e), Prentice Hall India, 1992.
3. J Gowar, *Optical fibre communication systems*, (3e),Prentice Hall, 1993.
4. J. C. Palais, *Introduction to optical electronics*, (5e), Prentice Hall, 2004.
5. Jasprit Singh, *Semiconductor opto electronics*, (1e), McGraw-Hill, Inc, 1995.
6. P Bhattacharya, *Semiconductor optoelectronic devices*, (2e), Pearson, 1996.
7. R. P. Khare, *Fibre Optics and Opto-electronics*, (1e), Oxford University Press, 2004.

EC4148 Nanophotonics [3 0 0 3]

Foundations for Nanophotonics: Confinement of Photons and Electrons, Propagation Through a Classically Forbidden Zone, Localization Under a' Periodic Potential, Axial and Lateral Nanoscopic Localization, Nanoscale Confinement of Electronic Interactions, Quantum Confinement Effects, Near-Field Interaction and Microscopy, Modeling of Near-Field Nanoscopic Interactions, Near-Field Microscopy, Quantum-Confined Materials, Manifestations of Quantum Confinement, Optical Properties, Quantum-Confined Stark Effect, Dielectric Confinement Effect, Growth and Characterization of Nanomaterials: Growth Methods for Nanomaterials, Nanochemistry, Nanostructured Molecular Architectures, Photonic Crystals, Theoretical Modeling of Photonic Crystals, Methods of Fabrication, Photonic Crystal Fibers (PCF), Photonic Crystals and Optical Communications, Photonic Crystal Sensors. Nanocomposites, Nanocomposite Waveguides, Multiphasic Nanocomposites, Nanocomposites for Optoelectronics, Industrial nanophotonics: Nanolithography, , Nanoparticle Coatings, Sunscreen Nanoparticles, Self-Cleaning Glass Fluorescent Quantum Dots, Nanobarcodes, Bio Nanophotonics and nanomedicine, Nanoparticles for Optical Diagnostics and Targeted Therapy, Semiconductor Quantum Dots for Bioimaging Biosensing, Nanoclinics for Optical Diagnostics and Targeted Therapy, Nanoclinic Gene Delivery Nanoclinics for Photodynamic Therapy.

References:

1. P N Prasad, *Nanophotonics,* (1e), Wiley Interscience, 2003.
2. P N Prasad, *Introduction to Biophotonics,* (1e), Wiley Publications, 2004.

EC4149 Free Space Optical Communication [3 0 0 3]

Overview of Wireless Optical Communication Systems, Outdoor/Free-Space Optical Communication, Comparison of FSO and Radio-Frequency Communication Systems, Choice of Wavelength in FSO Communication System, Range Equation for FSO Link, Technologies Used in FSO, Applications of FSO Communication Systems, Free-Space Optical Channel Models, Atmospheric Channel, Atmospheric Losses, Absorption and Scattering Losses, Free-Space Loss, Beam Divergence Loss, Loss due to Weather Conditions, Pointing Loss, Atmospheric Turbulence, Atmospheric Turbulent Channel Model, Techniques for Turbulence Mitigation. Optical Transmitter, Choice of Laser, Modulators, Modulation Schemes, Optical Receiver, Types of Detectors, Receiver Configuration, Link Design Trade-Off. Acquisition, Tracking, and Pointing, Scanning Techniques, Acquisition Approach, Beam Divergence and Power Criteria for Acquisition, Tracking and Pointing Requirements, Integration of Complete ATP System, ATP Link Budget. BER Performance of FSO System, Link Performance Improvement Techniques, Aperture Averaging, Aperture Averaging Factor, Aperture Averaging Experiment, Diversity, Types of Diversity Techniques, Diversity Combining Techniques, Coding, Channel Capacity, Channel Coding in FSO System. Link Feasibility Study, Link

Requirements and Basic Parameters, Transmitter Parameters, Atmospheric Transmission Loss Parameter, Receiver Parameters, Link Power Budget.

References:

1. H. Kaushal, V.K. Jain, S. Kar, *Free Space Optical Communication*, (1e), Springer, 2017.
2. B. Djordjevic, *Advanced Optical and Wireless Communications Systems*, (1e), Springer, 2018.
3. O. Bouchet, H. Sizun, C. Boisrobert, F. de Fornel and P. Favennec, *Free-Space Optics: Propagation and Communication* , (1e), Wiley, 2006.
4. N. Ismail, *Free Space Optics (FSO): Design and Analysis of a 50km Free Space Optical Communication Link (FSO) operating at 2.5Gbps* , (1e), LAP LAMBERT Academic Publishing, 2011.
5. Arun K. Majumdar, *Advanced Free Space Optics (FSO),* (1e), Springer, 2015.

EC4150 Optical Networks [3 0 0 3]

Optical system components: Light propagation in optical fibers – Loss & bandwidth, System limitations, Non-Linear effects; Solitons; Optical Network Components – Couplers, Isolators & Circulators, Multiplexers & Filters, Optical Amplifiers, Switches, Wavelength Converters. Optical Networking: Introduction: circuit switching and packet switching, optical layer, network evolution. Optical networking components/building blocks: Optical fibers, Optical transmitter, receiver and filters, multiplexers, switching elements, wavelength converter, and optical amplifiers. Client layers of the optical layer, WDM network elements. Optical switching: Packet switching, burst switching, MEMs based switching, switching with SOAs. Optical Metro Network: SONET/SDH, Fault management in SONET/SDH. Optical Access Network: Access networks, Photonic packet switching. Deployment considerations. Overview of PON technologies, Ethernet access network, WDM-PON. Control and management, network survivability, protection schemes.

References:

1. C. Sivaramamurthy & M. Gurusamy, *WDM Optical Networks: Concepts, Design, and Algorithms*, (1e), Prentice Hall, 2002.
2. Rajiv Ramaswami and Kumar N. Sivarajan, *Optical Networks : A Practical Perspective*, (2e), Harcourt Asia Pte Ltd., 2004..
3. John M. senior, *Optical fiber communication : Principles and Practice* , (3e), Pearson, 2009.
4. G.E. Keiser, *Optical fiber communication*, (5e), McGraw Hill, 2017.
5. P.E. Green, Jr., *Fiber Optic Networks*,(1e), Prentice Hall, NJ, 1993.
6. Biswanath Mukherjee, *Optical WDM Networks*, (1e), Springer, 2006.

EC4151 Power Electronics [3 0 0 3]

Power Semiconductor devices: SCR, GTO, BJT, Power MOSFET, IGBT – characteristics, safe operating area, device rating, base/gate drive requirements, Converter Topologies: Controlled Rectifiers, Single phase converters, Three-phase Converters- half controlled & fully controlled bridge, Line commutated inverters, Dual converters, AC to AC converters: Cycloconverters and AC voltage regulators, DC – DC Converters: Buck, Boost, Cuk, SEPIC, Isolated Converters DC – AC Converters: Single phase and three phase bridge inverters, Square wave operation, PWM Inverters- PWM techniques, harmonics in output voltage , Multi-level inverters, Space vector modulation, Resonant converters: Principle of soft switching- concept of zero current switching and zero voltage switching.

References:

1. D. W. Hart, *Introduction to Power electronics,* (1e), Prentice Hall, 1996.
2. M. H. Rashid, *Power Electronics Circuits, Devices and Applications*, (3e), Prentice-Hall of India, Private limited, New-Delhi, 2004.
3. N. Mohan, *Power Electronics – Converters, Applications and Design,* (3e), John Wiley & Sons. INC, 2002.
4. L. Umanand, *Power Electronics – Essentials and Applications*, Wiley India Pvt. Ltd., 2014.

