UG Syllabus

Department of E.T.C.E

Jadavpur University

Second Year First Semester

Subject Code	Subject Name	Category	Type	Contact	Credit	Marks
ET/PC/B/T/211	ELECTROMAGNETIC THEORY	PC	Basic	3+0+0	3	100
ET/PC/B/T/212	CIRCUIT ANALYSIS AND SYNTHESIS	PC	Basic	3+1+0	4	100
ET/PC/B/T/213	SIGNALS AND SYSTEMS	PC	Basic	3+1+0	4	100
ET/PC/B/T/214	DIGITAL LOGIC CIRCUITS	PC	Basic	3+1+0	4	100
ET/PC/B/T/215	ANALOG CIRCUITS – I	PC	Basic	3+1+0	4	100
ET/BS/B/T/216	MATHEMATICS - III	BS	Basic	3+0+0	3	100
ET/PC/B/S/211	ANALOG CIRCUITS - I LAB	PC	Basic	0+0+3	1.5	100
ET/PC/B/S/212	DIGITAL CIRCUITS - I LAB	PC	Basic	0+0+3	1.5	100
ET/PC/B/S/213	CIRCUIT THEORY LAB	PC	Basic	0+0+3	1.5	100
ET/PC/B/S/214	SEMICONDUCTOR MATERIAL AND DEVICE LAB	PC	Basic	0+0+3	1.5	100
					28	**1000**

ET/PC/B/T/211 ELECTROMAGNETIC THEORY 3 Periods/Week Credit 3

- Physical interpretation of differential vector operations: Green's theorem, divergence & Stroke's theorem.
- Electrostatics: Gauss law, electric potential, Laplace's & Poisson's equation, boundary value problems, method of images, energy storage in electric field.
- Magnetostatics, Faraday's law, Ampere's law, dielectric & magnetic media, magnetic vector potential, relationship between ES& MS fields.
- Equation of continuity for steady & time varying currents, Maxwell's law, displacement current & displacement current density.
- Wave equation: phasor concept for time harmonic fields, plane waves in simple media &lossy media, homogeneity, isotropy and anisotropy.
- Polarization, reflection, refraction, diffraction and scattering at different interfaces, Brewster's' angle, total internal reflection.
- Poynting Theorem -general & complex, power & power density, magnetic current concept.
- Hertz potentials, equivalence of electric & magnetic sources. Lorentz reciprocity theorem.

Text/Reference Books:

1. Jordan, Electromagnetic Waves and Radiating Systems.
2. Griffith, Electromagnetic Theory.
3. Harrington, Electromagnetic Theory.
4. Ryder, Networks Lines & Fields.

ET/PC/B/T/212 CIRCUIT ANALYSIS and SYNTHESIS 4 Periods/Week Credit 4

(a) Circuit Analysis

- **Graph theory:** Graph of a network, Incidence matrix, concepts of path, cycle and tree, spanning tree, independent loops, cut set - cut set matrix, applications of graph theory in solving network equations.
- **Circuit elements:** Passive circuit elements and their equilibrium equation, independent voltage and current sources, controlled sources, coupled circuits and their controlled source representa- tions.
- **Methods of Analysis:** Topological description of network; Network variables; Source transfor- mation technique; Mesh and Node analyses; Dual and Inverse networks.
- **Circuit equations:**Kirchoff's laws, formation of node equations, formation of loop Equation.
- **Transient & Steady-State Analysis:** Laplace transformation and Fourier transform and their comparison; Transient response in RL, RC and RLC circuits; Network equations and solutions using Laplace transform, initial conditions. Fourier analysis for periodic signals; Fourier trans- form, Steady- state response - Amplitude and Phasespectra, resonance.
- **Network Functions:** Driving point function, transfer function, concepts of poles and zeros. Impulse response and convolution. Bode plots.
- **Network Transformations & Network theorems:** Network configurations; Transformation to Equivalent T and PI networks: T - PI transformation; Source transformation, Theorems - superposition and reciprocity theorem, Thevenin's and Norton's theorem, maximum power transfer theorem, Tellegen's theorem; Inductive Coupling - Identification of relative polarities, Lineartransformer; tuned transformers.
- **Passive two port network:** different representation schemes, image impedance parameters, characteristic impedance and propagation constant, open circuit voltage transfer function.

(b) Circuit Synthesis

- **Positive Real function:** Definition; Properties; Testing of positive Hurwitz polynomial, driving point functions of a passive one port.
- **Passive Network Synthesis:** Poles and zeros, Foster's reactance theorem, Foster and Cauer forms of LC Networks, Synthesis of RC and RL networks Foster and CauerCanonicforms. Synthesis of RLC networks.
- **Two-Port Networks:** z parameter, y parameter, transmission matrix, ABCD matrix, and h parameters; Interconnection of two port network, Characteristic impedance and propagation function; Balanced and unbalanced networks; Bartlett's bisection theorem and its applications; Gyrator, Nullator, Salankey network, quad, biquad, Negative Impedance Converter.
- **Filters:** Low-pass, High-pass, Band-pass and Band-elimination filters; Different types of constant- k and m-derived filters. Composite filter design; Design of Butterworth and Chebyshev filters; Active filter analysis and synthesis using operational amplifier.

Text/Reference Books:

1.Network Analysis: M E VanValkenburg, Prentice Hall India.
2.Network Analysis and Synthesis: U. A. Patel ,Mahajan Publishing House.
3. Network Analysis with Applications: William D. Stanley, Pearson Education (I) Ltd. 4. Network Analysis and Synthesis: Franklin F. Kuo, Wiley India.
5. Basic Circuit Theory: Charles A. Desoer and Ernest S. Kuh, TataMcGrawhill.
6. Basic Circuit Theory: Lawrance P. Huelman, Prentice Hall of India.
7. Networks and Systems: D. Roy Chowdhuary, New Age International (P) Limited, Publishers
8. Circuits & Networks Analysis &Synthesis:ASudhakar
9. Fundamentals of Electric Circuit Theory: D. Chattopadhyay and P. C. Rakshit, S. Chand, 9th Edition (Revised), New Delhi, 2011.

ET/PC/B/T/213 SIGNALS AND SYSTEMS 4 Periods/Week Credit 4

- **Introduction, signal definition, different type of signals:**Analog and digital signals, continuous time and discrete time signals, periodic and aperiodic signals, energy and power signals, deterministic and non-deterministic signals, signals and vector analogy, orthogonality of signal functions, some useful signal operations.
- **Basis function and concept of generalized Fourier series:** different forms, Fourier series of some useful functions, Fourier transform, inverse Fourier transforms, some properties of Fourier trans- form, transform of some useful functions, convolution and correlation in time domain and frequency domain. Perseval's theorem, energy spectral density, essential bandwidth of a signal, time autocorre- lation function and the energy spectral density, power spectral density, time autocorrelation function of power signals, Input and output power spectral densities.
- **Sampling theorem:** Sampling and re-construction of signals, practical difficulties in signal reconstruction, Aliasing, different types of sampling, some applications of the sampling theorem.
- **Discrete time signals and systems:** some elementary discrete time signals, classification of discrete time signals, some useful signal operations, Discrete time systems: input-output description of discrete time system, block diagram representation, classification of discrete time systems, interconnection of discrete time systems, convolution sum, properties of convolution and the interconnection of LTI systems.
- **Some statistical terms:** random variable, random process, ensemble, sample function, time aver- age, ensemble average, stationary and ergodic process, correlation between two random variables, probability distribution function.
- **Sources of noise:** atmospheric noise, solar noise, cosmic noise, industrial noise, thermal noise, shot noise, transit-time noise, flicker noise.
- **Noise calculations:** resistor noise, multiple-resistor noise sources, signal-to-noise ratio, noise figure, noise temperature, calculation of noise due to several amplifiers in cascade, calculation of noise figure and equivalent noise temperature of a cascade.
- **Mathematical representation of noise**: frequency domain representation of noise, spectral components of noise, effect of a filter on the power spectral density of noise, linear filtering-RC low-pass filter, rectangular low-pass filter, rectangular band-pass filter, differentiating filter, integrator, noise bandwidth, quadrature components of noise, concept of additive white Gaussian noise channel.
- Familiarization with MATLAB tools for signal analysis.

Text/Reference Books:

1. Principles of Signal Processing and Linear Systems-B.P. Lathi
2. Signals and Systems-Simon Haykin and Barry Van Veen
3. Signals and Systems-Alan V. Oppenheim, Alan S. Willsky
4. Signals and Systems-Schaum's Outlines
5. Digital Signal Processing: Principles, Algorithms and Applications- Proakis and Manolakis
6. Communication Systems-Taub Schilling

ET/PC/B/T/214DIGITAL LOGIC CIRCUITS 4 Periods/Week Credit 4

- **Number systems and Codes:** Decimal, binary, octal and hexadecimal systems, conversion from one base to another. BCD, excess- 3, gray reflected ASCII, EBCDIC.
- **Algebra for logic circuits :** Logic variables, logic constants, Logic functions- NOT, AND, OR, NAND, NOR, Ex-OR, boolean algebra (including Shannon's expansion theorem and consensus theorem), canonical representations-minterm, maxterm, Karnaugh map simplification, Quin-Maclusky minimization.
- **Combinational circuits :** Analysis and synthesis of combinational circuits, multiplexer, de-multiplexer, encoder, decoder, code-converter, adder, subtractor, comparator, parity generator/checker, priority en- coder.
- **Sequential Circuits:**Flip-flops- SR, JK, D and T. Registers- buffer registers, shift registers etc..Counters- asynchronous and synchronous counters.

- **Interface circuits:**Digital to analog converter (DAC) - weighted resistor method, R-2R ladder method; Analog to Digital converter (ADC) - parallel comparator method, counter method, successive approximation method, dual-slope method.
- **Families of logic circuits**-DL,RTL,DTL, TTL,ECL,I^2L,MOS(PMOS,NMOS,CMOS).

Text/Reference Books:

1. Digital Design by Morris Mano, Pearson Education
2. Digital Principles and Applications by Malvino and Leach, McGraw Hill

ET/PC/B/T/215 ANALOG CIRCUIT-I4 Periods/Week Credit 4

- **Introduction to Electronic Circuits**
- **Diode & wave shaping circuits:** Different rectifier circuits, ripple factor, efficiency, TUF, PIV, power supply filters, clipper and clamper circuits, peak detector, voltage multiplier. RC filter response for non-sinusoidal signals, compensated attenuator.
- **BJT circuits:** Biasing and stability analysis: fixed bias, collector to base feedback bias, emitter bias, voltage divider bias, transistor as a switch,
  (a) ACanalysis:modeling(re,hybridequivalent,andhybridmodels),expressionsforinputimpedance, output impedance, voltage gain, current gain for different configurations including emitter fol- lower with different biasing circuits, DC bias with voltage negative feedback, effects of source and load resistance, two-port system approach- combination networks: Darlington pair, cascade and cascode configurations, current mirror circuits.
  (b) Frequencyresponse:Lowfrequencyandhighfrequencyresponse,Millereffect,briefoverview on multistage amplifier, frequency effects and square wave testing. Design application and SPICE Simulation.
- **FET circuits:** Biasing: fixed bias, self-bias, voltage divider bias, common drain, common gate con- figurations, AC analysis: Modeling (small signal model), expressions for input impedance, output impedance, voltage gain for different configurations like fixed bias, self-bias, voltage divider bias, common drain, common gate configurations Frequency response: low frequency and high frequency response, Miller effect . Design application and SPICE Simulation.
- **OPAMP circuits:** Basics, differential amplifier circuit, concept of open loop and closed loop gain, DC offset and frequency parameters, slew rate, differential and common mode operation , applica- tions: inverting and non-inverting amplifier, transresistance amplifier, transconductance amplifier, log and antilog amplifier, adder, subtractor, multiplier, divider, buffer, differentiator and integrator, active filters, Equation solver, Schmitt trigger and multivibrators, rectifier clipper and clamper circuits, peak detector.
- **Regulated Power Supply:** Voltage regulation, Zener diode & IC regulator, regulation factor, filter circuit's discrete transistor voltage regulation (series and shunt), switching regulators, switch mode power supply.

Text/Reference Books:

1. J. Millman, C. Halkias and S. Jit, "Electronic Devices and Cicuits", Tata McGraw-Hill, 4th edition, 2015.
2. Adel S. Sedra and Kenneth C. Smith, "Microelectronic Circuits-Theory and applications", seventh Edition , 2017
3. Ramakant A. Gayakwad, "Op-amps and Linear Integrated Circuits", Prentice Hall, 4th Edn

Reference Books

1. D. A. Neaman, "Electronic Circuits: Analysis And Design", 3rd Edition", Tata McGraw-Hill, 2010
2. Donald Schilling and Charles Belove, "Electronic Circuits: Discrete & Integrated", Tata McGraw- Hill Education 2002
3. Robert L. Boylestad, Louis Nashelsky, "Electronic Devices and Circuit Theory " Pearson; 10 edition 2009

ET/BS/B/T/216 MATHEMATICS-III 3 Periods/Week Credit 3

- **Vector Calculus** : Gradient, divergence, curl, vector integration, line integrals, surface integrals and volume integrals, Greens theorem, Gauss theorem, Stokes' Theorem, Tangent Normal and Binormal of space Curve, Serret-Frenet formulae, Normal plane, Rectifying plane and oscillating plane. Introduction to system of vector differential equations - Maxwell's Equation 9L

- **Probability and Stochastic Process** :Probability, Mutually Exclusive Events, Joint Probability of Related and Independent events, Random Variables (RV), Cumulative distribution (CD) function, Probability Density function(PDF) Relation between probability and probability density, Joint CD and PD, Average value of RV, Variance of RV, Mean and Variance of sum of Rv, PD of sum of RV, Correlation between RVs, Central Limit Theorem, Tchebyheff's Inequality, Probability distributions : Binomial, Poisson, Exponential, Gaussian, Error function, Complimentary error function, Chi- square, Rician, Fermian, Rayleigh and Gamma distribution, Random process, Autocorrelation and Power Spectral Density, Physical interpretation of them, Markov Chain and transition probability, Markovian query models. 11L
- **Complex Analysis** :Concepts of poles and residues, Cauchy's residue theorem, Schwarz-Christoffel transformation, Contour Integration, Conformal Mapping. 4L
- **Introduction to Analysis** :Totally and Partially Ordered Relations, Lattice Theory, Elements of Group Theory 4L
- **Matrices** : Matrix polynomial, Matrix differentiation
- **ODEs :** Second and Higher Order linear differential Equation of constant coefficients 2L
- **PDEs :** Partial Differential Equations and their solutions. Solution of 1-D wave and diffusion equation, Laplace equation of two dimensions.
- **Special Functions** : Bessel and Legendre functions.

