Course Curriculum

(Course Structure and Syllabi)

for

Dual Degree (B.Tech. and M.Tech.)

in

Electronics and Communication Engineering

(Second Year Onwards)

Department of Electronics and Communication Engineering

National Institute of Technology Hamirpur

Hamirpur – 177 005 (India)

Second Year

3rd Semester							4th Semester						
SN	Code	Subject	L	T	P	Credits	SN	Code	Subject	L	T	P	Credits
1	HS-203	Organizational Behavior	3	0	0	3	1	MA-203	Engineering Mathematics-III	3	1	0	4
2	EC-211	Digital Electronics and Logic Design	3	1	0	4	2	EC-221	Linear Integrated Circuits	3	1	0	4
3	EC-212	Analog Electronics	3	1	0	4	3	EC-222	Analog Communication Systems	3	1	0	4
4	EC-213	Communication Theory	3	1	0	4	4	EC-223	Electromagnetic Field Theory	3	1	0	4
5	CS-201	Data Structures	3	1	0	4	5	EC-224	VLSI Technology	3	0	0	3
6	EC-214	Digital Electronics and Logic Design Lab	0	0	2	1	6	EC-225	Linear Integrated Circuits Lab	0	0	2	1
7	EC-215	Analog Electronics Lab	0	0	2	1	7	EC-226	Analog Communication Lab	0	0	2	1
8	CS-202	Data Structures Lab	0	0	2	1	8	EC-227	Circuit Design and Simulation lab	0	0	2	1
		Total Hours = 25				**22**			**Total Hours = 25**				**22**

Third Year

5th Semester							6th Semester						
SN	Code	Subject	L	T	P	Credits	SN	Code	Subject	L	T	P	Credits
1	EC-311	Microprocessor Architecture and Applications	3	1	0	4	1	EC-321	Microcontroller and Embedded Systems	3	1	0	4
2	EC-312	Digital Communication and Systems	3	1	0	4	2	EC-322	Wireless Communication	3	1	0	4
3	EC-313	Digital Signal Processing	3	1	0	4	3	EC-323	VLSI Design Techniques	3	1	0	4
4	EC-314	Microwave Devices and Systems	3	0	0	3	4	EC-324	Antenna and Wave propagation	3	0	0	3
5	OET	Open Elective-I	3	0	0	3	5	OET	Open Elective-II	3	0	0	3
6	EC-315	Digital Communication Lab	0	0	2	1	6	EC-325	Microprocessor and Microcontroller Lab	0	0	2	1
7	EC-316	Microwave Devices and Systems Lab	0	0	2	1	7	EC-326	VLSI Design Lab	0	0	2	1
8	EC-317	Digital Signal Processing Lab	0	0	2	1	8	EC-329	Seminar	0	0	2	1
		Total Hours = 24				**21**			**Total Hours = 24**				**21**

Fourth Year																
7th Semester								8th Semester								
SN	Code	Subject	L	T	P	Credits		SN	Code	Subject	L	T	P	Credits
1	EC-411	Control System	3	0	0	3		1	HS-404	Engineering Economics and Accountancy	3	0	0	3
2	EC-412	Optical Communication Systems and Networks	3	0	0	3		2	EC-421	Communication and Computer Networks	3	0	0	3
3	DET#	PG Elective—I	4	0	0	4		3	DET#	PG Elective—III	4	0	0	4
4	DET#	PG Elective—II	4	0	0	4		4	DET#	PG Elective—IV	4	0	0	4
5	EC-611#	Information Theory and Coding	4	0	0	4		5	EC-622#	Modeling and Simulation of Communication System	4	0	0	4
6	EC-631#	Device Modeling for Circuit Simulation	4	0	0	4		6	EC-642#	Analog VLSI Design	4	0	0	4
7	EC-418	Industrial Training Presentation	0	0	2	1		7	EC-428	General Proficiency	0	0	0	1
8	EC-419	Major Project (Stage-I)	0	0	12	6		8	EC-429	Major Project (Stage-II)	0	0	12	6
		Total Hours = 36				**29**				**Total Hours= 34**				**29**

Fifth Year														
9th Semester							10th Semester							
SN	Code	Subject	L	T	P	Credits	SN	Code	Subject	L	T	P	Credits
1	EC-612#	Mobile Communication	4	0	0	4	1	EC-800#	M.Tech. Dissertation	-	-	-	20
2	EC-800#	M.Tech. Dissertation	-	-	-	20							
		Total Hours = 04				**24**							**20**

#PG Course

Semester Wise Credits											
Semester	1st	2nd	3rd	4th	5th	6th	7th	8th	9th	10th	**Total**
Credits	24	24	22	22	21	21	29 (UG=13, PG=16)	29 (UG=13, PG=16)	24 (PG=24)	20 (PG=20)	**236 (UG=160, PG=76)**
Hours/week	28	28	25	25	24	24	36	34	4	-	**228**

Post Graduate (PG) Elective Courses
(Communication Systems & Networks)

PG Elective-I

EC-701	Advanced Digital Communication
EC-702	Soft Computing
EC-703	Optimization Tools and Techniques
EC-704	Advanced Antenna Design

PG Elective-II

EC-705	Computer Communication and Networks
EC-706	Wi-Fi, Bluetooth and Zigbee Technology
EC-707	Wireless Sensor Networks
EC-708	Wi-Fi Telephony and VoIP

PG Elective-III

EC-709	Electromagnetic Interference & Compatibility
EC-710	RF and Microwave Circuit design
EC-711	Advanced Engineering Electromagnetics
EC-712	RF & Microwave Active Circuits
EC-713	Computational Electromagnetics

PG Elective-IV

EC-714	Digital Image Processing and Pattern Recognition
EC-715	Adaptive Signal Processing
EC-716	Signal Detection and Estimation Theory
EC-717	Multi-rate Signal Processing
EC-718	Wavelet Transforms & Applications

Post Graduate (PG) Elective Courses
(VLSI Design)

PG Elective-I

EC-731	MEMS & Micro Sensor Design
EC-732	Nano-Electronics
EC-733	Deep Learning & AI for VLSI
EC-734	Deep Submicron VLSI Design Issues

PG Elective-II

EC-735	Characterization of Semiconductor Materials & Devices
EC-736	CMOS RF Circuit Design
EC-737	VLSI Test & Testability
EC-738	VLSI Interconnects

PG Elective-III

EC-739	Low Power VLSI Design
EC-740	Advanced Semiconductor Devices
EC-741	Advanced IC Design
EC-742	Embedded System Design

PG Elective-IV

EC-743	SoC and FPGA based Design
EC-744	Hardware Algorithms for VLSI
EC-745	Digital ASIC Design
EC-746	Verification of VLSI Circuits

Open Elective Courses

Open Elective-I

EC-370	MEMS Design

Open Elective-II

EC-380	Microcontroller and its Applications

Course Name:	**Organizational Behaviour**
Course Code:	**HS-203**
Course Type:	**Core**
Contact Hours/Week: **3L**	Course Credits: **03**

Course Objectives

- To impart knowledge about the behavioural aspects related to professional organizations
- To introduce the fundamental concepts relevant to understanding of individual & group behavior in the organization
- To enable the students to understand the applied organizational themes like perception, motivation, interpersonal relationships, group dynamics, leadership theories, role of power & policies in organizational context, conflict and negotiation, organizational diversity, dynamics of personality, attitude and job satisfaction, etc.

Unit Number	Course Content	Lectures
UNIT-01	**Organizational Behavior (OB):** Concept, nature, characteristics, conceptual foundations, determinants and importance, management functions, role & skills, disciplines that contribute to the field of OB, Challenges & Opportunities for OB, diversity in Organizations, attitudes & Job satisfaction.	**04L**
UNIT-02	**Perception**: Concept, nature, process, importance, management and behavioral applications of perception. Personality: concept, nature, types and theories of personality shaping. Learning; concept and theories of learning.	**08L**
UNIT-03	**Motivation:** concept, principles, theories-content, process & contemporary, Monetary and non-monetary motivation, applications of motivation. Leadership: Concept, functions, styles, and theories of leadership- trait, behavioural, and situational.	**06L**
UNIT-04	**Group and Interpersonal Relationship:** Analysis of Interpersonal Relationship, developing interpersonal relationship, Group Dynamic: Definition of Group, stages of Group Development, Punctuated Equilibrium Model, Group Structure, Group Decision Making, understanding work teams.	**05L**
UNIT-05	**Organizational Power and Politics:** concept of power, structure of power, classification of power, contrasting leadership & power, dependence a key to power, causes & consequences of political behaviour. Organizational conflict: view of conflict, conflict process, negotiation & bargaining strategies.	**06L**
UNIT-06	**Conflict and Negotiation:** conflict definition in conflict thought: Traditional view, the Human relation view, interactionist view. Functional versus dysfunctional conflict, conflict process. Negotiation Bargaining strategies, the negotiation process and issues in negotiation.	**07L**

Course Outcomes

Upon successful completion of the course, the students will be able to

CO1: Identify the challenges of the present organization

CO2: Describe the organizational system

CO3: Apply the principles of organizational behavior to inculcate the habit of team work and which is essential for the organization

CO4: Assess the role of psychological and social principal in improvement of efficiency as well as quality of empoyee life

Books and References

1. Organizational Behavior by Robbins, S.P., Prentice Hall of India.
2. Organizational Behavior by Luthans F., McGraw-Hill.
3. Human Behavior at Work: Organizational Behavior by Davis K., Tata McGraw-Hill.

Course Name:	**Digital Electronics & Logic Design**
Course Code:	**EC-211**
Course Type:	**Core**

Contact Hours/Week: **3L + 1T** Course Credits: **04**

Course Objectives

- To impart knowledge about the concept of digital design, number system and codes.
- To introduce the fundamental concepts related to design of combinational logic circuits.
- To enable the students to understand the design of Sequential Circuits.