EC4152 Low Power VLSI Design [3 0 0 3]

Need for Low Power design, Sources of power dissipation in Digital Integrated circuits. Emerging low power approaches, Hierarchical Low Power Design Methodologies. Physics of power dissipation in CMOS devices, Dynamic and static power dissipation, Transistor sizing & gate oxide thickness. Impact of technology Scaling and Device innovation. Random logic signals, probability and frequency, probabilistic power analysis techniques, signal entropy, Power consumption in circuits. Design of Flip Flops and Latches. Low Power Dynamic logic families and Adiabatic Logic Families. Gate reorganization, pre-computation logic, signal gating, logic encoding, state machine encoding, reduction of power in address and data buses; Power dissipation in clock distribution, Zero skew versus Tolerable skew, Power and performance management, switching activity reduction, parallel architecture with voltage reduction, flow graph transformation, low power arithmetic components, low power memory design.

References:

1. G. K. Yeap, *Practical Low Power Digital VLSI Design,* (1e), Kluwer Academic, 2002.
2. Rabaey, Pedram*, Low power design methodologies*, (1e), Kluwer Academic, 1997.
3. K. Roy, S. Prasad, *Low Power CMOS VLSI Circuit Design*, (1e), Wiley, 2000.
4. Kiat, Samir S, R. S. Yeo, W. L. Goh, *CMOS/BiCMOS ULSI Low Voltage Low Power*, (1e),
5. Pearson, 2002.

EC4153 CAD Algorithms for Synthesis of Digital Systems [3 0 0 3]

Role of CAD in digital system design, levels of design, modeling & description and support of languages, RTL, gate and system level synthesis; Technological alternatives and technology mapping; CAD tools for synthesis, optimization, simulation and verification of design at various levels as well as for special realizations and structures such as PLAs, gate arrays etc. Technology mapping for FPGAs. Low power issues in high level synthesis and logic synthesis.

References:

1. G. D. Micheli, *Synthesis and optimization of digital systems*, (1e), Mc Graw Hill, 1994.
2. Dutt, N. D. and Gajski, D. D. *High level synthesis- Introduction to Chip and System Design*, (1e), Kluwer, 1992.
3. T. H. Cormen, C. E. Leiserson and R. L. Rivest, *Introduction to Algorithms*, (2e), McGraw-Hill, 2001.
4. N. Deo, *Graph Theory with Applications to Engineering and Computer Science*, (1e), PH India, 2004.

EC4154 MEMS Devices and Technology [3 0 0 3]

Overview of MEMS and Microsystems: Introduction Microsystem vs. Microelectronics, the Multidisciplinary Nature of Microsystem design and manufacture, Application of MEMS in various industries. MEMS and Miniaturization: Materials for MEMS and Microsystems – Si as substrate material, mechanical properties of Silicon, Silicon Compounds (SiO2, Si3N4, SiC, PolySi, Silicon), Piezoresistors, Piezoelectric crystals, Packaging Materials. Micromachining Processes: Overview of microelectronic fabrication processes used in MEMS, Bulk Micromachining – Isotropic & Anisotropic Etching, Comparison of Wet vs Dry etching, Surface Micromachining – General description, Processing in general, Mechanical Problems associated with Surface Micromachining, Introduction to LIGA process, Introduction to Bonding. Assembly of 3D MEMS - foundary process. Microsystems & MEMS Design: Design Considerations: Design constraints, Selection of Materials, Selection of Manufacturing processes, Selection of Signal Transduction, Electromechanical system, packaging. Process design, Mechanical Design – Thermo mechanical loading, Thermo mechanical Stress Analysis, Dynamic

Analysis, Interfacial fracture Analysis, Mechanical Design using Finite Element Method. Case study of MEMS Presure senor: Design and fabrication considerations.

References:

1. S. M. Sze*, VLSI Technology,* (2e), McGraw Hill, 1988.
2. S.K. Gandhi, *VLSI Fabrication Principles*, (2e), John Wiley & Sons, 1983.
3. S. A. Campbell, *The Science & Engineering of Microelectronic Fabrication*,(2e), Oxford University Press, 2005.
4. G.S. May & S. M. Sze, *Fundamentals of Semiconductor Fabrication*, Wiley, 2004.
5. Microsystem Design By Stephen D. Senturia, Kluwer Academic Publishers (2003)
6. Micro Technology and MEMS By M. Elwenspoek and R. Wiegerink, Springer (2000)

EC4155 Fundamental of Robotics system [3 0 0 3]

Introduction and Mathematical Representation of Robots: Brief History of Robotics, Types of Robots, Technology of Robots, Basic Principles in Robotics. Position and Orientation of a Rigid Body, Transformation Between Coordinate Systems, Representation of Joints, Representation of Links Using Denavit–Hartenberg Parameters, Link Transformation Matrices, examples. Kinematics of Serial Manipulators: Direct Kinematics of Serial Manipulators, Inverse Kinematics of Serial Manipulators, examples. Kinematics of Parallel Manipulators: Direct Kinematics of Parallel Manipulators, Inverse Kinematics of Parallel Manipulators, examples. Velocity Analysis and Statics of Manipulators: Linear and Angular Velocities of Links in Serial Manipulators, Serial Manipulator Jacobian, Parallel manipulator Jacobians, Singularities of Serial and Parallel Manipulators, Statics of Serial Manipulators, Statics of Parallel Manipulators, examples. Dynamics of Manipulators: Dynamic Equations in Cartesian Space, Inverse Dynamics of Manipulators, Recursive Formulations of Dynamics of Manipulators, Newton–Euler Formulation for Inverse Dynamics, Algorithms for Forward Dynamics, examples.

References:

1. Ashitava Ghosal, *Robotics Fundamental Concepts and Analysis*, (1e), illustrated, OUP India, 2006.
2. R K Mittal and I. J. Nagrath, *Robotics and Control*, (1e), Tata McGraw-Hill Education, 2003.
3. H. Asada and J. J. Slotine, *Robot Analysis and Control*, (1e), New York, NY: Wiley, 1986.
4. M. Spong, M. Vidyasagar, S. Hutchinson, *Robot Modeling and Control*, (1e), Wiley & Sons, 1989.
5. John J. Craig, *Introduction to Robotics: Mechanics and Control*, (3e), Addison-Wesley Publishing Company, 2003.

EC4156 Machine Learning & AI [3 0 0 3]

Introduction: Introduction to Artificial Intelligence, Foundations and History of Artificial Intelligence, Applications of Artificial Intelligence, Intelligent Agents, Structure of Intelligent Agents. Computer vision, Natural Language Possessing. Introduction to Search : Searching for solutions, Uniformed search strategies, Informed search strategies, Local search algorithms and optimistic problems, Adversarial Search, Search for games, Alpha - Beta pruning. Knowledge Representation & Reasoning: Propositional logic, Theory of first order logic Inference in First order logic, Forward & Backward chaining, Resolution, Probabilistic reasoning, Utility theory, Hidden Markov Models (HMM), Bayesian Networks. Machine Learning : Supervised and unsupervised learning, Decision trees, Statistical learning models, Learning with complete data - Naive Bayes models, Learning with hidden data - EM algorithm, Reinforcement learning. Pattern Recognition : Introduction, Design principles of pattern recognition system, Statistical Pattern recognition, Parameter estimation methods - Principle Component Analysis (PCA) and Linear Discriminant Analysis (LDA), Classification Techniques – Nearest Neighbor (NN) Rule, Bayes Classifier, Support Vector Machine (SVM), K – means clustering.

References:

1. Stuart Russell, Peter Norvig, *Artificial Intelligence – A Modern Approach*, (3e), Pearson Education, 2009.

2. Elaine Rich and Kevin Knight, *Artificial Intelligence*, (1e), McGraw-Hill,1990.
3. E Charniak and D McDermott, *Introduction to Artificial Intelligence*, (1e), Pearson Education, 2016.
4. Dan W. Patterson, *Artificial Intelligence and Expert Systems*, (1e), Prentice Hall of India, 1990.