Text/Reference Books:

1. Statistical Methods by N.G.Das
2. Probability and Statistics by Arup Mukherjee
3.Probability and Statistics by Banerjee, Dey and Sen
4.Mathematical Statistics by Dey and Sen
5.Vector Analysis by Murray R. Spiegel
6.Theory of Functions of a Complex Variable by E.T. Copson
7. Mathematical Methods for Physicists by Arfken and Weber

ET/PC/B/S/211 ANALOG CIRCUITS- ILAB 3 Periods/Week Credit 1.5

1. Full wave rectifier circuit with and without capacitor filter
2. Clipper and clamper circuits using pn junction diodes
3. Linear voltage regulator circuits using BJT
4. Different biasing schemes of transistors and to study their relative advantages
5. Measurement of (a) Frequency response (b) input and output impedances of CE amplifier (voltage divider bias with RE)
6. (a)Measurement of voltage gain, current gain input and output impedances of Emitter Follower
   (b) Modificationofthecircuitusingdifferentbiasingtechniquestoimproveitsimpedancecharacteristics.
7 (a) Inverting amplifier, non-inverting amplifier, adder, buffer using OPAMP
   (b) Measurement of Slew rate and open loop gain of OPAMP.
8. Differential amplifier, Instrumentation amplifier, differentiator, integrator
9. Schmitt Trigger and multi-vibrators using OPAMP

ET/PC/B/S/212 DIGITAL CIRCUITS-I LAB3 Periods/Week Credit 1.5

1. Familiarization with the experimental board and IC tester.
2. Truth table verification of SSI gates.
3. Logic function realization using SSI gates.
4. On multiplexers.
5. On demultiplexers / decoders.
6. On comparators.
7. On parity checkers/generators.
8. On flip-flops.
9. On registers.
10. On counters.
11. Experiments on DAC, ADC

ET/PC/B/S/213CIRCUITTHEORY LAB3 Periods/Week Credit 1.5

1. Study on the transient response characteristics of an RC series network.
2. Study on the transient response characteristics of an RC parallel network.
3. Study on series resonance circuit
4. Study on parallel resonance characteristics
5. Frequency response characteristics of passive RC networks.
6. Study on Thevenin's theorem.
7. Study on maximum power transfer theorem
8. Determination of two port parameters of a resistive two port.
9. Familiarity with controlled sources
10. Application of voltage controlled current sources - Gyrator
11. Determination of Thevenin's equivalent circuit of a network containing controlled source. 12. Study on Reciprocity theorem.
13. Study on Superposition theorem.
14. Study on Tellegen's theorem.

ET/PC/B/S/214SEMICONDUCTOR MATERIAL AND DEVICELAB 3 Periods/Week Credit 1.5

1. Study of various crystal structure
2. Measurement of resistivity of semiconductor by four probe method
3. Study of Hall Effect
4. Study of p-n junction
5.I-V characteristics of metal-semiconductor junction
6.I-V characteristics of LED
7.I-V characteristics of UJT
8.Input and output characteristics of BJT in CE configuration.
9. Output and transfer characteristics of JFET in CS configuration.
10. Output and transfer characteristics of MOSFET in CS configuration

Second Year Second Semester

Subject Code	Subject Name	Category	Type	Contact	Credit	Marks
ET/PC/B/T/221	Analog Circuits – II	PC	Basic	3+0+0	3	100
ET/PC/B/T/222	Digital Circuits and Systems	PC	Basic	3+1+0	4	100
ET/PC/B/T/223	Analog Communication Systems	PC	Basic	3+1+0	4	100
ET/PC/B/T/224	Transmission Lines and Waveguides	PC	Basic	3+1+0	4	100
ET/PC/B/T/225	Data Structures and Algorithms	PC	Basic	3+0+0	3	100
ET/PC/B/S/221	Analog Circuits - II Lab	PC	Basic	0+0+3	1.5	100
ET/PC/B/S/222	Digital Circuits - II Lab	PC	Basic	0+0+3	1.5	100
ET/PC/B/S/223	Analog Communication Lab	PC	Basic	0+0+3	1.5	100
ET/PC/B/S/224	Data Structures Lab	PC	Basic	0+0+3	1.5	100
					24	**900**

ET/PC/B/T/221 ANALOG CIRCUITS-II3 Periods/Week Credit 3

- **Multistage amplifiers**:Cascaded BJT and FET amplifiers, frequency response of R-C coupled multi- stage amplifier. (3L + 1T)
- **Power amplifiers:** Analysis and design of class A, class B, class AB, class C, class D amplifiers. Design of heat sink, IC power amplifiers.(5L + 2T)
- Feedback concepts, connection types, practical circuits, phase and frequency considerations. (2L + 1T)
- Tuned amplifiers, bandwidth consideration of tuned amplifiers, analysis of single and double tuned amplifiers, stagger tuning, Butter worth and Chebyshev response. (5L + 1T)
- Waveform generator, oscillation criteria and oscillator circuits. Blocking oscillator, relaxation oscillator, multivibrators, their classification and implementation using BJT, OPAMP and 555 timers, 555 timer as variable duty cycle square wave generator, variable frequency LC and RC sine wave oscillators, Phase shift oscillator ,Wien-bridge oscillator, Colpitts oscillator, Hartley oscillator and Clapp oscillator and crystal oscillators. Linear time base circuits, PLL-architecture and applications, VCO architecture and applications, synchronization and frequency division circuits. Bandwidth improvement with current feedback due to absence of Miller effect, the current mirror, current copier, current differentiating amplifier, and their applications, Widlar circuits. (10L + 3T)

Text Books:

1. J. Millman, C. Halkias and S. Jit, ”Electronic Devices and Circuits”, Tata McGraw-Hill, 4th edition, 2015.
2. Adel S. Sedra and Kenneth C. Smith, ”Microelectronic Circuits-Theory and applications”, seventh Edition , 2017
3. Thomas L. Floyd, David M. Buchla, ”Fundamentals of Analog Circuits”, Pearson, 2nd Edn

Reference Books

1. D. A. Neaman, ”Electronic Circuits: Analysis And Design”, 3rd Edition”, Tata McGraw-Hill, 2010
2. Donald Schilling and Charles Belove, ”Electronic Circuits: Discrete & Integrated”, Tata McGraw- Hill Education 2002
3. Robert L. Boylestad, Louis Nashelsky, ”Electronic Devices and Circuit Theory ” Pearson; 10 edition 2009

ET/PC/B/T/222 DIGITAL CIRCUITS AND SYSTEMS4 Periods/Week Credit 4

- **Analysis and synthesis of sequential circuits:** Basic models of sequential M/C, analysis of asyn- chronous and synchronous circuits, synthesis of completely and incompletely specified synchronous sequential M/Cs.
- **Fault detection and location in combinational circuits:** Fault detection and location, classical methods, path sensitizing method, equivalent-normal-Form method, two level circuit fault detection, multi-level-circuit fault detection, boolean difference method, SPOOF method.
- **Digital system design:** Hardware programming language (HPL), application of HPL in designing data unit and control unit of a digital system.
- **Timing circuits:** Timing circuits using gates, 74121 mono shot, re-triggerable mono shot- 74122, 74123.
- **Arithmetic circuits:** Fixed-point and floating-point representation of data, serial and parallel Addi- tion(CLA), subtraction, multiplication and division algorithms (add & shift & Booths' algorithm) and their circuit implementation and division for fixed-point signed magnitude data, fixed-point binary data in signed 2's complement representation, floating-point binary data and binary coded decimal (BCD) data.
- **Semiconductor Memory:** Read Only Memory (ROM) - PROM, EPROM, EEPROM, random access memory (RAM)-static, dynamic, memory characteristics, memory organization and applications.
- Digital system design using FPGA & CPLD.

Text/Reference Books:

1. Digital Electronics and Logic design .B. Somanthan Nair ,PHI
2. Digital Fundamental, UBS ,New Delhi , T. Floyd
3. Digital Electronics: An Introduction to Theory and Practice PHI,W.MGothmann.
4. Introduction to theory and logical Design :Wiley.J. Hill and G. Peterson.
5. Switching and Finite Automata Theory : TMH.Z. Kohavi.

ET/PC/B/T/223 ANALOG COMMUNICATION SYSTEMS4Periods/Week Credit 4

- Introduction to basic elements of communication systems.

- **Signal transmission through linear systems:** condition for distortion less transmission of signals through networks. Different types of distortion and their effect on the quality of output signals, transmission of transient signals, distortion analysis.

- **Amplitude modulation:** Modulation principle and definitions, sideband and carrier power, gener- ation of AM signal, demodulation of AM signal. Different type of modulator circuits, square law modulator, balanced modulator, etc.. Demodulator basic principle of coherent detections, square law detectors, average envelope and peak envelope detectors. quadrature amplitude modulation (QAM), amplitude modulation: single sideband (SSB), generation of SSB signals, selective filtering method, phase shift method, demodulation of SSB-SC signals, envelop detection of SSB signals with a car- rier (SSB+C), amplitude modulation: vestigial sideband (VSB), envelop detection of VSB+C signals, noise in AM receivers using envelope detection, concept of SNR.

- **Frequency and phase modulation:** principles and definitions, relationship between frequency and phase modulations. phase and frequency deviations, spectrum of FM signal, bandwidth considera- tions. Effect of modulation index on bandwidth, narrow band and sideband FM and PM principles, circuit for realization of FM and PM. Demodulation Principle of demodulation: different type of demodulator, discriminator, use of PLL etc.

- **Radio transmitter:** Basic block diagram of radio transmitter (AM and FM), Analysis of a practical circuit diagram used for medium power transmitter. Radio receiver Basic block diagram of TRF, superheterodyne principle, its advantages, Mixer principle and circuit, AVC, Radio receiver measure- ment. System noise calculation Signal to noise ratio of SSB, DSB, AM for coherent and envelope and square law detection, threshold effect. Signal to noise calculation for FM and threshold.

Text/Reference Books:

1. Modern Digital and Analog Communication Systems - B.P Lathi, Zhi Ding
2. Communication Systems - Simon Haykin
3. Principles of Communication Systems- Taub, Schilling

ET/PC/B/T/224 TRANSMISSION LINES AND WAVEGUIDES 4 Periods/Week

Credit 4

- Circuit representation of transmission lines, transients in a transmission line, sinusoidal excitation of trans-mission lines, distinction between distributed and lumped constant systems
- Discussions on line parameters, characteristic impedance. complex propagation constant, distortions in transmission lines, terminated trans- mission line, coaxial line.
- Impedance transformation, smith chart, impedance matching and two-port network analysis. Introduction to scattering matrix in transmission line analysis.
- Theory of guided waves parallel plate waveguide, NRD guide, rectangular waveguides. solutions of wave equations in rectangular coordinates. TE and TM modes in rectangular waveguide. Power transmission and losses in rectangular waveguide. Excitation of modes in rectangular waveguide, characteristics of standard rectangular waveguide.
- Circular waveguide, solutions of wave equations in cylindrical coordinates. TE and TM modes in circular waveguides, power transmission and losses in circular waveguide, excitation of modes in circular waveguide, characteristics of standard circular waveguide.
- Introduction to different planar transmission lines, microstrip line, strip line, characteristics of microstrip line, modes in Microstrip line. CPW line.

Text/Reference Books:

1. Pozar, Microwave Engineering.
2. Collin, Foundations for Microwave Engineering.
3. Samuel V. Liao, Microwave Devices and Circuits.
4. Peter A. Rizzi, Microwave Engineering Passive Circuit.

ET/PC/B/T/225DATA STRUCTURES AND ALGORITHMS 3 Periods/Week Credit 3

- **Data Structures** - Arrays and Linked Lists,Stacks and Queues, Trees – Binary trees, Pre-order, Post-order and In-order Traversals, Height-balanced trees – AVL Rotation, Red-Black Trees, Splay Trees, Graphs – Basic definitions
- **Time-complexity analysis** - Growth of functions, Solving Recurrence Relations using Substitution Method, Recurrence Trees and Master Method
- **AlgorithmsI** –Various Sorting and Searching methods
- **Algorithms II** -Dynamic Programming and Greedy Algorithms
- **Algorithms III -** Graph Algorithms – Breadth-First-Search (BFS), Depth-First-Search (DFS), Topological sorting – Minimum spanning trees (Kruskal and Prim's algorithms) – Shortest Paths (Dijkstra, Bellman-Ford and Floyd-Warshall algorithms) – Maximum-Flow Minimum-Cut (Ford-Fulkerson algorithm)
- **Idea of NP-Completeness**

Text/Reference Books:

1. Data Structures using C and C++ by Y. Langsam, M. J. Augenstein, A.M. Tanenbaum, Prentice Hall of India
2. Classic Data Structures by D. Samanta, Prentice Hall of India
3. Data Structures by S. Lipschutz, Tata McGraw Hill
4. Introduction to Algorithms by T.H. Cormen, C.E. Leiserson, R.L. Rivest and C. Stein, Prentice Hall of India

ET/PC/B/S/221 ANALOG CIRCUITS-II Lab3 Periods/Week Credit 1.5

1. Design a cascaded two stage RC coupled CE amplifier for a fixed gain and study it's a) Frequency response and b) input and output impedances .
2. Design a cascaded RC coupled CC CE amplifier for a fixed gain to achieve high input impedance and study it's a) Frequency response and b) input and output impedances .
3. Design and study of Low pass and high pass active filters using OPAMP
4. Design and study Wien Bridge oscillator for a given frequency of oscillation using OPAMP
5. Design and study RC Phase Shift oscillator for a given frequency of oscillation using OPAMP
6. Monostable timer, Astable timer, VCO using OPAMP
7. Monostable timer, Astable timer, VCO using 555 timer
8. Astable multi-vibrators and VCO using BJT /IC
9. Monostable multi-vibrators using BJT

ET/PC/B/S/222DIGITAL CIRCUITS-II Lab3 Periods/Week Credit 1.5

1. Experiment on Moore and Mealy Machine.
2. Experiment on sequence detectors (overlapping and non-overlapping modes).
3. Experiment on fault detection experiment in digital circuits.
4. Experiment on fault location determination experiments (single level and multiple-level fault).
5. Experiment on decoders (BCD to decimal using IC 7447).
6. Experiment on adder and subtractor.
7. Experiment on twos complements binary adder/subtractor.
8. Experiment on 64 bit read/write memory using IC74189.
9. Experiment on multivibrators using universal gates.
10. Experiment on monostablemultivibrator using ic 74121.
11. Experiment on astablemultivibrator using IC 74123.
12. Experiment on clock generation using nand gates and crystals. 13. Experiment on generation of square wave using IC 7414.