Unit Number	Course Content	Lectures
UNIT-01	**Introduction:** Analog versus Digital, Analog to Digital and Digital to Analog converter circuits; Number systems and their inter-conversion, Binary Arithmetic (Addition, Subtraction, Multiplication and Division), Diminished radix and radix compliments; BCD codes, Excess-3 code, Gray code, Hamming code, Error Detection and Correction.	**08L**
UNIT-02	**Logic Gates and Logic Families:** Digital Logic Gates, Various Logic Families: RTL, DTL, TTL and ECL; Working and their characteristics; MOS and CMOS devices.	**06L**
UNIT-03	**Combinational Logic Design:**Boolean Algebra, Basic Theorems and Properties of Boolean Algebra, Minimization of Logical functions, Karnaugh- Map method, Sum of Products and Product of Sums Simplification, NAND and NOR implementation, Incompletely Specified functions, VEM method, Tabulation method, Determination of Prime implicants, Selection of Essential Prime implicants, Iterative Consensus & Generalized Consensus method for minimization of Multiple Output Switching functions, Determination of Prime implicants, Selection of Essential Prime implicants and finding a minimal cover, Design of Combinational circuits with examples.	**08L**
UNIT-04	**MSI and PLD Components:** Binary Adder and Subtractor; Decoders and Encoders; Multiplexers and DE-Multiplexers circuits; Read Only Memory, Programmable Logic Arrays, Programmable Array Logic; Implementation of Combinatorial Logic using these devices.	**06L**
UNIT-05	**Sequential Logic Design:** Introduction and Classification of Sequential circuits, Flip-flops: Truth Table & Excitation Table of flip-flops, Interconversion of flip-flops, Design of Synchronous & Asynchronous Sequential circuits, Registers and Counters,	**08L**

Course Outcomes

Upon successful completion of the course, the students will be able to

CO1: Understand about the concept of digital system.

CO2: Apply principles of minimization techniques to simplify digital functions.

CO3: Design and analyse the combinational electronic circuit based on digital logic.

CO4: Design and analyse the sequential electronic circuit based on digital logic.

Books and References

1. Digital Design: M. Morris Mano, Prentice Hall of India.
2. Digital Principle and Applications: Malvino and Leach, Tata Mc-Graw Hill.
3. Fundamentals of Digital Electronics: Anand Kumar, Prentice Hall of India.
4. Modern Digital Electronic: R.P. Jain Tata Mc-Graw Hill.

Course Name:	**Analog Electronics**
Course Code:	**EC-212**
Course Type:	**Core**

Contact Hours/Week: **3L + 1T** Course Credits: **04**

Course Objectives

- To introduce the fundamental concepts relevant to bipolar junction transistor.
- To impart knowledge about the electrical modeling and analysis of small- and large-signal amplifiers.
- To enable the students to understand the factors that cause the gain to roll-off at high frequencies.

Unit Number	Course Content	Lectures
UNIT-01	**Low Frequency Transistor Amplifier:** Equivalent Circuit of BJT using h-parameter for CB, CE and CC & configuration, Calculation of Transistor Parameter for CB, CE & CC using h-parameters, Comparison of Transistor Amplifier Configuration	**05L**
UNIT-02	**Multistage Amplifier:** General Cascaded System, RC Coupled Amplifier and its Frequency Response, Merits and Demerits, Cascade Amplifier, Darlington Compound Configuration, Multistage Frequency Effect	**05L**
UNIT-03	**High Frequency Response of Transistor Amplifier:** High Frequency Model for CE Configuration, Approximate CE High Frequency Model with Resistive Load, CE Short Circuit Current Gain, HF Current Gain with Resistive Load	**06L**
UNIT-04	**Large Signal Amplifier:** Analysis and Design of class A, B, AB, C Amplifiers, Push-pull Amplifiers, Transformer Less Output Stages, Distortion Calculations	**05L**
UNIT-05	**Tuned Amplifier:** General Behavior of Tuned Amplifiers, Series and Parallel Resonant Circuit, Calculations of Circuit Impedance at Resonance, Variation of Impedance with Frequency, Q Factor of a Circuit & Coil, Bandwidth of Series and Parallel Resonant Circuit, Single Tuned Amplifiers, Voltage Gain and Frequency Response of Single Tuned Amplifiers, Double Tuned Amplifiers	**05L**
UNIT-06	**Feedback Amplifier:** Feedback concept, Characteristics of Negative and Positive Feedback, Effect of Negative and Positive Feedback on Input Impedance, Output Impedance, Gain, Noise and Frequency Response	**05L**
UNIT-07	**Oscillators:** Classification of Oscillators, Frequency Stability of Oscillatory Circuits, Tuned based Oscillators, Hartley Oscillator, Colpitt Oscillators, Clapp Oscillator, Crystal Oscillator, Phase Shift Oscillator and Wien Bridge Oscillator	**05L**

Course Outcomes

Upon successful completion of the course, the students will be able to

CO1: Develop the ability to analyze and design analog electronic circuits using discrete components

CO2: Understand the use of small-signal models to predict gain and behavior in transistor amplifier

CO3: Describe the design trade-offs in analog amplifier circuits

CO4: Design tuned amplifiers and apply them in a communications system

Books and References

1. Integrated Electronics: Analog and Digital Circuits and Systems by J. Millman and C. Halkias, McGraw-Hill, Inc.
2. Electronic Devices & Circuit Theory by R. Boylestad and L. Nashelsky, Pearson.
3. Microelectronic Circuits by A. Sedra and K. Smith, Oxford University Press.
4. Electronic Fundamental Applications: Integrated and Discrete Systems by J.D. Ryder, Prentice Hall.

Course Name:	**Communication Theory**
Course Code:	**EC-213**
Course Type:	**Core**
Contact Hours/Week: **3L + 1T**	Course Credits: **04**

Course Objectives

- To understand basic components of communication systems.
- To prepare mathematical background for communication signal analysis.
- To analyze signals in presence various types of noise and estimation of channel capacity.

Unit Number	Course Content	Lectures
UNIT-01	**Frequency and Time Domain Representation and Analysis:**Introduction to Information, Messages & Signals, Classification of Signals., The Discrete and Continuous Spectrum, Power Spectrum, Energy Density Spectrum, Dirac Delta Functions, Sampling Theory and Approximations, Convolution of Signals, LTI Systems.	**10L**
UNIT-02	**Random Signal Theory :** Discrete Probability Theory, Continuous Random Variables, Statistically Independent Random Variables, Probability Density Functions of Sums, Transformation of Density Functions, Ergodic Process, Correlation Functions, Spectral Density and White Noise.	**10L**
UNIT-03	**Noise:** Atmospheric, Thermal, Shot and Partition noise, Noise Figure and Experimental Determination of Noise Figure, Shot Noise In Temperature Limited Diode and Space Charge Limited Diodes, Pulse Response and Digital Noise.	**05L**
UNIT-04	**Transmission Through Networks:** Networks with Random Input, Auto-correlations, Spectral Density and Probability Density Input-output Relationships, Optimum System and Non-linear Systems, Maximum Criterion, Equivalent Noise Bandwidth.	**05L**
UNIT-05	**Basic Information Theory:** Definition of Information, Units of Information, Entropy, Uncertainty and Information Rate of Communication, Redundancy, Relation Between System Capacity and Information Content of Messages, Shannon's Theorem, Discrete Noisy Channel, Channel Capacity for Different Discrete Channels.	**06L**

Course Outcomes

Upon successful completion of the course, the students will be able to

CO1: Perform the time and frequency domain analysis of the signals in a communication system.

CO2: Analyze the performance of communication system and need of information theory for information transfer.

CO3: Select the blocks in a design of communication system and system capacity.

Books and References

1. Elements of Communication Theory by J.C. Hancock, McGraw-Hill Education Publisher.
2. Principals of Communication System by Taub & Schilling, McGraw-Hill Education Publisher.
3. Communication Systems by S. Haykin, Wiley Publication.

Course Name: **Data Structures** Course Code: **CS-201** Course Type: **Core**		
Contact Hours/Week: **3L + 1T**		Course Credits: **04**
Course Objectives • To impart knowledge about linear and non-linear data structures as the foundational base for computer solutions to problems. • To introduce the fundamental concepts relevant to binary trees, binary tree traversals, binary search trees and perform related analysis to solve problems. • To enable the students to understand various types of sorting algorithms.		
Unit Number	**Course Content**	**Contact Hours**
UNIT-01	**Introduction:** Data types, data structures, abstract data types, the running time of a program, the running time and storage cost of algorithms, complexity, asymptotic complexity, big O notation, obtaining the complexity of an algorithm.	7L
UNIT-02	**Development of Algorithms:** Notations and Analysis, Storage structures for arrays - sparse matrices - structures and arrays of structures, Stacks and Queues: Representations, implementations and applications. Linked Lists: Singly linked lists, Linked stacks and queues, operations on Polynomials, Doubly Linked Lists, Circularly Linked Lists, Operations on linked lists- Insertion, deletion and traversal, dynamic storage management – Garbage collection and compaction.	10L
UNIT-03	**Trees:** Basic terminology, General Trees, Binary Trees, Tree Traversing: in-order, pre-order and post-order traversal, building a binary search tree, Operations on Binary Trees - Expression Manipulations - Symbol Table construction, Height Balanced Trees(AVL), B-trees, B+-trees.	7L
UNIT-04	**Graphs:** Basic definitions, representations of directed and undirected graphs, the single-source shortest path problem, the all-pair shortest path problem, traversals of directed and undirected graphs, directed acyclic graphs, strong components, minimum cost spanning tress, articulation points and biconnected components, graph matching.	6L
UNIT-05	**Sorting and Searching Techniques:** Bubble sorting, Insertion sort, Selection sort, Shell sort, Merge sort, Heap and Heap sort, Quick sort, Radix sort and Bucket sort, Address calculation, Sequential searching, Binary Searching, Index searching, Hash table methods.	6L
Course Outcomes Upon successful completion of the course, the students will be able to CO1: Interpret and compute asymptotic notations of an algorithm to analyze the time complexity. CO2: Use of linear and non-linear data structures as the foundational base for computer solutions to problems. CO3: Demonstrate the ability to implement various types of static and dynamic lists. CO4: Implement binary trees, binary tree traversals, binary search trees and perform related analysis to solve problems. CO5: Implement various types of sorting algorithms.		
Books and References 1. An Introduction to Data Structures with applications by J.P. Tremblay and P.G. Sorenson, Tata McGraw Hill. 2. Data structures, Algorithms ad Applications in C++ by Sartaj Sahni, WCB/McGraw Hill. 3. Data Structures and Algorithms by Alfred V. Aho, Jeffrey D. Ullman, John E. Hopcroft, Addison Wesley. 4. Data Structures using C by Y. Langsam, M. J. Augenstein and A. M. Tenenbaum, Pearson Education. 5. Data Structures – A Pseudocode Approach with C by Richard F. Gilberg and Behrouz A. Forouzan, Thomson Brooks /Cole.		