EC4157 Neural Networks & Deep Learning [3 0 0 3]

Introduction: Various paradigms of earning problems, Perspectives and Issues in deep learning framework, review of fundamental learning techniques. Feedforward neural network: Artificial Neural Network, activation function, multi-layer neural network. Training Neural Network: Risk minimization, loss function, backpropagation, regularization, model selection, and optimization. Conditional Random Fields: Linear chain, partition function, Markov network, Belief propagation, Training CRFs, Hidden Markov Model, Entropy. Deep Learning: Deep Feed Forward network, regularizations, training deep models, dropouts, Convolutional Neural Network, Recurrent Neural Network, Deep Belief Network. Probabilistic Neural Network: Hopfield Net, Boltzman machine, RBMs, Sigmoid net, Autoencoders. Deep Learning research: Object recognition, sparse coding, computer vision, natural language processing. Deep Learning Tools: Caffe, Theano, Torch, Matlab.

References:

1. Goodfellow, I., Bengio,Y., and Courville, A., *Deep Learning,* MIT Press, 2016.
2. Bishop, C., M., *Pattern Recognition and Machine Learning,* (1e), Springer, 2006.
3. Yegnanarayana, B., *Artificial Neural Networks*, (1e), PHI Learning Pvt. Ltd, 2009.
4. Golub, G., H., and Van Loan, C., F*., Matrix Computations*,(3e), JHU Press,1996.
5. Satish Kumar, *Neural Networks: A Classroom Approach,* (1e), Tata McGraw-Hill Education, 2009.
6. A. Ravindran, K. M. Ragsdell , and G. V. Reklaitis, *Engineering Optimization: Methods and Applications*, (2e), John Wiley & Sons, Inc. , 2006.
7. A. Antoniou, W. S. Lu, *Practical Optimization Algorithms and Engineering Applications,* (1e), Springer, 2007.

EC4158 Energy Sources & Technology [3 0 0 3]

Energy sources & Availability: Conventional, Non-conventional, renewable, non-renewable sources of energy, prospects & perspectives & advantages. Introduction to different types of non-conventional source of energy - solar, wind, biomass, OTEC, geothermal, hydrogen energy, fuel cells, MHD, thermonic convertor, thermoelectric power. Solar Radiation and Measurement: Solar radiation on the earth surface - Extraterrestrial radiation characteristics, Terrestrial radiation, solar isolation, spectral energy distribution of solar radiation. Depletion of solar radiation - Absorption, scattering. Beam radiation, diffuse and Global radiation. Measurement of solar radiation. Solar time - Local apparent time (LAT), equation of time (E). Solar Radiation Geometry and Calculations, Prediction of solar radiation availability. Solar Electrical Energy Conversion: Solar photovoltaic energy conversion Principles - Physics and operation of solar cells. Classification of solar PV systems, Solar cell energy conversion efficiency, I-V characteristics. Wind Energy: Energy available from wind, basics of wind energy conversion system, windmill rotors, Fuel Cells. Principle & Classification, types conversion efficiency, polarization & advantages MHD power generation. Bio Energy: Types of biogas plants, biogas generation, factors affecting biogas generation, advantages and disadvantages. Ocean Energy: OTEC principle, open, closed and hybrid cycle OTEC system, advantages and disadvantages.

References:

1. S. P. Sukhatme and J. K. Nayak, *Solar Energy: Principles of Thermal Collection and Storage*, (3e), McGraw Hill Education, 2009.
2. J. A. Duffie, William A. Beckman, *Solar Engineering of Thermal Processes*, (4e), John Wiley, New York, 2013.
3. S. N. Singh, *Non-conventional energy resources*,(1e), Pearson India, 2015.
4. S. Kalogirou, *Solar Energy Engineering*, (2e), Elsevier/Academic Press, 2013.

5. D. Yogi Goswami, F. Krieth & J. F Kreider, *Principles of Solar Energy,* (2e), John Wiley, New York,1999.

EC4159 RF Circuits and Components [3 0 0 3]

Review of Electromagnetic Theory, Transmission Lines and Waveguides, Impedance Matching and Tuning, Network Analysis. Introduction to Microstrip lines, Parallel Striplines, Coplanar Striplines, Shielded Striplines, Slot lines, Integrated Fin line, Non-radiative guide, Transitions, Bends and Discontinuities. RF circuits: Basic Architectures Transmission media and Reflections Resonant Circuits and RF Filter Design. High Frequency Amplifier Design. Microwave Integrated Circuits (MIC): Technology of hybrid MICs, Design of MIC components transitions, couplers, Power dividers, oscillators, modulators, phase shifters and mixers.

References:

1. S. A. Maas, *Nonlinear Microwave and RF Circuits*, (2e), Artech, 2003.
2. David M. Pozar, *Microwave Engineering*, (4e), John Wiley & Sons, 2013.
3. G. Gonzales, *Microwave Transistor Amplifiers,* (2e), Pearson, 1996.
4. B.Bhat, S.K. Koul, *Stripline Like Transmission Lines For Microwave Integrated Circuits*, (1e), New Age Intl. Pvt Ltd., 2007.

EC4162 RF AND MICROWAVE CIRCUITS [3 0 0 3]

Review of basic microwave theory: Transmission lines & concepts-characteristics impedance, reflection coefficient, standing and propagating waves, equivalent circuit. Smith chart, **Network analysis:** Z, ABCD, Y, T, S-parameters, Impedance matching technique, Implementation using simulators.

Transmission lines for microwave circuits: waveguides, stripline, microstrip, slot line; microwave circuit design principles; **Devices:** Low pass, band pass, high pass and band stop filters- lumped, distributed element realization. Directional coupler-Hybrid branch line, rat race and parallel coupled types. Power divider- design. Device implementation using Simulator

Reference Books:

1. D. M. Pozar, Microwave Engineering, Wiley, 2011.
2. B. Bhat and S. K. Koul, Strip line Like Transmission Lines for Microwave Integrated Circuits, New Age Intl. Pvt Ltd., 2007.
3. K. C. Gupta, R. Garg,I. Bahl and P. Bhartia, Microstrip Lines and Slotlines, Second Edition, Artech House, 1996
4. P.A. Rizzi, Microwave Engineering-Passive Circuits, Prentice Hall,1988
5. Robert E. Collin, Foundations for microwave engineering 2ed, 2012

OPEN ELECTIVES

EC2080 Introduction to Communication Systems [3 0 0 3]

Optical Fiber Communications: Types of Optical Fibers, Numerical Aperture, Time Delay and Group Delay, Concept of V number, Attenuation and Dispersion (dispersion shifted and dispersion flattened fibers), Macro and Micro Bending, Pulse Broadening, Optical Sources and Detectors, Optical Communication System. Satellite Communications: Satellite orbits, Keplers laws, speed, period, angle of elevation, orbital effects in communication satellites, launching of a satellite, Earth Station technology, Space Segment, Modern Trends in Satellite Communications.

References:

1. J. M. Senior, *Optical Fiber Communications- Principles and Practise*, (3e), Pearson Education India, 2010.
2. R.P. Khare, *Fiber Optics and Optoelectronics*, (1e), Oxford University Press, 2004.
3. R. N. Mutagi, *Satellite Communications Principles and Applications*, (1e), Oxford University Press, 2016.
4. Wilbur L. Pritchard et al, *Satellite Communication Systems Engineering*, (2e), Prentice Hall, 1993.

