North Eastern Regional Institute of Science and Technology
(Deemed University)
Nirjuli, Itanagar-791109, Arunachal Pradesh

Department of Electronics and Communication Engineering

Ph. D. Syllabus

Ph. D.in Electronics and Communication Engineering (PT/FT)

Course Code	Names of Subjects	L	T	P	C
EC 9049	ENGINEERING RESEARCH METHODOLOGY	4	0	0	4
EC 90XX	3 COURSES	3	0	0	3
				TOTAL	13

No.	Names of Subjects	L	T	P	C
EC 9001	TELECOMMUNICATION SWITCHING AND NETWORKS	3	0	0	3
EC 9002	MOBILE COMMUNICATION	3	0	0	3
EC 9003	RF INTEGRATED CIRCUITS	3	0	0	3
EC 9004	MICROWAVE DEVICES AND CIRCUITS	3	0	0	3
EC 9005	INFORMATION THEORY AND CODING TECHNIQUES	3	0	0	3
EC 9006	COMPUTER COMMUNICATION NETWORKS	3	0	0	3
EC 9007	OPTICAL COMMUNICATION	3	0	0	3
EC 9008	SATELLITE COMMUNICATION SYSTEM	3	0	0	3
EC 9009	RF COMPONENT AND CIRCUIT DESIGN	3	0	0	3
EC 9010	RADAR SIGNAL PROCESSING	3	0	0	3
EC 9011	ANTENNAS AND PROPAGATION FOR WIRELESS COMMUNICATION	3	0	0	3
EC 9012	ADVANCED NETWORKS TECHNOLOGIES	3	0	0	3
EC 9013	ERROR CONTROL TECHNIQUE	3	0	0	3
EC 9014	ELECTROMAGNETIC INTERFERENCE AND COMPATIBILITY	3	0	0	3
EC 9015	CHANNEL MODELLING FOR WIRELESS COMMUNICATION	3	0	0	3
EC 9016	HIGH SPEED COMMUNICATION TECHNIQUES	3	0	0	3
EC 9017	SIGNAL PROCESSING FOR COMMUNICATION	3	0	0	3
EC 9018	ADVANCED DIGITAL SIGNAL PROCESSING	3	0	0	3
EC 9019	VLSI TECHNOLOGY	3	0	0	3
EC 9020	CMOS ANALOG IC DESIGN	3	0	0	3
EC 9021	LOW POWER VLSI DESIGN	3	0	0	3
EC 9022	DIGITAL IC DESIGN	3	0	0	3
EC 9023	CAD FOR VLSI	3	0	0	3
EC 9024	DIGITAL AUDIO AND VIDEO COMMUNICATION	3	0	0	3
EC 9025	DESIGN OF SEMICONDUCTOR MEMORIES	3	0	0	3
EC 9026	MEMS AND MICROSYSTEMS TECHNOLOGY	3	0	0	3
EC 9027	ADVANCED COMPUTER ARCHITECTURE	3	0	0	3
EC 9028	ANALOG FILTER DESIGN	3	0	0	3
EC 9029	VLSI SIGNAL PROCESSING	3	0	0	3
EC 9030	VLSI DATA CONVERSION CIRCUIT	3	0	0	3
EC 9031	TESTING AND VERIFICATION OF VLSI CIRCUITS	3	0	0	3
EC 9032	DIGITAL SYSTEM DESIGN USING FPGA	3	0	0	3
EC 9033	PHOTONICS INTEGRATED CIRCUITS	3	0	0	3
EC 9034	NANOELECTRONICS	3	0	0	3
EC 9035	NEURAL NETWORKS, ARCHITECTURE AND ITS APPLICATIONS	3	0	0	3
EC 9036	ADAPTIVE SIGNAL PROCESSING	3	0	0	3
EC 9037	SOFT COMPUTING	3	0	0	3

EC 9038	STATISTICAL SIGNAL PROCESSING AND MODELLING	3	0	0	3
EC 9039	DIGITAL IMAGE PROCESSING	3	0	0	3
EC 9040	SPEECH PROCESSING	3	0	0	3
EC 9041	MODERN CONTROL ENGG	3	0	0	3
EC 9042	BIOMEDICAL SIGNAL PROCESSING	3	0	0	3
EC 9043	EMBEDDED SYSTEM DESIGN	3	0	0	3
EC 9044	BIO-SENSORS AND BIO MEMS	3	0	0	3
EC 9045	MODERN DIGITAL COMMUNICATION TECHNIQUES	3	0	0	3
EC 9046	SEMICONDUCTOR DEVICE MODELLING	3	0	0	3
EC 9047	WIRELESS COMMUNICATION	3	0	0	3
EC 9048	CMOS MIXED SIGNAL CIRCUITS	3	0	0	3
EC 9049	ENGINEERING RESEARCH METHODOLOGY	4	0	0	4

EC 9001	**TELECOMMUNICATION SWITCHING AND NETWORKS**	**3-0-0**	**3**
Unit I	Multiplexing: Transmission Systems, FDM Multiplexing and modulation, Time Division Multiplexing, Digital Transmission and Multiplexing: Pulse Transmission, Line Coding, Binary N – Zero Substitution, Digital Biphase, Differential Encoding, Time Division Multiplexing, Time Division Multiplex Loops and Rings	6	Hrs
Unit II	SONET/SDH: SONET Multiplexing Overview, SONET Frame Formats SONET Operations, Administration and Maintenance, Payload Framing and Frequency Justification, Virtual Tributaries, DS3 Payload Mapping, E4 Payload Mapping, SONET Optical Standards, SONET Networks. SONET Rings: Unidirectional Path-Switching Ring, Bidirectional Line-Switched Ring	8	Hrs
Unit III	Digital Switching: Switching Functions, Space Division Switching, Time Division Switching, two-dimensional switching: STS Switching, TST Switching, No.4 ESS Toll Switch, Digital Gross-Connect Systems, and Digital Switching in an Analog Environment. Elements of SSNO7 Signaling	10	Hrs
Unit IV	Network Synchronization Control and Management Timing: Timing Recovery: Phase-Locked Loop, Clock Instability, Jitter Measurements, Systematic Jitter. Timing Inaccuracies: Slips, Asynchronous Multiplexing, Network Synchronization, U.S. Network Synchronization, Network Control, Network Management	8	Hrs
Unit V	Digital Subscriber Access and traffic analysis, ISDN: ISDN Basic Rate Access Architecture, ISDN U Interface, ISDN D Channel Protocol. High-Data-Rate Digital Subscriber Loops: Asymmetric Digital Subscriber Line, VDSL. Digital Loop Carrier Systems: Universal Digital Loop Carrier Systems, Integrated Digital Loop Carrier Systems, Next-Generation Digital Loop Carrier, Fiber in the Loop, Hybrid Fiber Coax Systems, and Voice band Modems: PCM Modems, Local microwave Distribution Service, Digital Satellite Services. Traffic Characterization: Arrival Distributions, Holding Time Distributions, Loss Systems, And Network Blocking Probabilities: End-to-End Blocking Probabilities, Overflow Traffic, And Delay Systems: Exponential Service Times, Constant Service Times, Finite Queues.	10	Hrs

Text/References:

1. Bellamy John, “Digital Telephony”, John Wily & Sons, Inc. 3rd ed. 2000
2. Viswanathan. T., “Telecommunication Switching System and Networks”, PHI 1994
3. Robert G. Winch, “Telecommunication transmission systems”, 2nd ed. TMH 2004
4. Marion Cole, “Intro. to Telecommunications” 2nd ed. Pearson education 2008.
5. Tom Sheldon, “Encyclopedia of Networking and telecom.” TMH seventh reprint 2006

EC 9002	**MOBILE COMMUNICATION**	**3-0-0**	**3**
Unit I	Introduction to Cellular Mobile Systems: A basic cellular system, performance criteria, uniqueness of mobile radio environment, operation of cellular systems, planning a cellular system, overview of generations of cellular systems. Elements of Cellular Radio Systems Design and interference: General description of the problem, concept of frequency reuse channels, co-channel interference reduction factor, desired C/I from a normal case in an omni directional antenna system, cell	10	Hrs

	splitting, consideration of the components of cellular systems. Introduction to co-channel interference, co-channel measurement design of antenna system, antenna parameter and their effects		
Unit II	Cell Coverage for Signal & antenna structures: General introduction, obtaining the mobile point to point mode, propagation over water or flat open area, foliage loss, propagation near in distance, long distance propagation, point to point prediction model- characteristics, cell site, antenna heights and signal coverage cells, mobile to mobile propagation. Characteristics of basic antenna structures, antenna at cell site, mobile antennas. Frequency Management & Channel Assignment, Hand Off & Dropped Calls: Frequency management, fixed channel assignment, non-fixed channel assignment, traffic & channel assignment. Why hand off, types of handoff and their characteristics, dropped call rates & their evaluation.	10	Hrs
Unit III	Modulation methods and coding for error detection and correction: Introduction to Digital modulation techniques, modulation methods in cellular wireless systems, OFDM. Block coding, convolution coding and Turbo coding. Multiple access techniques: FDMA, TDMA, CDMA; Time-division multiple access (TDMA), code division multiple access (CDMA), CDMA capacity, probability of bit error considerations, CDMA compared with TDMA	12	Hrs
Unit IV	Second generation, digital, wireless systems, GSM, IS_136 (D-AMPS), IS-95, mobile management, voice signal processing and coding.	10	Hrs

Text/References:

1. Mobile Cellular Telecommunications; 2nd ed.; William, C Y Lee McGraw Hill
2. Mobile wireless communications; Mischa Schwartz, Cambridge University press, UK, 2005
3. Mobile Communication Hand Book; 2nd Ed.; IEEE Press
4. Wireless communication principles and practice, 2nd Ed, Theodore S rappaport, Pearson Education.
5. 3G wireless Demystified; Lawrence Harte, Mc. Graw Hill pub.

EC 9003	RF INTEGRATED CIRCUITS	3-0-0	3
Unit I	RF Filter design: Basic resonator and filter configurations-special filter realization-filter implementation-coupled filter	10	Hrs
Unit II	Active RF Components: RF diodes-bipolar junction transistor –RF field effect transistor-high electron mobility transistors-diode models-transistor models-measurement of active devices-scattering parameter device characterization.	8	Hrs
Unit III	Matching and biasing networks: Impedance matching using discrete components-micro strip line matching networks-amplifier classes of operation and biasing networks	14	Hrs
Unit IV	RF Transistor amplifier design: Characteristics of amplifier-amplifier power relations-stability consideration-constant gain-broadband, high power, and multistage amplifiers, Oscillators and mixers: Basic oscillator model-high frequency oscillator configuration-basic characteristics of mixer	10	Hrs

Text/References:

1. Reinhold Ludwig, “RF circuit design, theory and applications” Pavel Bretchko, “Pearson Asia Education”, edition 2001
2. D.Pozar, “Microwave Engineering”, John Wiley & Sons, New York, 1998
3. Bahil and P. Bhartia, “Microwave Solid State Circuit Design, John Willey & Sons, New York,

EC 9004	**MICROWAVE DEVICES AND CIRCUITS**	**3-0-0**	**3**
Unit I	Microwave frequencies, Interactions between electrons and fields, Electromagnetic plane waves, Electric and magnetic wave equations, Poynting theorem, Uniform plane waves and reflection, Plane wave propagation in free space and lossless dielectric, Plane wave propagation in lossy media, Plane wave propagation in metallic film coating on plastic substrate	10	Hrs
Unit II	Transmission line equations and solutions, Reflection coefficient and transmission coefficient, Standing wave and standing wave ratio, Line impedance and admittance, Smith chart, Microwave waveguides and components, Rectangular waveguides, Microwave cavities, Directional couplers, Circulators and isolators, Microwave transistors and tunnel diodes, Microwave bipolar transistors, Heterojunction transistors, Microwave tunnel diodes, Microwave field effect transistors, Junction field effect transistors, Metal semiconductor field effect transistors	10	Hrs
Unit III	Transferred electron devices, Gunn – effect diodes – GaAs diode, Ridley-watkins-Hilsum (RWH) theory, Modes of operation, LSA diodes, InP diodes, Avalanche transit time devices, Read diode, IMPATT diode, TRAPATT diodes, BARITT diodes, Microwave linear beam tubes (O Type), Conventional vacuum triodes, , Tetrodes and pentodes, klystrons, Multicavity klystron amplifiers, Reflex klystrons, Helix traveling wave tubes (TWT), Coupled cavity traveling wave tubes, Microwave crossed filed tubes (M Type), Magnetron oscillators, Forward wave crossed field amplifier (FWCFA OR CFA)	12	Hrs
Unit IV	Strip lines, Microstrip lines, Parallel strip lines, Coplanar strip lines, Shielded strip lines, Monolithic microwave integrated circuits, Materials, Monolithic microwave integrated circuit growth, MOSFET fabrication.	10	Hrs