Course Name: **Digital Electronics and Logic Design Lab** Course Code: **EC-214**	
Contact Hours/Week: **2P**	Course Credits: **01**

Course Objectives

- Familiarization with digital integrated circuits and equipment's.
- Implementation and design of combinational logic circuits using different gates.
- To understand concepts of sequential circuits and to analyze and design sequential circuits.

List of Experiments

1. To study about the logic gates and verify their truth table.
2. Realization of AND and OR gates using
   (i) Diodes and resistors.
   (ii) Universal gates
3. Design and implement half adder and full adder circuits and verifies the truth table using logic gates.
4. Design and implement half subtractor and full subtractor circuits and verifies the truth table using logic gates.
5. Design and implement 4-bit binary to gray code converter and gray to binary code converter circuits.
6. Design and implement BCD to excess-3 code converter and excess-3 to BCD code converter.
7. Design and implement
   (i) 2-Bit magnitude comparator using basic gates
   (ii) 8-Bit magnitude comparator using IC 7485
8. Design and implement multiplexer and demultiplexer using logic gates and study of IC 74150 and IC 74154.
9. Design and implementation of the function using multiplexer
   (i) $F(A,B,C)=\Sigma m(1,2,5,6)$
   (ii) $F(A,B,C)=\Sigma m(0,2,5,6,7)$
10. Design and implement encoder and decoder using logic gates and study of IC 7445 and IC 74147.
11. Realization of SR, JK, D and T flip flop using gates.
12. Design and implement 3-bit synchronous up counter.
13. Design and implement 3-bit asynchronous up/down counter.
14. Design BCD to seven segment display with decoder Using IC 7447.

Note: *The concerned Course Coordinator will prepare the actual list of experiments/problems at the start of semester based on above generic list.*

Course Outcomes

Upon successful completion of the course, the students will be able to

CO1: Understand the digital signals, applications of ICs and logic circuits.

CO2: Develop skills for designing combinational logic circuits and their practical implementation on breadboard.

CO3: Analyze, design and implement sequential logic circuits.

Course Name: **Analog Electronics Lab** Course Code: **EC-215**	
Contact Hours/Week:**2P**	Course Credits: **01**

Course Objectives

- To provide skills for designing various oscillator circuits
- To provide skills for understanding frequency stability in amplifiers
- To enable the students to plot the characteristic property of various transducers

1. To study the working of Hartley Oscillator and measure the frequency of oscillations
2. To study the working of Colpit's Oscillator and measure the frequency of oscillations
3. To study the functioning of Crystal Oscillator and measure the frequency of oscillations
4. To study the frequency response of two-stage RC coupled amplifier and find the voltage gain
5. To identify the type of feedback used in an amplifier and determine the voltage gain
6. To study the push-pull amplifier and plot the frequency response
7. To study the transformer coupled amplifier and determine the frequency response
8. To study the voltage gain and frequency response of FET amplifier
9. To study the astable, monostable and bistable multivibrators and their timing parameters.

Note: *The concerned Course Coordinator will prepare the actual list of experiments/problems at the start of semester based on above generic list.*

Course Outcomes

Upon successful completion of the course, the students will be able to

CO1: Analyze and design analog electronic circuits using discrete components

CO2: Design and implement an analog circuit project application utilizing knowledge and skills learned

CO3: Establish the biasing of an FET amplifier

CO4: Calculate power efficiency of large–signal amplifier

Course Name: **Data Structures Lab** Course Code: **CS-202**	
Contact Hours/Week: **2P**	Course Credits: **01**

Course Objectives

- To provide skills for designing & writing algorithms.
- To provide skills for writing C/C++ programs.
- To enable the students to debug programs.

List of Experiments

1. Write a program to sort an array (make a dynamic array) using Bubble sort. Use 1-bit variable FLAG to signal when no interchange take place during pass. If FLAG is 0 after any pass, then list is already sorted and there is no need to continue.
2. WAP to search an ITEM (integer) in an array using binary search, if FOUND then delete that item from array and if NOT FOUND than insert that item in kth position (Input "k" from user).
3. WAP to enter records of Five students, which should contain fields like roll No., name, CGPI, semester.
a. List all record of all students having CGPI greater than k.
b. Insert a new record of student at kth position and print the final record.
4. Implement linked list and insert and delete an element into the list.
5. Evaluate a postfix algebraic expression with the help of stack.
6. Implement a circular queue by adding or deleting few elements. Make sure to incorporate "Queue Empty", "Queue Full" constraints in your program.
7. WAP to implement Binary Search Tree with insertion and deletion operation.
8. Implement any one of the tree traversing techniques.
9. Implement various sorting algorithms like Quick sort, Merge Sort, Insertion Sort, Selection Sort etc.
10. Implement hashing.

Note: *The concerned Course Coordinator will prepare the actual list of experiments/problems at the start of semester based on above generic list.*

Course Outcomes

Upon successful completion of the course, the students will be able to

CO1: To gain knowledge of popular available data stuctures.

CO2: To develop programming skills in students.

CO3: To impart knowledge of syntax and sementics of basic laungages.

Course Name:	**Engineering Mathematics-III**
Course Code:	**MA-203**
Course Type:	**Core**

Contact Hours/Week: **3L + 1T** Course Credits: **04**

Course Objectives

- To introduce the fundamental concepts relevant to function of complex variable, numerical differentiation and integration and numerical solution of linear, non-linear and system of equations.
- To have the idea of evaluation of real integrals using complex variable.
- To understand the concept of approximating & interpolating polynomials and finding values of function at arbitrary point.
- To impart knowledge of various numerical technique to solve ODE.

Unit Number	Course Content	Lectures
UNIT-01	**Functions of Complex Variable** Applications of De Moivre's theorem, Exponential, Circular, Hyperbolic and Logarithmic functions of a complex variable, Inverse Hyperbolic functions, Real and imaginary parts of Circular and Hyperbolic functions, Summation of the series-'C+iS' method. Limit and derivative of complex functions, Cauchy-Riemann equations, Analytic functions and its applications, Complex integration, Cauchy's theorem, Cauchy's integral formula, Series of complex function, Taylor series, singularities and Laurent's series, Cauchy's residue theorem and its application for the evaluation of real definite integrals.	**12L**
UNIT-02	**Interpolation** Least square curve fit and trigonometric approximations, Finite differences and difference operators, Newton's interpolation formulae, Gauss forward and backward formulae, Sterling and Bessel's formulae, Lagrange's interpolation.	**6L**
UNIT-03	**Numerical Integration** Integration by trapezoidal and Simpson's rules 1/3 and 3/8 rule, Romberg integration, and Gaussian quadrature rule, Numerical integration of function of two variables.	**5L**
UNIT-04	**Numerical Solution of Ordinary Differential Equations** Taylor series method, Picard's method, Euler's method, Modified Euler's method, Runge-Kutta method. Predictor corrector methods, Adam Bashforth and Milne's method, convergence criteria, Finite difference method.	**7L**
UNIT-05	**Numerical Solution of Linear and Non Linear Equations** Non Linear Equations: Bisection Method, Regula Falsi Method, Newton-Raphson Method, Iteration method. Linear Equations: Jacobi and Gauss Seidal Iteration methods, Relaxation method.	**06 L**

Course Outcomes: Upon successful completion of the course, the student will be able to:

CO1: Understand and analyze the concept of Numerical Solution of Linear and Non Linear Equations, Ordinary Differential Equations and Function of complex variable.

CO2: Identify an appropriate technique to solve the linear, non-linear equations, ordinary differential equations.

CO3: Formulate the problems on related topics and solve analytically.

CO4: Apply the concepts of linear, non-linear equations, differential equations and complex analysis in various engineering problems.

CO5: Demonstrate the concepts through examples and applications.

Books and References

1. Complex variables and Applications: by R. V. Churchill, T. J. Brown & R. F. Verhey, McGraw Hill.
2. A first course in complex analysis with applications: by Dennis D. Zill & P. D. Shanahan, Jones and Bartlett.
3. Numerical Methods for Scientific and Engineering Computations: by M. K. Jain, S. R. K. Iyenger and R. K. Jain, New Age International Publishers, New Delhi
4. Numerical Methods for Engineers and Scientists(2nd Ed.): by J D Hoffman, CRC Press
5. Numerical Analysis Mathematics and Scientific computing (3rd ed.): by D. Kincaid and W. Cheney, American Mathematical Society.