EC2081 Transducers and Instrumentation [3 0 0 3]

Measurement, significance of measurement, instruments and measurement systems, mechanical, electrical and electronic instruments, Deflection & Null type instruments. Analog and digital modes of operation, applications of measurement systems. Transducers, Classifications of transducers, Factors influencing the choice of transducers/instruments. Dynamic response: dynamic characteristics, time domain analysis &different types of inputs, frequency domain analysis. Principles of Transduction, Variable resistance devices, Hall Effect Devices, Proximity Devices, Digital Transducer, differential pressure level detector, float level devices. Force measuring sensor: Load cells, column types devices, proving rings, cantilever beam. Hydraulic load cell, Electronic weighing system. Transduction methods – potentiometric device, strain gauge transducer, variable reluctance, LVDT type, variable capacitance device.

References:

1. Alan S Morris, *Measurement and Instrumentation Principles*, (3e), Butterworth, 2001.
2. A. de Sa, Principles of Electronic Instrumentation,(2e),Butterworth-Heinemann, 1990.
3. David A. Bell, *Electronic Instrumentation and Measurements*, (3e), Oxford Press, 2013.
4. S. Tumanski, *Principles of Electrical Measurement,* (1e), Taylor & Francis, 2006.
5. Ilya Gertsbakh, *Measurement Theory for Engineers*, (1e), Springer, 2010.

EC2082 Consumer Electronics [3 0 0 3]

Audio Systems: Microphones, Head Phones and Hearing Aids, Loud Speakers, Loud Speaker Systems, Optical Recording and reproduction systems –CDs, DVDs, Blue ray technology, iPods, MP4 players and accessories, Home Audio systems. Television: Elements of TV Communication System, Scanning, Composite Video signal, Need for synchronizing and blanking pulses, Picture Tubes, Construction and working of Camera Tubes, Block diagram of TV Receiver, LCD and Plasma TV fundamentals, Block diagram and principles of working of cable TV and DTH. Telecommunication Systems: Basics of Telephone system, Caller ID Telephone, Intercoms, Cordless Telephones, Cellular mobile systems. Office electronics: Automatic Teller Machines, Facsimile machines, Digital Diaries, Safety and security systems. Home electronics: Digital Camera system, Microwave ovens, Washing Machines, Air Conditioners and Refrigerators.

References:

1. S.P. Bali, *Consumer Electronics*, (1e), Pearson Education, 2005.
2. R.R.Gulati, *Monochrome and Color Television*, (2e), New Age International Publisher,2005.

EC2083 Introduction to Game Theory [3 0 0 3]

Introduction Examples: Markets/ Politics/ Auctions. Prisoners' Dilemma, Best Response and Nash Equilibrium, Dominant Strategies, Stag Hunt – Coordination and Bank Runs. Multiple Nash Equilibria, Tragedy of Commons, Cournot Duopoly, Mixed Strategies, Battle of Sexes, Best Response Dynamic, Paying Taxes. Portfolio Management Game, Rationality, Choice and Common Knowledge, Iterated Elimination of Domination Strategies, Auction: As a Normal Form Game, Traffic at Equilibrium and Braess's Paradox. Extensive Form Games, Strategies in Extensive from Games, Sub Game Perfect Equilibrium, The Art of War, Ultimatum Game, Stackelberg Model. Bayesian Games, Bayesian Nash Equilibrium, Yield vs Fight, Bayesian Cournot Game, Bayesian Games with mixed strategies, Auctions, Sealed Bid First Price Auction, Expected Revenue, Bayesian Second Price Auction, Second Price Auction, All Pay Auction. Evolutionary Biology, Evolutionary stable Strategy (ESS), Repeated

Games, Multiple Equilibriums, Chain-Store Paradox, Non – Cooperative Bargaining; Extensive Form Game with Incomplete Information, Introduction to perfect Bayesian Equilibrium, Obtaining PBE, Gift Game.

References:

1. Martin Osborne, *An Introduction to Game Theory*, (1e), Oxford University Press, 2003.
2. Ken Binmore, *Game Theory*: A *Very Short Introduction*, (1e), Oxford University Press, 2007.

EC3080 Electronic Measurement & Measuring Instruments [3 0 0 3]

Basics of Measurements: Fundamental & Importance of Instrumentation, types of instruments, selection of instruments, performance of instruments, error in measurement, calibration & standard, Calibration of Instruments: Methods & analysis, Introduction to Transducer & types. Analog DC and AC meters: Electromechanically meter movements, PMMC, Analog DC ammeters, Analog DC voltmeters, Analog AC ammeters and Voltmeters, Analog multimeters, Special purpose analog meters, Use of basic meters, meter errors, problems. Extending the range of meters, Loading effects and their elimination, true rms voltmeters. Digital Meters: DVM and Digital multimeter, vector voltmeters, 7 segment and LCD display. Analog to Digital Converters and Digital to Analog Converters. Oscilloscope: Oscilloscope subsystem, Principle of Operation, Cathode Ray Tube ,Display subsystem, Vertical deflection subsystem, Dual trace/Dual beam feature, Horizontal deflection subsystems, oscilloscope probes, oscilloscope controls, Front panel of an oscilloscope, Lissajous patterns oscilloscope photography, Digital storage oscilloscopes (DSO), Power scope. Attenuation probes, problems.

References:

1. W. D. Cooper And A. D. Helstrick, *Modern Electronics Instrumentation & Measurement Techniques*, (4e), Pearson, 1990.
2. J. J. Carr., *Elements of Electronics Instrumentation and Measurement*, (3e), Pearson, 2003.
3. M. M. S Anand, *Electronics Instruments and Instrumentation Technology*, (1e), PHI, 2009.
4. E.O. Deoblin, *Measurement Systems*, (4e), Mcgraw Hill, 1990.
5. S. Wolf & R.F.M Smith, *Student Reference Manual for Electronic and Instrumentation Measurement*, (2e), PHI Publication, 2004.

EC3081 Electronic Product Design & Packaging [3 0 0 3]

Industrial design: Product planning, Creativity, Aesthetics, Ergonomics, control panel organization, Product detailing, Product finishes. Thermal management: Introduction to thermal sources, heat calculations, heat transfer methods, heat sink selection, cooling methods in electronic systems. Packaging Techniques: Introduction to Electronic Packaging, Microelectronics and Packaging Technologies, Introduction to Silicon Integrated Circuit Chips, Semiconductor Devices, Area Array Technologies: Ball Grid Arrays, Flip Chip, Chip-Scale Packaging, First Level Packages-IC packaging. Second Level Packages: Printed Circuit Boards and Other Substrates; Third Level Packages: Connectors, Cables, Modules, Cages and Cabinets, Reliability Prediction and Measurement. Noise and EMI: Introduction to Noise and EMI, Interfacing of analog and digital systems. PCB design and layout; System assembly considerations, Sources of EMI, Shielding of signal lines, Ground loops, Introduction to functional aspects of SMPS and other power electronic equipment.

References:

1. C. H. Flurshiem, *Industrial design and Engineering*, (1e), Springer Verilog, 1983.
2. P. Horowitz, W Hill, *The art of electronics*, (2e), Cambridge, 1995.
3. H.W. Ott, *Noise Reduction Techniques in Electronic Systems*, (2e),Wiley, 1988.
4. W.C. Bosshart, *Printed Circuit Boards: Design and Technology*, (1e),Tata McGraw Hill, 1992.

EC3082 Advanced Functional Devices Technology [3 0 0 3]

Introduction of present scenario, Introduction to Smart and Functional Materials, Properties of active materials and their assessment. Application: temperature, strain, stress, magnetic field, electrical field,

mechanical quantities, adaptive structures. MEMS/NEMS Actuators: piezo-actuators for advanced robotics and sonar communications, Organic and inorganic semiconductor devices. Energy: solar cells, solar absorbers, perovskite solar cells, piezoelectric energy harvesting. Biomedical devices: Digital microfluidics, Lab-on-chip and Cancer detection devices and treatment using Nano particles etc. Recycling Technique: Electronic Waste, Acceptance of new materials and systems in industry: Process and materials optimization, Economic models, Standardization, Future perspectives.