Text/References:

1. Samuel Y.Liao, “ Microwave Devices and Circuits” Third edition,PHI
2. SK Roy, M Mitra, “Microwave semiconductor devices”, PHI 2003
3. David M. Pozar, “Microwave Engineering” Wiley

EC 9005	**INFORMATION THEORY AND CODING TECHNIQUES**	**3-0-0**	**3**
Unit I	Definitions, Uniquely Decodable Codes, Instantaneous Codes, Krafts Inequality, McMillan's Inequality, Optimal Codes, Binary Huffman Codes, r-ary Huffman codes, Information and Entropy, Properties of Entropy Function, Entropy and Average Word-Length, Shannon-Fano Coding, Shannon's First Theorem, Information Channels, Binary Symmetric Channel, System Entropies, System Entropies for Binary Symmetric Channel, Extension of Shannon's First Theorem to Information Channels, Mutual Information, Mutual Information for the Binary Symmetric Channel, Hamming Distance, Shannon's Second (Fundamental) Theorem, Converse of Shannon's Theorems.	10	Hrs
Unit II	Review: Algebra, Krawtchouk Polynomials, Combinatorial Theory, Probability Theory. Linear Codes: Block Codes, Linear Codes, Hamming Codes, Majority Logic Coding, Weight Enumerators, The Lee Metric, Hadamard Codes, Golay Codes (Binary and Ternary), Reed Muller Codes, And Kerdock Codes.Bounds on Codes: Gilbert Bound, Upper Bound, Linear Programming Bounds, Hamming's Sphere –Packing Bound, Gilbert Varshamov Bound, Hadamard Matrices and Codes	10	Hrs
Unit III	Cyclic Codes: Generator Matrix, Check polynomial, Zeros of Cyclic Codes, BCH Codes, Reed-Solomon Codes, Quadratic Residue Codes, Generalized Reed-Muller Codes. Perfect Codes and Uniformly Packed Codes: Lloyd's Theorem, Characteristic Polynomial of a Code, Uniformly Packed Codes, Nonexistence Theorems	12	Hrs
Unit IV	Quaternary Codes, Binary Codes Derived from codes over Z4, Galois Rings over Z4, Cyclic Codes over Z4. Goppa Codes. Algebraic Curves, Divisors, Differentials on a Curve, Riemann – Roch Theorem, Codes from Algebraic Curves. Arithmetic Codes: AN Codes, Mandelbaum – Barrows Codes, Convolutional Codes	10	Hrs

Text/References:

1. G. A. Jones and J. M. Jones, "Information and Coding Theory", Springer, 2000.
2. J. H. van Lint, "Introduction to Coding Theory", Springer, 1999.
3. Cover Thomas, "Elements of Information Theory", and Wiley 2006.
4. R. W. Hamming, "Coding and Information Theory", Prentice Hall, 1986.
5. T. M. Cover and J. A. Thomas, "Elements of Information Theory", Wiley, 1991.
6. R. E. Blahut, "Principles and Practice of Information Theory," AWL, 1987.

EC 9006	COMPUTER COMMUNICATION NETWORKS	3-0-0	3
Unit I	Concept of CCN/DCN, characteristics of data – Users' sub-network, topological design etc. Accessing techniques, Data Modeling – M/M/1 analysis, Circuit switching, message switching,	10	Hrs
Unit II	Packet switching, and ATM cell switching, Protocols, ISO, OSI, Networking objectives, classification of networks – LAN, MAN, WAN, ISDN	8	Hrs
Unit III	Techniques and theories of CSMA/CD Bus, Token Ring, Token passing bus-throughput analysis, Modeling (Stalling Models, IEEE Model etc.)	14	Hrs
Unit IV	Introduction to wireless networks, GSM, TDMA & CDMA-design and analysis, PCS concepts, Network operation and maintenance, Network Delay analysis, Routing, Flow Control, Congestion Control	10	Hrs

Text/References:

1. Behrouz A. Forouzan, "TCP/IP Protocol Suit", TMH, 2000
2. Wayne Tomasi, "Introduction to Data communications and Networking", Pearson Ed. 2007
3. Tananbaum A. S., "Computer Networks", 3rd Ed., PHI, 1999
4. Black U, "Computer Networks-Protocols, Standards and Interfaces", PHI, 1996
5. Stallings W., "Data and Computer Communications", 6th Ed., PHI, 2002.
6. Stallings W., "SNMP, SNMPv2, SNMPv3, RMON 1 & 2", 3rd Ed., Addison Wesley, 1999
7. Laurra Chappell (Ed), "Introduction to Cisco Router Configuration", Techmedia

EC 9007	**OPTICAL COMMUNICATION**	**3-0-0**	**3**
Unit I	Introduction: concepts of information, general communication systems, evolution of optical fiber communication systems, advantages, disadvantage of optical fiber, communication systems. Wave propagation in dielectric waveguide: snell's law, internal reflection, dielectric slab wave guide, numerical aperture, propagation of model & rays. Step-index fibers, graded index fibers.	8	Hrs
Unit II	Attenuation in optics fibers: Fiber attenuation, connectors &splices, bending loses, Absorption, scattering, very low loss materials, plastic & polymer-clad-silica fibers. Wave propagation in fibers: wave propagation in step index & graded index fiber, fiber dispersion, single mode fibers, multimode fibers, dispersion shifted fiber, dispersion flattened fiber, polarization	10	Hrs
Unit III	Optical sources & detectors: principles of light emitting diodes (LED's) , design of LED's for optical fiber communications, semiconductor LASER for optical fiber communication system ,principles of semiconductor photodiode detectors, PIN photodiode, Avalanche photodiode detectors. Optical fiber communication system: telecommunication, local distribution series, computer networks local data transmission & telemetry, digital optical fiber communication system, first & second generation system, future system.	14	Hrs
Unit IV	Advanced multiplexing strategies: Optical TDM, subscriber multiplexing (SCM), WDM. Optical networking: data communication networks, network topologies, MAC protocols, Network Architecture- SONET/TDH, optical transport network, optical access network, optical premise network.	10	Hrs

Text/References:

1. Senior J., optical fiber communications, principles & practice, PHI.
2. Keiser G., optical fiber communications, McGraw-hill.
3. Gowar J., optical communication systems, PHI.
4. William B. Jones jr., Introduction to optical fiber communication systems, Holt, Rinehart and Winston, Inc

EC 9008	SATELLITE COMMUNICATION SYSTEM	3-0-0	3
Unit I	Introduction: Origin and brief history of satellite communications, an overview of satellite system engineering, satellite frequency bands for communication. Orbital theory:Orbital mechanics, locating the satellite in the orbit w.r.t. earth look angle determination. Azimuth & elevation calculations.	10	Hrs
Unit II	Spacecraft systems: Attitude and orbit control system, telemetry, tracking and command (TT&C), communications subsystems, transponders, spacecraft antennas. Satellite link design: Basic transmission theory, noise figure and noise temperature, C/N ratio, satellite down link design, satellite uplink design	10	Hrs
Unit III	Modulation, Multiplexing, Multiple access Techniques: Analog telephone transmission, Fm theory, FM Detector theory, analog TV transmission, S/N ratio Calculation for satellite TV linking, Digital transmission, base band and band pass transmission of digital data, BPSK, QPSK , FDM, TDM, Access techniques: FDMA, TDMA, CDMA	14	Hrs
Unit IV	Encoding & FEC for Digital satellite links: Channel capacity, error detection coding, linear block, binary cyclic codes, and convolution codes. Satellite Systems: Satellite Earth station Technology, satellite mobile communication, VSAT technology, Direct Broadcast by satellite (DBS)	8	Hrs

Text/References:

1. Timothy Pratt, Charles W. Bostian, “Satellite communication”, John Wiley &sons , Publication, 2003
2. J.J. Spilker, “Digital Communication by satellite, PHI Publication, 1997
3. J. Martin, “Communication satellite systems”, PHI publication, 2001

EC 9009	RF COMPONENT AND CIRCUIT DESIGN	3-0-0	3
Unit I	Transmission lines ,Broadband Mactching, Scattering Parameters, microwave transistors	10	Hrs
Unit II	Passive Components: Inductors, Inductor Model, Analytical model, Printed Inductors, Inductors on Si substrate and GaAs substrate. Thick film inductors,Thin film inductors, LTCC inductors. Wire Inductors. Capacitors, Monolithic capacitors, interdigital capacitors. Resistors, chip resistor ,MCM resistor, Monolithic resistors, Microwave Resonators and Narrowband Filters, Broadband Filters Microwave Amplifier Design: Two-Port Power Gains, Amplifier Stability Low Noise Amplifier Design,Broadband Amplifier Design	8	Hrs
Unit III	Microwave Amplifier Design: Two-Port Power Gains, Amplifier Stability Low Noise Amplifier Design,Broadband Amplifier Design	14	Hrs
Unit IV	Microwave Oscillators: One Port negative resistance oscillators, Two Port negative resistance oscillators, Oscillator configurations	10	Hrs

Text/References:

1. Lumped Elements for RF and Microwave Circuits " I. J. Bahl ,Artech House
2. Microwave Transistor Amplifier: Analysis and Design, Gonzalez G. Prentice Hall 1984.
3. Microwave Semiconductor Circuit Design, Davis W. Alan, Van NostrandReinhold, 1984.
4. Microwave Circuit Analysis and Amplifier Design, Samuel Y. Liao, Prentice Hall 1987.
5. High Frequency Amplifier, Ralph S. Carson, Wiley Interscience, 1982

EC 9010	**RADAR SIGNAL PROCESSING**	**3-0-0**	**3**
Unit I	Introduction: Classification of Radars based on functions, principles of operation etc., performance measures and interplay between Radar parameters, Target parameters and Environment parameters. Classical Detection and Estimation Theory, Binary Hypotheses Testing, Likelyhood Ratio Test, Neymon square,MAP, Maximum Likelihood Estimation of parameters, Cramer-Rao Bounds,Chemoof Bounds	10	Hrs
Unit II	Representation of Signals, K-L expansion, Equivalent Low-pass representation of Band pass signals and noise. Detection of Slowly Fluctuating point Targets in white noise and coloured noise. Swerling Target models. Optimum receivers. Correlator and Band pass M atohed Filter Receivers. PD – PF performance;Coherent and non-coherent Integration sub-optimum Reception. Radar Power –Aperture product.	10	Hrs
Unit III	Range and Doppler Resolution: Ambiguity function and its properties. Local and Global Accuracy. Signal Design. LFM. Polyphase coded signals Detection of a Doppler shifted slowly fluctuating point target return in a discrete scatterer environment. Dobly dispersive Fading Target and Clutter models-Scattering function description. Land clutter-pulse length limited and Beam width limited clutter. Sea clutter.	14	Hrs
Unit IV	Optimum / Sub optimum reception of Range Spread / Doppler Spread / Doubly spread targets in the presence of noise and clutter. Introduction to Adaptive Detection and CFAR Techniques.	8	Hrs

Text/References:

1. Di Franco. JV and Rubin, WL., “Radar Detection”, Artech House, 1980.
2. Gaspare Galati (Ed), “Advanced Radar Techniques and Systems”, Peter Perigrinus Ltd., 1993.
3. Ramon Nitzberg, “Radar Signal Processing and Adaptive Systems”, Artech House, 1999.
4. W Rihaczek, “Principles of High Resolution Radar”, Artech House,1996.