Course Name:	**Linear Integrated Circuits**
Course Code:	**EC-221**
Course Type:	**Core**
Contact Hours/Week: **3L + 1T**	Course Credits: **04**

Course Objectives

- To impart strong foundation of IC based design.
- To introduce the various applications of operational amplifiers and its integration with other devices.
- To learn circuits design using op amps for power management, signal conditioning and communication

Unit Number	Course Content	Lectures
UNIT-01	**Differential And Cascode Amplifiers** Emitter coupled differential amplifiers & its circuit configurations, FET differential amplifier, Differential amplifier with swamping resistor, constant current bias & current mirror. Cascade differential amplifier stages. Level translator, Cascode configuration	**8L**
UNIT-02	**Introduction to Operational Amplifiers** The basic operational amplifier & its schematic symbol, Block diagram representation of OP-AMP, Power supply requirements of an OP-AMP, Evolution of OP-AMP, Specification of a typical OP-AMP(741).	**3L**
UNIT-03	**The Practical Op-Amp And Its Frequency Response** Input offset voltage, input bias current, input offset current. Total output offset voltage, thermal drift, error voltage, variation of OP-AMP parameter with temperature & supply voltage. Supply voltage rejection ration (SVRR), CMRR-Measurement of OP-AMP parameters, Frequency response of compensator networks, Open loop voltage gain as a function of frequency, Slew rate, causes of slew rates and its effects in application	**6L**
UNIT-04	**Operational Amplifier Configurations & Linear Application** Open loop OP-AMP configurations- The differential amplifier, inverting amplifier, non-inverting amplifier, negative feedback configurations - inverting and non-inverting amplifiers, voltage followers & high input impedance configuration, differential amplifiers, closed loop frequency response & circuit stability, single supply operation of OP-AMP, summing, scaling and averaging amplifier, voltage to current & current to voltage converters, integrators & differentiators, logarithmic & anti logarithmic amplifiers	**6L**
UNIT-05	**Active Filters & Oscillators** Advantages of active filters, classification of filters, response characteristics of butter worth, chebyshev, causal filters, first order and second order butter worth filters- low pass and high pass types. Band pass & band reject filters. Oscillator principles, types of oscillators - phase shift, Wien Bridge & quadrature. Square wave, triangular wave and saw tooth wave generators, voltage controlled oscillator	**5L**
UNIT-06	**Comparators & Converters** Basic comparator & its characteristics, zero crossing detector, voltage limiters, clippers & clampers, small signal half wave & full wave rectifiers, sample and hold circuit, ADC, DAC	**5L**
UNIT-07	**Voltage Regulators** Fixed Voltage Regulator, Adjustable voltage regulators, Switching regulators, special regulators	**3L**

Course Outcomes

Upon successful completion of this course students will be able to :

CO1: Understand and design the basic circuits using op-amp and perform operations and their troubleshooting

CO2: To learn how to detect, amplify, store, create and manipulate signals using operational amplifiers\

CO3: To design and analyze the responses of IC based designed circuits in the area of power management, signal conditioning, analog and digital communication

CO4 : To develop IC based projects in the above areas

Books and References

1. OP-AMP and Linear Integrated Circuits, Ramakant A. Gayakwad, PHI Publication.
2. Design with Operation Amplifiers and Analog Integrated circuits, Sergei Franco, TMH.
3. Integrated Electronics: Analog and Digital Circuits & System, Millman & Halkias, TMH.
4. Linear Integrated Circuits, D. Choudhari, S. Jain, New Age International limited.

Course Name:	**Analog Communication Systems**
Course Code:	**EC-222**
Course Type:	**Core**

Contact Hours/Week: **3L + 1T** Course Credits: **04**

Course Objectives

- To introduce the concepts of analog communication systems.
- To equip students with various issues related to analog communication such as modulation, demodulation, transmitters and receivers and noise performance.
- Differentiate between different modulation techniques and necessities of the same.

Unit Number	Course Content	Lectures
UNIT-01	**Modulation Techniques** Various Frequency Bands Used for Communication, Types of Communication and Need of Modulation. Introduction to AM, FM, PM, Frequency Spectrum of AM Waves, Representation of AM, Power Relation in AM Waves, Need and Description of SSB, Suppression of Carrier, Suppression of Unwanted Side-bands, Independent Sideband System, Vestigial Sideband System, Mathematical Representation of FM, Frequency Spectrum of AM Waves, Phase Modulation, Comparison Between Analog and Digital Modulation, Wideband and Narrow Band FM.	**10L**
UNIT-02	**AM Transmitters and Receivers** AM Transmitters: Generation of AM, Low Level and High Level Modulation, AM Transmitter Block Diagram, Collector Class C Modulator, Base Modulator, Transistor Vander Bill Modulator, DSB S/C Modulator. AM Receiver: Tuned Radio Frequency (TRF) Receiver. Super Heterodyne Receiver, RF Section and Characteristics, Mixers, Frequency Changing and Tracking, IF Rejection and IF Amplifiers. Detection and Automatic Gain Control (AGC), AM Receiver Characteristics.	**10L**
UNIT-03	**FM Transmitters and Receivers** FM Transmitters: Basic Requirements and Generation of FM, FM Modulation Methods: Direct Methods, Variable Capacitor Modulator, Varactor Diode Modulator, FET Reactance Modulator, Transistor Reactance Modulator, Pre-emphasis, Direct FM Modulator, AFC in Reactance Modulator, Disadvantages of Direct Method, Indirect Modulators, RC Phase Shift Modulators, Armstrong FM Systems. FM Receivers: Limiters, Single and Double-Tuned Demodulators, Balanced Slope Detector, Foster-Seeley or Phase Discriminator, De-emphasis, Ratio Detector, Block Diagram of FM Receivers, RF Amplifiers, FM Receiver Characteristics.	**05L**
UNIT-04	**SSB Transmitters and Receivers** Generator of SSB, Balanced Modulator Circuit, Filter Method, Phase Shift Method, Third Method, Phase Cancellation Method, Demodulation of SSB, Product Demodulator, Diode Detection Technique of SSB.	**05L**
UNIT-05	**Pulse Modulation Techniques** Pulse Amplitude Modulation and Demodulation, Pulse Width Modulation and Demodulation, Pulse Position Modulation and Demodulation, Sampling Theorem, Time Division Multiplexing, Frequency Division Multiplexing.	**06L**

Course Outcomes

Upon successful completion of the course, the students will be able to

CO1: Differentiate AM and FM transmission.

CO2: To analyze various methods of base band /band pass analog transmission and detection.

CO3: Gain the knowledge of components of analog communication system

Books and References

1. Electronic communication Systems by G. Kennedy, McGraw-Hill Education Publisher.
2. Principals of Communication System by Taub & Schilling, McGraw-Hill Education Publisher.
3. Electronic communication Systems by S. Haykin, Wiley India Pvt. Limited Publisher.

Course Name:	**Electromagnetic Field Theory**
Course Code:	**EC-223**
Course Type:	**Core**

Contact Hours/Week: **3L + 1T** Course Credits: **04**

Course Objectives

- To understand the basic concepts of vector analysis, co-ordinate transformation and space derivative.
- To introduce the fundamental concepts relevant to electrostatic field and application of Gauss' law.
- To introduce the fundamental concepts relevant to magnetostatic field and application of Biot-Savart's law.
- To introduce the concept of Maxwell's equations and how electromagnetic wave propagates.
- To give the understating of wave propagation in guided media.

Unit Number	Course Content	Lectures
UNIT-01	**Introduction:** Fundamental of vector algebra, Scalar &vector fields, Introduction and transformation on different coordinate systems: (rectangular, cylindrical and spherical co-ordinate system), introduction to line, Surface and volume integrals, Definition of gradient, Divergent and curl of a vector and their physical significance.	**04L**
UNIT-02	**Electrostatics:** Principle of Coulomb's law, Definition of electric field intensity from point charges, Field due to continuous distribution of charges on an infinite and finite line, Electric Field due to an infinite uniformly charged sheet, Gauss's law and its applications, Electric flux density, Potential fields duo to electric dipole, Laplace's and Poison's equations.	**07L**
UNIT-03	**Magnetostatics:** Definition and explanation on Magnetic Field intensity due to a finite and infinite wire carrying current, Magnetic field intensity on rectangular loop carrying current, Ampere's Circuital law and its applications, Biot-Savart's law, Lorentz force equation for a moving charge, Magnetic Vector Potential.	**07L**
UNIT-04	**Time Varying EM Field:** Maxwell's equation in differential and integral vector form and their interpretations, Continuity of currents, Conduction and displacement current, Boundary conditions, Helmholtz equations, uniform plane wave in dielectric and conductor media, Skin effect and depth of penetration, reflection and refraction of plane waves at boundaries for normal incidence and surface impedance, Energy Flow and Poynting theorem.	**08L**
UNIT-05	**Transmission Lines:** Transmission line model, Parameters and properties of transmission line equations, Reflections in transmission lines, Voltage, current and impedance relations-open, Short circuit and matched lines, Standing wave ratio, Impedance matching, Quarter and half wave lines, Single stub and double stub matching; Circle diagram – Smith-chart.	**10L**

Course Outcomes

Upon successful completion of the course, the students will be able to

CO1: Describe the fields using vector algebra and filed transformation from one co-ordinate system to other.
CO2: Describethe force between charges and equipotential surfaces and electrostatic shielding/ screening.
CO3: Describe the magnetic field due to a current element and force on a chage particle due to magnetic filed.
CO4: Describe the electriomagnetic wave phenomenon and power carried by an lectromagnetic wave.
CO5: Identify that the KVL and KCL law (Circuit theory) are not suitable to apply at microwave frequencies and Maxwell's equations (Field theory) are too complex to apply for each problem. And, how, the transmission line theory bridges the gap between circuit theory and field theory. Also, how to design PCB.

Books and References

1. Elements of Engineering Electromagnetics by Matthew N.O. Sadiku, Oxford University Press.
2. Engineering Electromagnetics by William Hayt, TATA McGraw-Hill.
3. Elements of Engineering Electromagnetics by Narayana Rao, N, Pearson Education.
4. Electromagnetic Waves and Radiating Systems by Jordan and Balmain, PHI, Second Ed.
5. Electromagnetics by J.D. Kraus, McGraw-Hill.