ET/PC/B/S/223 ANALOG COMMUNICATION LAB3 Periods/Week Credit 1.5

1. Study of pulse amplitude modulation and demodulation
2. Study of IF tuned amplifier
3. Study of class B push pull power amplifier
4. Study of transistor mixer
5. Study of amplitude modulation and demodulation
6. Study of frequency modulation and demodulation
7.Study of synthesis of Fourier series for wave form generations 8.Study of different types of sampling
9. Study of effect of noise on signals
10. Study of PLL and frequency synthesis

ET/PC/B/S/224 DATA STRUCTURES LAB3 Periods/Week Credit 1.5

1. Linked Lists - Singly Connected, Doubly Connected
2. Stacks - Different Implementations (fixed memory and dynamic memory), Application
3. Queues - Different Implementations (fixed memory and dynamic memory), Circular queue, Applica- tion - Priority Queue
4. Recursion - Tower of Hanoi
5. Binary Tree - Representation and Traversals (Preorder, Postorder and Inorder)
6. Binary Search Tree - Insertion and Deletion
7. Sorting Algorithms
8. Searching Algorithms
9. Graphs - Representation, Breadth-First Search (BFS), Depth-First Search (DFS)

Third Year First Semester

Subject Code	Subject Name	Category	Type	Contact	Credit	Marks
ET/PC/B/T/311	Microprocessors and Microcontrollers	PC	Basic	3+0+0	3	100
ET/PC/B/T/312	Control Engineering	PC	Basic	3+1+0	4	100
ET/PC/B/T/313	Digital Communication Systems	PC	Basic	3+1+0	4	100
ET/PC/B/T/314	Antennas and Propagation	PC	Basic	3+0+0	3	100
ET/PC/B/T/315	Computer Organization and Architecture	PC	Basic	3+0+0	3	100
ET/PC/B/T/316	Analog CMOS Design and Technology	PC	Basic	3+1+0	4	100
ET/PC/B/S/311	Microprocessors and Microcontrollers Lab	PC	Basic	0+0+3	1.5	100
ET/PC/B/S/312	Control Engineering Lab	PC	Basic	0+0+3	1.5	100
ET/PC/B/S/313	Digital Communication Lab	PC	Basic	0+0+3	1.5	100
					25.5	**900**

ET/PC/B/T/311 MICROPROCESSORS AND MICROCONTROLLERS 3 Periods/Week Credit 3

- **Overview of Microcomputer systems and their building blocks** – Intel 8085 Microprocessor Unit (MPU) Architecture – Interfacing with Memory and I/O Devices
- **Introduction to 8085**: Instruction Set and Assembly Language Programming (ALP), Counters and Time Delays, Stack and Subroutines
- Concept of Interrupts and Direct Memory Access
- **Interfacing with Peripheral Devices** – D/A and A/D Converters, Parallel I/O, Timer – Serial I/O and Data Communication
- Application / System Level Interfacing Design, Introduction to Single-chip Microcomputer / Intel 8051 Microcontroller Architecture and Programming
- **Trends in Microprocessor Technology:** Introduction to Intel 8086 / 8088 – Arithmetic Coprocessor – Advanced Coprocessor Architecture -286, 486, Pentium - Introduction to RISC Processors.
- **Keyboard Interface controller-8279**
- **DMA Controller**

Text/Reference Books:

1. R. S. Gaonkar, Microprocessor Architecture: Programming and Applications with the 8085/8080A, Penram International Publishing, 2013/2015
2. D A Patterson and J H Hennessy, "Computer Organization and Design: The hardware and software interface. Morgan Kaufman Publishers.
3. Douglas Hall, Microprocessors Interfacing, Tata McGraw Hill, 1991.
4. Kenneth J. Ayala, The 8051 Microcontroller, Penram International Publishing, 1996.

ET/PC/B/T/312 CONTROL ENGINEERING 4 Periods/Week Credit 4

- **Control System Components**
  Introduction to control systems, concept of feedback. Typical servo components and transducers: electrical servo motors, hydraulic actuator, pneumatic controller, potentiometer, synchros, tachogenerator, gears, LVDT, pressure transducers, accelerometer, gyroscope, resolver, amplidyne, operational amplifier.

- **System Modelling**
  Mathematical models of typical components, systems and subsystems in frequency domain and time domain,

- **State Variable**
  State variable representations, controllability and observability.

- **Stability Analysis and Controller Design**
  Time domain and frequency domain analysis and associated mathematical tools, control system performance specifications: transient and steady state, stability of systems. Routh Hurwitz, Lyapunov functions. Controller design: state feedback, compensators. Typical case studies identification and control of oven, hydraulic position control in rolling mills. AC servo voltage stabilizer design and analysis of control systems using MATLAB and SIMULINK.

Text/Reference Books:

1. I.J. Nagrath and M. Gopal, Control Systems Engineering.
2. FaridGolnaraghi and B.C. Kuo, Automatic Control Systems.
3. K. Ogata, Modern Control Engineering.

ET/PC/B/T/313 DIGITAL COMMUNICATION SYSTEMS4Periods/Week Credit 4

- **Formatting in base band transmission techniques:**
  Why digital communication, Analog vs. digital communication, Model of digital communication system, Dig. Comm.. goal, Performance metrics, two basic steps of digital communication, Sampling, quantization, revisited the concept of sampling and the concept of sampling in transmitting multiple band limited signal, PAM signal, channel BW of PAM, concept of signal reconstruction, practical examples of sampling, quantization of signals, PCM system, quantization error, PCM modulator, demodulator, pros and cons, uniform and non-uniform quantization, companding, μ-law and A-law compressions, input-output characteristics, DPCM, DM, start-up, hunting, slope-overload error, ADM, algorithms for varying step size.
- **Signalling formats –** unipolar, bipolar, NRZ, RZ, Manchester and Gray with emphasis on power spectra, ISI, eye pattern, concept of equalization, linear transversal equalizer.
- **Signal detection:**
  Geometric interpretation of signals, Schwarz's inequality, concepts of orthogonality and orthonormality, Gram-Schmidt orthogonalization process, roles of multipliers and correlators, bank of correlators in noisy environment, channel characterization, likelihood functions, memory less channel, signal detection in presence of noise, maximum-likelihood detector, observation space, decision regions, conditional probability of symbol error, error function, complementary error function, correlation receiver, matched filter receiver, maximization of signal to noise ratio, properties of matched filter.
- **Digital modulation techniques:**
  Digital modulation formats, coherent systems – BPSK, BFSK, QPSK& MSK: signal constellation, average probability of symbol error, Generatoins and degenerations of various modulations, non-coherent systems – BFSK & DPSK: derivation of transmitter and receiver, concept of M-ary communication, bandwidth efficiency, comparison of binary and quaternary modulation systems.
- **Information theory and coding:**
  Concept of uncertainty, discrete messages, amount of information, probability of occurrence, concept of binit, unit of information, Entropy, properties of entropy, information rate, source coding theorem, Shanon-

Fanoalgorithm, Shanon's theorem, channel capacity, Gaussian channel, bandwidth-SNR trade off, Shannon's limit, introductory idea of linear block code, generator and parity-check matrices, encoder, error detection and correction, syndrome decoding, decoder.

Text Books:

1. Communication Systems, Simon Haykin, 4th Edition, Wiley
2. Modern Analog and Digital Communication systems, B.P. Lathi, Oxford Publication, 4th Edition

Reference Books:

1. Wireless Communication Networks, 3G and Beyond, ItiSahaMisra, 2nd edition, Mc. GrawHill India

ET/PC/B/T/314ANTENNAS AND PROPAGATION3 Periods/Week Credit 3

Antenna

- **Introduction to Antenna:**
  Brief history of antenna, sources of radiation, different types of antenna, Antenna equation, equivalent circuit.

- **Radiation Mechanism:**
  Radiation mechanism, Oscillating Dipole, Mechanism of wave particle duality, Larmore's formula. Relativistic and non relativistic domain, Newton's laws of motion for oscillating particle.

- **Transmission line equivalence:**
  Transmission line analogy, relation among E and H in free space, equi-potential surface along length of dipole.

- **Field computation mechanism:**
  Vector magnetic potential, Hertzian Dipole, different field components, E and H plane concept, Generation of magnetic scalar and vector potential, Lorentz Gauge condition

- **Antenna Characteristics:**
  Power radiation, Poynting theorem, antenna equivalent circuit, impedance and bandwidth of antenna system, concept of antenna polarization, linear, circular and elliptic polarization, antenna effective aperture, gain directivity relation.

- **Dipole Antenna:**
  Monopole and dipole antennas, radiation properties, effect of ground, effect of scalar potential, time dilation, retarded potential, effect of dipole radiation in relativistic and non relativistic domain, different zone of field measurement

- **Circular loop antenna:**
  Effect of loop antenna, radiation method from loop.

- **Antenna array:**
  Antenna array concepts, Different types of antenna array, computation of different array parameters, feeding mechanism, array factor, element factor, pattern multiplication, parasitic array Yagi-Uda array, Concept of frequency independent antenna, spiral and log periodic antenna

- **Synthesis of antenna array:**

Antenna synthesis using binomial, Chebychev and Taylor parameter distribution. Concept of Fourier transform in array synthesis, idea of planar array, array discretization.

- **Different types of antenna :**
  Helical antenna, Horn antenna, parabolic reflector, antennas for wireless applications, duality principle, concept of aperture antenna, antennas used for radio astronomy.

- **New Design techniques in antenna:**
  Fractal, miniaturized antenna, impedance converter.

Propagation

- **Introduction:**
  Effect of link on EM wave propagation in different frequency ranges. Reflection, refraction, LOS vs non-LOS propagation, Medium impedance, effects of dielectric medium.

- **Propagation communication channel:**
  NOLS propagation, scattering, frequency and time spreading, multipath fading, link budget, link margin, Friss equation, EIRP, link calculation, power budget calculation in propagation.

- **Ground wave propagation:**
  Ground wave propagation, free space propagation, reflection from ground, antennas located over flat & spherical earth coverage diagram

- **Diffraction:**
  Effect of diffraction in propagation, Rayleigh scattering, Effect of knife edge, Newton's ring phenomenon.

- **Surface waves:**
  Interference effects of ground, dipole model, method of image.

- **Tropospheric propagation:**
  Tropospheric scatter, ducts & non-standard refraction. 4/3 model.

- **Propagation attenuation:**
  Effects of gaseous molecules over propagation, frequency dependency, 60GHz model, rain attenuation, effects of snow on propagation model.

- **Ionosphere:**
  Basic physics of ionosphere, ionospheric propagation, including effects of the earths' magnetic fields, zyro frequency, virtual height, MUF, oblique propagation, wireless and mobile environment, optimal effective height.

Text/Reference Books:

1. Feynman lecture series :Vol 2 Feynman
2. Antenna Theory analysis and design : Balanis 3rd Ed
3. Antenna :J.D.Kraus
4. Fields and waves in communication electronics :Ramo Whinnery, 3rd ed
5. Electromagnetic waves and radiating system: Jordon Balmain , 2nd ed
6. Ionospheric radio; electromagnetic wave series 31, IET: K. Davies
7. Antenna and radio wave propagation. McGraw-Hill ed : Collin RE

ET/PC/B/T/315 COMPUTER ORGANISATION AND ARCHITECTURE
3 Periods/Week Credit 3

- **Introductory Concepts**
  Moore's Law, Basic Organization of a Computer and Underlying technologies.

- **ComputerPerformance**
  CPU time, Amdahl's Law, CPU Performance Equation.

- **Computer Instructions**
  Operations and Operands of the hardware, example conversions from C to MIPS.

- **ALU Design**
  Realization of basic arithmetic (addition, subtraction) and logical (AND, OR, NOT) operations, Faster Addition using Carry Lookahead.

- **Computer Arithmetic**
  Representation of numbers, Addition, Subtraction, Multiplication, Division operations (flowcharts, block level hardware designs).

- **Processor Design**
  CPU Design, Datapath Building, Control Unit Design using Hardwired Control and Microprogrammed Control, Parallel Processing.

- **Memory Design**
  Memory Hierarchy, Basics of Cache, Cache Performance, Different Cache Designs - direct mapped, fully associative and set associative caches, virtual memory.

- **I/O Organization**
  Basics, Programmed I/O –memory-mapped I/O and I/O mapped I/O.

Text/Reference Books:

1. D. A. Patterson and J. H. Hennessy, "Computer Organization and Design: The Hardware/Software Interface", Morgan Kaufman.
2. J. P. Hayes, "Computer Organization and Architecture", McGraw Hill.

ET/PC/B/T/316 ANALOG CMOS DESIGN AND TECHNOLOGY4 Periods/Week Credit 4

- **MOS Device Models**- Device Layout, Device capacitances, Small signal model, Spice models, Long versus Short Channel Devices.