References:

1. William A. Goddard III, Donald Brenner, Sergey Edward Lyshevski, Gerald J Iafrate, *Handbook of Nanoscience, Engineering, and Technology*, (3e), CRC press, 2012.
2. Roger J Narayan, *Medical Biosensors for Point of Care (POC) Applications*, (1e), Elsevier, 2016.
3. Bent Sørensen, *Renewable Energy: Physics, Engineering, Environmental Impacts, Economics and Planning*, (4e), Academic Press, 2010.
4. Hugo Marcelo Veit, Andréa Moura Bernardes, *Electronic Waste: Recycling Techniques, (1e),* Springer; 2015.
5. Vlad-Victor Oncescu, *Development of Point-of-care Devices for Rapid Diagnostics and Preventive Care, 2014.*

EC3083 Mobile Cellular Communication [3 0 0 3]

Global system for Mobile Communication (GSM) system overview: GSM Architecture, Mobility Management, Network signalling. General Packet Radio Services (GPRS): GPRS architecture, GPRS Network nodes. Overview of Cellular Systems and Evolution 2G/3G/4G/5G. Cellular Concepts Frequency Reuse, Cellular Capacity, Capacity Building, Cochannel and Adjacent Channel Interference, ,C/I, Handoff, Hidden and Exposed Node problems for Medium Access Control. Improvement of Coverage Capacity (cell splitting, cell sectoring, microzoning). Wireless Propagation. Free Space path Loss, Refraction, Diffraction and Scattering, Link Budget, Multipath Fading (small scale, large scale, multipath propagation, Rayleigh and Ricean Fading), Shadowing. Diversity Techniques including Antenna Diversity. Introduction to MIMO, OFDMA techniques, UHF and Millimeter Wave Communications . Channel Models and Large Scale Propagation effects.

References:

1. Yi –Bing Lin & Imrich Chlamatac, *Wireless and mobile Networks Architecture*, (1e), John Wiley & Sons, 2001.
2. Raj Pandya, *Mobile & Personnel communication Systems and Services*, (1e), Prentice Hall India, 2001.
3. Theodore S. Rappaport, *Wireless Communication- Principles and practices*, (2e), Pearson Education Pvt. Ltd, 2003.
4. Jochen Schiller, *Mobile communications,* (2e),Pearson Education Pvt. Ltd., 2009.
5. Singhal & Bridgman et. Al, *The Wireless Application Protocol*, (1e), Pearson Education, 2000.

EC3084 Audio & Video Systems [3 0 0 3]

Basic Components of Audio and Video: Construction & Working of Microphone, types of microphone, Construction & Working of Loud Speaker, Tweeter, Wooffer, Mid range, CCD Camera. HI-FI and Stereophony : Meaning of Hi-Fi, Basic components, Fundamental of sound harmonics, Loudness, Pitch, Timbre, Sensitivity, Stereophony recording, Broadcasting of stereophony and its reproduction, Graphic equalizer, Basic idea about audio pre amplifier and power amplifiers. Scanning and Composite Video Signal : Scanning Process, Flicker & Inter lace scanning, Contrast Ratio & Aspect ratio and viewing distance, Composite Video signal dimensions, Horizontal and vertical sync details, TV standards for 625 line system. Basics of T.V. Signal Transmission & Reception: Block diagram of TV transmitter and TV Receiver. Colour T.V.: Introduction to Colour T.V. & colour T.V. Essentials. Basic Concept of New Trends : Audio CD player, Audio conferencing, Digital versatile disk (DVD), Home theatre system, LCD & LED TV, Plasma TV, Blue ray disc.

References:

1. A.K. Sawhney, *A Course in Electrical & Electronic Measurement & Instruments*, (7e), Dhanpat Rai pvt ltd, 2015.
2. B. Grob, C. E. Herndon, *Basic Television & Video System*, (6e), McGraw-Hill, 1999.
3. R. G. Gupta, *Audio and Video Systems- Principles, Maintenance and Troubleshooting*, (2e), McGraw Hill Education Limited, 2010.
4. R.R. Gulati, *Monochrome & Colour TV System*, (3e), New age International, 2009.
5. R. R. Gulati, *Modern Television – Practice, Principles, Technology & Servicing*, (3e), New age International, 2007.
6. A.M. Dhake, *T.V. and Video Engineering*, (2e), McGraw Hill Education Ltd, 2000.

EC3085 Optical Fibre Technology [3 0 0 3]

Optical fibre, Types of fibres, Step index and graded index fibres, Characteristics of optical fibre, Input, output couplers. Optical fibres and cables: Fabrication of optical fibre, Fibre drawing, Vapour phase deposition techniques, Cable design Optical fibre connection: joints and couplers Fibre splices, fusion splices, mechanical splices, Fibre connectors, expanded beam connectors, Fibre couplers,Source to fibre and fibre to fibre coupling, Coupling losses. Transmission characteristics of optical fibres: Attenuation, absorption losses, linear scattering losses, nonlinear scattering losses, Stimulated Raman and stimulated Brillouin scattering, Fibre bend losses. Dispersion: Phase and group velocities, Material dispersion, intramodal dispersion and wave guide dispersion, Overall fibre dispersion. Dispersion modified fibres; Optical Fibre sensors: Intensity modulation sensors, Phase modulation sensors, Temperature, pressure, chemical and rotation sensors, Fibre optic gyroscopes, Evanescent wave sensors.

References

1. Ajoy Ghatak and K. Thyagarajan, *Introduction to fiber optics*, (1e), Cambridge UnivPress, 1998.
2. John M Senior, *Optical Fiber communication,* (3e), Pearson, 2009.
3. Clifford R. Pollock and Iswing, *Fundamentals of Opto electronics,* (1e), Richard d Irwin, 1994.
4. J. Palais, *Fiber optic communication,* (1e), PHI, 1998.
5. B.P.Pal, *Fundamentals of fibre optics in communication,* (1e), Wiley Eastern, 1995.

EC3086 Solar Photovoltaic Technology [3 0 0 3]

Photovoltaic Basics: Structure and working of Solar Cells - Types, Electrical properties and Behavior of Solar Cells - Cell properties and design - PV Cell Interconnection and Module Fabrication - PV Modules and arrays - Basics of Load Estimation. Stand Alone PV Systems: Schematics, Components, Batteries, Charge Conditioners - Balance of system components for DC and/or AC Applications - Typical applications for lighting, water pumping etc. Grid Connected PV Systems: Schematics, Components, Charge Conditioners, Interface Components - Balance of system Components - PV System in Buildings. Hybrid Systems: Solar, Biomass, Wind, Diesel Hybrid systems - Comparison and selection criteria for a given application. Design of PV Systems: Radiation and load data - Design of System Components for different PV Applications - Sizing and Reliability - Simple Case Studies.

References:

1. C. S. Solanki, *Solar Photovotaics – Fundamentals, Technologies and Applications*, (2e), PHI Learning Pvt. Ltd., 2011.
2. A. L. Fahrenbruch and R. H. Bube, *Fundamentals of Solar Cells*, (1e), Academic Press, New York, Elsevier, 1983.
3. M. A. Green, *Solar Cells Operating Principles, Technology and System Applications*, (1e), Prentice-Hall, 1981.
4. J. Nelson, *The Physics of Solar Cells,* (1e), Imperial College Press, 2003.
5. M. Thomas, *Solar Electricity*, (2e), John Wiley and Sons, 2000.