Course Name: **VLSI Technology** Course Code: **EC-224** Course Type: **Core**		
Contact Hours/Week: **3L**		Course Credits: **03**
Course Objectives: • To impart knowledge about the miniaturization of Electronic Systems. • To introduce the fundamental concepts relevant to VLSI fabrication. • To enable the students to understand the various VLSI fabrication techniques.		
Unit Number	**Course Content**	**Lectures**
UNIT-01	**Introduction to VLSI:** Concept Miniaturization of Electronic Systems & its impact on characterization.	**03L**
UNIT-02	**Monolithic Fabrication Techniques:** Crystal growth: Source of silicon; Single crystalline and Poly crystalline; Requirement of purity for electronics industry; Electronics grade silicon production; Crystal growth techniques: Bridgeman method, Float zone method, Czocharalski method, Modified Czocharalski method; refining; Silicon Wafer Preparation & Crystal Defects. **Epitaxial Process:** Need of epitaxial layer; vapors phase epitaxy -reactor design, Chemistry of epitaxial process, Transport mechanism doping & auto doping; selective epitaxy, Epitaxial process induced defects, Molecular beam epitaxy, Merits and demerits among epitaxial processes; recent trends in Epitaxy. **Oxidation:** Importance of oxidation; types of oxidation techniques; growth mechanism & kinetics; factors affecting the growth mechanisms; silicon oxidation model, dry & wet oxidation; oxidation induced faults; recent trends in oxidation. **Lithography:** Basic steps in lithography; Lithography techniques-optical lithography, Electron beam lithography, X-ray lithography, Ion beam lithography; resists and mask preparation of respective lithographies, Printing techniques-contact, Proximity printing and projection printing; merits and demerits of lithographies; recent trends in lithography at nano regime. **Etching:** Performance metrics of etching; types of etching- wet and dry etching; dry etching techniques-ion beam or ion-milling, Sputter ion plasma etching and reactive ion etching (RIE); merits and demerits of etching; etching induced defects; recent trends in epitaxy. **Diffusion and Ion Implantation:** Diffusion mechanisms; diffusion reactor; diffusion profile; diffusion kinetics; parameters affecting diffusion profile; Dopants and their behavior, choice of dopants; Ion Implantation- reactor design, impurity distribution profile, Properties of ion implantation, Low energy and high energy ion implantation. **Metallization:** Desired properties of metallization for VLSI; metallization choices; metallization techniques – vacuum evaporation, Sputtering.	**21L**
UNIT-03	**Packaging of VLSI Chip:** Introduction to packaging; packaging process; package design considerations, Various packages types.	**04L**
UNIT-04	**Isolation Techniques in Monolithic Components:** Isolation techniques in Diodes, BJT and MOSFETs (Enhancement and depletion mode)	**04L**
UNIT-05	**Monolithic Components- Prototype Fabrication:** Prototype fabrication of Diodes, npn BJT, pnp BJT, MOSFETs (Enhancement and depletion mode), n-MOS, p-MOS, CMOS, Resistors and Capacitors.	**04L**
Course Outcomes Upon successful completion of the course, the students will be able to CO1: Identify the material properties and ambient conditions for chips fabrication. CO2: Describe the analysis of technology scaling. CO3: Understand the complexities involved in the integrated circuits. CO4: Apply principles toIdentify and Analyze the various steps for the fabrication of various components CO5: Assess the various reliability issues in VLSI technology		
Books and References 1. VLSI Technology by S.M. Sze, Tata Mc-Graw Hill 2. VLSI Fabrication Principles by S.K. Gandhi, John Willey & Sons 3. Integrated Circuits by K. R. Botkar, Khanna Publishers 4. Micromachined Transducer by G.T.A. Kovacs, McGraw Hill, 1998 5. Principles of Microelectronics Technology by D. Nagchoudhary, PHI		

Course Name: **Linear Integrated Circuits Lab** Course Code: **EC-225**	
Contact Hours/Week: **2P**	Course Credits: **01**

Course Objectives

- To learn practical applications of operational amplifier.
- To design and develop circuits using operational amplifiers.
- To learn how to detect, amplify, store, create and manipulate signals using operational amplifiers.

List of Experiments

1. To demonstrate the relationship between input and output in for the inverting and non-inverting configuration of the Op-Amp. 741.
2. To verify the function of OP-Amp's a summer and as a difference amplifier.
3. To perform the mathematical operation of differentiation using basic and practical circuit of Op-Amp's.
4. To perform the mathematical operation of integration using basic and practical circuit of Op-Amp's.
5. To study the half wave and full wave rectifier circuits using Op-Amp's
6. To design a first order butter worth low pass and high pass filter and determining its frequency response.
7. To plot the frequency response of the band pass filter for a specified frequency range.
8. To design a square, triangular and sawtooth wave generator using Op-Amp's.
9. To design the Wien Bridge oscillator using Op-Amp's.
10. To study the clipping and clamping circuits using operational amplifiers.

Note: *The concerned Course Coordinator will prepare the actual list of experiments/problems at the start of semester based on above generic list.*

Course Outcomes

Upon successful completion of the course, the students will be able to

CO1: To learn the basic applications of the operational amplifier

CO2: To learn how to detect, amplify, store, create and manipulate signals using operational amplifiers

CO3: To design and analyze the responses of IC based designed circuits in the area of power management, signal conditioning, analog and digital communication

Course Name: **Analog Communication Lab** Course Code: **EC-226**	
Contact Hours/Week: **2P**	Course Credits: **01**

Course Objectives

- To understand practical implementation of various analog modulation schemes.
- To analyze and measure the performance of various analog modulation schemes.
- To understand practical implementation of pulse modulation, TDM and FDM.

List of Experiments

1. Amplitude Modulation and Demodulation
2. DSB SC Modulation and Demodulation
3. SSB SC Modulation and Demodulation
4. Frequency Modulation and Demodulation
5. To Observe and Measure Frequency Deviation and Modulation Index.
6. Pre Emphasis - De Emphasis.
7. PAM Generation and Reconstruction
8. PWM Generation and Reconstruction
9. PPM Generation and Reconstruction
10. Verification of Sampling Theorem
11. Time Division and Frequency Division Multiplexing
12. Phase Locked Loop

Note: *The concerned Course Coordinator will prepare the actual list of experiments/problems at the start of semester based on above generic list.*

Course Outcomes

Upon successful completion of the course, the students will be able to

CO1: Design and implement AM and FM based analog communication systems.

CO2: Design and implement Pulse modulation systems.

CO3: Design and implement FDM and TDM systems.

CO4: Analyze the performance measure of Analog Communication Systems.

Course Name: **Circuit Design and Simulation Lab** Course Code: **EC-227**	
Contact Hours/Week: **2P**	Course Credits: **01**

Course Objectives

- To provide skills for designing Electronics circuits in circuit simulator
- To provide skills for analyzing the electronics circuits
- To enable the students to be able to design a new electronic circuit.

List of Experiments

1. Introduction to Tanner and Cadence EDA simulation tool.
2. To study the time and frequency response of series RLC circuit.
3. To study the frequency response of common emitter configuration of BJT.
4. To simulate N-MOS transistor and obtain its transfer and output characteristics.
5. To simulate-MOS transistor and obtain its transfer and output characteristics.
6. To simulate MOS inverter using resistive load, CMOS inverter, pseudo NMOS inverter and enhancement mode CMOS inverter and obtain their VTC.
7. To simulate NAND and NOR logic gate using CMOS and study its performance.
8. To simulate EX-OR and EX-NOR logic gate using CMOS and study its performance.
9. To simulate half adder and Full adder using CMOS and study its performance.
10. Introduction to Physical simulation and TCAD.
11. Build a simulation mesh for diode and study its characteristics.
12. Build a simulation mesh for BJT and study its characteristics.
13. Build a simulation mesh for MOSFET and study its characteristics.
14. To study the CMOS inverter characterization using proto-type fabricated NMOS and PMOS.

Note: *The concerned Course Coordinator will prepare the actual list of experiments/problems at the start of semester based on above generic list.*

Course Outcomes

Upon successful completion of the course, the students will be able to

CO1: Identify and introduce simulate the electronic circuits

CO2: Design electronic circuit for a concerned application.

CO3: Write a TCAD program for the performance analysis of electronic device

Course Name:	**Microprocessor Architecture and Applications**
Course Code:	**EC-311**
Course Type:	**Core**

Contact Hours/Week: **3L + 1T** Course Credits: **04**

Course Objectives

- To impart knowledge about the architecture and instruction set of typical 8-bit microprocessor.
- To introduce the fundamental concepts relevant to, Assembly Language, Timers, Interrupts.
- Input-output techniques and important programmable support chips used in microprocessor-based systems are discussed in detail.

Unit Number	Course Content	Lectures
UNIT-01	**Introduction to Microprocessors:** History and Evolution, types of microprocessors, Microcomputer Programming Languages, Microcomputer Architecture, Pipelining, Clocking, Intel 8085 Microprocessor, Register Architecture, Bus Organization, ALU, Control section, ISA of 8085, Instruction format, Addressing modes, Types of Instructions.	**06L**
UNIT-02	**Assembly Language Programming and Timing Diagram:** Assembly language programming in 8085, Macros, Labels and Directives, Microprocessor timings, Micro instructions, Instruction cycle, Machine cycles, T-states, State transition diagrams, Timing diagram for different machine cycles, Memory and I/O interface.	**08L**
UNIT-03	**Serial I/O, Interrupts:** Serial I/O using SID, SOD, Interrupts in 8085, RST instructions, Issues in implementing interrupts, Multiple interrupts and priorities, Daisy chaining, Interrupt handling in 8085, Enabling, Disabling & masking of interrupts.	**09L**
UNIT-04	**Data Transfer techniques:** Data transfer techniques, Parallel & Programmed data transfer using 8155, Programmable parallel ports & handshake input/output, Asynchronous and Synchronous data transfer using 8251, PIC (8259), PPI (8255), DMA controller (8257). Interfacing Traffic Light Interface, Stepper Motor, 4 Digit 7 Segment LED, stepper motor and LCD.	**06L**
UNIT-05	**16-Bit Microprocessors (Intel 8086):** Introduction to a 16 bit microprocessor, Memory address space and data organization, Segment registers and Memory segmentation, Generating a memory address, I/O address space, Addressing modes, Comparison of 8086 & 8088, Basic configurations of 8086/8088, Min. Mode, Max. Mode & System timing, Introduction to Instruction Set of 8086.	**07L**

Course Outcomes

Upon successful completion of the course, the students will be able to

CO1: Understand the architecture of 8085 and 8086

CO2: Impart the knowledge about the instruction set

CO3: Understand the basic idea about the data transfer schemes and its applications

Books and References

1. Microprocessor Architecture, Programming & Applications with the 8085/8080A by R.S. Gaonkar, Wiley Eastern Ltd.
2. Microprocessors & Interfacing by D.V. Hall, McGraw Hill.
3. Microprocessors: Theory & Applications (Intel & Motorola) by M. Rafiquzzman, PHI.
4. INTEL 8086/88, 80186, 286, 386, 486, Pentium Pro & Pentium IV by Berry B. Bray.