- **Single-stage MOS Amplifiers**- Common source stage with resistive, diode-connected and current source loads, CS stage with source degeneration, Source follower, Common Gate stage and Cascode Stage, Choice of Device models.

- **Differential Amplifiers**- Single-ended and Differential operation, Qualitative and Quantitative analysis of basic Differential Amplifiers, Common mode response, Differential pair with MOS Loads, Gilbert cell.

- **Operational Amplifiers-** Single stage and multistage OP-AMPs, Performance analysis: Gain Boosting, Common Mode Feedback, Slew Rate, PSRR, Noise. Stability and compensation of OP AMPs: Multipole

Systems, Phase Margin, Frequency Compensation and other compensation techniques, High Performance OPAMPs and applications.

- **Current Mirrors**- Cascode Current Mirrors, Active Current Mirrors, Large/Small-signal Analysis, Common-Mode properties.
- **Feedback-** Topologies of MOS feedback circuits, Effect of Loading, Effect of Feedback on Noise.
- **Switched**-Capacitor Circuits- Sampling Switches using MOS, Switched-capacitor Amplifiers, Switched-capacitor Integrator.
- **MOS Oscillators**- Ring oscillator, Voltage-controlled Oscillators, LC Oscillators.
- **Phase-Locked Loops**- Basic PLL Topology, Charge-Pump PLLs, Non-ideal effect in PLLs, Delay-Locked Loops.
- **CMOS Processing Technology**-Wafer processing, Photolithography, Oxidation, Ion Implantation, Deposition and etching, Device fabrication, Latch-up.

Text/Reference Books:

1. Behzad Razavi, Design of Analog CMOS Integrated Circuits

ET/PC/B/S/311 MICROPROCESSORS AND MICROCONTROLLERS LAB
3 Periods/Week Credit 1.5

List of Experiments

1. Kit awareness and a simple Assembly Language Program
2. Addressing modes
3. Array processing
3. Arithmetic operations
4. Logical operations
5. Delay processing
6. Stack-handling
7. Interrupts- handling
8. Peripheral interfacing
9. Timer Interfacing

ET/PC/B/S/312CONTROL ENGINEERING LAB3 Periods/Week Credit 1.5

List of Experiments

1.Synchro in AC position control
2.DC position control system
3.Amplidyne in DC position control
4.DC motor study
5.Temperature control system
6.Controller design using MATLAB
7.SCR as a control element

ET/PC/B/S/313 DIGITAL COMMUNICATION LAB 3 Periods/Week Credit 1.5

List of Experiments

1. Generation of maximal length PN sequences
2. Details study of properties of PN sequences with mathematical background
3. Study of pulse code modulation and demodulation
4. Study of delta modulation and demodulation
5. Study of adaptive delta modulation and demodulation
6. Study of ASK modulation and demodulation
7. Study of PSK modulation and demodulation
8. Study of FSK modulation and demodulation
9. Study of DPSK modulation and demodulation
10. Study of Auto correlation of PN sequences
11. Study of cross correlation of PN sequences
12. Study of constellation, Eye diagram, error vector spectrum and symbol error table for BPSK and QPSK modulations using vector signal generator and vector signal analyzer software

Third Year Second Semester

Subject Code	Subject Name	Category	Type	Contact	Credit	Marks
ET/PC/B/T/321	Digital Signal Processing	PC	Basic	3+1+0	4	100
ET/PC/H/T/322	Digital Switching and Computer Networks(*)	PC	Honours	3+1+0	4	100
ET/PC/B/T/323	Digital Control Systems	PC	Basic	3+0+0	3	100
ET/PC/H/T/324	Operating System(*)	PC	Honours	3+0+0	3	100
ET/PC/H/T/325	Embedded Systems(*)	PC	Honours	3+1+0	4	100
ET/PC/B/S/321	IC Design Lab	PC	Basic	0+0+3	1.5	100
ET/PC/B/S/322	Digital Signal Processing Lab	PC	Basic	0+0+3	1.5	100
ET/PC/B/S/323	Communication Networks Lab	PC	Basic	0+0+3	1.5	100
ET/PC/B/S/324	Digital Control Lab	PC	Basic	0+0+3	1.5	100
					24	**900**

ET/PC/B/T/321 DIGITAL SIGNAL PROCESSING 4 Periods/Week Credit 4

- **Review of Discrete-time Signals and Systems:** Introduction to continuous time & discrete-time signals & systems, discrete-time sinusoidal properties. Sequences: classification based on length, symmetry, periodicity, energy, power, generation of sequences, special sequences, arithmetic operations on sequences.

- **LTI Systems:** Convolution, graphical & analytical techniques, overlap & add method, sliding tape method, numerical problems on LTI systems, properties of convolution and interconnection of LTI systems, de-convolution, stability of systems, casual systems, recursive and non-recursive systems, difference equation

- **Discrete Fourier Transform:** DFT and IDFT relationship, Twiddle factors, linear transformations, basic properties, , multiplication of DFTs, circular convolution, linear filtering using DFT, filtering of long data sequences, overlap and save method, overlap and method.

- **Fast Fourier Transform:** Efficient computation of DFT, FFT algorithms, Radix-2 algorithm, decimation in-time and decimation-in-frequency algorithms, signal flow graph, butterflies, computation in one place, bit reversal, DFT computations using DIT & DIF algorithms.

- **Digital Filter Structures:** System describing equations, filter categories, direct form I and II structures, cascade and parallel communication of second order systems, linear phase FIR filter structures, frequency sampling structure for FIR filter.

- **FIR Filter Design :** Windowing method for designing FIR filters, DFT method for approximating the desired unit sample response, combining DFT and window method for designing FIR filters, frequency sampling method for designing FIR filters

- **IIR Filter Design:** Analog lowpass filter design techniques, methods to convert analog filters into digital filters, frequency transformations for converting lowpass filters into other types, all-pass filters for phase response compensation.

- **Typical DSP Hardware:** Texas Instruments family of DSP Processors, study of TMS320C5416 Processor's architecture, extensive parallel operations, MAC operations, different addressing techniques, common instructions used for extensive DSP applications, familiarity with Code Composer Studio.

Text/Reference Books:

1. Proakis and Manloakis, Digital Signal Processing.
2. Li Tan, Digital Signal Processing.
3. S.K.Mitra, Digital Signal Processing.
4. Openhiem and Schafer, Discrete Time Signal Processing.

ET/PC/H/T/322 DIGITAL SWITCHING AND COMPUTER NETWORKS
4 Periods/Week Credit 4

- **Telecommunication and Traffic Engineering:** Introduction to voice and data communication systems, Circuit, message and packet switching, Evolution of switching systems, Basics of EPABX, Definition of traffic load, grade of service and blocking probability, definition of Markov chain, probability distribution of arrival service and termination process, Birth-Death (B-D) process, Modeling of switching system, Basics of Queueing Theory,Erlang's formula, Data transmission in PSTNs.
- **Basics of Data Communications:**Introduction of computer networks and data communication services, Goals, applications and classification of computer networks, Network topologies, Layered network architecture, OSI reference model, and Overview of TCP/IP protocol suite, Brief review of physical layer.
- **Data Link Layer:** Framing, flow and error control, error detection, Cyclic Redundancy Codes (CRC) for error detection, Internet Checksum, Flow and error control strategies, HDLC protocol. Media Access Control (MAC): Pure and Slotted ALOHA, CSMA, CSMA/CD, CSMA/CA, polling, token ring, MAC for wired and wireless Local Area Networks, Ethernet protocol, WiFi MAC protocol.
- **Network Layer:** IPv4 and IPv6 addressing, Routing algorithms, hierarchical routing, Link State and Distance Vector routing, Internet routing, RIP, OSPF, BGP, packet format, addressing, subnetting, CIDR, ARP, RARP, fragmentation and reassembly, ICMP; DHCP, NAT, routing for mobile hosts.
- **Transport Layer:** UDP, segment structure and operation; TCP, segment structure and operation; Sockets; Reliable stream transport service; congestion control algorithms and connection management.
- **Application Layer:** World Wide Web and HTTP, electronic mail (SMTP), file transfer protocol (FTP), Domain Name Service (DNS).
- **Network security:**Basics of cryptographic systems, public key and private key cryptography, digital signatures, authentication, certificates, firewalls, Security for Wi-Fi systems
- **LAN, VLAN, VPN, WLAN**

Text/Reference Books:

1.T. Viswanathan and M. Bhatnagar, Telecommunication Switching system and Networks, PHI.
2. B. A. Forouzan, Data Communications and Networking, TMH.
3.L. L. Peterson and B. S. Davie Computer Networks: A Systems Approach, Morgan Kaufmann Series.
4. A. S. Tanenbaum, Computer Networks, PHI.
5. W. Stallings, Data and Computer Communications, Pearson.
6. J. F. Kurose and K. W. Ross, Computer Networking: A Top-Down Approach, Pearson.

ET/PC/B/T/323 DIGITAL CONTROL SYSTEMS3 Periods/Week Credit 3

- **Discrete Signal Representation and Mapping** Benefits of digital control: representation of discrete systems: Z-transforms, pulse transfer function, sampling process and its frequency domain interpretation,

aliasing. Mapping S domain to Z domain, bilinear transformation and frequency prewarping, discretization of continuous system, hold circuits.

- **Analysis of Discrete Systems** State variable representation. Time and frequency domain analysis: controller specification, stability of sampled data systems, Jury's test and Lyapunov's stability criterion design of discrete controller.

- **State Variable Representation**State feedback, observers, linear quadratic controller, and compensator design in W-domain.

- **Controller Realization and System Performance Analysis** Implementation of digital controllers: effect of finite bits, quantization error and overflow. Series, parallel and cascade realization of digital controllers, word length requirements of ADC and CPU for a given controller function and prescribed noise figure case studies: position control of an antenna dish, read write head of computer hard drive, and twin rotor multi input multi output system design and analysis of control systems using MATLAB and SIMULINK.

Text/Reference Books:

1. B.C.Kuo, "Digital Control Techniques.'
2. Paul Katz, 'Digital Control using Microprocessor".

ET/PC/H/T/324 OPERATING SYSTEMS3 Periods/Week Credit 3

- **Hierarchical and extended machine view.**
- **Processor management**: State model, job scheduling, process scheduling, multi-processor scheduling, process synchronization, deadlock problem.
- **Memory management:** Single contiguous allocation, partitioned allocation, paging, segmentation, demand paged memory management.
- **Device management:** Dedicated, shared and virtual devices, channels and I/O control units, device allocation, I/O traffic controller, I/O scheduler.
- **Information management:** File systems, allocation, strategy, recovery of files.
- **Introduction to the distributed operating systems**.
- **Case study:** DOS, UNIX, LINUX WINDOWS etc

Text/Reference Books:

1. Operating Systems by Staru E. Madnick and John J. Donovan
2. Operating Systems Concepts by Abraham Silberschatz, Peter B. Galvin and Gerg Gagne

ET/PC/H/T/325 EMBEDDED SYSTEMS3 Periods/Week Credit 3

- **Introduction to Embedded Systems (ES)** – Definition - Difference between general purpose computing system and embedded system; classification of embedded systems - RISC and CISC Processors - Characteristics and Quality Attributes of Embedded Systems- Concepts of Embedded System Design – Examples of Embedded Systems

- **Embedded Microcontroller** Cores / Designing with 8-bit Microcontroller: Architecture, Addressing modes and Instruction Set of Intel 8051 Microcontroller

- **Introduction to other Embedded Processors:** ARM, Digital Signal Processors, Field Programmable Gate Array, ASIC - Choice of Embedded Hardware Platform

- **Interfacing Standards** – Real Time System Design, Example RTOS- Hardware Software co-design
- **ASIC Design**
- **Semicustomed ICs including FPGA**
- **Microcontroller Design**
- **Cloud and IOT**

Text / Reference Books:

1. Shibu K V, "Introduction to Embedded Systems", McGraw Hill, New Delhi (2/e)
2. SantanuChattopadhyay,"Embedded System Design", PHI Learning (2/e)
3. K.J. Ayala, "The 8051 Microcontroller: Architecture, Programming, and Applications", Penram Intl, 1996.
4. J.W. Valvano, "Embedded Microcomputer System: Real Time Interfacing", Brooks/Cole, 2000.
5. 8051 Microcontroller- Internals, Instructions, Programming and Interfacing, SubrataGhosal, Pearson, New Delhi (2/e)
6. Jack Ganssle, "The Art of Designing Embedded Systems", Newness, 1999

ET/PC/B/S/321IC DESIGN LAB3 Periods/Week Credit 1.5

SPICE based experiments

1. Schematic design of MOS inverter with different loads.
2. Schematic and lay-out of two input NAND gate.
3. Schematic and lay-out of two input NOR gate.
4. V.I characteristics of CMOS inverter charging the value of channel width (w) and channel length (L).

VHDL/Verilog based experiments

1. Design a 4:1 MUX with four inputs, two select inputs, one enable input and one output
2. Design of a full adder and full subtractor circuit.
3. Design of a three input majority and minority circuit.
4. Design a priority encoder using 4-bit inputs and two outputs, where both input and outputs are active high.
5. Design a 2 to 4 line decoder circuit.
6. Design a 2-bit digital magnitude comparator circuit.
7. Design the following Flip-Flop i) J-K Flip-Flop ii) D - type' Flip-Flop and iii) T - Flip-Flop.
8. Design and simulate a 4 bit UP/DOWN counter.

ET/PC/B/S/322DIGITAL SIGNAL PROCESSING LAB3 Periods/Week Credit 1.5

1. Generation of different sequences and performing various operations on the given sequences using MATLAB.
2. Performing Linear and Circular Convolution of two given sequences using MATLAB.
3. Study of Autocorrelation and Cross-correlation of the given sequence(s) in MATLAB.
4. Computation of DFT and IDFT of a sequence using MATLAB.
5. Design of Low-Pass, High-Pass, Band-Pass and Band-Stop Butterworth/Chebyshev filters using MATLAB.
6. Design of Low-Pass, High-Pass, Band-Pass and Band-Stop FIR filters using MATLAB.