EC 9011	**ANTENNAS AND PROPAGATION FOR WIRELESS COMMUNICATION**	**3-0-0**	**3**
Unit I	Radiation fields of wire antennas: Concept of vector potential. Modification for time varying retarded case. Fields associated with Hertzian dipole. Radiation resistance of elementary dipole with linear current distribution. Radiation from half-wave dipole and quarter – wave monopole. Use of capacity hat and loading coil for short antennas	6	Hrs
Unit II	Antenna Fundamentals and Antenna Arrays: Definitions: Radiation intensity, Directives gain, Directivity, Power gain, Beam Width, Band Width, Gain and radiation resistance of current element. Half-wave dipole and folded dipole. Reciprocity principle, Effective length and Effective area. Relation between gain effective length and radiation resistance.	12	Hrs
Unit III	Loop Antennas: Radiation from small loop and its radiation resistance. Antenna Arrays: Expression for electric field from two and three element arrays. Uniform linear array. Method of pattern multiplication. Binomial array. Use of method of images for antennas above ground	8	Hrs
Unit IV	Traveling wave (wideband) antennas: Radiation from a traveling wave on a wire. Analysis and design of Rhombic antenna. Coupled Antennas: Self and mutual impedance of antennas. Two and Three element Yagi antennas, Log periodic antenna. Aperture and Lens Antennas: Radiation from an elemental area of a plane wave (Huygen's Source). Radiation from the open end of a coaxial line. Radiation from a rectangular aperture treated as an array of Huygen's sources. Relation between dipole and slot impedances. Method of feeding slot antennas. Thin slot in an infinite cylinder. Field on the axis of an e-plane sectoral horn. Radiation form circular aperture. Beam width and effective area. Reflector type of antennas (dish antennas). Dielectric lens and metal plane lens antennas. Lumeberg lens. Spherical waves and biconical Antenna	8	Hrs
Unit V	Propagation: Ground wave, space wave and sky wave propagation. Sky wave propagation: Structure of the ionosphere. Effective dielectric constant of ionized region. Mechanism of refraction. Refractive index. Critical frequency. Skip distance. Effect of earth's magnetic field. Energy loss in the ionosphere due to collisions. Maximum usable frequency. Fading and Diversity reception. Space wave propagation: Reflection from ground for vertically and horizontally polarized waves. Ground wave propagation: Attenuation characteristics for ground wave propagation. Calculation of field strength at a distance.	8	Hrs

Text/References:

1. E.C. Jordan and Balmain, "Electro Magnetic Waves and Radiating Systems", PHI, 1968, Reprint 2003
2. John D. Kraus and Ronalatory Markefka, "Antennas", Tata McGraw-Hill Book Company, 2002
3. R.E. Collins, "antennas and Radio Propagation", McGraw-Hill, 1987
4. Ballany, "Antenna Theory", John Wiley & Sons, Second Edition, 2003

EC 9012	**ADVANCED NETWORKS TECHNOLOGIES**	**3-0-0**	**3**
Unit I	Internetworking model, application & upper layers, physical & data link layers network layer & path determination, router basics: Types, configuration & operation	8	Hrs
Unit II	TCP/IP, IP Addressing, IP routing configuration, Multi protocol routing, IP Subnets, IP routing protocols: OSPF, RIP, BGP, IP forwarding, classless inter domain routing, traffic management with access lists.	10	Hrs
Unit III	Transport protocols: TCP, basic behavior, versions of TCP, UDP, and link layer technologies: ARP, RARP, Ethernet, HDLC, and LAP-B. Modems, CSU/DSU, B.35 and G.7.3 interfaces, ISDN, Fire walling, IPSEC basics, L2TP, New services over internet	14	Hrs
Unit IV	Introduction to WAN connection, configuration of X.25, configuration of frame-relay, new services over the Internet: VOIP, Fax over IP, VOATM, VOFR, RTP/RTCP, SIP, H.323. Virtual private network, IP-multicast, QOS architectures in the Internet, IntServ, DiffServ, Core Stateless fare Queing., Internet access technologies- security, directory enabled networking, network caching technologies	10	Hrs

Text/References:

1. W R Stevens, " TCP/IP Illustrated- Volume 1- The Protocols, Pearson Edition Asis Education,
2. Duglas Comer, "Internetworking withTCP/IP Volume 1 – Principles, protocols and architecture, Prentice Hall, 4th Edition 2000
3. Internetworking Technologies handbook, 2nd edition, 1999, Cisco Press
4. Introduction to CISCO router configuration; 1998, Cisco Press

EC 9013	**ERROR CONTROL TECHNIQUE**	**3-0-0**	**3**
Unit I	Basic Digital Communication, Signal Detection, Memoryless Channels, Hamming Codes, Overview of Information Theory (Random variables, Entropy, Conditional Entropy, Relative Entropy, Mutual Entropy, Channel Capacity, Channel Coding Theorem (without proof) and its implication). Groups (Definition and properties, Subgroups, Cyclic groups and order, Cosets, Lagrange's theorem, Isomorphism, Homomorphism), Linear Algebra (Vector Spaces, Independence, Basis, dimension, inner product, dual space, orthogonality), Rings (Definition, Polynomials, Quotient Rings, Ideals); Number Theory and Algebra (Divisibility, Euclidean Algorithm, Sugiyama Algorithm, Congruences, f function, Chinese Remainder Theorem, Fields over R and C, Galois Fields, Galois Field Arithmetic, Irreducible and Primitive Polynomials, Krawtchouk Polynomials).	8	Hrs
Unit II	Linear Block Codes (Generator Matrix, Parity Check Matrix, Dual Codes, Weight Distribution, Hamming Codes and their Dual, Erasure Decoding); Cyclic Codes (Cyclic Encoding, Syndrome Decoding, Binary CRC Codes); BCH, Reed Solomon Codes, Goppa Codes, Peterson's Algorithm, Belekamp – Massey Algorithm, Forney's Algorithm	10	Hrs
Unit III	Welch – Berlekamp Key Equation, Guruswami –Sudan Decoding Algorithm and Soft RS decoding, Hadamard Matrices and Codes, Reed Muller Codes, Quadratic Residue Codes, Golay Codes; Gilbert – Varshamov Bound, Plotkin Bound, Griesmer Bound, Linear Programming and Related Bounds, McEliece – Rodemich – Rumsey – Welch Bound; Bursty Channels, Interleavers and Concatenation; Soft Decision Decoding Algorithms;	14	Hrs
Unit IV	Convolutional Codes, Viterbi Algorithm, Error Analysis, Puncturing, Suboptimal decoding algorithm for Convolutional codes, convolutional codes as block codes, Trellis representation of Block and Cyclic Codes, Trellis Coded Modulation. Turbo Codes – Encoding parallel concatenated codes, decoding algorithms, Error Floor and Weight Distribution. Low Density Parity Check Codes – Construction, Tanner graphs, Decoding. Space Time Coding – Fading Channels, Rayleigh Fading, MIMO Channel, Space Time Block Codes, Space – Time Trellis Codes.	10	Hrs

Text/References:

1. T. K. Moon, "Error Correction Coding: Mathematical Methods and Algorithms", Wiley, 2006
2. W. C. Huffman and V. Pless, "Fundamentals of Error – Correcting Codes", CUP, 2003.
3. S. Lin and D. J. Costello, "Error Control Coding: Fundamentals and Application", 1983.
4. R. H. Morelos-Zaragoza, "The Art of Error Correcting Codes", Wiley, 2002.

EC 9014	ELECTROMAGNETIC INTERFERENCE AND COMPATIBILITY	3-0-0	3
Unit I	Introduction to Electromagnetic Compatibility (EMC), EMC Requirements for Electronic Systems,Radiated Emissions,Conducted Emissions ,Spectra of Digital Waveforms,The Spectrum of Trapezoidal (Clock) Waveforms,pectral Bounds for Trapezoidal Waveforms, Effect of Rise/Falltime on Spectral Content,Bandwidth of Digital Waveforms, Effect of Repetition Rate and Duty Cycle,Effect of Ringing (Undershoot/Overshoot)	6	Hrs
Unit II	Transmission Lines and Signal Integrity:The Transmission-Line Equations,Printed Circuit Board (PCB) Structures,High-Speed Digital Interconnects and Signal IntegritySinusoidal Excitation of the Line and the Phasor Solution	6	Hrs
Unit III	Conducted Emissions and Susceptibility: Measurement of Conducted Emissions,1 The Line Impedance Stabilization Network (LISN),Common- and Differential-Mode Currents Again, Power Supply Filters,Basic Properties of Filters, A Generic Power Supply Filter Topology,Effect of Filter Elements on Common	8	Hrs
Unit IV	Differential-Mode Currents,Separation of Conducted Emissions into Common and Differential-Mode Components for Diagnostic Purposes,Power Supplies,Linear Power Supplies,Switched-Mode Power Supplies (SMPS), Effect of Power Supply Components on ConductedEmissions, Power Supply and Filter Placement,Conducted Susceptibility	6	Hrs
Unit V	Crosstalk: Three-Conductor Transmission Lines and Crosstalk,The Transmission-Line Equations for Lossless Lines,The Per-Unit-Length Parameters,Homogeneous versus Inhomogeneous Media, Wide-Separation Approximations for Wires, Numerical Methods for Other Structures,Wires with Dielectric Insulations(Ribbon Cables),Rectangular Cross-Section Conductors(PCB Lands),The Inductive –Capacitive Coupling Approximate Model, Frequency-Domain Inductive-Capacitive Coupling Model, Inclusion of Losses: Common-Impedance Coupling,Time-Domain Inductive – Capacitive Coupling Model\	8	Hrs
Unit VI	Shielding Effectiveness: Far-Field Sources, Exact Solution, Approximate Solution, Shielding Effectiveness: Near-Field Sources, Near Field versus Far Field,Electric Sources,Magnetic Sources, Low-Frequency, Magnetic Field Shielding, Effect of Apertures, System Design for EMC.	8	Hrs

Text/References:

1. Clayton R Paul: Introduction to Electromagnetic Compatibility Wiley 2nd Edition
2. V.P. Kodali, "Engineering Electromagnetic Compatibility",S. Chand & Co. Ltd., New Delhi, 2000.
3. "Electromagnetic Interference and Compatibility", IMPACT series, IIT-Delhi, Modules1-9.
4. Keiser, "Principles of Electromagnetic Compatibility", 3rd ed., , Artech House

EC 9015	**CHANNEL MODELLING FOR WIRELESS COMMUNICATION**	**3-0-0**	**3**
Unit I	Propagation Mechanisms - Free space propagation, reflection and transmission, diffraction, scattering on rough surfaces, wave guiding	6	Hrs
Unit II	Statistical Description of Wireless Channels - The time-invariant two-path model, time-variant two-path model, small-scale fading without line-of-sight, small-scale fading with line-of-sight, Doppler spectra, level crossing rate and random FM, large-scale fading	6	Hrs
Unit III	Wideband Channel Characterization - Narrowband vs. wideband systems, system-theoretic description of propagation channels, the WSSUS model, description methods for time dispersion, description methods for angular dispersion	8	Hrs
Unit IV	Channel Models - Narrowband models, wideband models, spatial models, deterministic models, models for ultra wideband channels	6	Hrs
Unit V	Channel Sounding - Time-domain methods, frequency-domain methods, generalizations, spatially resolved methods	8	Hrs
Unit VI	Antenna aspects in wireless systems - Requirements for antennas in mobile radio, antennas for mobile stations, antennas for base stations, aspects of multiple antenna systems	8	Hrs

Text/References:

1. Wireless Communications, 2nd Edition, by Andreas F. Molisch, Wiley
2. Wireless Communications, 2nd Edition, by Andrea Goldsmith, Cambridge University Press
3. Wireless Communication: Principles and Practice, 2nd Edition, by Theodore Rappaport, Prentice Hall

EC 9016	**HIGH SPEED COMMUNICATION TECHNIQUES**	**3-0-0**	**3**
Unit I	High Speed Networks: Frame Relay Networks – Asynchronous transfer mode – ATM Protocol Architecture, ATM logical Connection, ATM Cell – ATM Service Categories – AAL. High Speed LAN's: Fast Ethernet, Gigabit Ethernet, Fiber Channel – Wireless LAN's: applications, requirements – Architecture of 802.11	10	Hrs
Unit II	Congestion and Traffic Management: Queuing Analysis – queuing Models – Single Server Queues – Effects of Congestion – Congestion Control – Traffic Management – Congestion Control in Packet Switching Networks – Frame Relay Congestion Control	8	Hrs
Unit III	TCP and ATM Congestion Control: TCP Flow Control – TCP Congestion Control – Retransmission – Timer Management – Exponential RTO back off – KARN's Algorithm – Window Management – Performance of TCP over ATM Traffic and Congestion control in ATM – Requirements – Attributes – Traffic Management Frame work, Traffic control – ABR traffic Management - ABR rate control, RM cell formats ABR Capacity allocations – GFR traffic management	14	Hrs
Unit IV	Integrated and Differentiated Services: Integrated Services Architecture – Approach, Components, Services – Queuing Discipline, FQ, PS, BRFQ, GPS, WFQ – Random Early Detection, Differentiated Services. Protocols for QOS Support: RSVP – Goals & Characteristics, Data Flow, RSVP operations, Protocol Mechanisms – Multiprotocol Label. Switching – Operations, Label Stacking, Protocol details – RTP – Protocol Architecture, Data Transfer Protocol, RTCP	10	Hrs

Text/References:

1. High Speed Networks and Internet", Communication networks, Edition, 2001, By William Stallings, ean Harcourt Asia Pvt. Ltd
2. MPLS and VPN architecture, Volume 1 and 2, 2003, by Irvan Pepelnjk, Jim Guichard and Jeff Apcar, Cisco Press.
3. Encyclopedia of Networking and telecommunications, 2001, By Tom Sheldon, TMH.