Course Name:	**Digital Communication and Systems**
Course Code:	**EC-312**
Course Type:	**Core**
Contact Hours/Week: **3L + 1T**	Course Credits: **04**

Course Objectives

- To impart knowledge about the key modules of digital communication systems with emphasis on digital modulation techniques.
- To introduce the fundamental concepts relevant to reception of digital signals
- To enable the students to understand the concept and basics of information theory and the basics of channel coding/decoding.

Unit Number	Course Content	Lectures
UNIT-01	**Introduction:** Concepts of Digital Communication, Advantages/Disadvantages of Digital Communication Systems over Analog Communication Systems. Block Diagram of Basic Digital Communication Transmitter/Receiver.	**02L**
UNIT-02	**Analog to Digital Conversion:** Noisy Communications Channels, Sampling Theorem: Low Pass Signals And Band Pass Signals, Pulse Amplitude Modulation, Channel Bandwidth For PAM Signal, Natural Sampling, Flat Top Sampling, Signal Recovery & Holding, Quantization of Signal, Quantization Error, Pulse Code Modulation (PCM), Delta Modulation, Adaptive Delta Modulation.	**08L**
UNIT-03	**Digital Modulation Techniques:** Binary Phase Shift Keying, Differential Phase Shift Keying, Differential Encoded PSK, QPSK, Quadrature Amplitude Shift Keying (QASK), Binary Frequency Shift Keying.	**8L**
UNIT-04	**Data Transmission:** Base Band Signal Receiver, Probability of Error, Optimum Filter, White Noise- Matched Filter, Probability of Error of The Matched Filter, Coherent Reception: Correlation, Application of Coherent Reception In PSK And FSK. Correlation Receiver for QPSK.	**7L**
UNIT-05	**Noise in Pulse Code & Delta Modulation Systems:** PCM Transmission, Calculation of Quantization Noise, O/P Signal Power, The Effect of Thermal Noise, O/P Signal to Noise Ratio in PCM, Delta Modulation, Quantization Noise in Delta Modulation, The O/P Signal to Quantization Noise Ratio in Delta Modulation, O/P Signal to Noise Ratio in Delta Modulation.	**6L**
UNIT-06	**Information Coding and Decoding:** Coding for Error Detection and Correction, Basics of Block Coding and Decoding, Introduction to Cyclic Codes, Basic Convolution Coding /Decoding and Viterbi Algorithm.	**05L**

Course Outcomes

Upon successful completion of the course, the students will be able to

CO1: Apply the knowledge of statistical theory of communication and explain the conventional digital communication system.

CO2: Apply the knowledge of signals and system and evaluate the performance of digital communication system in the presence of noise.

CO3: Apply the knowledge of digital electronics and describe the error control codes like block code, cyclic code.

CO4: Design as well as conduct experiments, analyze and interpret the results to provide valid conclusions for digital modulators and demodulator using hardware components and communication systems using CAD tool.

Books and References

1. Principles of communication systems by Taub & Schilling, McGraw-Hill Education (India).
2. Communication Systems by Simon Haykin, John-Wiley & Sons, Inc.
3. Digital Communication by J.G. Proakis, McGraw – Hill.
4. Digital Communications: Fundamentals & Applications by B. Sklar, Pearson Education.
5. Introduction to Digital Communication by R.E. Zimer & R.L. Peterson, PHI.

Course Name:	**Digital Signal Processing**
Course Code:	**EC-313**
Course Type:	**Core**
Contact Hours/Week: **3L+1T**	Course Credits: **04**

Course Objectives

- Digital Signal processing explains the basics of discrete time signals and systems. It focuses on the operation on the signals in time and frequency domain. It covers the different design techniques for FIR and IIR filters and also their realization structures.

Unit Number	Course Content	Lectures
UNIT-01	**DISCRETE-TIME SIGNALS AND SYSTEMS** Basic Elements of a Digital Signal Processing System, Advantages of Digital Signal Processing, Classification of Signals, The Concept of Frequency In Continuous-Time and Discrete-Time Domain, Discrete-Time Signals and Systems, Analysis Of Discrete-Time Linear Shift-Invariant Systems, Linearity, Causality And Stability Criterion, Discrete-Time Systems Described By Difference Equations.	**07L**
UNIT-02	**DISCRETE-TIME FOURIER TRANSFORM** The Fourier Transform Of Discrete-Time Signals (DTFT), Properties Of The DTFT, The Frequency Response Of An LTI Discrete-Time System, The Fourier Series Of Discrete-Time Signals (DTFS).	**05L**
UNIT-03	**DISCRETE FOURIER TRANSFORM** Frequency Domain Sampling And The DFT, Properties Of The DFT, Linear Filtering Methods Based On The DFT, Efficient Computation Of The DFT: Decimation-In-Time And Decimation-In Frequency Fast Fourier Transform Algorithms.	**07L**
UNIT-04	**Z-TRANSFORM** Introduction To The Z-Transform & The Inverse Z-Transform, Properties Of The Z-Transform, Relationship Between The Fourier Transform And The Z-Transform, Rational Z-Transforms & The System Function, Analysis Of Linear Time-Invariant Systems In The Z-Domain.	**05L**
UNIT-05	**DIGITAL FILTER STRUCTURES** Digital Filter Categories, Realization Structures For FIR & IIR Digital Filters, Representation Of Numbers: Fixed-Point, Floating Point, Error Resulting From Rounding And Truncation.	**04L**
UNIT-06	**DIGITAL FILTER DESIGN** General considerations; design of IIR filter from Analog filters: IIR filter design using Approximation of derivative, impulse invariant method, Bilinear transformation; Design of linear phase FIR digital filters: Symmetry and Anti-symmetry FIR filters, FIR digital filter design using the windowing method and the frequency-sampling method.	**08L**

Course Outcomes

Upon successful completion of the course, the students will be able to
CO1: Understand the discrete time signals and systems.
CO2: Understand the Fourier transform and Fourier series of discrete time signals.
CO3: Analysis the discrete time signals in frequency domain using DFT and FFT.
CO4: Understand the Z-Transform and its properties.
CO5: Understand the realization structures for FIR and IIR digital filters.
CO6: Analysis the design characteristic of FIR and IIR filters.

Books and References

1. Digital Signal Processing: Principles, Algorithms and Applications by John G. Proakis & Dimitris G. Manolakis, Pearson Education.
2. Digital Signal Processing by Sanjit K. Mitra, Tata McGraw Hill Publication.
3. Digital Signal Processing by P Ramesh Babu, SCITECH Publication (India) Pvt Lmt.

Course Name:	**Microwave Devices and Systems**
Course Code:	**EC-314**
Course Type:	**Core**
Contact Hours/Week: **3L**	Course Credits: **03**

Course Objectives

- To impart knowledge about the usage of microwave communication.
- To introduce the fundamental concepts relevant to waveguide problems, microwave devices and components.
- To enable the students to understand the factors that cause the power, frequency, operating limitations of the devices.

Unit Number	Course Content	Lectures
UNIT-01	**Introduction on Microwaves:** Frequency Allocations and Frequency Plans, Microwave Waveguide, Rectangular Waveguide and its Analysis, Circular Waveguide, Modes of Propagation, Dominant Modes, Cut-off wavelength, Mode Excitation.	**06L**
UNIT-02	**Microwave Generators and Amplifiers:** Limitations of Conventional Tubes at Microwave Frequency, Reflex Klystron, Two and Multicavity Klystron Amplifiers and Oscillators and their Analysis, Basics on Magnetrons and Traveling Wave Tube and their Applications.	**06L**
UNIT-03	**Microwave Devices:** Scattering Matrix of Microwave Waveguide Junction, Properties of S-Matrix, E-Plane Tee, H-plane Tee, Magic Tee, Attenuators, Directional Couplers, Ferrite Devices, Faraday Rotation, Gyrator, Isolator, Circulators and Cavity Resonators	**06L**
UNIT-04	**Microwave Solid-State Devices:** Gunn Diode and its Modes of Operation, Avalanche IMPATT Diode, TRAPATT Diode, Operations and V-I Characteristics of Tunnel Diode, Schottky Diode, Backward Diode and Varactor Diodes, PIN Diode and its Applications.	**06L**
UNIT-05	**Micro-Strip Lines:** Introduction on Micro Strip Lines, Characteristic Impedance of Micro Strip Lines, Losses in Micro Strip Lines, Quality Factor of Micro Strip, Parallel Strip Lines, Coplanar Strip Lines and Shielded Strip Lines.	**06L**
UNIT-06	**Microwave Measurements:** Measurement of Standing Wave Ratio, Measurement of Wavelength and Frequency, Measurement of Power, Radiation Pattern Measurement of Antenna, Microwave Link.	**06L**

Course Outcomes

Upon successful completion of the course, the students will be able to

CO1: Identify the knowledge of generations and amplifications of the signals at high frequencies

CO2: Describe the microwave components, devices and system.

CO3: Apply principles of transmission lines at microwave frequencies, reflection and transmission of the wave.

CO4: Assess the usage of microwave spectrum, microwave measurement techniques.

Books and References

1. Microwave Engineering by David M. Pozar, Wiley Publication, New Delhi
2. Microwave Devices and Circuits by Samuel Y. Liao, Prentice-Hall, U.S.A
3. Microwave and Radar Engineering by M. Kulkarni, Umesh Publications, India.
4. Foundations for Microwave Engineering by R.E. Collins, Wiley Interscience, New York.
5. Microwave Engineering by Das and S. K. Das, McGraw-Hill, New Delhi.
6. Elements of Microwave Engineering by Rajeswari Chatterjee, Ellis Horwood Ltd.