7. Familiarization of TMS 320C713 DSP Starter Kit and performing various operations using Code Composer Studio (CCS).
8. Real-time FIR filtering using TMS 320C6713 CCS.
9. Audio Processing using TMS 320C6713.

ET/PC/B/S/323COMMUNICATIONS NETWORK LAB3 Periods/Week Credit 1.5

1. Introduction to NS2: Node and link creation using NS2.
2.Introduction to Data Link Layer: To study the transmission packets over Ethernet LAN and to verify CSMA/CD protocol suing NS2
3. Introduction to Network layer: Verification of Distance vector Routing Protocol using NS2
4. Introduction to Transport Layer: To study the performance of
    - UDP using NS2
    - TCP using NS2
    - UDP and TCP together using NS2
5. Assignment/Exercises on NS2
6. Implementation of PC to PC Serial Communication using RS-232C Serial Port
7. Cryptography
    - Implementation of RSA Algorithm (Wireless Mode)
    - Implementation of RC4 Algorithm (Wireless Mode)
9. To transmit and receive strings of Data/Messages through MQTT Protocol using HiveMQ and MQTTBox
10. Sending SMS using GSM module and Arduino Uno Board

ET/PC/B/S/324DIGITAL CONTROL LAB3 Periods/Week Credit 1.5

1. Motion control of a BOE-BOT robot
2. Leg movement control of 6-legged robots
3. Digital controller design using MATLAB
4. Digital sun-tracking system: study of locking and tracking
5. Using microcomputer as a controller in a digital control system
6. Multi-robot motion planning simulator
7. Multi-robot coordination in box-pushing

Fourth Year First Semester

Subject Code	Subject Name	Category	Type	Contact	Credit	Marks
ET/PC/H/T/411	System Software(*)	PC	Honours	3+0+0	3	100
ET/PC/B/T/412	Microwave Engineering	PC	Basic	3+1+0	4	100
ET/PC/B/T/413	VLSI Design and Algorithms	PC	Basic	3+0+0	3	100
ET/PE/B/T/414	Elective-I	PE	Basic	3+0+0	3	100
ET/PC/B/S/411	Computer Architecture and System Software Lab	PC	Basic	0+0+3	1.5	100
ET/PC/B/S/412	Microwave Lab	PC	Basic	0+0+3	1.5	100
ET/PS/B/S/413	Seminar	PS	Basic	0+0+3	1.5	100
ET/PS/B/S/414	Project	PS	Basic	0+0+6	3	100
					20.5	**800**

ET/PC/H/T/411 SYSTEM SOFTWARE3 Periods/Week Credit 3

- **Assemblers:** Basic functions of assemblers, design of one-pass and multi-pass assemblers, cross-assemblers, MASM. Macroprocessor: Design of one-pass and two pass macroprocessors,
- **Loaders and linkers:** Absolute loaders, subroutine-linkage, relocating loaders, direct linking loaders, binders, linking loaders, overlays, dynamic binders.
- **Compliers:** Different phases - lexical analysis, syntax analysis, intermediate code generation, introduction to code generation and optimization, interpreters, compilercompilers-YACC.
- **Operating systems:** Extended M/C view of an operating system, operating system as an user interface, Operating system as a resource manager, features of processor management module, memory management module, device management module and information management module,
- **Introduction to Text-editors and Debuggers.**

Text/Reference Books:

1.System Software, An Introduction to Systems Programming by Leland L. Beck and D. Manjula
2.System Software by SantanuChattopadhayay
3.Principles of Compiler Design by Alfred V. Aho and Jeffrey D. Ullman

ET/PC/B/T/412 MICROWAVE ENGINEERING4 Periods/Week Credit 4

- **Introduction:** History of Microwaves, frequency bands, Advantages of Microwaves, Areasof application, transmission line analogy of waveguides.
- **Cavity Resonators**— Introduction, Rectangular Cavities, Dominant Modes and Resonant Frequencies, Q Factor and Coupling Coefficients.
- **Waveguide Discontinuities** — Waveguide Windows, Tuning Screws and Posts, Matched Loads
- **Microwave circuit analysis:** General approach to microwave circuit analysis, impedance or Z - parameter and Scattering or S-parameter representation of microwave circuits: relation between Z and S parameters, properties of S-parameters, applications to microwave junctions, signal flow graph and decompositionrules.

- **Passive circuit components:** E, H and E- H plane tee, E and H-Plane Bend, Magic Tee, Directional couplers, Power Divider, Wave-guide Corners, Bends, Twists, Attenuator, Properties of Ferrites, Circulator, Isolator.
- **Microwave Active components:** Tunnel diode, Varactor diodes, Step recovery diodes, Schottky Barrier diodes, PIN diodes, Gunn Diodes, IMPATT and TRAPATT diodes.
- **Microwave Tubes:** Different Types. Limitations of conventional sources in microwave frequency range. Klystron- 2 cavity & multi-cavity, Reflex Klystron, Magnetrons
- **Travelling Wave Tubes:** Periodic structures, Floquets' Theorem, helix TWT.
- **Solid State Microwave Devices:**TransferElectron Devices, GUNN oscillators, IMPATT devices, microwave transistors & FET, PIN diode single stage microwave amplifier design.
- **Microwave Measurement:** Frequency, impedance and power measurement, noise figure measurement, antenna measurements, principle of operation of network analyzer.

Text/Reference Books:

1.Microwave Devices and Circuits — Samuel V. Liao, Pearson, 3rd Edition, 2003.

2.Foundations for Microwave Engineering — R.E. Collin, IEEE Press, John Wiley, 2ndEdition, 2002.

3.Microwave Engineering Passive Circuits — Peter A. Rizzi, PHI, 1999.

4.Microwave Engineering - David M**.** Pozar, John Waey & Sons, Inc**.**

ET/PC/B/T/413VLSI DESIGN AND ALGORITHMS3 Periods/Week Credit 3

- **CMOS circuit design**: Basic structure of p-well CMOS Inverter, circuit operation, voltage transfer characteristics, calculation of critical points and their physical significance, noise margins, design of symmetric inverter, power dissipation issues,

  Combinational circuit design and capacitance; Parasitic delay, logical effort and electrical effort; Gate sizing, buffering; symmetric and asymmetric gate, skewed gates, ratioed logic; Dynamic gates, domino logic and static timing analysis; transmission gates, NAND and NOR logic gates, stick diagrams, comparison of performances , AND-ORINVERT gate, complex gates, pseudo-NMOS, Domino and NORA circuits, Cascode voltage switch logic, complementary pass-transistor logic(CPL), λ- based design rules. Sequential circuits and feedback, Clock Strategies for Sequential Design, BI CMOS circuit technique.

- **IC Design**: Introduction Discrete and Integrated Circuit: TTL, DTL, IIL, ECL, MOS and CMOS IC

- **Arithmetic subsystem**: Concept of pipelined multiplier, systolic array, gated full adder, 4-bit X 4-bit systolic array multiplier, expandability of basic circuit, 2-D systolic array, basic cell, 3 X 3 matrix multiplication, wave front array processors, barrel shifter-NMOS implementation with shift control, concept of wraparound feature, lay out of 8 X 4 barrel shifter.

- **VLSI Physical Design Automation**: Introduction to Digital VLSI Design Flow. Objectives and goals of partitioning, floor planning and placement, Global routing. Introduction to Digital VLSI Testing.

Text/Reference Books:

1. S.M Kang and Y.Leblebici, "CMOS Digital Integrated Circuits, Analysis and Design." 3rd Ed., McGraw-Hill
2. Randall Geiger, N. R. Strader, R. L. Geiger, "VLSI Design Techniques for Analog and Digital Circuits" McGraw-Hill
3. Wayne Wolf, "Modern VLSI Design systems on Silicon", Pearson Education Asia.
4. M. Sarafzadeh and C. K. Wong, An Introduction to VLSI Physical Design, McGraw-Hill
5. D. D. Gajski, N. D. Dutt,A.C.-H. Wu and S.Y.-L. Lin, High-Level Synthesis: Introduction to Chip and System Design : Springer USA
6. J. Rabaey, A. Chandrakasan and B. Nikolic, Digital Integrated Circuits: A Design Perspective, Prentice Hall of India.

ET/PC/B/S/411 COMPUTER ARCHITECTURE AND SYSTEM SOFTWARE LAB 3 Periods/Week Credit 1.5

Computer architecture lab

1. Design and realize binary multiplier circuits (signed and unsigned) and verify functionality.
2. Design and implementation of binary divider circuits and verify functionality.
3. Design a 4-bit ALU and verify its functionality.
4. Design an 8-bit ALU by cascading two 4-bit ALU chip and verify functionality.
5. Design a simple control unit with four inputs and two outputs which encode the four inputs into two bit output code.

System software lab

1. Specify a prototype HLL and design a lexical analyzer for the same.
2. Design of a recursive descent parser.
3. Design of a predictive parser.
4. Design of an assembler.
5. Design of a macroprocessor.

ET/PC/B/S/412MICROWAVE LAB3 Periods/Week Credit 1.5

1. Study of Klystron tubes.
2. V-I Characterictics of GUNN diode and study of tuning of GUNN oscillator.
3. Study of standing wave ratio and frequency by slotted waveguide.
4. Study of radiation pattern of horn antenna
5. Study of characteristics of different antennas.
6. Determination of coupling coefficient and directivity of directional coupler.
7. Measurement of impedance and transmission characteristics of a slotted line.
8. Study of network analyzer.

Fourth Year Second Semester

Subject Code	Subject Name	Category	Type	Contact	Credit	Marks
ET/PC/H/T/421	Wireless Communication Systems(*)	PC	Honours	3+0+0	3	100
ET/HS/B/T/422	Industrial Management	HS	Basic	4+0+0	4	100
ET/PC/H/T/423	Optical Fibre Communication(*)	PC	Honours	3+0+0	3	100
ET/PE/B/T/424	Elective-II	PE	Basic	3+0+0	3	100
	Open Elective	OE	Basic	3+0+0	3	100
ET/PC/B/S/421	General Viva Voce	PC	Basic	0+0+0	1	100
ET/PS/B/S/422	Project	PS	Basic	0+0+9	4.5	100
					21.5	**700**

ET/PC/H/T/421 WIRELESS COMMUNICATION SYSTEMS3 Periods/Week Credit 3

- **Fundamentals of Wireless Cellular Communication and Design Principle:**
- History of wireless communication, concept of mobile and personal communication, wireless cellular platform, the design fundamentals of cellular networks, frequency reuse, spectrum capacity enhancement techniques, co-channel and adjacent channel interference, location management, handoff management. Concept of mobile IP for mobility management issues
- **Propagation effects and path-loss models in wireless communication:**
- Propagation models for wireless networks, two-ray ground reflection model, a micro-cell propagation model, a macro-cell propagation model, shadowing model, large scale path loss and shadowing, multi path effects in mobile communication, linear time variant channel model, concept of coherent bandwidth, coherent time, Doppler Shift - Effect of velocity of the mobile, models for multi path reception, mobile communication antennas.
- **Evolution of modern mobile wireless communication systems: personal area networks:** PAN, Public wide-area wireless networks, wireless Local Area Networks.
- **Multiple access Techniques in wireless cellular communication:**
  Why and what multiple access, Frequency division multiple access technology (FDMA), time division multiple access (TDMA), space division multiple access (SDMA), code division multiple access (CDMA), spectral efficiency of different wireless access technologies: spectral efficiency in FDMA system, spectral efficiency in TDMA system, spectral efficiency for DS-CDMA system.
- **Evolution of Mobile communication Networks:**
  First generation Analog circuit based network, AMPS, Second Generation Mobile Networks-GSM: architecture and protocols, access technology, call set up procedure, 2.5 G networks: evolution to GPRS, concept of data communication on GPRS, session management and PDP Context, data transfer through GPRS network and routing. Introduction to 3G – 3GPP and 3GPP2 , The WCDMA based universal mobile telecommunication system (UMTS), concept of long term evolution 4G and 5G.

Text Books:

1. Wireless Communication : Principle and Practice, T.S. Rappaport, Pearson Publication
2. Wireless Communication Networks, 3G and Beyond, ItiSahaMisra, 2nd edition, Mc. GrawHill India

Reference Books: Modern Wireless Communications, by Simon Haykin and Michael Moher , Pearson 2011

ET/HS/B/T/422 INDUSTRIAL MANAGEMENT4 Periods/Week Credit 4

- **Growth of industries, management thoughts and scientific management, taylorism;** factory system of production, introduction to management problems, types of manufacture, planning analysis and control aspects in industries.

- **Types of business ownership**, means of finance and business combinations, organization structures, committee organization, authority and responsibility, duty and span of control. Plant location, factory buildings and physical facilities, plant layout, tools and techniques of plant layout, materials - handling arrangements.

- **Product development, standardization, simplification and diversification.** Functions of production, planning and control, production forecasting, production scheduling and network techniques, Gantt chart, CPM, pert etc. work study, job evaluation and merit rating; purchase system and inventory control. inspection and quality control of systems, statistical quality control, maintenance and replacement policies for machine and equipments; decision making theories, breakeven analysis cost benefit analysis, evaluation of financial and managerial efficiencies.

- **Introduction to operational research techniques**. Application of fuzzy logic in modern management concepts. Human relations in industry and labour compensation. personnel management, provision of industrial legislations in India. Wage and salary administrations. Welfare and safety provisions, trade union acts. Study of environmental impacts and environmental laws

ET/PC/H/T/423 OPTICAL FIBRE COMMUNICATION3 Periods/Week Credit 3

- **Propagation of signals in optical fiber:** loss and bandwidth windows, intermodal dispersion, waveguide properties, fiber modes, polarization modes and dispersion, chromatic dispersion, nonlinear effects, Raman scattering, self phase modulation, cross phase modulation, four-wave mixing, solitons.

- **Components:** couplers, isolators and circulators, , multiplexers and filters, Bragg and fiber gratings, Fabry –Perot filters, multilayer dielectric thin film filters, Mach-Zehnder interferometers, arrayed waveguide grating, acousto-optic tunable filter.

- **Optical amplifiers:** stimulated emission, spontaneous emission, Erbium-doped fiber amplifiers, Raman amplifiers, semiconductor optical amplifiers.