EC 9017	**SIGNAL PROCESSING FOR COMMUNICATION**	**3-0-0**	**3**
Unit I	History and philosophy. Descret time signals. Definitions: Descrete time abstraction, Basic signals, deigital frequency, Elementary operator, reproducing formula, energy and power. Classes of Descret time signals	6	Hrs
Unit II	Signal space and Hilbert spaces: Euclidean Geometry, Vector spaces to Hilbert spaces.Subspace, base and projections. Finite length signals, Periodic signals and Infinite sequences. Fourier analysis: DFT, DFS, DTFT, Relationship between transforms, FT Properties, Time and Frequency Analysis	8	Hrs
Unit III	Stochastic Signal Processing: Random Variables, Random Vectors, Random Processes. Spectral representation of Stataionary Random Processes: Power Spectral Density, PSD of a Stationary Process, White Noise. Stochastic Signal Processing	10	Hrs
Unit IV	Interpolation and Sampling: Continuous Time Signals. Interpolation: Local Interpolation, Polynomial interpolation, Sinc interpolation. Sampling Theorem. Anliasing: Intuition and proof. Non-Bandlimitted Signals. Descrete Time processing of analog Signals: Digital differentiator, Fractional Delays	8	Hrs
Unit V	Data Comvertors and Multirate Signal Processing: Quantixzation, Uniform Scalar Quantization, Advanced Quantizer, ADC and DAC. Multirate Signal processing: Downsampling: Downsampling OperatorProperties, Frequency Domain Representation. Upsampling and Interpolation. Oversampled ADC and DAC.	10	Hrs

Text/References:

1. Paolo Prandoni, Martin Vetterli, "Signal Processing for Communications" EPEL Press.
2. Fredric J. Harris, "Multirate Signal Processing for Communication Systems" Pearson.
3. Martin Vetterli, Jelena Kovacevic, Vivek K Goyal, "Foundations of Signal Processing".
4. Ananthram Swami, Qing Zhao, Yao-Win Hong, Lang Tong, "Wireless Sensor Networks: Signal Processing and Communications Perspectives" Wiley.

EC 9018	ADVANCED DIGITAL SIGNAL PROCESSING	3-0-0	3
Unit I	Parametric methods for power spectrum estimation: Relationship between the auto correlation and the model parameters – The Yule – Walker method for the AR Model Parameters – The Burg Method for the AR Model parameters – unconstrained least-squares method for the AR Model parameters – sequential estimation methods for the AR Model parameters – selection of AR Model order	6	Hrs
Unit II	Adaptive signal processing :FIR adaptive filters – steepest descent adaptive filter – LMS algorithm – convergence of LMS algorithms – Application: noise cancellation – channel equalization – adaptive recursive filters – recursive least squares.	8	Hrs
Unit III	Multirate signal processing :Decimation by a factor D – Interpolation by a factor I – Filter Design and implementation for sampling rate conversion: Direct form FIR filter structures – Polyphase filter structure.	10	Hrs
Unit IV	Linear prediction and optimum linear filters: Innovations Representation of a Stationary Random Process, Forward and Backward Linear Prediction, Solution of the Normal Equations, Levinson-Durbin Algorithm, Schiir Algorithm, Properties of the Linear Prediction-Error Filters, Wiener Filters for Filtering and Prediction	8	Hrs
Unit V	Wavelet transforms :Fourier Transform : Its power and Limitations – Short Time Fourier Transform – The Gabor Transform - Discrete Time Fourier Transform and filter banks – Continuous Wavelet Transform – Wavelet Transform Ideal Case – Perfect Reconstruction Filter Banks and wavelets – Recursive multi-resolution decomposition – Haar Wavelet – Daubechies Wavelet.	10	Hrs

Text/References:

1. John G.Proakis, Dimitris G.Manobakis, Digital Signal Processing, Principles, Algorithms and Applications, Third edition, (2000) PHI.
2. Monson H.Hayes – Statistical Digital Signal Processing and Modeling, Wiley, 2002.
3. L.R.Rabiner and R.W.Schaber, Digital Processing of Speech Signals, Pearson Education(1979).
4. Roberto Crist, Modern Digital Signal Processing, Thomson Brooks/Cole (2004)
5. Raghuveer. M. Rao, Ajit S.Bopardikar, Wavelet Transforms, Introduction to Theory and applications, Pearson Education, Asia, 2000

EC 9019	**VLSI TECHNOLOGY**	**3-0-0**	**3**
Unit I	Environment for VLSI Technology: Clean room and safety requirements. Wafer cleaning processes and wet chemical etching techniques. Solid State diffusion modelling and technology; Ion Implantation modeling, technology and damage annealing	7	Hrs
Unit II	Oxidation and Lithography: Kinetics of Silicon dioxide growth both for thick, thin and ultrathin films. Oxidation technologies in VLSI and ULSI;Photolithography, E-beam lithography and newer lithography techniques for VLSI/ULSI; Mask generation	9	Hrs
Unit III	Chemical Vapor Deposition techniques : CVD techniques for deposition of polysilicon, silicon dioxide, silicon nitride and metal films; Epitaxial growth of silicon; modelling and technology.Metal film deposition : Evaporation and sputtering techniques. Failure mechanisms in metal interconnects; Multi-level metallization schemes	14	Hrs
Unit IV	Plasma and Rapid Thermal Processing: PECVD, Plasma etching and RIE techniques; RTP techniques for annealing, growth and deposition of various films for use in ULSI.Process integration for NMOS, CMOS and Bipolar circuits; Advanced MOS technologies.	12	Hrs

Text/References:

1. C.Y. Chang and S.M.Sze (Ed), ULSI Technology, McGraw Hill Companies Inc, 1996.
2. S.K. Ghandhi, VLSI Fabrication Principles, John Wiley Inc., New York, 1983.
3. S.M. Sze (Ed), VLSI Technology, 2nd Edition, McGraw Hill, 1988.

EC 9020	**CMOS ANALOG IC DESIGN**	**3-0-0**	**3**
Unit I	A Review of MOS equations in weak (sub-threshold) and strong inversion regions, MOS controlled switch; MOS diode; MOS capacitor; MOS active resistor, single-stage common source, common gate and common drain amplifiers.	5	Hrs
Unit II	MOS current mirrors (simple, cascode and low-voltage wide swing types), supply and temperature independent biasing method. Multiple current source and sink design	6	Hrs
Unit III	Stability analysis of closed loop amplifier, loop-gain, frequency and time domain behavior, open-loop gain and gain bandwidth product, gain and phase cross-over frequencies, multiple poles and zeros of closed loop amplifier, pre-dominant and non-dominant poles, gain margin and phase margin optimization for stable system design, various frequency-compensation techniques (Miller's and feed-forward path)	6	Hrs
Unit IV	Op-amp at the block level, ideal and real behaviors of op-amp, multi-stage op-amp and its frequency compensation, Two-stage current mirror op-amp, telescopic and folded cascode op-amp design equations, non-ideal behavior such as slew rate, DC off-set, Ibias offset and device mismatch effects.	6	Hrs
Unit V	Voltage gain, limit of input common mode range (ICMR), significance of CMRR and PSRR, inverting and non-inverting amplifiers, op-amp-mismatch and noise effects, single-ended and fully differential op-amps, common-mode feedback circuit for FD-Op-amp, MOS thermal and flicker noise equations, O noise and Inoise spectral densities, noise corner frequency	7	Hrs
Unit VI	Operational transconductance amplifier (OTA), transconductance gain equations in weak and strong inversion regions, two-stage OTA design (telescopic, cascode and folded-cacode types), single ended and fully-differential OTAs, frequency compensation techniques to increase phase margin for stable OTA structures.	4	Hrs
Unit VII	Voltage and current reference, band-gap reference; beta multiplier, active RC bi-quadratic filters using integrators loop, switched capacitor (SC) filter, OTA-C bi-quadratic filters	6	Hrs

Text/References:

1. Analog Circuit Design: Art, Science and Personalities (EDN Series for Design Engineers) (Paperback), Jim Williams, Newnes; Reprint edition, 1991.
2. Analog Integrated Circuit Design, David Johns and Ken Martin, John Wiley & Sons, 1997.
3. Mixed Analog Digital VLSI Devices and Technology (An introduction), Y. Tsividis, World Scientific, New Jersey, 2002.
4. Analysis and design of Analog Integrated Circuits, Gray, Hurst, Lewis, and Meyer, 4th Edition, John Wiley and Sons.

EC 9021	**LOW POWER VLSI DESIGN**	**3-0-0**	**3**
Unit I	Introduction: Power dissipation analysis, Physics of Power Dissipation in CMOS FET Devices, Dynamic power, Static power	9	Hrs
Unit II	Low-power circuit techniques –Voltage scaling and threshold-voltage hurdle in low-power design, Low power design Using Energy Recovery Technique	7	Hrs
Unit III	Advanced Techniques - Low Power CMOS VLSI Design, Low-power circuit level and device level approach	10	Hrs
Unit IV	Low-power Analog and digital design issues in weak inversion and strong inversion regions of operation	6	Hrs
Unit V	Power Estimation - Synthesis for Low Power - Design and Test of Low Voltages - CMOS Circuits.	8	Hrs

Text/References:

1. Gary Yeap " Practical Low Power Digital VLSI Design",1997.
2. Kaushik Roy, Sharat Prasad, "Low Power CMOS VLSI Circuit Design", 2000.

EC 9022	**DIGITAL IC DESIGN**	**3-0-0**	**3**
Unit I	Introduction; Metrics; Switch Logic; Process; Gates; MOS Transistor; Inverter VTC,MOS Capacitor; Inverter Delay; Power Buffer Sizing; Wires; CMOS Logic; Logical Effort; Process variation Effects, Introduction to VLSI fabrication.	9	Hrs
Unit II	Memory; Decoders; Pass Transitor; Dynamic and Static Logic; Domino Logic; Scaling; Adders; Multipiers; Latches; Timing; Clock; SRAM; Design for Performance; Power Performance Tradeoff.	7	Hrs
Unit III	Analysis and Design of Digital Integrated Circuits. Circuit analysis of piecewise linear single energy storage element networks. Rules for determining states of diodes and transistors. Bipolar junction and field effect transistors as switches.	14	Hrs
Unit IV	Basic digital logic gates. Integrated circuit logic and building blocks (TTL, MOS, CMOS, ECL, Integrated Injection Logic). Sweep circuits (constant current, Miller, bootstrap), Monostable, Astable, and Bistable (Schmitt Trigger) switching circuits, Applications (pulse width modulator, triangle wave generator, FM function generator design).	10	Hrs

Text/References:

1. Ivan Sutherlnd, Robert F Sroull, David Harris, Logical Effort: Designing Fast CMOS Circuits
2. N. Weste and K. Eshranghian, Principles of CMOS VLSI Design, Addison Wesley. 1985
3. L. Glaser and D. Dobberpuhl, The Design and Analysis of VLSI Circuits, Addison Wesley, 1985
4. C. Mead and L. Conway, Introduction to VLSI Systems, Addison Wesley, 1979.
5. J. Rabaey, Digital Integrated Circuits: A Design Perspective, Prentice Hall India, 1997.