Course Name: **Digital Communication Lab** Course Code: **EC-315**	
Contact Hours/Week: **2P**	Course Credits: **01**

Course Objectives

- To understand practical implementation of various digital modulation schemes.
- To analyze and measure the performance of various digital modulation schemes.
- To understand practical implementation of line coding formats.

List of Experiments

1. Time Division Multiplexing & Demultiplexing.
2. Pulse Code Modulation & Demodulation.
3. Delta Modulation and Demodulation.
4. Adaptive Delta Modulation and Demodulation.
5. Binary Phase Shift Keying (BPSK) Modulation and Demodulation.
6. Frequency Shift Keying (FSK) Modulation and Demodulation.
7. Amplitude Shift Keying (ASK) Modulation and Demodulation.
8. Quadrature Phase Shift Keying (QPSK) Modulation and Demodulation
9. To Study Characteristics of Gaussian Noise and to Measure its Spectral Height in Frequency Band over Which Its Spectral Density is flat.
10. To Study Line Coding Techniques.
11. To Study The Characteristics of The Phase Shifter, Multiplier and The Integrate-And-Dump Filter.

Note: *The concerned Course Coordinator will prepare the actual list of experiments/problems at the start of semester based on above generic list.*

Course Outcomes

Upon successful completion of the course, the students will be able to

CO1: Design and implement BPSK, QPSK, ASK and BFSK based digital communication systems.
CO2: Design and implement PCM, DM and ADM based digital communication systems.
CO3: Analyze the performance measure of Digital Communication Systems.

Course Name: **Microwave Devices and Systems Lab**
Course Code: **EC-316**

Contact Hours/Week: **2P** Course Credits: **01**

Course Objectives

- To provide skills for operating microwave benches at designed X band setup
- To provide skills for usage of microwave sources
- To enable the students to practical know how the microwave measurements.

List of Experiments

1. To Study the Microwave Components, Sources and Different Types of Loads at X Band Setup.
2. To Study the Characteristics of Reflex Klystron Oscillator and Determine its Mechanical and Electronics Tuning Range.
3. To Study the V-I Characteristics of Gunn Diode and Determine its Negative Resistance.
4. To Determine the Insertion Loss Parameter and Isolation Parameter of a Ferrite Based Isolator and Circulators.
5. To Measure the Frequency in a Rectangular Waveguide and Demonstrate the Relationship among the Frequency, Free Space Wavelength and Guide Wavelength.
6. To Plot the Radiation Pattern of a Pyramidal Horn Antenna and determine its Gain and Beam width.
7. To Study the Characteristics of Various Tees, i.e. E-Plane Tee, H-Plane Tee and Magic Tees.
8. To Measure the Coupling and Directivity of a 3 dB, 10 dB and 20 dB Directional Couplers.
9. To Measure the Low, Medium, and High VSWR of DUT Using Slotted Lines Section.
10. To Measure the Unknown Impedances using Smith Chart.
11. To Measure of VSWR, Insertion Loss, Attenuation of Fixed and Variable Attenuators.
12. To Measure of Phase Shift of a Phase Shifter.

Note: *The concerned Course Coordinator will prepare the actual list of experiments/problems at the start of semester based on above generic list.*

Course Outcomes

Upon successful completion of the course, the students will be able to

CO1: Identify a practical approach for testing and measurement of these devices in real environment.
CO2: Design any microwave device and components at.
CO3: Understanding of basic requirements of microwave components and sources in real time applications

Course Name: **Digital Signal Processing Lab** Course Code: **EC-317**	
Contact Hours/Week: **2P**	Course Credits: **01**

Course Objectives

- To perform the time domain and frequency operations on discrete signals in MATLAB software
- To impart the knowledge of TMS320C6713 Processor and various operation using it.

List of Experiments

1. Generation of Basic continuous and discrete signals.
2. Write a MATLAB program to find the linear convolution of two discrete signals.
3. Write a MATLAB program to find the correlation of two signals.
4. Write a MATLAB program to find the circular convolution of two discrete signals.
5. Write a MATLAB program to find the DFT and IDFT of a discrete signal using FFT algorithm.
6. Write a MATLAB program to find the Z-transform of a discrete signal.
7. Design a FIR filters (LPF, HPF, BPF and BSF) using windowing technique and plot their magnitude and phase spectrum.
8. Design a FIR filters (LPF, HPF, BPF and BSF) using frequency sampling technique and plot their magnitude and phase spectrum.
9. Design a Butterworth IIR filters (LPF, HPF, BPF and BSF) and plots their magnitude and phase spectrum.
10. Design a Cheby-I and Cheby-II IIR filters (LPF, HPF, BPF and BSF) and plot their magnitude and phase spectrum.
11. Design a filter to remove noise from a signal.
12. Introduction to TMS320C6713 Processor.
13. Addition, Subtraction and multiplication in fixed point representation.
14. Addition, Subtraction and multiplication in floating point representation.
15. Linear Convolution using DSP kit.

Note: *The concerned Course Coordinator will prepare the actual list of experiments/problems at the start of semester based on above generic list.*

Course Outcomes

Upon successful completion of the course, the students will be able to

CO1: Understand various signal operations in time and frequency domain.

CO2: Design the FIR and IIR filters and will be able to remove noises from signal using filters.

CO3: Understand the TMS320C6713 Processor and various operations using it.

Course Name:	**Microcontroller And Embedded Systems**
Course Code:	**EC-321**
Course Type:	**Core**
Contact Hours/Week: **3L + 1T**	Course Credits: **04**

Course Objectives

- To impart knowledge about the microcontrollers, its programming, interrupts timers and assembly language.
- The concepts of ARM architecture and real-time operating system.
- To provide experience to integrate hardware and software for microcontroller application system.
- To impart ability to put together processor, peripherals and memory and build a real time system.

Unit Number	Course Content	Lectures
UNIT-01	**Microcontroller:** Introduction to Microcontrollers, Evolution, Architectures, Implementations, Background and History of Embedded Systems, Characteristics of ES, Hardware/Software Co-Design, RISC vs CISC, MCS-51 Family Overview, Important Features, Architecture, 8051 Pin Functions, Architecture, Addressing Modes, Instruction Set, Instruction Types, Applications of ASIC and FPGA in ES.	**05L**
UNIT-02	**Programming:** Assembly Programming, Timer Registers, Timer Modes, Overflow Flags, Clocking Sources, Timer Counter Interrupts, Baud Rate Generation, Serial Port Register, Modes of Operation, Processing Interrupts, Interrupt Service Routines, Look-up Tables.	**10L**
UNIT-03	**Embedded Software Development:** Software development flow, Polling, Interrupt driven, Multi-tasking systems, Architecture of an RTOS, Important features of RTOS, Embedded Systems Programming, Locks and Semaphores, Operating System Timers and Interrupts, Exceptions, Tasks, Task states and scheduling, Task structures, Synchronization, Communication and concurrency, Semaphores, Real-time clock.	**08L**
UNIT-04	**32-Bit Cortex-M Architecture:** CPU architecture, Memory model, Registers, Modes, Exceptions, Interrupts, Exception handlers, interrupt controllers, Power modes, Hardware features and optimizations, Advanced bus standards like AMBA, The NVIC on ARM Cortex-M.	**07L**
UNIT-05	**Instruction Set of ARM:** Syntax, Addressing modes and operands, Memory access instructions, Logical operations, Shift operations, Arithmetic operations, Stack, Functions and control flow, Assembler directives, Thumb and arm instruction differences, Development with Keil and Mbed, Applications like IoT and machine learning with cortex-M.	**06L**

Course Outcomes

Upon successful completion of the course, the students will be able to

CO1: Write the programs for microcontrollers

CO2: Understand the role of embedded systems in industry.

CO3: Understand the design concept of embedded systems.

Books and References

1. The 8051 Microcontroller and Embedded Systems (2nd Ed.) by Mazidi Muhammad Ali, Pearson publications.
2. The Definitive Guide to ARM Cortex-M3 processors (3rd Ed.) by Joseph Yiu, Newnes publication.
3. Introduction to ARM Cortex-M Microcontrollers, Vol. 1 (5th Ed.) by Jonathan W. Valvano, Create Space.
4. Real-Time Interfacing to ARM Cortex-M Microcontrollers, Vol. 2 (4th Ed.) by Jonathan W. Valvano, Create Space.
   Real-Time Operating Systems for ARM Cortex-M Microcontrollers, Vol. 3 (2nd Ed.) by Jonathan W. Valvano, Create Space.

Course Name:	**Wireless Communication**
Course Code:	**EC-322**
Course Type:	**Core**
Contact Hours/Week: **3L + 1T**	Course Credits: **04**

Course Objectives

- To understand the cellular concept of wireless communications
- To study large-scale and small-scale propagation effects in wireless channels
- To study different techniques that improve radio link performance in wireless communications
- To understand general concepts of various multiple access techniques used in wireless communication

Unit Number	Course Content	Lectures
UNIT-01	**Introduction:** Evolution of wireless communication systems, Examples of wireless communication systems.	**2L**
UNIT-02	**The Cellular Concept – System Design Fundamentals:** Concept of frequency reuse, Channel assignment strategies, Handoff strategies, Interference and system capacity, Trunking and grade of service, Improving coverage and capacity in cellular systems.	**9L**
UNIT-03	**Propagation Models:** Free space propagation model, Two-ray ground reflection model, Distance power loss, Macrocell propagation model, Micro-cell propagation model, Shadowing model, Multipath effects in mobile communication, Models for multipath reception.	**8L**
UNIT-04	**Equalization, Diversity and Channel Coding:** Fundamentals of equalization, Adaptive equalizers, Linear and nonlinear equalization, Algorithms for adaptive equalization, Diversity techniques, Fundamentals of channel coding, Overview of error detection and correction codes.	**9L**
UNIT-05	**Multiple Access Techniques:** Introduction to multiple access, Frequency division multiple access, Time division multiple access, Spread spectrum multiple access, Space division multiple access, Packet radio, Orthogonal frequency division multiple access; Introduction to wireless systems and standards.	**8L**