6. S. R. Wenham, Martin A. Green, Muriel E. Watt, Richard Corkish (Editors), *Applied Photovoltaics,* (2e), Routledge, 2006.
7. M. Boxwell, *The Solar Electricity Handbook*, Code Green Publishing, UK, 2018.
8. R. DeGunther, *Solar Power Your Home for Dummies*, (1e), Wiley Publishing Inc, 2008.
9. *Photovoltaics: Design and Installation Manual,* (1e),New Society Publishers, 2004.

EC3087 Hybrid Soft Computing Techniques [3 0 0 3]

Neural Network: History, structure and function of single neuron, neural net architectures, neural learning, use of neural networks, supervised learning networks, Associative memory networks, unsupervised learning networks, Special networks like Simulated Annealing Network, Cascade Correlation network, and Optical neural network. Applications of Neural Network. Engineering optimization: Introduction to optimization, Genetic algorithms, Simulated Annealing, Particle swarm optimization, Ant colony optimization, Fuzzy based optimization techniques, Neural network based optimization techniques.

References:

1. S. S. Rao, *Engineering optimization theory and practice*, (4e), John Wiley & Sons, 2009.
2. S.N. Deepa, S.N. Sivanandam, *Principles of Soft Computing*, (2e), Wiley, 2011.
3. S.N. Sivanandam, S. Sumathi, S. N. Deepa, *Introduction to Fuzzy Logic using MATLAB, (1e),* Springer-Verlag Berlin Heidelberg, 2007.
4. S. Rajasekaran, G. A. Vijayalakshmi Pai, *Neural Networks, Fuzzy Logic, and Genetic Algorithms : Synthesis and Applications, (1e),* PHI, 2013.
5. Samir Roy, Udit Chakraborty, *Soft Computing: Neuro-Fuzzy and Genetic Algorithms,* (1e), Pearson, 2013.
6. Kalyanmoy Deb, *Optimization for Engineering Design: Algorithms and Examples*, (2e), PHI, 2013.
7. Dr. Shailendra Jain, *Modeling and Simulation using MATLAB – Simulink, (2e),* Wiley, 2015.
8. Rajjan Shinghal, *Introduction to Fuzzy Logic, (1e),* PHI, 2013.

PROGRAM ELECTIVES-MINOR SPECIALIZATION

MINOR SPECIALIZATION-COMMUNICATION NETWORKS & SYSTEMS

EC3240 Wireless Communication & Networks [3 0 0 3]

Introduction to wireless channels and wireless networks, wireless channel as a random linear time varying system, Wireless channel modeling, Advantages and disadvantages of Wireless Networks, WLAN Topologies, WLAN Standard IEEE 802.11 and IEEE 802.11 a, b, g and n standards. Outdoor Propagation Models- Longley Ryce Model, Okumura Model, Hata Model, PCS Extension to Hata Model, Walfisch and Bertoni Model, Wideband PCS Microcell Model, Indoor Propagation Models-Partition losses (Same Floor), Partition losses between Floors, Log-distance path loss model, Ericsson Multiple Breakpoint Model. Fading and diversity techniques, Diversity improvement, Maximal Ratio Combining, Practical Space Diversity, Selection Diversity, Scanning Diversity, Equal Gain Combining, Polarization Diversity, Frequency Diversity, Time Diversity, RAKE Receiver. Wireless channel capacity, ergodic capacity and outage capacity. Introduction to MIMO systems

References:

1. Upena Dalal, *Wireless Communication, (1e),* Oxford University Press, 2009.
2. T. S. Rappaport, *Wireless Communication: Principles and Practice, (2e),* Pearson, 2010.
3. Andreas.F. Molisch, *Wireless Communications, (2e),* John Wiley – India, 2013.
4. William Stallings, *Wireless Communications & Networks,* (2e), Pearson, 2005.

EC3241 Radar & Satellite Communication [3 0 0 3]

Introduction to Radar: Introduction, block diagram, applications, radar frequencies, different types of radar, basic pulsed radar system, radar equation, system losses. Radar Antennas: Introduction, parameters of radar antennas, different types of radar antennas, Radomes. Radar Transmitter: Introduction, radar RF source. Radar Receiver: Introduction, radar receiver noise, and Duplexers: Introduction types, used in modern radar, Radar Display Units: Introduction, types of scope. Navigation: Introduction, history, methods of navigation. Satellite Communications: The Origin of satellite communications, brief history of satellite communications, advantages and disadvantages, current status of satellite communication, active and passive satellites. Satellite Subsystems: Introduction, satellite subsystems, altitude and orbit control system, telemetry, tracking and command, communication subsystem, communication subsystem components. Earth Station Technology: Introduction, earth station design requirements, earth station antenna design, earth station sub-system, tracking monitoring and control. Satellite Applications: Introduction, satellite for earth observation, satellite for weather forecast, satellite for scientific studies, and satellite for military applications, direct broadcast satellite system, very small aperture terminal, global positioning system.

References:

1. M. I. Skolnik, Introduction to Radar Systems, (3e), McGraw Hill, 2003.
2. T. Pratt, C. W. Bostian, J. E. Allnutt, Satellite communication system, (2e), John Wiley and Sons (2002).
3. P. Z. Peebles Jr., Radar Principles, (1e), John Wiley, 1998.
4. E. Byron, Radar: Principles, Technology, Applications, (1e), Prentice- Hall education, 1992.
5. D. Barton, Radar system analyses and Modeling, (2e), Artech house, 2005.
6. M. Antonio, Bistatic radar emerging technology, (1e), John Wiley, 2008.
7. D. Roddy, Satellite communications, (4e), McGraw-Hill international edition, 2017.

EC4140 Mobile Communication & Networks [3 0 0 3]

Evolution and Fundamentals, Examples of Wireless Communication Systems, Cellular network systems, Trends in Cellular Radio and Personal Communication Systems; Cellular Concepts: Frequency for Radio Transmission, Frequency Reuse, Channel Assignment Strategies. Handoff Strategies, Interference and System Capacity, Cell Splitting, Sectoring. Medium Access Control, Hidden, Exposed and Capture nodes, Far and Near Problem, Protocol for MAC; Mobile Radio Propagation: Large Scale Path Loss, Free Space Propagation Model, Ground Reflection Model, Diffraction, Scattering, Practical Link Budget Design using Path Loss Models. Multipath Measurements, Parameters of Multipath Measurements. Modulation Techniques used for Mobile Radio, System Architecture, Radio Subsystem Wireless Systems and Standards; Channel Types, Frame Structure, Signal Processing in GSM and CDMA; Digital Cellular Standards, Emerging technologies including 4G and 5G, and infrastructure less networks, Future advancement in Mobile Network.

References:

1. T. S. Rappaport, *Wireless Communications Principles and Practice*, (2e), Pearson Education, Asia, 2002.
2. K. Feher, *Wireless Digital Communications, Modulation and Spread Spectrum Applications*, (1e), Eastern Economy Edition, 1995.
3. W. C. Y. Lee, *Mobile Cellular Telecommunications*, (2e), McGraw Hill International, NY, 1995.
4. J. H. Schiller, *Mobile Communication, (2e),* Harlow: Addison-Wesley, 2003.

EC4141 Modern Antenna Technology [3 0 0 3]

Antenna Terminology: Basic antenna parameters, patterns, isotropic antenna, Gain, Directivity, lobes, polarizations, Field regions. Reflector antenna- Introduction, plane Reflector, corner, parabolic, spherical reflector. Microstrip antennas: Microstrip radiators, various microstrip antenna configurations, Analytical models for microstrip antennas, Transmission line model, Cavity Model, Full wave analysis of microstrip antennas. Modern antennas: Frequency Independent antenna, Reconfigurable antenna, Active antenna, Dielectric antennas, Electronic band gap structure and applications. Smart Antennas –

Introduction, smart antenna analogy, smart antenna benefits & drawbacks, antenna beamforming. Antenna Measurements: Introduction, Antenna ranges, Radiation pattern, Return loss, Gain /Directivity measurements, Polarization measurements.