- **Transmitters:** lasers, light emitting diodes, tunable lasers, direct and external modulation, pump sources for Raman amplifiers. Detectors: photo-detectors, front end amplifiers.

- **Optical switch fabric:** crossbar, Closs, Spanke, Benes, Spanke-Benes, optical switch technologies, bulk mechanical switches, MEMs switches, liquid crystal switches, electro-optic and thermo-optic switches, SOA switches.

- **Wavelength converters:** optoelectronic approach, optical gating, interferometric techniques. Modulation: subcarrier modulation and multiplexing, clipping and intermodulation products, spectral efficiency, optical duobinary modulation, optical single sideband modulation, multilevel modulation.

- **Demodulation:** Ideal receiver, direct detection receiver, front end amplifier noise, APD noise, optical preamplifiers, bit error rates, coherent detection, timing recovery, equalization, error detection and correction.

- **Transmission system engineering:** system model, power penalty, crosstalk, overall design considerations.

Text/Reference Books:

1.Optical Fibre Communication, Keiser.
2.Optical Fibre Communication-Principle and Practice, J. M. Senior Kane

DEPARTMENTAL ELECTIVES (1st Semester)
ET/PE/B/T/414 - 3 Periods/Week Credit 3

(Elective courses will be offered from the following list of subjects according to availability of teachers)

ET/PE/B/T/414/A ADVANCED DIGITAL SIGNAL PROCESSING

- **Review of Digital Filter Design:**
  Digital filter design specifications, Linear phase FIR filters, FIR filter design using windowing method and frequency sampling method, Optimum equiripple design of FIR filters-Alteration theorem, IIR filter design using Impulse invariant transformation and Bilinear transformation methods, Discrete-time Butterworth and Chebyshev filter design, Quantization effects in digital filters.

- **Digital Signal Processors:**
  Digital signal processor architecture, Circular buffering, MAC and barrel shifting, General-purpose digital signal processors, Implementation of DSP algorithms on general-purpose digital signal processors, Special purpose DSP hardware. Case study of TMS320C6713 processor and SHARC processor.

- **Linear Prediction:**
  Lattice structure realization, Forward linear prediction-Autocorrelation method, Covariance method, Lattice methods-Burg algorithm, Line spectral frequencies, Line spectral pair frequencies, Linear prediction based Vocoders.

- **Multirate Processing:**
  Decimation by an integer factor D, Interpolation factor by an integer factor I, Sampling rate conversion by a factor I/D, Efficient implementation of Decimator/Interpolator, Polyphase filter structures. Multistage filter design, Design of DFT filter bank, Oversampling ADC/DAC.

- **Adaptive Filters:**
  FIR adaptive filters, Adaptive filters based on steepest descent method, Widrow Hoff LMS adaptive algorithm, Adaptive channel equalization, Adaptive echo cancellation, Adaptive noise cancellation, RLS adaptive filters.

- **Spectrum Estimation and Analysis:**
  Estimation of density spectrum, Nonparametric methods- use of DFT, Barlett method, Welch method; Parametric methods- AR model, MA model, ARMA model; Evaluation of Formants, Evaluation of Cepstrum, Evaluation of higher order spectra.

Text/Reference Books:

1.J. G. Proakis, D. G. Manolakis, Digital Signal Processing: Principles, Algorithms and Applications, Prentice Hall.
2.E. Ifeachor, B. W. Jervis, Digital Signal Processing: A Practical Approach, Pearson.

ET/PE/B/T/414/B NEURO-FUZZY CONTROL

- **Basics of fuzzy sets**: classical set to fuzzy set, operations on fuzzy set, membership functions, extension principle, fuzzy arithmetic, fuzzy logic and approximate reasoning,
- **Fuzzy logic based control system**: its relationship to conventional control systems, Fuzzifier, fuzzy rule base, Defuzzifier, inference engine, Mamdani and Sugeno scheme. Design methodology of fuzzy control systems, stability analysis and applications.
- **Introduction to neural nets**: common types of neural nets, feed forward, HoffieldLearning of neural nets: supervised and unsupervised learning, back- propagation learning.
- **Adaptive controller** using neural nets, neuro-fuzzy adaptive control.

Text / Reference Books:

Computational Intelligence: Principles, Techniques and Applications, AmitKonar, Springer
Fuzzy Logic with Engineering Applications, T.J. Ross, Wiley
Neural Network Design, M.T. Hagan, H.B. Demuth, M.Beale, PWS Publishing

ET/PE/B/T/414/C ELECTRONIC DESIGN AUTOMATION

- **Introduction:**

Behavioral model of system design. Chip flow process, simulation vs modeling

- **VHDL:**

Advance programming using VHDL.Component level programming. Library files, type declaration and usage, parameter types and overloading, types and type related issues, predefined and user-defined attributes, package declaration and usage.Delta delay modeling, insertion and transport delay. Use of signal drivers.Multiple processes.

- **MOSFET model and scaling:**

MOSFET small signal model, MOSFET parasitic capacitance value and modification in model.Scaling of MOS structure. SPICE level -1, level-2 and level 3 model. BSIM and CSIM models.Comparison between models.Scaling of MOSFET, Introduction of different types of modelling. Advantages of compact model

- **Design of Manufacturability:**

Process variations, yield analysis, fault model, designable and noise model, Response surface model, Factorial model,

- **Physical design flow**

IC design flow, floorplaning, routing, partitioning etc, Basics of design algorithm

CADENCE

- **Introduction to CADENCE**: Use of CADENCE.Basic modeling using CADENCE.Layout generation using CADENCE.

Text/Reference Books:

1. VHDL Primer, J Bhaskar PHI, 2nd Ed

2. VHDL programming by example, D.L.Perry, TMH
3. CMOS digital integrated circuit and analysis, Kang, Leblebici, TMH
4. Design of Analog CMOS integrated circuit, B. Razavi, TMH
5.Electronic Design Automation: Synthesis, Verification, and Test (Systems on Silicon), Yao-Wen Chang, Kwang-Ting, Morgan Kaufmann Pub.
6. Application-Specific Integrated Circuits, Smith, Pearson Education
7. Algorithms for VLSI Design Atomation, Sabih H. Gerez, Wiley

ET/PE/B/T/414/D CRYPTOGRAPHY AND NETWORK SECURITY

- **Basicsof Cryptography:**
  Introduction, Overview on Modern Cryptography, Classical Cryptosystems, Cryptanalysis of Classical Cryptosystems, Probability and Information Theory, Shannon's Theory.

- **Symmetric Key Cryptography:**
  Algebraic structures, Modular arithmetic, Euclid's algorithm, Groups, Rings, Fields, Finite fields, Block cipher design principles, Block cipher mode of operation, Principle of DES, Strength of DES, Evaluation criteria for AES, Advanced Encryption Standard, Stream Ciphers, Pseudorandom functions, Hash functions, Message Authentication Codes, RC4, Key distribution, Differential cryptanalysis, linear cryptanalysis and other basic cryptanalysis techniques.

- **Asymmetric Key Cryptography:**
  Primes, Primality Testing, Factorization, Euler's totient function, Fermat's and Euler's Theorem, Chinese Remainder Theorem, RSA cryptosystem, Key distribution, Key management, Diffie Hellman key exchange, ElGamal cryptosystem, Elliptic curve arithmetic, Elliptic curve cryptography.

- **Network Security:**
  Authentication Applications: Kerberos, X.509 Directory Authentication Service; Electronic Mail Security: Pretty Good Privacy (PGP), S/MIME; IP Security: IP Security Overview, IP Security Architecture, Authentication Header, Encapsulating, Security Payload, Combining Security Associations, Key Management; Web Security: Web security requirements, Secure Socket layer (SSL) and Transport layer Security (TLS), Secure Electronic Transaction (SET); Firewalls; Intruders and Viruses; Malware; Software-based attacks; Digital Right management.

Text/Reference Books:

1.Douglas Stinson, "Cryptography Theory and Practice", 2nd Edition, Chapman & Hall/CRC.
2. B. A. Forouzan, "Cryptography & Network Security", Tata McGraw Hill.
3. W. Stallings, "Cryptography and Network Security", Pearson Education.
4. Matt Bishop, "Computer Security", Pearson Education.
5. Wade Trappe, Lawrence C Washington, "Introduction to Cryptography with coding theory", Pearson.

ET/PE/B/T/414/E PATTERN RECOGNITION

- **Mathematical Foundations -** Basic Probability, Basic Linear Algebra
- **Parameter Estimation –** Method of Moments, Maximum Likelihood Estimation, Expectation Maximization Algorithm
- **Parametric Decision Making -** Bayesian Classifier, Decision Boundaries and Regions, Hidden Markov Models,
- **Non-parametric Decision making** – Histogram, Parzen Window, K Nearest Neighbor algorithm

- **Neural Classifiers** – Perceptrons for linear and nonlinearly separable pattern classes
- **Support Vector Machines** – linear, non-linear, kernelized
- **Feature Selection and Dimensionality Reduction** – Karhunen-Loeve Transform/Principal Component Analysis, Linear Discriminant Analysis
- **Clustering Algorithms** – Hierarchical, Partitional, Graph-based, Learning-based, Clustering via cost optimization.

Text/Reference Books:

1. Pattern Recognition and Image Analysis by E. Gose, R. Johnsonbaugh and S. Jost, Prentice Hall of India.
2. Pattern Recognition by S. Theodoridis and K. Koutroumbas, Elsevier.
3. Pattern Classification by R. Duda, P.E. Hart and D.G. Stork, Wiley.

ET/PE/B/T/414/F MEMS AND NEMS

- **Introduction to microsensors, microelectromechanical systems (MEMS) and microinstruments.** Evolution of MEMS & Microsensors, MEMS & Microsensors applications, Microelectronic technologies for MEMS, MEMS materials (substrate and wafers, Silicon, silicon compounds, polymers, crystal structure, single crystal and polycrystalline, mechanical properties, gallium arsenide, quartz, piezo-electric crystals, polymers, packaging materials); Micromachining Technology – Surface and Bulk Micromachining, Lithography, Thin film deposition – spin coating, thermal oxidation, chemical vapour deposition (CVD), LPCVD poly silicon deposition, electron beam evaporation, sputtering; doping, oxidation, Wet etching- isotropic and anisotropic, Etch stop – Electrochemical etching, Dry etching, as well as their combination in process integration, Comparison of Bulk and Surface micromachining, LIGA; SU-8; Moulding processes; Stiction.

- **Micro and nano mechanics –** principles, methods and strain analysis, Micromachined Microsensors and Microactuators, Mechanical, Inertial, Pull-in parallel plate capacitor, Pressure Sensor: piezo-resisitivity; Diffused Si, Poly, porous Si Beams: Structure; force, moments, spring constant; Stress, pull-in, pull-out; resonance frequency, etc. Accelerometer, Quasistatic, capacitive, equivalent circuit; Thermal sensors – thermopiles, thermistors, micromachined thermocouple probes, thermal flow sensors, MEMS magnetic sensor, thermally activated MEMS relay, Thermal accelerometer: Rate Gyroscope; Biosensor and BioMEMS; Microfluidics; Digital Microfluidics; Ink jet printer, Optical MEMS: Displays -DMDs, LGVs, active and passive components, Data storage cantilever;RF MEMS: switches, active and passive components;Measurement principles for MEMS transducers.

- **Microsystems Technology,** Design methods and design constraints for sensitivity and stability, Implementation of control methods and improving measurements sensitivity, linearity and reproducibility; Integrated Smart Sensors and MEMS, Interface Electronics for MEMS, Introduction to MEMS Simulators: COMSOL & Intelli-suite, Bonding & Packaging of MEMS, Scaling, Conclusions & Future Trends.

- **Introduction to NEMS, MEMS vs. NEMS, NEMS physics –** manifestation of charge discreteness, quantum electrodynamical (QED) forces, quantum interference, quantum resonant tunneling and quantum transport, Wave phenomena in periodic and aperiodic media – electronic and photonic band gap crystals and their applications, NEMS architecture, Surface Plasmon effects and NEMS fabrication for nanophotonics and nanoelectronics, Surface Plasmon detection – NSOM/SNOM.

Text/Reference Books:

1.Introduction to Micro-Electro-Mechanical Microwave Systems, H. J. De Loss Santos, 2nd edition, Norwood, MA: Artech, 2004

2.Introduction to Microelectronics Fabrication, Vol. V, G. W. Neudeck and R. F. Pierret (eds.), Addison– Wesley, 1988
3.Electromechanical Sensors and Actuators, Ilene J. Busch-Vishniac, Springer, 2008

ET/PE/B/T/414/G PRINCIPLES OF ELECTROMAGNETIC COMPATIBILITY

- **Introduction**, Causes of EMI, EMI effects, EMC practices, EMI standards, biological effects.
- **Sources of conducted interference,** its characteristics, non-functional sources: commutators, heater circuits. Fluorescent lamps, static power devices, automatic sources. Functional sources. The conducted spectrum.
- **Characteristics of Interference Bandwidth**, narrowband interference, broadband interference, amplitude behaviour, thermal noise, impulsive noise, design practice for minimizing conducted interference, noise source treatment, modes of operation, tube design, arc discharge, sensitive device treatment.
- **Sources of radiated interference,** its characteristics, nature of sources of radiated interference, non-functional sources, functional sources.
- **Interference coupling** by conduction and radiation, coupling via conductive patches. Resistive transfer, inductive and capacitive transfer, grounding bonding, shielding and filtering, materials and special devices Mathematical models for sources coupling and susceptors.