EC 9023	**CAD FOR VLSI**	**3-0-0**	**3**
Unit I	VLSI Physical Design Automation: VLSI Design Cycle, New Trends in VLSI Design Cycle, Physical Design Cycle, New Trends in Physical Design Cycle, Design Styles, System Packaging Styles	9	Hrs
Unit II	Partitioning, Floor Planning, Pin Assignment and Placement: Partitioning – Problem formulation, Classification of Partitioning algorithms, Kernighan-Lin Algorithm, Simulated Annealing, Floor Planning – Problem formulation, Classification of floor planning algorithms, constraint based floor planning, Rectangular Dualization, Pin Assignment – Problem formulation, Classification of pin assignment algorithms, General and channel Pin assignments, Placement – Problem formulation, Classification of placement algorithms, Partitioning based placement algorithms	7	Hrs
Unit III	Global Routing and Detailed Routing: Global Routing – Problem formulation, Classification of global routing algorithms, Maze routing algorithms, Detailed Routing – Problem formulation, Classification of routing algorithms, Single layer routing algorithms.	10	Hrs
Unit IV	Physical Design Automation of FPGAs: FPGA Technologies, Physical Design cycle for FPGAs, Partitioning, Routing – Routing Algorithm for the Non - Segmented model, Routing Algorithms for the Segmented Model; Physical Design Automation of MCMs: Introduction to MCM Technologies, MCM Physical Design Cycle	6	Hrs
Unit V	Chip Input and Output Circuits: ESD Protection, Input Circuits, Output Circuits and noise, On-chip clock Generation and Distribution, Latch-up and its prevention	8	Hrs

Text/References:

1. N.A. Sherwani, “Algorithms for VLSI Physical Design Automation ", 1999.
2. S.H.Gerez, “Algorithms for VLSI Design Automation ", 1998.

EC 9024	DIGITAL AUDIO AND VIDEO COMMUNICATION	3-0-0	3
Unit I	Introduction, Speech production model, speech coding, Quantizers for speech signal, mew-law and optimum Quantizer, Adaptive quantizer, Differential quantization, LDM and ADM, DPCM and Adaptive prediction, linear prediction of speech	6	Hrs
Unit II	CCITT recommendations for speech digitization, HDTV, Low resolution TV and videoconferencing requirements	8	Hrs
Unit III	Frequency domain waveform coding of speech-LTC, ATC; Parameter coding of speech channel, format and LPC vecoders	10	Hrs
Unit IV	Coding of monochrome and colour video signals-Transform and Adaptive transform coding; Sub band coding; Vector quantization; Inter-frame and Hybrid coding; Delayed decision and run length coding	8	Hrs
Unit V	Effects of transmission errors; Audio and Video conference; Video telephone	10	Hrs

Text/References:

1. Digital processing of speech signals by Rabiner L.R., Prentice Hall
2. Principles of Computer Speech by I.H.Witten
3. Digital speech : Coding for Low Bit Rate Communication System by A.M.Kondoz, Willey, 2nd ed.
4. Voice and Data Communication handbook by R.J.Bates, McGrow Hill
5. A practical handbook of Speech Coder by R.Goldberg and L.Rick, CRC Pr

EC 9025	**DESIGN OF SEMICONDUCTOR MEMORIES**	**3-0-0**	**3**
Unit I	RANDOM ACCESS MEMORY TECHNOLOGIES Static Random Access Memories (SRAMs): SRAM Cell Structures-MOS SRAM Architecture-MOS SRAM Cell and Peripheral Circuit Operation-Bipolar SRAM Technologies-Silicon On Insulator (SOl) Technology-Advanced SRAM Architectures and Technologies- Application Specific SRAMs. Dynamic Random Access Memories (DRAMs): DRAM Technology Development-CMOS DRAMs-DRAMs Cell Theory and Advanced Cell Strucutures-BiCMOS DRAMs-Soft Error Failures in DRAMs-Advanced DRAM Designs and Architecture-Application Specific DRAMs	9	Hrs
Unit II	NONVOLATILE MEMORIES Masked Read-Only Memories (ROMs)-High Density ROMs-Programmable Read-Only Memories (PROMs)-Bipolar PROMs-CMOS PROMs-Erasable (UV) - Programmable Road-Only Memories (EPROMs)-Floating- Gate EPROM Cell-One-Time Programmable (OTP) Eproms-Electrically Erasable PROMs (EEPROMs)-EEPROM Technology And Arcitecture-Nonvolatile SRAM-Flash Memories (EPROMs or EEPROM)-Advanced Flash Memory Architecture	7	Hrs
Unit III	MEMORY FAULT MODELING, TESTING, AND MEMORY DESIGN FORTESTABILITY AND FAULT TOLERANCE RAM Fault Modeling, Electrical Testing, Peusdo Random Testing-Megabit DRAM Testing-Nonvolatile Memory Modeling and Testing-IDDQ Fault Modeling and Testing-Application Specific Memory Testing.	10	Hrs
Unit IV	SEMICONDUCTOR MEMORY RELIABILITY AND RADIATION EFFECTS General Reliability Issues-RAM Failure Modes and Mechanism-Nonvolatile Memory Reliability-Reliability Modeling and Failure Rate Prediction-Design for Reliability-Reliability Test Structures-Reliability Screening and Qualification. Radiation Effects-Single Event Phenomenon (SEP)-Radiation Hardening Techniques-Radiation Hardening Process and Design Issues-Radiation Hardened Memory Characteristics-Radiation Hardness Assurance and Testing - Radiation Dosimetry-Water Level Radiation Testing and Test Structures	6	Hrs
Unit V	ADVANCED MEMORY TECHNOLOGIES AND HIGH-DENSITY MEMORYPACKAGING TECHNOLOGIES Ferroelectric Random Access Memories (FRAMs)-Gallium Arsenide (GaAs) FRAMs-Analog Memories-Magnetoresistive Random Access Memories (MRAMs)-Experimental Memory Devices. Memory Hybrids and MCMs (2D)-Memory Stacks and MCMs (3D)-Memory MCM Testing and Reliability Issues-Memory Cards-High Density Memory Packaging Future Directions	8	Hrs

Text/References:

1. Ashok K.Sharma, " Semiconductor Memories Technology, Testing and Reliability ", Prentice-Hall of India Private Limited, New Delhi, 1997.
2. R. Jacob Baker, “DRAM”

EC 9026	**MEMS AND MICROSYSTEMS TECHNOLOGY**	**3-0-0**	**3**
Unit I	Historical Background: Silicon Pressure sensors, Micromachining, MicroElectroMechanical Systems	7	Hrs
Unit II	Microfabrication and Micromachining : Integrated Circuit Processes, Bulk Micromachining : Isotropic Etching and Anisotropic Etching, Wafer Bonding, High Aspect-Ratio Processes (LIGA)	8	Hrs
Unit III	Physical Microsensors: Classification of physical sensors, Integrated,	9	Hrs

	Intelligent, or Smart sensors, Sensor Principles and Examples : Thermal sensors, Electrical Sensors, Mechanical Sensors, Chemical and Biosensors		
Unit IV	Microactuators : Electromagnetic and Thermal microactuation, Mechanical design of microactuators, Microactuator examples, microvalves, micropumps, micromotors-Microactuator systems: Success Stories, Ink-Jet printer heads, Micro-mirror TV Projector	9	Hrs
Unit V	Surface Micromachining: One or two sacrificial layer processes, Surface micromachining requirements, Polysilicon surface micromachining, Other compatible materials, Silicon Dioxide, Silicon Nitride, Piezoelectric materials, Surface Micromachined Systems: Success Stories, Micromotors, Gear trains, Mechanisms,RF/Electronics device/systemand Applications.	9	Hrs

Text/References:

1. Stephen D. Senturia, "Microsystem Design" by, Kluwer Academic Publishers, 2001.
2. Marc Madou, “Fundamentals of Microfabrication” by, CRC Press, 1997.Gregory Kovacs, “Micromachined Transducers Sourcebook” WCB McGraw-Hill, Boston, 1998.
3. M.-H. Bao, “Micromechanical Transducers: Pressure sensors, accelrometers, and gyroscopes” by Elsevier, New York, 2000.

EC 9027	ADVANCED COMPUTER ARCHITECTURE	3-0-0	3
Unit I	Introduction: review of basic computer architecture, quantitative techniques in computer design, measuring and reporting performance. CISC and RISC processors	9	Hrs
Unit II	Pipelining : Basic concepts, instruction and arithmetic pipeline, data hazards, control hazards, and structural hazards, techniques for handling hazards. Exception handling, Pipeline optimization techniques, Compiler techniques for improving performance	7	Hrs
Unit III	Hierarchical memory technology: Inclusion, Coherence and locality properties; Cache memory organizations, Techniques for reducing cache misses; Virtual memory organization, mapping and management techniques, memory replacement policies	10	Hrs
Unit IV	Instruction-level parallelism: basic concepts, techniques for increasing ILP, superscalar, super pipelined and VLIW processor architectures, Array and Vector processors	6	Hrs
Unit V	Multiprocessor architecture: taxonomy of parallel architectures. Centralized shared-memory architecture: synchronization, memory consistency, interconnection networks. Distributed shared-memory, architecture, Cluster computers, Non Von Neumann architectures: data flow computers, reduction computer architectures, systolic architectures	8	Hrs

Text/References:

1. Kai Hwang, “Advanced Computer Architecture ", McGraw Hill International, 1993.
2. William Stallings, “Computer Organization and Architecture ", Macmillan Publishing Company, 1990.
3. M.J. Quinn, “Designing Efficient Algorithms for Parallel Computers ", McGraw Hill International, 1994.

EC 9028	**ANALOG FILTER DESIGN**	**3-0-0**	**3**
Unit I	Introduction: transfer function, pass bands and attenuation band of ideal and realizable filters, comparison between passive and active filters, Design of second order filters (all types i.e. low pass, high pass, band pass, band reject, all pass) with unity and variable gain. Design of second order state variable filters, switched capacitor circuits, switched capacitor integrators (inverting and non-inverting type), universal SC filters, frequency limitation of SC filters, multiple order cascade filters, sensitivity of passive and active filters	9	Hrs
Unit II	Introduction to operational transconductance amplifier, bipolar and MOS OTA, OTA characteristic, OTA biasing techniques, OTA based tunable filters, active only Biquadratic filters, high frequency OTA RF filters, two integrators loop g_m-C universal Biquadratic filters, OTA based LC filters, Voltage mode vs current mode filters, Adjoint and transpose conversion methods.	7	Hrs
Unit III	Introduction to Current mode Filters: Current conveyors, all generation of current conveyors and their transfer matrix, Bi-polar and CMOS CC cells, detailed analysis of second generation current conveyors (CC-II), Filter design methods using CC-I and CC-II, CCC-II	14	Hrs
Unit IV	Introduction to Current Feedback operational Amplifier: CC-II and buffer based CFOA CMOS Cell, merits of CFOA over op-amp, CFOA based oscillator, CFOA based active universal filters	10	Hrs

Text/References:

1. Design with Operational Amplifier and Analog Integrated Circuits, Third Edition by Sergio Franco, Tata Mc Graw-Hill.
2. Linear Integrated Circuits, by S Salivahannn, V S Kanchana Bhaaskaran, The Mc Graw-Hill Companies.
3. A Text book of Operational Transconductance Amplifier and Analog Integrated Circuits, by Tahira Parveen, Reprint 2010, I.K. International Publishing HousePvt. Ltd. New Delhi & Bangalore, ISBN: 978-93-80026-55-8.
4. Low Voltage Low Power CMOS Current Conveyorsby Giuseppe Ferri and Nicola C. Guerrini, Kluwer Academic Publisher Boston/ Dordrecht/ London, 2003.ISBN: 1-4020-7486-7.

EC 9029	**VLSI SIGNAL PROCESSING**	**3-0-0**	**3**
Unit I	Introduction to DSP systems - Iteration Bound - Pipelined and parallel processing	9	Hrs
Unit II	Retiming - Unfolding - Algorithmic strength reduction in filters and transforms.	7	Hrs
Unit III	Systolic architecture design - fast convolution - Pipelined and parallel recursive and adaptive filters.	10	Hrs
Unit IV	Scaling and round off noise - Digital lattice filter structures - Bit level arithmetic architecture - Redundant arithmetic	6	Hrs
Unit V	Numerical strength reduction - Synchronous, wave and asynchronous pipe lines - low power design - programmable digital signal processors	8	Hrs

Text/References:

1. Keshab K.Parthi, " VLSI Digital Signal Processing systems, Design and implementation ", Wiley, Inter Science, 1999.
2. Mohammed Isamail and Terri Fiez, " Analog VLSI Signal and Information Processing ", Mc Graw-Hill, 1994.
3. S.Y. Kung, H.J. White House, T. Kailath, " VLSI and Modern Signal Processing ", Prentice Hall, 1985.
4. Jose E. France, Yannis Tsividis, " Design of Analog - Digital VLSI Circuits for Telecommunication and Signal Processing ", Prentice Hall, 1994.