References:

1. C. A. Balanis, *Antenna Theory*, (3e), John Wiley & Sons, Inc, U.K. 2005.
2. J. D. Kraus, *Antennas*, (1e), McGraw-Hill, New York, 1988.
3. R. E Collin, *The Receiving Antennas*, (1e), McGraw-Hill, 1969.
4. C. Fernandes, R. K. Jha, C. Salema, *Solid Dielectric Horn Antennas*, (1e), Artech House, 1998.
5. S. Drabowitch, *Modern Antennas,* (2e), Springer Publications, 2007.

MINOR SPECIALIZATION-VLSI DESIGN

EC3242 VLSI Testing & Testability [3 0 0 3]

Physical Faults and their modeling: Stuck at Faults, Bridging Faults; Fault collapsing; Fault Simulation: Deductive, Parallel and Concurrent Fault Simulation. Critical Path Tracing. ATPG for Combinational Circuits: D-Algorithm, Random, Deterministic and Weighted Random Test Pattern Generation; Aliasing and its effect on Fault Coverage.; Controllability and Observability Scan Design, Boundary Scan for Board Level Testing; Memory Testing: Permanent, Intermittent and Pattern Sensitive Faults, Marching Tests;. PLA Testing: Cross Point Fault Model and Test Generation. Compression Techniques: General Aspects of Compression Techniques; Ones-Count, Transition Count and Parity Check Compression; Syndrome Testing; Signature Analysis; Built-In-Self-Test (BIST) Concept: Test-Pattern generation for BIST; Specific BIST Architecture; Introduction to Built-In-Self-Repair (BISR) Approaches.

References:

1. M. Abramovici, M. A. Breuer, & A.D. Friedman, *Digital Systems Testing and Testable Design, (1e),* Piscataway, New Jersey: IEEE Press, 1994.
2. M. L. Bushnell and V. D. Agrawal, *Essentials of testing for digital, memory and mixed-signal VLSI circuits*, *(1e),* Boston: Kluwer Academic Publishers, 2000.

EC3251 VLSI DESIGN WITH VERILOG HDL [2 1 0 3]

Introduction to Verilog HDL, Hardware Simulation & Synthesis, Verilog Attributes: Switch level, Gate level. Pin to Pin Delay, Dataflow, Top-Down design with Verilog, Subprograms, Operators, Syntax and constraints. Characterization of HDL: Timing, concurrency, data types, nets, Verilog primitives. Modeling oof Test Bench. Combinational and Sequential Design. Usage of subprograms, parametrization and specifications, path delay specification. Utilities for high level Description. Dataflow description, Behavioral Description of Hardware, Modeling for Hardware Design. Interface design & Modeling.

Reference Books:

1. Kenneth S Kundert, Olaf Zinke, *Designers Guide to Verilog AMS*, Springer, 2004
2. Samir palnitkar, *Verilog HDL,* Pearson education, Second Edition, 2003.
3. J. Bhasker, *A Verilog HDL Primer,* Second Edition, Star Galaxy, 2005.

EC4143 VLSI CAD [3 0 0 3]

Introduction to CAD tools: Evolution of Design Automation, Basic Transistor Fundamentals, CMOS realizations of basic gates, Modeling techniques, Types of CAD tools and Introduction to logic simulation. Simulation and Logic Synthesis: Simulation, Gate-level modeling and simulation, Switch-level modeling and simulation, Combinational Logic Synthesis, Binary Decision Diagrams, Two Level

Logic Synthesis. Logic synthesis: two-level and multilevel gate-level optimization tools, state assignment of finite state machines, Estimating delays in a circuit, issues in Dynamic and Static Timing Analysis. Basic concepts of high-level synthesis: partitioning, scheduling, allocation and binding, Memory modeling Synthesizable and non- synthesizable constructs, Logic Optimization, Optimizing logic using resource sharing, Introduction to Logical Effort, Multistage Logic Networks, Logical Effort and Gain Based Synthesis, Logical Effort Optimizing performance.

References:

1. Samir Palnitkar, *Verilog HDL*, (2e), Pearson, 2004.
2. S.Imam, M. Pedram, *Logic Synthesis for Low Power VLSI Designs*, (1e), Kluwer, 1997.
3. M.Smith, Application *Specific ICs*, (1e), Pearson, 1997.
4. S.Palnitkar, Verilog HDL, *A Guide to Digital Design and Synthesis*, (2e), Prentice Hall PTR, 2003.
5. S.Brown S., Z.Vranesic, *Fundamentals of Digital Logic with Verilog Design*, (2e), TMH, 2007.
6. Rabaey, J. M., Chandrakasan, A. P., & Nikolic, B., *Digital integrated circuits* (2e), Englewood Cliffs, Prentice hall, 2002.

EC4161 SYSTEM VERILOG FOR DESIGN & VERIFICATION [2 1 0 3]

Introduction to System Verilog, System Verilog declaration Spaces, System Verilog Literal Values and Built in Data types: assignments, variables, models. System Verilog user defined data types and enumerated types, Arrays, Structures and Unions. Procedural Blocks, Tasks and Functions. System Verilog Procedural Statements. Modeling FSMs with System Verilog.

Reference Books:

1. Christian B. Spear, SystemVerilog for Verification: A Guide to Learning the Testbench Language Features, Springer 2012
2. Mark Glasser, Harry Foster, Tom Fitzpatrick, Adam Rose, Dave Rich ,Open Verification Methodology Handbook: Creating Testbenches in SystemVerilog and SystemC, Morgan Kaufmann, 2009
3. Faisal Haque, Jonathan Michelson, Khizar Khan ,The Art of Verification with SystemVerilog Assertions, , Verification Central, 2006.

PROCTORED OPEN ELECTIVES-SWAYAM PLATFORM

EC0001 DIGITAL CIRCUITS [3 0 0 3]

Number System: Introduction to number system**,** Number conversion, Boolean Algebra. **Combinational Logic Design:** Combinational circuit analysis, Combinational function minimization – K Map, Boolean identities, Logic Gates, **Arithmetic circuits:** Code converters, Multiplexers, Decoders, PLA. **Sequential Circuits** – Latches and Flip-flops, Counters, Shift Registers, **Finite State Machines**; Mealy and Moore machine. **Data Converters** – Sample and hold circuits, ADCs, DACs, **Semiconductor Memories** – ROM, SRAM, DRAM.

Introduction to Microprocessor 8085, instruction set.

Recommended Books:

[1]. M. Morris Mano, Michael D. Ciletti, “Digital Design”, Pearson, 2013.
[2]. A. K. Maini, “Digital Electronics: Principles, Devices And Applications, Wiley, 2007.
[3]. R. Gaonkar, “Microprocessor Architecture, Programming and Applications with the 8085”, Prentice Hall, 2014.

EC0002 INFORMATION THEORY [3 0 0 3]

Introduction to entropy as a measure of uncertainty and randomness. **Binary hypothesis testing:** bayes optimal binary hypothesis testing and total variation distance, Neyman-Pearson formulation, Stein's lemma, and KL divergence. **Measures of information and their properties:** Chain rule and additivity, concavity, and variational formulae. Data processing inequality, Pinsker's inequality, and Fano's inequality. **Data compression:** _xed and variable length source coding theorems and entropy. Huffman code, Shannon-Fano-Elias code, arithmetic code, hash tables. Universal compression. **Channel coding:** Channel capacity theorem, sphere packing bound, maximal code construction. Random coding and ML decoding

LDPC and Polar codes. Quantization. Minmax lower bounds in statistics

Recommended Books:

[1]. T. Cover and J. Thomas, Elements of Information Theory, Second edition, Wiley, 2006.
[2]. I. Csiszar and J. Korner, Information Theory: Coding Theorems for Discrete Memoryless Systems, Second edition, Cambridge, 2011.
[3]. J. Wolfowitz, Coding Theorems of Information Theory, Probability Theory and Stochastic Processes series, Springer, 1978.
[4]. A. Khinchin, Mathematical foundations of information theory, Dover, 2001 edition.
[5]. A. Feinstein, Foundations of Information Theory, McGraw-Hill, 1958.
[6]. T. S. Han, Information spectrum methods in Information Theory, fifth edition, Springer, 2003.