Text/Reference Books:

1. Electromagnetic Compatibility Engineering – Henry Ott
2. Introduction to Electromagnetic Compatibility - Clayton R. Paul

ET/PE/B/T/414/H MODERN DEVICES FOR VLSI CIRCUITS

- **Advanced MOSFET devices:**Basics of MOSFET, Device scaling in MOSFETs, Types of scaling, impact of scaling: Short channel effects: few types of short channel effects: Drain-induced barrier lowering, Hot carrier effect, threshold voltage lowering, Subthreshold slope degradation and their discussions, Velocity Saturation and High-Field Transport, Channel Length Modulation, Source-Drain Series Resistance, MOSFET Degradation and Breakdown at High Fields, improved MOSFET structures: Silicon-On-Insulator (SOI) MOSFET: fabrication of SOI technology, SOI CMOS Partially Depleted SOI MOSFETs, Fully Depleted SOI MOSFETs, advantages and disadvantages of SOI technology, Silicon-On-Nothing (SON) MOSFET, fabrication of SON technology, advantages of SON technology.
- **Multi-gate MOSFET devices:** Double-Gate MOSFETs: An Analytic Drain Current Model for Symmetric DG MOSFETs, the Scale Length of Double-Gate MOSFETs ,fabrication requirements and Challenges ofDG MOSFETs, Tri-gate MOSFET: advantages over planar MOSFETs, Gate-all-around MOSFETs, Work Function Engineering in MOSFETS: Dual-Material Gate, Triple-Material Gate, Linearly Graded Binary Metal Alloy Gate, Lateral Channel Engineered MOSFETs: Graded Channel technology, halo doped MOSFET, Strained Silicon channel, dielectric pocket induced MOSFET,

Dielectric Engineered MOSFET: Use of High-k gate stack architecture: vertically stacked and horizontally stacked, Source and Drain engineering in MOSFETs.

- **Heterojunction Devices:** Concept of a heterojunction, Energy band diagram, Heterojunction bipolar transistor (HBT), High electron mobility transistor (HEMT), Photonic Devices.
  Quantum-Effect Devices: Tunnel effect, Tunnel diode, Tunnel junction, Double tunnel junction, Single-electron transistor, Tunneling Field Effect Transistor, Spintronics devices.

Text/Reference Books:

1. J. P. Colinge and C. A. Colinge,"Physics Of Semiconductor Devices", Kluwer Academic Publishers
2. Yuan Taur and Tak H. Ning, "Fundamentals of Modern VLSI devices", Cambridge University Press

ET/PE/B/T/414/I INTRODUCTION TO INTERNET OF THINGS (IOT)

- **Introduction to IoT**: Sensing, Actuation, Basics of Networking, Communication Protocols, Sensor Networks, Machine-to-Machine Communications, Interoperability in IoT,
- **Introduction to Arduino Programming**, Integration of Sensors and Actuators with Arduino, Introduction to Python programming,
- **Introduction to Raspberry Pi**, Implementation of IoT with Raspberry Pi,
- **Introduction to SDN**, SDN for IoT, Data Handling and Analytics, Cloud Computing, Sensor-Cloud, Fog Computing, Smart Cites and Smart Homes, Connected Vehicles, Smart Grid,
- **Industrial IoT, Case Study**: Agriculture, Healthcare, Activity Monitoring

Text / Reference Books:

1. Introduction to IoT, SudipMisra, Anandarup Mukherjee, Arijit Roy, Indian Institute of Technology, Kharagpur, Cambridge University Press, Jan. 2021.
2. Internet Of Things - Architecture and Design Principles, Raj Kamal, McGraw Hill Education, 1/e, India, 2017
3. Introduction to Industrial IoT and Industry 4.0, SudipMisra, Chandana Roy, Anandarup Mukherjee, Indian Institute of Technology, Kharagpur, CRC Press, UK, Dec. 2020.
4. Internet of Things,Shriram K Vasudevan, Abhishek S Nagarajan, RMD Sundaram, Wiley India, 2019.

ET/PE/B/T/414/J BRAIN-COMPUTER INTERFACING AND APPLICATIONS

- **The Human Brain:** Anatomy and Physiology of the brain, The brain lobes and their functionality, Basic Sub-division of the brain lobes
- **Modality of Brain Signal Acquisition:** EEG, f-MRI, f-NIRs, PET, MEG, ECoG, Intra-Cortical electrode placement
- **Common Brain Signals:** P300, SSVEP, ERD-ERS, ErrP, N400
- **Brain Signal Processing:** Spatial Filtering- Common Average Referencing, Laplacian Filtering, Nearest Neighbor Filtering, Independent Component Analysis, Temporal Filtering: Butterworth, Chebyshev and Elliptical Digital Filter

- **Feature Extraction and Selection:** Hzorth parameters, Autoregressive parameters, Power Spectral Density, Wavelet coefficients, Principal Component Analysis, Common Spatial Patterns, Feature Selection by Swarm/Evolutionary algorithms
- **Classification of Brain Signals:** Linear Discriminant Analysis, Quadratic Discriminant Analysis, Support Vector Machines, Neural Classifier using Gradient Descent Learning and Back-propagation algorithm, Classical and Type-2 Fuzzy Classifiers for noisy classification of brain signals
- **BCI Control:** Open-loop control using BCI, ErrP and P300 based bio-feedback for BCI control, Adaptive Control Strategies
- **BCI Design and Applications:** Artificial Robotic Limb design for neuro-prosthetic applications, Online cognitive failure detection in Driving, BCI in Memory/Learning and Perceptual applications.

Text / Reference Books:

1. Cognitive Modeling of Human Memory and Learning: A Non-Invasive Brain-Computer Interfacing Approach by Lidia Ghosh, Amit Konar and Pratyusha Rakshit, IEEE-Wiley Press, 2021.
2. Adaptive Processing of Brain Signals by Saeid Sanei, Wiley, 2018.

ET/PE/B/T/414/K INDUSTRIAL ELECTRONICS

- **Learning the characteristics of Single-&multi-phase rectifiers with filter design**; Analysis of power efficiency
- **Study of controlled rectification with SCR & TRAIC Devices with communication**; UJT firing angle control; Inverter design with complementary transistorized circuit
- **Principles of Industrial Welding technique**; Resistance wielding; High frequency heating technology; Induction & dielectric heating; Design equations
- **Studies on Industrial servo system**: DC motor servomechanism; System stability based on Laplace transform model
- **Evaluation of Root-Locus**, Setting time, rise time, %-overshoot; Problem solving
- **Learning characteristics of industrial process controllers** (P, I, PID); Controller tuning methods
- **Learning the principle of PLC & Relay Ladder Logic**; Design Applications

Text/Reference Books:

1. Terry Bartlet - Industrial Electronics (Thomson Delmar learning).
2. M.S.J. Asghar - Power Electronics (PHI Learning Private Limited).
3. V.Jagannathan - Introduction to Power Electronics (PHI Learning Private Limited).

DEPARTMENTAL ELECTIVES (2nd Semester)
ET/PE/B/T/424 - 3 Periods/Week Credit 3

ET/PE/B/T/424/A ADVANCED ALGORITHMS

- **Time-complexity Analysis –** Revisiting Substitution Method, Recurrence Tree and Master Theorem with proof
- **Dynamic Programming and Greedy Algorithms –** Examples from different domains with theoretical foundations
- **Graph Algorithms -** Minimum Spanning Trees, Single-Source Shortest Paths, All-Pairs Shortest Paths , Maximum-Flow Minimum-Cut
- **Linear Programming–**Standard and slack forms, simplex algorithm, duality

- **NP-Completeness–** Polynomial time, Polynomial-time verification, NP-completeness - reducibility, proofs and problems
- **Approximation Algorithms–** Vertex-cover problem, traveling-salesman problem, set-covering problem, subset-sum problem

Text/Reference Books:

1. T.H. Cormen, C.E. Leiserson, R.L. Rivest and C. Stein, "Introduction to Algorithms", Prentice Hall of India.

ET/PE/B/T/424/B PATTERN ANALYSIS AND MACHINE INTELLIGENCE

- **Statistical Pattern Classification**: Linear discriminant analysis, Bayesian classification, model-free technique including the K-nearest neighbors method.
- **Neural Classifiers**: Perceptron, Multi-layered perceptrons and back-propagation algorithm, support vector machine classifier.
- **Clustering Techniques**: K-means, Fuzzy C-means, SOFM Neural net, Hopfield neural net.
- **Feature Minimization Techniques**: Principal component analysis, Independent component analysis.
- **Intelligent Search**: Problem solving by search, Heuristic search.
- **Machine Learning Techniques**: Decision tree learning; analogy based learning, inductive learning, Q-learning.
- **Reasoning Using Logic**: Propositional and predicate logic, unification and resolution principle, deductive and abductive reasoning, fuzzy reasoning.
- **Perception**: Visual and linguistic perception.

Text/Reference Books:

1. Artificial Intelligence and Soft Computing,AmitKonar, CRC Press, 2000.
2. Computational Intelligence: Principles, Techniques and Applications,AmitKonar, Springer, 2005.
3. Pattern Classification, Richard O. Duda, Peter E. Hart and David G. Stork, Wiley, 2010.

ET/PE/B/T/424/C SIGNAL PROCESSING ARCHITECTURE

- **Pipelining and Parallel Processing:**
  Typical DSP algorithms, Representation of DSP algorithms, Data flow graph and dependence graphs – critical path, Loop bound and Iteration bound, Algorithms for computing iteration bound, Pipelining and parallel processing of FIR filters.

- **Algorithmic Strength Reduction-I:**
  Retiming – definition and properties, Unfolding – an algorithm for unfolding, properties of unfolding, sample period reduction and parallel processing applications, Algorithmic strength reduction in filters and transforms – 2-parallel FIR filter, 2-parallel fast FIR filter.

- **Systolic Architecture Design:** Systolic array design methodology, FIR systolic arrays, Selection of Scheduling vector, Matrix-matrix multiplication and 2-D Systolic array design, Systolic design for space representations.

- **Algorithmic Strength Reduction- II:**

  Fast convolution – Cook-Toom algorithm, Iterated convolution, Cyclic convolution, Pipelined and parallel recursive filters – Look-ahead pipelining in first-order IIR filters, Parallel processing of IIR filters, combined pipelining and parallel processing of IIR filters.

- **Numerical Strength Reduction:**
  Subexpression elimination, multiple constant multiplication, iterative matching, synchronous pipelining and clocking styles, clock skew in edge-triggered single phase clocking, two-phase clocking.

- **Bit-level Arithmetic Architectures:**
  Parallel multipliers with sign extension, parallel carry- ripple and carry save multipliers, Design of Lyon's bit-serial multipliers using Horner's rule, bit-serial FIR filter. Distributed arithmetic fundamentals and FIR filters.

Text/Reference Books:

1. Keshab K. Parhi, "VLSI Digital Signal Processing Systems: Design and Implementation",Wiley.
2. U. Meyer – Baese, "Digital Signal Processing with Field Programmable Gate Arrays", Springer

ET/PE/B/T/424/D ADVANCED ELECTRON DEVICES

- **Semiconductor Band structure Engineering: Alloying of semiconductors –** Virtual Crystal Approximation in Random alloy, Semiconductor Heterostructures – Type I, Type II and Type III hetero-interfaces, Built-in Strain in heterostructures – Poisson Effect, Pseuodomorphic and Metemorphic growth.

- **Low-dimensional systems: Concept of quantum confinement -** Wave mechanical description of free particles, Bound particles, Quantum well (QW), Quantum well wire (QWW), Quantum Dot (QD), Multiple quantum well (MQW), Superlattices (SL) – Compositionally graded SL and Doping SL .

- **High Frequency Devices:** Heterojunction Bipolar transistor (HBT),Metal semiconductor field effect transistor (MESFET), High electron mobility transistor (HEMT), Resonant tunneling diode (RTD) and Resonant tunneling transistor (RTT).

- **Optoelectronic Device: Laser diodes -** Laser physics, Laser operating characteristics; Specialty Lasers – Quantum-Well, Quantum-Wire and Quantum-Dot Lasers, Vertical-Cavity Surface-Emitting Laser (VCSEL), Quantum-Cascade Laser.

- **Optical Devices:** Basic concept of Quantum confined Stark effect (QCSE), Self electro-optic effect device (SEED) – Optical modulator, Optical switch.

- **Fundamentals of Emerging Devices:** Single electron devices, Spintronic devices, Graphene based devices, Van der Waals Heterostructures – 2D crystals.

Text Books:

1. S. M. Sze and Kwok K. Ng, Physics of Semiconductor Devices, John Wiley and Sons, India.
2. J. H. Davies, The Physics of Low dimensional Semiconductors, An Introduction, Cambridge University Press 1998.

ET/PE/B/T/424/E BIOMEDICAL ELECTRONICS

- **Bioelectric Signals and Electrodes**: Sources of biomedical signals, basic medical instrumentation system, PC based medical instruments, general constraints in design of medical instrumentation systems, origin of bioelectric signals, Electrocardiogram (ECG), Electroencephalogram (EEG), Electromyogram (EMG), Electrooculogram (EOG). Electrode-tissue interface, polarization, skin contact impedance, motion artefacts, Silver Chloride electrodes, Electrodes for ECG, Electrodes for EEG, Electrodes of EMG, Electrical conductivity of electrode jellies and creams, microelectrodes. Electrocardiograph-block diagram, ECG leads, effects of artefacts, multi-channel, ECG machine, vector cardiograph, phonocardiograph-origin of heart sounds, microphones and amplifiers for PCG
- **Pacemakers & Defibrillator:**
- Need for cardiac pacemaker, external pacemaker, implantable pacemakers-types, ventricular synchronous demand pacemaker, programmable pacemaker, power sources for implantable pacemakers. Need for defibrillator, DC defibrillator, automatic external defibrillator, implantable defibrillators.
- **Blood Flow & Cardiac Output Measurement :** Electromagnetic blood flowmeter- principle, square wave electromagnetic flowmeter, Doppler shift ultrasonic flowmeter
- **Advanced Diagnostic & Therapeutic Instruments :** Principle of surgical diathermy & surgical diathermy machine, Electrodiagnosis - Electrotherapy-functional block diagram and working, interferential current therapy. Artificial kidney-Principle and haemodialysis machine.
- **Biosensors:**
  Electrochemical transducers, Electrode potential and reference electrodes, potentiometric sensors, amperometric sensors, electrochemical gas sensors, chemical transducers of acoustic and thermal principles. Biosensors – Enzyme based biosensors, immune sensors, and microbial sensors. Continuous measurement of chemical quantities.