EC 9030	**VLSI DATA CONVERSION CIRCUIT**	**3-0-0**	**3**
Unit I	Sampling, Spectral properties of sampled signals, Oversampling and its implications on anti-alias filter design, Time Interleaved Sampling, Analysis of a Ping-Pong Sampling system, Analysis of Offset and Gain Errors in Time-Interleaved Sample and Holds.	7	Hrs
Unit II	Bottom Plate Sampling, Gate Bootstrapped Switch, the Nakagome Charge-Pump, Characterizing a Sample-and-Hold, Correct choice of input frequency, Discrete Fourier Series Refresher, FFT Leakage and the Rectangular Window, Spectral Windows, the Hann Window, the Blackman Window	8	Hrs
Unit III	Switch Capacitor Circuits, Parasitic Insensitive SC Amplifiers, Nonidealities in SC Amplifiers: Finite Opamp Gain and DC Offset., Finite Opamp Gain-Bandwidth Product, Introduction to Fully Differential Operation	8	Hrs
Unit IV	Integral Nonlinearity (INL), Dynamic Characterization of ADCs, SQNR, Quantization Noise Spectrum, SFDR, Flash A/D Converter Basics, the Regenerative Latch, Preamp Offset Correction (Auto-zeroing)	9	Hrs
Unit V	Coupling Capacitor Considerations in an Auto-zeroed Preamp, Transistor Level Preamp Design, Timing issues in a flash ADC. Bubble Correction Logic in a Flash ADC, Comparator Meta-stability, D/A Converter Basics, INL/DNL, DAC Spectra and Pulse Shapes.NRZ vs RZ DACs and Oversampled Approaches to Data Conversion.	10	Hrs

Text/References:

1. Understanding Delta - Sigma Data Converters: R. Schreier, Wiley
2. Understanding Delta-Sigma Data Converters : R.Schreier and G.Temes
3. John Wiley CMOS Data Converters for Communications: N.Tan, Springer.

EC 9031	TESTING AND VERIFICATION OF VLSI CIRCUITS	3-0-0	3
Unit I	Scope of testing and verification in VLSI design process. Issues in test and verification of complex chips, embedded cores and SOCs	9	Hrs
Unit II	Fundamentals of VLSI testing. Fault models. Automatic test pattern generation. Design for testability	7	Hrs
Unit III	Scan design. Test interface and boundary scan. System testing and test for SOCs. Iddq testing. Delay fault testing. BIST for testing of logic and memories. Test automation	14	Hrs
Unit IV	Design verification techniques based on simulation, analytical and formal approaches. Functional verification. Timing verification. Formal verification. Basics of equivalence checking and model checking. Hardware emulation	10	Hrs

Text/References:

1. M. Bushnell and V. D. Agrawal, "Essentials of Electronic Testing for Digital, Memory and Mixed-Signal VLSI Circuits", Kluwer Academic Publishers, 2000.
2. M. Abramovici, M. A. Breuer and A. D. Friedman, "Digital Systems Testing and Testable Design", IEEE Press, 1990.
3. T.Kropf, "Introduction to Formal Hardware Verification", Springer Verlag, 2000.
4. P. Rashinkar, Paterson and L. Singh, "System-on-a-Chip Verification-Methodology and Techniques", Kluwer Academic Publishers, 2001.

EC 9032	**DIGITAL SYSTEM DESIGN USING FPGA**	**3-0-0**	**3**
Unit I	Introduction to Digital design, hierarchical design, controller (FSM), case study	9	Hrs
Unit II	FSM issues, timing issues, pipelining, resource sharing, metastability, synchronization	7	Hrs
Unit III	MTBF Analysis, setup/hold time of various types of flip-flops, synchronization between multiple clock domains, reset recovery, proper resets	10	Hrs
Unit IV	VHDL: different models, simulation cycles, process, concurrent and sequential statements, loops, delay models, library, packages, functions, procedures, coding for synthesis, test bench	6	Hrs
Unit V	FPGA: logic block and routing architecture, design methodology, special resources, Virtex-II, Stratix architectures, programming FPGA, constraints, STA, timing closure, case study.	8	Hrs

Text/References:

1. Wakerly, J.F., Digital Design: Principles and Practices, Prentice Hall.
2. Kevin Skahil, VHDL For Programmable Logic, Addison Wesley.
3. FPGA Data sheets, Application Notes.
4. Current literature from relevant journals and conference proceedings.

EC 9033	**PHOTONICS INTEGRATED CIRCUITS**	**3-0-0**	**3**
Unit I	Principles: Introduction to photonics, optical waveguide theory, numerical techniques and simulation tools, photonic waveguide components – couplers, tapers, bends, gratings. Electro-optic, acousto-optic, magneto-optic and non-linear optic effects. Modulators, switches, polarizers, filters, resonators, optoelectronics integrated circuits. Amplifiers, mux/demux, transmit receive modules	16	Hrs
Unit II	Technology: materials – glass, lithium niobate, silicon, compound semiconductors, polymers. Fabrication – lithography, ion-exchange, deposition, diffusion. Process and device characterization. Packaging and environmental issues	14	Hrs
Unit III	Applications: photonic switch matrices. Planar lightwave circuits, delay line circuits for antenna arrays, circuits for smart optical sensors. Optical signal processing and computing. Micro-opto-electro-mechanical systems.	8	Hrs
Unit IV	Photonic bandgap structures. VLSI photonics	4	Hrs

Text/References:

1. Pollock, C.R., and Lip Son, M., Integrated Photonics, Kluwer Pub., 2003.
2. Tamir, T. (ed.), Guided-wave optoelectronics, Second Edn, Springer Verlag, 1990.
3. Nishihara, H., Haruna, M., and Suhara, T., Optical Integrated Circuits, McGraw Hill, 1988.
4. Murphy, E.J. (ed.), Integrated Optical Circuits and Components: Design and Applications, Marcel and Dekker, 1999.
5. Current literature: Special issues of journals and review articles.

EC 9034	**NANOELECTRONICS**	**3-0-0**	**3**
Unit I	INTRODUCTION TO NANOTECHNOLOGY: Background to nanotechnology: Types of nanotechnology and nanomachines Molecular Nanotechnology: Electron microscope nanodots; nanolithography. Nanomaterials: preparation – plasma arcing – chemical vapor deposition – sol-gels – electrodeposition – ball milling – applications	6	Hrs
Unit II	FUNDAMENTALS OF NANOELECTRONICS: Fundamentals of logic devices:- Requirements – dynamic properties – threshold gates; physical limits to computations; concepts of logic devices:- classifications –spintronics – quantum cellular automata – quantum computing – DNA computer; performance of information processing systems;- of biological neurons – performance estimation for the human brain. Ultimate computation:- power dissipation limit – dissipation in reversible computation – the ultimate computer	8	Hrs
Unit III	SILICON MOSFETs & QUANTUM TRANSPORT DEVICES: Silicon MOSFETS - Novel materials and alternate concepts:- scaling rules –advanced MOSFET concepts. Quantum transport devices based on resonant tunneling:- Electron tunneling; Single electron devices for logic applications:- Single electron devices – applications of single electron devices to logic circuits	10	Hrs
Unit IV	CARBON NANOTUBES: Carbon Nanotube: Fullerenes - types – assemblies – purification of carbon nanotubes – electronic propertics – synthesis of carbon nanotubes – carbon nanotube interconnects – carbon nanotube FETs – Nanotube for memory applications – prospects of an all carbon nanotube nanoelectronics	8	Hrs
Unit V	MOLECULAR ELECTRONICS: Electrodes & contacts – functions – molecular electronic devices – first test systems – simulation and circuit design – fabrication; Future applications: MEMS – robots – random access memory – mass storage devices	10	Hrs

Text/References

1. Michael Wilson, Kamali Kannangara, Geoff Smith, Michelle Simmons and Burkhard Raguse, Nanotechnology: Basic Science and Emerging Technologies, Chapman & Hall / CRC, 2002
2. T. Pradeep, NANO: The Essentials – Understanding Nanoscience and Nanotechnology, TMH'07
3. Rainer Waser (Ed.), Nanoelectronics and Information Technology: Advanced Electronic Materials and Novel Devices, Wiley-VCH, 2003
4. George W. Hanson,"Fundamentals of Nanoelectronics", Prentice Hall, 2007.
5. Karl Goser et.al, "Nanoelectronics and Nanosystems: From Transistors to Molecular and Quantum devices", Springer, 2005.
6. Mark. A. Reed and Takhee, "Molecular Electronics", American Scientific Publishers, 2003.
7. Michael C. Petty, "Molecular Electronics: From Principles to Practice", John Wiley & Sons, Ltd, 2007.

EC 9035	**NEURAL NETWORKS, ARCHITECTURE AND ITS APPLICATIONS**	**3-0-0**	**3**
Unit I	Network architecture, Artificial intelligence and neural networks, Learning processes, Learning with or without a teacher, Memory adoption, and statistical nature of learning process	6	Hrs
Unit II	Single layer perception, Adaptive filtering problem, LMS Algorithm, Learning curve, Perception convergence	8	Hrs
Unit III	Multi-layer perception: Back propagation, algorithm, output presentation and decision rule, supervised learning as optimization problem, Generalized radial basics, Function network	10	Hrs
Unit IV	Temporal processing using feed forward network, Network Architectures, Distributed time lagged feed forward network, Temporal back propagation algorithm	8	Hrs
Unit V	Dynamically driven recurrent networks, Sate space model, Learning algorithms, Real time recurrent learning, Kalman Filter, De-coupled extended kalman filters	10	Hrs

Text/References:

1. Neural network- A Comprehensive foundation, 2nd Ed, Simon Haykin, Addison Wiseley Longman, New York, 2001.
2. Neural Network- Algorithms, Applications and progggramming, J A Freeman and D M Skapura, AWL, NY, 2000.
3. An introduction to Neural Network, James A Anderson, Prentice Hall of India, New Delhi.

EC 9036	**ADAPTIVE SIGNAL PROCESSING**	**3-0-0**	**3**
Unit I	Introduction to vectors spaces, Review of notion of random variable, stochastic process, moments, ergodicity, LSI filtering of WSS processes, power density spectrum	8	Hrs
Unit II	Stochastic processes: Cross-correlation, filtering of WSS processes introduction to Wiener filtering. bandlimited processes, harmonic processes, the general linear process, and autoregressive processes stochastic models, autoregressive models, AR process, stochastic processes, MA and ARMA processes.	6	Hrs
Unit III	Simulation of AR processes and Wiener filtering. Comparison of time averages and ensemble averages. IIR Wiener filter for general linear process.	10	Hrs
Unit IV	Introduction to eignenvalue and eigenvector analysis of correlation matrix. Wiener filter using eigenvector basis, finished Wiener filter slides	8	Hrs
Unit V	Linear Prediction: FIR and IIR MMSE linear prediction. Introduction to "Backward Linear Prediction". Backward linear prediction, Gram Schmidt orthogonalization, Levinson algorithm. Prediction error filters, the lattice structure, joint-process estimation	10	Hrs

Text/References:

1. S. Haykin, Adaptive Filter Theory, fifth edition, Prentice Hall, 2013.
2. A. Sayed, Adaptive Filters, Wiley-IEEE Press, 2008. Available as ebook through University of Ottawa library.