EC0003 INTRODUCTION TO WIRELESS AND CELLULAR COMMUNICATIONS [3 0 0 3]

Overview of Cellular Systems and evolution 2g/3G/4G/5G. **Cellular Concepts** – Frequency reuse, Cochannel and Adjacent channel Interference, C/I, Handoff, Blocking, Erlang Capacity. **Wireless propagation Part 1** - Link budget, Free-space path loss, Noise figure of receiver. **Wireless propagation Part II** - Multipath fading, Shadowing, Fading margin, Shadowing margin. Antenna Diversity, Wireless Channel Capacity, MIMO, CDMA, OFDM, LTE, Large Scale Propagation effects and Channel Models.

Recommended Books:

[1]. T. S. Rappaport, “Wireless Communications – Principles and Practice” (2nd edition) Pearson, 2010, ISBN 9788131731864
[2]. A. Molisch, "Wireless Communications," Wiley, 2005Haykin & Moher, "Modern Wireless Communications" Pearson 2011 (Indian Edition)
[3]. J. G. Proakis, "Digital Communications," McGraw Hill
[4]. A. Goldsmith, "Wireless Communications," Cambridge Univ Press, 2005
[5]. D. Tse and P. Viswanath, "Fundamentals of Wireless Communications," Cambridge Univ Press, 2005

EC0004 SEMICONDUCTOR DEVICES AND CIRCUITS [3 0 0 3]

Introduction, Important components of transmission system,Insulation coordination, Design and selection of insulators for transmission/distribution ,Basics of Semiconductors: Concept of Mobility and Carrier concentration Basics of Semiconductors: Continuity Equation Metal-Semiconductor Junctions p-n JunctionsIntroduction to Transistors - BJTs, JFETs and MESFETs, Introduction to MOSFETs, MOSFET Details: Scaling, Threshold Voltage, Leakage, Other ParasiticMOSFETs: Parameter

Extraction via ExperimentsCircuit Design with MOSFETs - Impact of Device Physics on CircuitsAdvanced Topics - Flexible Electronics.

EC0005 PEER TO PEER NETWORKS [3 0 0 3]

Cryptographic Hash, Public Key Cryptography Principles, Security Certificates, Structured and Unstructured P2P Networks, Inconsistent Hashing, Consistent Hashing, Rendezvous Hashing, Locality Preserving Hashing, Distributed Hash Tables. Logarithmic Partitioning of Node ID Space and Index Entry Authenticity, Implementation of Voice Over Internet Telephony in P2P Way, Leaf node, Core node and Type of Messages in DHT Networks, Static and Dynamic Partitioning of Node ID Space: Fixed and floating partitioning. DHT Routing Protocol: Pastry and Kademlia. Tapestry Routing Protocol, Multi-dimensional Distributed Hash Table, and Multi-Layer DHT. Keeping <Key, Value> Pairs at Correct Root Nodes, Abrupt and Graceful Exit of Root Node, Resilience of <Key, Value> Pairs, Distributed File System, Storage Space Problem and Incentives to Share Storage. P2P Nodes Communications Challenges in Heterogeneous Network Environments, P2P Overlaid Multicast, and A Design of P2P Email System. P2P Mailing List Services, P2P Web, P2P Search Engine, On Being Anonymous and P2P in Blockchain. P2P Anonymous Communication, The Anonymous Communication on the Internet through TOR Network, An Introduction to TOR Browser, Hidden Services on TOR Network.

PROCTORED OPEN ELECTIVES-COURSERA PLATFORM

EC0051 Hardware Description languages for FPGA Design [3 0 0 3]

Basics of VHDL: This module introduces the basics of the VHDL language for logic design. It describes the use of VHDL as a design entry method for logic design in FPGAs and ASICs. To provide context, it shows where VHDL is used in the FPGA design flow. Then a simple example, a 4-bit comparator, is used as a first phrase in the language. VHDL rules and syntax are explained, along with statements, identifiers and keywords. Finally, use of simulation as a means of testing VHDL circuit designs is demonstrated using ModelSim, a simulator software tool. Programming assignments are used to develop skills and reinforce the concepts presented. **VHDL Logic Design Techniques:** In this module use of the VHDL language to perform logic design is explored further. Many examples of combinatorial and synchronous logic circuits are presented and explained, including flip-flops, counters, registers, memories, tri-state buffers and finite state machines. Methods of hierarchical design and modular design techniques are explained and demonstrated. How to create test benches is described as a means for design verification. Students are giving ample opportunity to practice and refined their design technique using the programming assignments. **Basics of Verilog:** This module introduces the basics of the Verilog language for logic design. It describes the use of Verilog as a design entry method for logic design in FPGAs and ASICs, including the history of Verilog's development. Then a simple example, a 4-bit comparator, is used as a first phrase in the language. Verilog rules and syntax are explained, along with statements, operators and keywords. Finally, use of simulation as a means of testing Verilog circuit designs is demonstrated using ModelSim, a simulator tool. Programming assignments are used to develop skills and reinforce the concepts presented. **Verilog and System Verilog Design Techniques:** In this module use of the Verilog language to perform logic design is explored further. Many examples of combinatorial and synchronous logic circuits are presented and explained, including flip-flops, counters, registers, memories, tri-state buffers and finite state machines. Methods of hierarchical design and modular design techniques are explained and demonstrated. How to create test benches is described as a means for design verification. Students are giving ample opportunity to practice and refined their design technique by writing code as required by the programming assignments.

EC0052 Introduction to FPGA Design for Embedded Systems [3 0 0 3]

Introduction to Programmable Logic Devices - History and Architecture: The history and architecture of programmable logic devices including Field Programmable Gate Arrays (FPGAs), difference between an FPGA, a CPLD, an ASSP, and an ASIC, the historical development of programmable logic devices; and design logic circuits using LUTs. Case study: designs of digital adders and multipliers in FPGAs. **FPGA Design Tool Flow; An Example Design:** FPGA design flow, how to use Intel Altera's Quartus Prime Development Suite to create a pipelined multiplier, and how to verify the integrity of the design using the RTL Viewer and by simulation using ModelSim. Using the TimeQuest timing analyzer, you will analyze the timing of your design to achieve timing closure. **FPGA Architectures: SRAM, FLASH, and Anti-fuse:** The pros and cons of FLASH-based, SRAM-based, and Anti-Fuse based FPGAs. A survey of modern FPGA architectures will give you the tools to determine which type of FPGA is the best fit for a design. Architectures will be explored from the basic core logic cell up to consideration of large Intellectual Property (IP) blocks that are available on many FPGAs. **Programmable logic design using schematic entry design tools:** Completing the design by adding IP blocks, implementing pin assignments and creating a programming file for the FPGA. One outcome will be improved design productivity, by use of design techniques like pipelining, and by the use of system design tools like Qsys, the system design tool in Quartus Prime. You will complete a Qsys system design by creating a NIOS II softcore processor design, which quickly gives you the powerful ability to customize a processor to meet your specific needs.

EC0053 Introduction to Programming with MATLAB [3 0 0 3]

MATLAB environment, Matrices and operators, functions, Programmer's toolbox, selection, Loops, Datatypes, File input/output.