Text/Reference Books:

1.Biomedical Instrumentation And Measurements, L. Cromwell, PHI
2.Introduction To Biomedical Instrumentation, Christe Barbara L. Cambridge University Press
3.Biomedical Signals Imaging And Informatics, 4Th Edition 2015 By Bronzino J D, Taylor & Francis Ltd

ET/PE/B/T/424/F POWER OPTIMIZATION TECHNIQUES IN VLSI CIRCUITS

- **VLSI Design:** Overview of digital VLSI design flow; High-level Synthesis, logic synthesis and physical synthesis and optimization techniques; Impact of compiler optimization on hardware synthesis, 2-level logic optimization, multi-level logic optimizations.

- **Technology Mapping:** DSP and RAM inference for FPGA. RTL Optimizations: Area, power and timing optimization techniques like retiming, register balancing, folding. Pipelining and clock gating.

- **VLSI Test:** Introduction to Automatic Test Pattern Generation (ATPG), optimization Techniques for ATPG, design for Testability, optimization Techniques for design for testability, High-level fault modeling.

- **RTL level Testing Verification**: LTL and CTL based hardware verification, verification of large systems, binary decision diagram (BDD) based verification, arithmetic decision diagram based (ADD) and high-level decision diagram (HDD) based verification, symbolic model checking, bounded model checking.

Text/Reference Books:

1. Neelam Swami "Synthesis of High Performance Low Power CMOS Circuit Design: Power Optimization Approach"LAP LAMBERT Academic, 2012
2. Gary K. Yeap, "Practical Low Power Digital VLSI Design", KAP, 2002
3. Rabaey, Pedram, "Low Power Design Methodologies", Kluwer Academic, 1997
4. Kaushik Roy, Sharat Prasad, "Low-Power CMOS VLSI Circuit Design", Wiley, 2000

ET/PE/B/T/424/G DIGITAL IMAGE PROCESSING

- **Image Representation and Modeling:** Monochrome and color representation, color cordinate systems Monochrome and Color vision Model, sampling and Quantization – Rectangular and Nonrectangular Grid sampling and interlacing. Optimum Lioyd-Max quantizer, Compandor design, Practical limitations.

- **Image Transforms :** Two dimensional Orthogonal Transforms, Basic Image, Kronecker products and Dimensionality: proportion Algorithm etc. for D F T. Hadamard Haar, Slant, DCT and KL Transforms, SUD techniques Image Enhancement, Point operation, Histogram Modeling, Spatial operations, Transform cooperations, Image Restoration Increase and Weian Filtering, Filtering using transforms, Least square and constrained least square restoration. Maximum Entropy Restoration.

- **Image Analysis and Vision:** Spatial features extraction, Transform, Features, Edge detection, Boundary detection, region representation, Moment representation, Structure from shape, Texture, Scene Matching, Image segmentation and classification techniques.

- **Image Data Compression:** Pixel coding: Entropy coding, Run length coding, Bit plane coding. Predioctive coding. Delta and DPCM techniques, Transform coding –zonal versus threshold coding. Adaptive transform coding. Vector quantization for compression

Text/Reference Books:

1. RafaleC.Gonzales& R. E. Woods, Digital Image Processing, Pearson
2. Anil Jain, Fundamentals of Digital Image Processing PHI

ET/PE/B/T/424/H MICROWAVE MONOLITHIC INTEGRATED CIRCUIT

- **Introduction to MMIC**, processing, MMIC performance, MMIC status, GaAs MMIC reliability, yield cost, future developments, MMIC applications: military, commercial and consumer applications.
- **Device Modeling**: Single-Gate FET, Basic operation, device performance analysis, characterization, equivalent circuits and parameter extraction, device modeling, design considerations and applications, noise modeling. dual-Gate FET, DC characterization and basic device operation, high frequency lumped element equivalent circuit, applications of dual gate FETs.
- **Planer resistors**, transmission lines, microstrip and coplanar lines for MMICs line discontinuities, planer lumped elements, planer capacitors, coupling structures, Lange couplers, passive baluns, Marchandbaluns, spiral transformers. Wilkinson divider with high pass and low pass sections, active power splitter and combiners, active baluns.
- **MMIC Design considerations** and amplifier design, design consideration for MMICs, chip size, thermal design and wafer thickness, low-inductance grounds and crossovers, propagation modes and other design considerations.

- **Microwave amplifier design**, design considerations, procedure for general design of an amplifier, low-noise amplifier design, circuit performance, combining techniques for power amplifiers.On-chip tuning, tuning techniques using addition of elements. airbridge removal technique.
- **Mixer design**: diode mixers, single ended diode mixers and its planar implementation, doubled balanced diode mixer, active FET mixers, single ended FET mixers, single balanced FET mixers, double balanced FET mixers, resistive FET mixers, distributed FET mixers.Phase shifter design: analogue phase shifters, single stage refection type phase shifters, cascaded match reflection type phase shifters, digital implementations, switched line phase shifters, loaded line phase shifters, intrinsic phase shifters.
- **Switch and attenuators**: microwave switches, PIN diode switches, FET MMIC switches, switched FET equivalent circuit, attenuators, variable attenuator, switched attenuators, analogue attenuators.
- **MMIC CAD tools and simulation techniques**.

Text/Reference Books:

1. RFIC & MMIC design & technology, I. D. Robertson & S. Lucyszyn, 2001.
2. Foundations for Microwave Engineering; Second Edition; By Robert E. Collin; McGraw Hill International Edition; 1992.
3. Microwave Engineering; Second Edition; by David M. Pozar; John Wiley & Sons; Inc., 2001.

ET/PE/B/T/424/I RADAR AND NAVIGATION

RADAR

- **Introduction:**
- Basic radar, radar equation, monostatic, biastatic radar, threshold detection, Radar range equation, RADAR losses
- **Detection of signal**
- False alarm and missed detection, Statistical nature, Modified range equation.
- **MTI and pulsed RADAR**
- Internal and external noise. MTI and pulse Doppler radars, range and speed ambiguities, Doppler Filter Banks, Digital MTI Processing, MTD, Limitations to MTI performance.
- **Tracking RADAR**
- Tracking process, sequential lobing and conical scan, Monopulse, Receiver for Monopulse, Amplitude and Phase comparison. Low angle tracking
- **RCS:**
- Basic of RCS, RCS model, Effects of clutter, introduction of stealth.
- **RADAR signal processing**
  Ambiguity diagram, Matched filter receiver, automatic detection, detectors & integrators, CFAR, Pulse compression technique, FMCW

Navigation

- **Introduction:**
  Guidance and navigation, categories of navigation.navigation equations, co-ordinate frame, dead reckoning computations, positioning, terrain matching navigation, course computation, navigation errors.
- **Inertial Navigation:**
  Instruments, Platforms, Mechanization Equations, Error Analysis & Fundamental Limits.
- **Satellite Navigation:**

Ranging Equations, Range Rate Equations and Clock Errors, NAVSTAR GPS: Principles, coverage, configuration, Control & Signal Structure, DGPS, GPS Accuracy; GLONASS, GAGAN, combined GPS/GLONASS.

Text/Reference Books:

1. Introduction to RADAR System, M.Skolnik, Third Ed, Tata McGraw Hill Ed.
2. RADAR Principles, technology Applications, B. Edde, Person
3. Radar Cross Section, E.F.Knott, Second Ed, Scitech Pub.
4. RADAR Handbook, M.Skolnik, Third Ed, McGraw Hill Ed.
5. Introduction to Airborne RADAR, Stimson, 3rd Ed Scitech Pub.
6. An Introduction to GNSS, Charles Jeffrey, Novtel Inc. first Ed

ET/PE/B/T/424/J INTRODUCTIONTO ARM7/TDMI ARCHITECTURE

- **ARM Processor Fundamentals**: Registers, Current Program Status Register, Pipeline, Exceptions, Interrupts, and the Vector Table
- **Introduction to the ARM Introduction Set:** Data Processing Instructions, Branch Instructions, Load-Store Instructions, Software Interrupt Instructions, Program Status Register Instructions, Loading Constants, Conditional Execution, Read only and Read/Write Memory
- **Introduction to the Thumb Instruction Set:** Thumb Register Usage, ARM-Thumb Internetworking, other Branch Instructions, Data Processing Instructions, Single-Register-Load-Store Instructions, Multiple-Register-Load-Store Instructions, Stack Instructions, Software Interrupt Instructions
- **Peripheral Programming of ARM using C Language**: Block Diagram and Features of LPC214x Family, Peripherals of LPC2148, Introduction to ARM9 and ARM Cortex M3

Text Book / Reference Book:

1. Embedded Systems : An Integrated Approach, 1/e – 2013 By Lyla B Das, Pearson
2. ARM System on Chip Architecture, 2/e Paperback – 2012 By Steve Furber, Pearson
3. ARM System's Developer's Guide: Designing and Optimizing System Software, Andrew N.
4. The Designer's Guide to the Cortex-M Processor Family:: A Tutorial Approach, Trevor Martin, 1st Edition, Newnes

ET/PE/B/T/424/K CYBER SECURITY

- **Introduction to Cyber Security:** Introduction to cyber space and Cyber Security, Internet Governance – Challenges and Constraints, Cyber Threats, Need for a Comprehensive Cyber Security Policy
- **Computer security:**Bios security, System security, Boot loader/Boot manager security, Vulnerabilities in hardware, System security: system administrator/root and kernel level security

- **LAN/WAN Security:** Network level Vulnerabilities in software and web based services: Data access, Weak Authentication, Unprotected Broadband communications, Poor Cyber Security Awareness. Cyber Security Safeguards: Access control, Authentication, Biometrics, Cryptography, Deception, Denial of Service Filters, Firewalls, Intrusion Detection Systems, Response, Scanning of services and ports
- **Data Security and Safeguards:**VIRUS, Trojan, Malicious program, Data access privilege levels and access preventions, antivirus, anti malware, data recovery
- **Securing Web Application, Services and Servers:** Basic security for Web based Applications and Services, Basic Security for Simple Object Access Protocol (SOAP) Services, Security Considerations
- **Intrusion Detection and Prevention:** Intrusion, Physical Theft, Abuse of Privileges, Unauthorized Access by Outsider, Malware infection, Intrusion detection and Prevention Techniques, Network Session Analysis
- **Password security and Encryption:**Password policies, Password shadowing, password crackers, Basic Cryptography, Message Authentication, Digital Signatures, PGP and Public-Key Cryptography
- **Network Security:** Firewalls, User Management, VPN Security, Security at the Application Layer, Transport Layer (SSL and TLS) and Network Layer (IPSec).
- **Cyber Forensics:** Introduction to Cyber Forensics, Conducting disk-based analysis, Investigating Information-hiding, Scrutinizing E-mail, Validating E-mail header information, Tracing Internet access, Tracing memory in real-time.

Text/Reference Books:

1. William Stallings, "Cryptography and Network Security: Principles and Practice" (6th Edition,)Pearson
2. Brij Gupta, Gregorio Martinez Perez, Dharma P. Agrawal, Deepak Gupta, "Handbook Of Computer Networks And Cyber Security: Principles And Paradigms", Springer
3. Brook S. E. Schoenfield, "Secrets of a Cyber Security Architect", CRC Press

ET/PE/B/T/424/L INSTRUMENTATION AND MEASUREMENTS

- **Characteristics of measurement systems:** Errors in measurements, classification of transducers: variable resistive, inductive, capacitive, photo electric and piezoelectric electric transducers; thermocouple; smart / intelligent sensors.
- **Digital instruments:** Digital frequency meter - frequency measurements, errors and reciprocal counting technique; time and ratio measurements; digital voltmeter System (DVM), digital measurement of current, resistance and AC quantities; digital multimeter, digital LCR measurements.
- **Display Systems:** CRO, measurement of voltage, frequency and phase, pulse measurement, oscilloscope probes, dual trace CRO, analog and digital storage oscilloscope.
- **Graphic recording instruments:** Strip Chart Recorder, XY recorder and memory recorder Signal analyzers: Distortion analyzer; spectrum analyzer, Q meter.

Text/Reference Books:

1. Electronic Instrumentation and Measurements, David A. Bell, Oxford Higher Education, 3/e

2. Principles of Measurement Systems, John B Bentley, Pearson, Prentice Hall (4/e), 2005
3.A Course in Electrical and Electronic measurements and Instrumentation, A. K. Sawhney Dhanpatrai & sons, 2005.
4 Instruments Devices And System, Rangan C.S, Tata Mc-Graw Hill, 1998.
Electronic Instrumentation And Measurement Techniques, Cooper, Prentice Hall Of India,1998.

ET/PE/B/T/424/M AUDIO AND SPEECH PROCESSING

- **Fundamentals of Speech :** The human speech production mechanism, LTI model for speech production, Nature of speech signal, Phonetics, Types of speech, Voiced and unvoiced decision making

- **Parameters of Speech :** Pitch frequency, Pitch contour, Pitch period measurement – spectral domain, cepstral domain, Formants, Evaluation of formants – using cepstrum, using log spectrum, Estimation of formants, Spectral parameters of speech

- **Linear Prediction of Speech:** Lattice structure realization, Forward linear prediction – Autocorrelation method, Covariance method, Lattice methods-Burg algorithm, Line Spectral frequencies, Line spectral pair frequencies, Linear prediction based Vocoders.

- **Speech Quantization and Coding:** Uniform and non-uniform quantizers and coder, Companded quantizer, Adaptive quantizer, Waveform coding of speech, Parametric speech coding techniques, Transform domain coding of speech.

- **Speech Synthesis :** Texts-to-Speech system, Synthesizer technologies – formant based, LPC based, HMM based, Speech transformations, Emotion recognition from speech, Watermarking for authentication of a speech signal.

- **Speech Processing Applications :** Speech recognition system, Deterministic sequence recognition for ASR, Statistical sequence recognition for ASR, Speech recognition for understanding, Speaker recognition, Distortion measures, Speech enhancement, Adaptive echo cancellation

Text/Reference Books:

1. Nelson Morgan and B. Gold, “Speech and Audio Processing”, Wiley.
2. Rabiner, “Digital Processing of Speech Signals”, Pearson