EC 9037	SOFT COMPUTING	3-0-0	3
Unit I	Fuzzy Logic: Crisp set and Fuzzy set, Basic concepts of fuzzy sets, membership functions. Basic operations on fuzzy sets, Properties of fuzzy sets, Fuzzy relations	6	Hrs
Unit II	Propositional logic and Predicate logic, fuzzy If – Then rules, fuzzy mapping rules and fuzzy implication functions, Applications	10	Hrs
Unit III	Neural Networks: Basic concepts of neural networks, Neural network architectures, Learning methods, Architecture of a back propagation network, Applications	8	Hrs
Unit IV	Genetic Algorithms: Basic concepts of genetic algorithms, encoding, genetic modeling	8	Hrs
Unit V	Hybrid Systems: Integration of neural networks, fuzzy logic and genetic algorithms.	10	Hrs

Text/References:

1. S. Rajasekaran and G.A.Vijaylakshmi Pai.. Neural Networks Fuzzy Logic, and Genetic Algorithms, Prentice Hall of India.
2. K.H.Lee.. First Course on Fuzzy Theory and Applications, Springer-Verlag.
3. J. Yen and R. Langari.. Fuzzy Logic, Intelligence, Control and Information, Pearson Education

EC 9038	STATISTICAL SIGNAL PROCESSING AND MODELLING	3-0-0	3
Unit I	Review of random variables: Distribution and density functions, moments, independent, uncorrelated and orthogonal random variables; Vector-space representation of Random variables, Schwarz Inequality Orthogonalit principle in estimation, Central Limit theorem, Random processes, wide-sense stationary processes, autocorrelation and autocovariance functions, Spectral representation of random signals, Wiener Khinchin theorem Properties of power spectral density, Gaussian Process and White noise process, Linear System with random input, Spectral factorization theorem and its importance, innovation process and whitening filter, .Random signal modelling: MA(q), AR(p) , ARMA(p,q) models	6	Hrs
Unit II	Parameter Estimation Theory: Principle of estimation and applications, Properties of estimates, unbiased and consistent estimators, Minimum Variance Unbiased Estimates (MVUE), Cramer Rao bound, Efficient estimators; Criteria of estimation: the methods of maximum likelihood and its properties ; Baysean estimation : Mean square error and MMSE, Mean Absolute error, Hit and Miss cost function and MAP estimation	6	Hrs
Unit III	Estimation of signal in presence of white Gaussian Noise: Linear Minimum Mean-Square Error (LMMSE) Filtering: Wiener Hoff Equation, FIR Wiener filter, Causal IIR Wiener filter, Noncausal IIR Wiener filter, Linear Prediction of Signals, Forward and Backward Predictions, Levinson Durbin Algorithm, Lattice filter realization of prediction error filters	8	Hrs
Unit IV	Adaptive Filtering: Principle and Application, Steepest Descent Algorithm Convergence characteristics; LMS algorithm, convergence, excess mean square error, Leaky LMS algorithm;Application of Adaptive filters ;RLS algorithm, derivation, Matrix inversion Lemma, Intialization, tracking of nonstationarity	6	Hrs
Unit V	Kalman filtering: State-space model and the optimal state estimation problem, discrete Kalman filter, continuous-time Kalman filter, extended Kalman filter	8	Hrs
Unit VI	Spectral analysis: Estimated autocorrelation function, periodogram, Averaging the periodogram (Bartlett Method), Welch modification, Blackman and Tukey method of smoothing periodogram, Prametric method, AR(p) spectral estimation and detection of Harmonic signals, MUSIC algorithm	8	Hrs

Text/References:

1. M. Hays: Statistical Digital Signal Processing and Modelling, John Willey and Sons, 1996.
2. M.D. Srinath, P.K. Rajasekaran and R. Viswanathan: Statistical Signal Processing with Applications, PHI, 1996.
3. Simon Haykin: Adaptive Filter Theory, Prentice Hall, 1996.
4. D.G. Manolakis, V.K. Ingle and S.M. Kogon: Statistical and Adaptive Signal Processing, McGraw Hill, 2000.
5. S. M. Kay: Modern Spectral Estimation, Prentice Hall, 1987.

EC 9039	**DIGITAL IMAGE PROCESSING**	**3-0-0**	**3**
Unit I	Fundamental concepts of digital geometry, Digital image representation, Fundamental steps in image processing, Elements of digital image Processing systems, Image acquisitions, Storage, Processing, Communication, Display digital image fundamentals. Elements of visual perception, Simple image model, Sampling and quantization, Basic relationships between pixels, neighbour of pixels, Connectivities, Relation, Equivalence and transitive clause, Distance measures , Arithmetic/logic operations	6	Hrs
Unit II	Imaging Geometry: basic transformations, perspective transformations, Camera models; Photographic films- Film structure and exposure, film Characteristics diaphragm and shutter setting. Introduction to Fourier Transform, the discrete Fourier Transform, some properties of two dimensional Fourier Transform, separability, translation periodicity and conjugate symmetry, rotation, distributivity, and scaling, average value, Laplacian, convolution, and Correlation sampling, Fast Fourier Transforms, FFT algorithm, Inverse FFT , Implementation	8	Hrs
Unit III	Image enhancement: Spatial domain methods, Frequency domain method, Enhancement by point processing , Simple intensity transforms, Histogram processing, Image subtraction, Image averaging, Spatial filtering, Smoothing filters Image restoration : Degradation model, Degradation model for continuous Functions, algebra approach to restoration, Un-constrained restoration, constrained restoration, Removal of blur caused by uniform linear motion, Blind image, Deconvolution, Some algorithms	10	Hrs
Unit IV	Image coding- Redundancy, Interpixel redundancy, Measuring information, Information channel, Fundamental coding theorem, Image Segmentation , Line detection, Edge detection, Thresholding , Region splitting and merging	8	Hrs
Unit V	Image compression, Image compression models: The source encoder and decoder, Channel encoder and decoder, Error free compression, Variable length coding, Lossless predictive coding, Lossy compression: Lossy predictive coding, Transformed coding, Synthesis and analysis of image, Recognition, interpretation	10	Hrs

Text/References:

1. Digital Image Processing (3rd Edition) by Rafael C. Gonzalez and Richard E. Woods
2. Digital Image Processing Using Java, Efford, AWL, NY, 2000.
3. The Computer Image, A Watt and F.Policarpo AWL,NY, 1999
4. Fundamentals of Image Processing by A.K.Jain, PHI

EC 9040	**SPEECH PROCESSING**	**3-0-0**	**3**
Unit I	The Speech Production mechanism: Physiological and Mathematical Model.Relating the physiological and mathematical model. Categorization of Speech Sounds based on the source-system and the articulatory model	6	Hrs
Unit II	Speech Signal Processing Concepts: Discrete time speech signals, relevant properties of the fast Fourier transform and Z-transform for speech recognition, convolution, linear and non linear filter banks. Spectral estimation of speech using the Discrete Fourier transform. Pole-zero modeling of speech and linear prediction (LP) analysis of speech. Homomorphic speech signal de convolution, real and complex cepstrum, application of cepstral analysis to speech signals	8	Hrs
Unit III	The Speech Recognition Front End: Feature extraction for speech recognition, Static and dynamic features for speech recognition, robustness issues, discrimination in the feature space, feature selection. Mel frequency cepstral co-efficients (MFCC), Linear prediction cepstral coefficients (LPCC), Perceptual LPCC	10	Hrs
Unit IV	Distance measures for comparing speech patterns : Log spectral distance, cepstral distances, weighted cepstral distances, distances for linear and warped scales. Dynamic Time Warping for Isolated Word Recognition	8	Hrs
Unit V	Statistical models for speech recognition: Vector quantization models and applications in speaker recognition. Gaussian mixture modeling for speaker and speech recognition. Discrete and Continuous Hidden Markov modeling for isolated word and continuous speech recognition.Using the HTK toolkit for building a simple speech recognition system	10	Hrs

Text/References:

1. Digital Processing of Speech Signals, LR Rabiner and RW Schafer, Pearson Education.
2. Discrete-Time Speech Signal Processing: Principles and Practice, Thomas F. Quatieri, Cloth, 816 pp. ISBN: 013242942X Published: OCT 29, 2001.
3. Fundamentals of Speech Recognition, L. Rabiner and B. Juang, Prentice-Hall SignalProcessing Series, Pages: 507, Year of Publication: 1993, ISBN:0-13-015157-2.
4. Speech and Audio Signal Processing: Processing and perception of speech and music B. Gold and N. Morgan, Wiley 2000, ISBN: 0-471-35154-7.
5. Corpus-Based Methods in Language and Speech Processing, Steve Young et. al editors, 234 pages, Kluwer, ISBN 0-7923-4463-4.
6. Discrete Time Processing of Speech Signals, JR Deller, JG Proakis, JH Hansen, Year of Publication: 1993, ISBN:0023283017.
7. Hidden Markov Models for Speech Recognition, XD Huang, Y Ariki, MA Jack, Edinburgh University Press.

EC 9041	MODERN CONTROL ENGG	3-0-0	3
Unit I	Discrete Time Systems: Introduction to discret time systems, the Z transformation:, Solving differential equations by z-transformation methods, the inverse z-transformation, Pulse transfer function, Theorems of the z-transformation, zero order hold, response between sampling instants	6	Hrs
Unit II	Stability Analysis: Introduction, Relation between s-plane z-plane, Stability analysis using JHRY criterion, Stability analysis using bilinear transformation	8	Hrs
Unit III	Time domain analysis of S.D. System: Introduction, Time response of S.D System, Root Loci for digital control systems, Steady state effort analysis of S.D Systems. Frequency domain analysis of S.D Systems, the loci for digital control systems	10	Hrs
Unit IV	The Bode Diagram C.M and P.M, State Space analysis of control systems: Introduction, state space representation of continuous and discrete time systems, Solutions of time invariant and time varying state equation. State transition metric; Relation between state equation and transfer function	8	Hrs
Unit V	Characteristic equation, Eigen values and Eigen vectors. State model form T.F., Controllability: Introduction, Definitions, Theorems on controllability, Observability: Introduction, Definition, Theorems on observability, Control system design: Design of digital control systems with deadbeat response, pole placement design by state feedback, state observer, Design of full and reduced order observer. Introduction to nonlinear control systems: describing function techniques, Phase plane techniques	10	Hrs

Text/References:

1. Digital Control System, Kuo, International Edition, Saunders College Publishing, New York.
2. Digital Control System Analysis and Design, Philips and H T Nagle, PHI
3. Digital Control of Dynamic Systems, Franklin, Addision Wesley, Tokyo

EC 9042	**BIOMEDICAL SIGNAL PROCESSING**	**3-0-0**	**3**
Unit I	Introduction: General measurement and diagnostic system, classification of signals, introduction to biomedical signals, Biomedical signal acquisition and processing, Difficulties in signal acquisition. ECG: ECG signal origin, ECG parameters-QRS detection different techniques, ST segment analysis, Arrhythmia, Arrhythmia analysis, Arrhythmia monitoring system	6	Hrs
Unit II	ECG Data Reduction: Direct data compression Techniques: Turning Point, AZTEC, Cortes, FAN, Transformation Compression Techniques: Karhunen - Loeve Transform, Other data compression Techniques: DPCM, Huffman coding, Data compression Techniques comparison. Signal averaging: Basics of signal averaging, Signal averaging as a digital filter, A typical averager, Software and limitations of signal averaging	8	Hrs
Unit III	Frequency Domain Analysis: Introduction, Spectral analysis, linear filtering, cepstral analysis and homomorphic filtering. Removal of high frequency noise (power line interference), motion artifacts (low frequency) and power line interference in ECG, Time Series Analysis: Introduction, AR models, Estimation of AR parameters by method of least squares and Durbin's algorithm, ARMA models. Spectral modeling and analysis of PCG signals	10	Hrs
Unit IV	Spectral Estimation: Introduction, Blackman- tukey method, The periodogram, Pisarenko's Harmonic decomposition, Prony' method, Evaluation of prosthetic heart valves using PSD techniques. Comparison of the PSD estimation methods. Event Detection and waveform analysis: Need for event detection, Detection of events & waves, Correlation analysis of EEG signals, The matched filter, Detection of the P wave , Identification of heart sounds, Morphological analysis of ECG waves, analysis of activity	8	Hrs
Unit V	Adaptive Filtering: Introduction, General structure of adaptive filters, LMS adaptive filter, adaptive noise cancellation, Cancellation of 60 Hz interference in ECG, cancellation of ECG from EMG signal, Cancellation of maternal ECG in fetal ECG. EEG: EEG signal characteristics, Sleep EEG classification and epilepsy	10	Hrs

Text/References:

1. "Biomedical Signal Analysis" A case study approach, Rangaraj M Rangayyan, John Wiley publications.
2. "Biomedical Signal Processing Time and Frequency Domains Analysis (Volume I)", Arnon Cohen, CRC press.
3. "Biomedical Signal Processing Principles and Techniques" D.C.Reddy, Tata Mc Graw-Hill
4. "Biomedical Digital Signal Processing", Willis J. Tompkins, PHI.

EC 9043	**EMBEDDED SYSTEM DESIGN**	**3-0-0**	**3**
Unit I	Introduction to Microcontrollers and Microprocessors: Basic Architectures of Microcontrollers, Processor Types and Memory Structures, Organization of Data Memory; Instruction Set, Addressing Modes and Port Structure, External Memory Access, Timers, Interrupts, Program Branching Instructions, and Serial Communication	6	Hrs
Unit II	Introduction to Real Time Embedded Systems: Embedded Systems Components, Memory, Digital Signal Processors, General Purpose Processors, Embedded Processors and Memory-Interfacing	8	Hrs
Unit III	Embedded Systems I/O: Interfacing bus, Protocols, Timers, Interrupts, DMA,USB and IrDA, AD and DA Converters, Analog Interfacing	10	Hrs
Unit IV	Design of Embedded Processors: Field Programmable Gate Arrays and Applications, Introduction to Hardware Description Languages, Embedded Communications: Serial, Parallel, Network, Wireless Communication	8	Hrs
Unit V	Embedded System Software and Software Engineering issues: Introduction to Real-Time Systems, Real-Time Task Scheduling, Concepts in Real-Time Operating Systems, Commercial Real-Time Operating Systems, Introduction to Software Engineering, Requirements Analysis and Specification, Modeling Timing Constraints, Software Design	10	Hrs

Text/References:

1. David E Simon, " An embedded software primer ", Pearson education Asia, 2001.
2. John B Peat man " Design with Microcontroller ", Pearson education Asia, 1998.
3. Jonartthan W. Valvano Brooks/cole " Embedded Micro computer Systems. Real time Interfacing ", Thomson learning 2001.
4. Burns, Alan and Wellings, Andy, " Real-Time Systems and Programming Languages ", Second Edition. Harlow: Addison-Wesley-Longman, 1997.
5. Raymond J.A. Bhur and Donald L.Bialey, " An Introduction to real time systems: Design to networking with C/C++ ", Prentice Hall Inc. New Jersey, 1999.
6. Grehan Moore, and Cyliax, " Real time Programming: A guide to 32 Bit Embedded Development. Reading " Addison-Wesley-Longman, 1998.
7. Heath, Steve, " Embedded Systems Design ", Newnes 1997.

EC 9044	**BIO-SENSORS AND BIO MEMS**	**3-0-0**	**3**
Unit I	Approaches to designing electronic systems Sensor classification & sensing principles Introduction to biosensors & bioMS	8	Hrs
Unit II	Semiconductor sensors for physical measurands Physicochemical sensors integrable on silicon.	10	Hrs
Unit III	Biosensors: Structures & device analysis Catalytic biosensors Affinity biosensors	14	Hrs
Unit IV	BioMS: Architectures & analytic models	10	Hrs

Text/References:

1. SM Sze John Wiley, Semiconductor Devices: Physics & Technology` by, India, 2002.
2. RS Muller, RT Howe, SD Senturia, RL Smith and RM White, `Microsensors`, IEEE Press, New York, 1991.
3. Mohamed Gad-el-Hak (R), MEMS handbook` CRC Press, Boca Raton, 2002.
4. Anthony P.F.Turner, Isao Karube and George S. Wilson, `Biosensors :fundamentals and applications` , Oxford University Press, Oxford, 1987.
5. S Middelhoek & SA Audet , `Silicon sensors`, Academic Press Limited,London,1989.
6. A Sandana. `Engineering biosensors: kinetics and design applications`, Academic Press, San Diego, 2002.
7. D Voet & JG Voet , `Biochemistry`, J Wiley & Sons, New York, 1990.

EC-9045	**MODERN DIGITAL COMMUNICATION TECHNIQUES**	**3-0-0**	**3**
Unit I	Analog-to-Digital Conversion: Sampling theorem, Pulse-Amplitude Modulation, Channel bandwidth for PAM signal, Natural sampling, Flat top sampling, Quantization of signals, Quantization error, Pulse-code modulation (PCM), Electrical representation of binary digits, The PCM system, Companding, Multiplexing PCM signals, Differential PCM, Delta modulation, Adaptive delta modulation, Vocoders, Channel Vocoder, Linear Predictive coder.	8	Hrs
Unit II	Digital Modulation Techniques: Binary Phase-Shift Keying (BPSK), Differential Phase-Shift Keying, Differentially-Encoded PSK (DEPSK), Quadrature Phase-Shift Keying (QPSK), Quadrature Amplitude Shift Keying (QASK), Binary Frequency-Shift Keying (BFSK), Similarity of BPSK and BFSK, M-ary FSK, Minimum Shift Keying (MSK).	12	Hrs
Unit III	Data Transmission: A base band signal receiver, Probability of error, The Optimum Filter, Matched Filter, Probability of error in Matched filter, Coherent reception, Coherent reception of PSK and FSK, Non-Coherent reception of FSK, PSK and QPSK, Calculation of error probability of BPSK and BFSK, Error probability for QPSK] Bit-by-bit encoding versus Symbol-by-Symbol encoding, Relationship between Bit error rate and Symbol Error rate and comparison of modulation systems.	12	Hrs
Unit IV	Information Theory and Coding: Discrete messages, The concept of amount of information, Entropy, Information rate, Coding to increase average information per bit, Shannon's theorem, Capacity of a Gaussian channel, Bandwidth-S/N tradeoff, use of orthogonal signals to attain Shannon's limit, Efficiency of orthogonal signal transmission, Coding: Parity check bit coding for error detection, Coding for error detection and error correction, Block codes (coding and decoding), Convolution codes (coding and decoding), Comparison of error rates in coded and uncoded transmission.	10	Hrs

Text/References:

1. Wayne Tomasi, "Electronic communications systems" 5th edition Pearson Educaion Asia, 2006
2. Taub and Schilling, "Principles of Communication Systems", TMH, IInd Edition, 2006
3. S. Haykin, "Digital Communication", Wiley, 2006.
4. S. Haykin, "Analog and Digital Communication", Wiley.

EC-9046	**SEMICONDUCTOR DEVICE MODELLING**	**3-0-0**	**3**
Unit I	Concentration and motion of carriers in Semiconductor bulk Equilibrium concentration in intrinsic and extrinsic semiconductors, Excess carriers, Drift and Diffusion transport, continuity equation. Concentration and motion of carriers at the interfaceSurface recombination, surface mobility etc	7	Hrs
Unit II	Device ModelingBasic equations for device analysis, approximation to these equations for deriving analytical expressions	9	Hrs
Unit III	PN Homojunctionideal static IV characteristics and deviations including breakdown, ac small signal equivalent circuit, switching characteristics. MIS Junction/capacitorideal CV characteristics and deviations due to interface states/charges and work function differences, threshold voltage.	14	Hrs
Unit IV	BJTTransistor action, Static Characteristics, ac small signal equivalent circuit, switching characteristics. FETsField effect, types of transistors (JFET, MESFET, MISFET, MOSFET), Static characteristics of MISFET and MOSFET, small signal equivalent circuit, difference between BJT and FETS.	10	Hrs

Text/References:

1. Physics of Semiconductor Devices, Simon M. Sze and Kwok K. Ng,2006
2. E.S. Yang, Microelectronic Devices, McGraw Hill, Singapore, 1988.
3. B.G. Streetman, Solid State Electronic Devices, Prentice Hall of India, New Delhi,
4. Semiconductor Device Modeling,Giuseppe Massobrio and Paolo Antognetti

EC-9047	**WIRELESS COMMUNICATION**	**3-0-0**	**3**
Unit I	Introduction to Wireless Communication Systems – evolution of mobile radio communications, mobile radio systems around the world, radio communication systems – paging systems, cordless telephone systems, cellular telephone systems; comparison of common wireless communications, trends in cellular radio and personal communication, second generation (2G) cellular networks, third generation (3G) wireless networks, Introduction to 4G, introduction to radio wave propagation, free space propagation model.	10	Hrs
Unit II	Basics of mobile communication – Limitations of conventional mobile system, mobile cellular communication – introduction, concept of frequency reuse, cluster size, cellular system architecture – mobile station, base station, MSC, channel assignment strategies, call handover strategies, interference and system capacity, improving capacity in cellular systems – cell splitting, sectoring, repeaters, microcell, zone concept.	10	Hrs
Unit III	Global system for mobile communication, GSM services and features, system architecture, GSM radio subsystem, GSM channel types, location updating and call setup, introduction to CDMA digital cellular standard, comparison between GSM and CDMA	12	Hrs
Unit IV	Wireless networking – wireless local area network standards, technology – RF and IR wireless IT – LAN, diffuse, quasi-diffuse and point-to-point IR wireless LAN, advantages and applications of Wireless LAN, introduction to WI-FI, Bluetooth	10	Hrs

Text/References:

1. Wireless communication principles and practice, 2nd Ed, Theodore S Rapaport, Pearson Education.
2. Wireless communication, 1st Edition, Andrea Goldsmith, Cambridge
3. Fundamentals of Wireless Communication, 1st Edition by David Tse, Cambridge

EC-9048	**CMOS MIXED SIGNAL CIRCUITS**	**3-0-0**	**3**
Unit I	Analog and discrete-time signal processing, Analog integrated continuous-time and discrete-time (switched-capacitor) filters	9	Hrs
Unit II	Basics of Digital to analog converters (DAC). DACs. Voltage, current, and charge scaling DACs, Cyclic DAC, Pipeline DAC.	7	Hrs
Unit III	Basics of Analog to digital converters (ADC). Successive approximation ADCs. Dual slope ADCs. High-speed ADCs (e.g. flash ADC, pipeline ADC and related architectures).High-resolution ADCs (e.g. delta-sigma converters)	14	Hrs
Unit IV	Mixed-Signal layout. Interconnects. Phase locked loops, Delay locked loops and their applications.	10	Hrs

Text/References:

1. CMOS mixed-signal circuit design by R. Jacob Baker Wiley India, IEEE press, reprint 2008.
2. CMOS circuit design, layout and simulation by R. Jacob Baker Revised second edition, IEEE press.
3. Design of analog CMOS integrated circuits by Behad Razavi McGraw-Hill, 2003.

EC 9049	**ENGINEERING RESEARCH METHODOLOGY**	**4-0-0**
Unit I	Research Preparation and Planning: Objectives of research – research and its goals. Critical thinking. Techniques for generating research topics. Topic selection and justification. Development of a research proposal – Theoretical and Experimental Processes.	8
Unit II	Research Resources: Sources of information. Literature search. World Wide Web, Online data bases – search tools. Citation indices - Principles underlying impact factor – literature review – Case studies, review articles and Meta-analysis – record of research review - Role of the librarian. Ethical and Moral Issues in Research, Plagiarism, tools to avoid plagiarism – Intellectual Property Rights – Copy right laws – Patent rights.	10
Unit III	Academic Writing and Presentation: Proposal submission for funding agencies, Elements of Style. Organization of proposals, Basic knowledge of funding agencies, Research report writing, Communication skills, Tailoring the presentation to the target audience – Oral presentations, Poster preparations, Submission of research articles for Publication to Reputed journals, Thesis writing, and Research report writing. Elements of excellent presentation: Preparation, Visual and Delivery. Oral Communication skills and Oral defense.	12
Unit IV	Data Collection, Analysis and Inference: Basic Statistical Distributions and their applications - Binomial, Poisson, Normal, Exponential, Weibull and Geometric Distributions. Sample size determination & sampling Techniques-Random sampling, stratified sampling, systematic sampling and cluster sampling. Large Sample Tests and Small Sample Tests-Student–t-test, F-test and χ 2 test and their applications in research studies. Correlation and Regression Analysis-Time series Analysis-Forecasting methods. Factor analysis, Cluster Analysis and Discriminant Analysis. Principles of Experimentation, Basic Experimental Designs: Completely Randomized Design Randomized Block Design and Latin Square Design. Factorial Designs: 22 , 23 and 24 – Accuracy, Precision and error analysis.	12
Unit V	Mathematical Modelling: Basic concepts of modeling of Engineering systems – static and dynamic model – Model for prediction and its limitations. System simulation -- validation. Use of optimization techniques – Genetic Algorithm, Simulated Annealing, Particle Swarm Optimization.	14

Text/References:

1. Research Methodology for Engineers, Ganesan R, MJP Publishers, Chennai.
2. Probability & Statistics for Engineers and Scientists,Walpole R.A., Myers R.H., Myers S.L. and Ye, King: Pearson Prentice Hall, Pearson Education.
3. Thesis and assignment writing, Anderson B.H., Dursaton, and Poole M., Wiley Eastern.
4. How to write and illustrate scientific papers?, Bijorn Gustavii, Cambridge University Press.
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