Course Outcomes

Upon successful completion of the course, the students will be able to

CO1: Understand the operation of wireless and cellular communication systems

CO2: Analyze various design related issues associated with improving coverage and capacity of cellular systems

CO3: Analyze large-scale and small-scale radio propagation effects in mobile cellular systems

CO4: Understand the concepts of equalization, diversity and channel coding in wireless communications

CO5: Understand general concepts of various multiple access techniques for wireless communication

Books and References

1. Wireless Communications: Principles and Practice by Theodore S. Rappaport, Pearson / PHI Publication
2. Wireless Communications and Networks: 3G and Beyond by Iti Saha Misra, Tata McGraw Hill Publication
3. Mobile Cellular Telecommunications: Analog and Digital Systems by William C. Y. Lee, Tata McGraw Hill Publication
4. Wireless Digital Communications by Kamilo Feher, PHI Publication

Course Name: **VLSI Design Techniques** Course Code: **EC-323** Course Type: **Core**		
Contact Hours/Week: **3L + 1T**		Course Credits: **04**
Course Objectives • To introduce the fundamental concepts relevant to MOSFETs and physical design of VLSI circuits. • To impart knowledge about various CMOS VLSI Design styles. • To design MOS memories and learn high performance design techniques. • To enable the students understand the parameters on which the circuit performance depends and their control strategies.		
Unit Number	**Course Content**	**Lectures**
UNIT-01	**MOSFETS**: Fundamentals of Enhancement Mode MOSFETs, Depletion Mode MOSFETs, Weak & strong Inversion Conditions, Threshold Voltage Concept in MOSFETs, Current-Voltage (IV), Characteristics of a MOSFET, Limitations in IV Model and MOSFET parasitics, Trends & Projections in VLSI Design & Technology, Flow of VLSI Circuit Design, Scaling in MOS devices.	**05L**
UNIT-02	**VLSI Design Styles**: NMOS, CMOS Process flow, Noise Margin, Inverter Threshold Voltage, NMOS Inverter design and characteristics, CMOS Inverter Design and Properties, Delay and Power Dissipation, Parallel & Series Equivalent circuits, Static CMOS Circuit Design.	**09L**
UNIT-03	**VLSI Physical Design**: Stick Diagrams, Physical Design Rules, Layout Designing, Euler's Rule for Physical Design, Reliability issues in CMOS VLSI, Latching.	**05L**
UNIT-04	**High Performance Logics:** Precharge-Evaluate logic, Dynamic CMOS logic, NORA logic, Complementary Pass Logic (CPL), Transmission gate logic.	**07L**
UNIT-05	**MOS Memory Design**: MOS memories: ROM design, SRAM Cell design and DRAMs.	**06L**
UNIT-06	**CMOS Amplifiers**: Single stage MOS Amplifiers: Common Source amplifier, Common Gate amplifier, Common Drain amplifier	**04L**
Course Outcomes Upon successful completion of the course, the students will be able to CO1: Comprehend and utilize digital and analog VLSI circuit design techniques and their advancements. CO2: Identify, select and design any static and dynamic CMOS VLSI logic circuits for practical applications and memory design. CO3: Analyse CMOS circuits with equivalent parameters and build upon the theoretical, mathematical and experimental models. CO4: Use EDA tools and SPICE for analysis, verification and physical design simultaneously for efficient and optimal design of VLSI Circuits. CO5: Generate interest and competence in self-directed continuing professional development and for sustainable research and Development in VLSI design for societal and global interest.		
Books and References 1. CMOS Digital Integrated Circuits-Analysis & Design by S.M. Kang and Y. Leblebici, TMH. 2. Design of Analog CMOS Integrated Circuits by B. Razavi, TMH. 3. Solid State Electronic Devices by B.G. Streetman and S. Banerjee, PHI. 4. Principles of CMOS VLSI Design- A Systems Perspective by Neil H E Weste and K. Eshraghian. 5. Introduction to VLSI by K. Eshraghian and Pucknell, PHI.		

Course Name:	**Antenna and Wave Propagation**
Course Code:	**EC-324**
Course Type:	**Core**
Contact Hours/Week: **3L**	Course Credits: **03**

Course Objectives

- To impart knowledge about the Electromagnetic radiation, antenna basic parameters, antenna arrays and their patterns, special antennas, wave propagation over ground, through troposphere and ionosphere.
- To introduce the fundamental concepts relevant to electromagnetic theory and its application to antennas and wave propagation.

Unit Number	Course Content	Lectures
UNIT-01	**Electromagnetic radiation:** Radiation phenomenon from an oscillation dipole in free space, Induction and radiation fields, Retarded potentials, Radiated power and radiation resistance from a short dipole, Half wave dipole and quarter wave monopole.	**06L**
UNIT-02	**Antenna Fundamentals:**Directional properties of antennas, Radiation patterns, Antenna gain and aperture, Antenna terminal impedance, Self and mutual impedance, Front to back ratio, Antenna beam width and bandwidth, Antenna efficiency, Antenna beam area, Polarization, Antenna temperature and Reciprocity properties of antennas.	**06L**
UNIT-03	**Antenna Arrays:** Classification of arrays, Linear arrays of two point sources, Linear arrays of n-point sources, Pattern multiplication, Array factor, Linear arrays of equal amplitude and spacing (Broad side and end fire arrays) of n-point sources, Directivity and beam width, Non-uniform arrays excitation using Binomial series.	**08L**
UNIT-04	**Special Antennas:** VLF and LF antennas(Hertz and Marconi antennas), Rhombic antennas, Loop antennas ,Folded dipole antennas, Yagi-Uda antenna, Horn antennas, Microwave dish antennas, Helical antennas, Microstrip Patch antennas, Fractal antennas.	**08L**
UNIT-05	**Ground Wave Propagation:** Characteristics for ground wave propagation, Reflection at the surface of a finitely conducting plane and on earth, Attenuation Calculation of field strength at a distance.	**03L**
UNIT-06	**Ionosphere Propagation:** The ionosphere structure, Effective characteristics of the various layers of ionosphere, Reflection and Refraction of waves by ionosphere, Virtual height, Maximum usable frequency, Skip distance, Regular and irregular variation of ionosphere, Fading and Diversity reception. **Space Wave Propagation:** Space wave range, Troposphere waves-reflection, Refraction, Duct propagation, Troposphere propagation link.	**05L**

Course Outcomes

Upon successful completion of the course, the students will be able to

CO1: Identify basic antenna parameters
CO2: Design and analyze wire antennas
CO3: Design and analyze antenna arrays
CO4: Analyze different antennas
CO5: To identify characteristics of radio wave propagation

Books and References

1. Antennas Theory by C.A. Balanis, Willey Publication.
2. Antennas by J. D. Kraus, McGraw Hill.
3. Antennas and Radio Propagation by R. E. Collins, McGraw-Hill.
4. Electromagnetic waves & radiating System, E. C. Jorden and B. C. Balmann, P.H.I.
5. Antenna & Wave Propagation, K. D. Prasad, Satya Prakashan New Delhi.

Course Name: **Microprocessor and Microcontroller Lab** Course Code: **EC-325**	
Contact Hours/Week: **2P**	Course Credits:**01**

Course Objectives

- To provide skills for designing flowcharts and writing algorithms
- To provide skills for writing Embedded programs
- To enable the students to debug programs

List of Experiments

1. On 8085 kit, find the Factorial of a number
2. On 8085 kit, find if a number is prime or a perfect square
3. On 8051 kit, write a program to perform serial data transfer
4. On 8051 kit, generate square wave for a given frequency and duty cycle
5. On cortex M3, write a program to perform LED binking
6. On cortex M3, write a program to verify Digital out
7. On cortex M3, write a program to display clock on 7-segment display
8. On cortex M3, write a program to generate Analog output
9. On cortex M3, write a program to read in Analog input
10. On cortex M3, write a program to debug using serial pc
11. On cortex M3, write a program to generate PWM output
12. On cortex M3, write a program to perform counting on LCD counter
13. On cortex M3, write a program to learn Interrupt function
14. On cortex M3, write a program to understand 12c master and slave communication
15. On Intel Galileo Gen 2, plot a graph for analog input
16. On Intel Galileo Gen 2 write an Array in Arduino

Note: The concerned Course Coordinator will prepare the actual list of experiments/problems at the start of semester based on above generic list.

Course Outcomes

Upon successful completion of the course, the students will be able to

CO1: Write algorithms and programming task involved for a given problem

CO2: Design and develop modular programming skills

CO3: Trace and debug a program

Course Name: **VLSI Design Lab**
Course Code: **EC-326**

Contact Hours/Week: **2P** Course Credits: **01**

Course Objectives

- To learn Physical Design i.e. Layout making of VLSI circuits.
- Programming in SPICE and its use for design and analysis.
- To extract various design parameters from simulation results.
- Provide students with an opportunity to practice on EDA software & tools for VLSI Design.

List of Experiments

1. Familiarity with Tanner L-EDIT EDA Tools: To study the main features and utilities of the tools for design and physical design of circuits. Report the pros and cons of the tool.
2. To find dc and transient response of a CMOS Inverter Circuit and its Physical Design using minimum dimension criteria. Hence extract various design parameters from simulation results.
3. To simulate transient response of CMOS NAND Gate (Fig.1). Physical Design the logic gate or design the layout, using minimum dimension criteria.

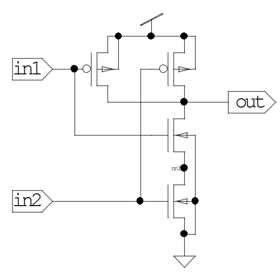

Fig.1. CMOS NAND Gate.

4. Simulate firstly minimum dimension CMOS inverter circuit using SPICE. Hence analyze and plot power and delay variations i) with voltage scaling, ii) For dimension, load and frequency variations.
5. Simulate CMOS NAND, NOR and XOR circuits using SPICE. Hence analyze and plot their power and delay variations i)with voltage scaling, ii)For dimension, load and frequency variations.
6. Design a differential amplifier circuit for a voltage gain of 10. Design its layout.
7. Physical Design of a complex circuit AOI/ OAI, making layout using Euler's method, for delay, power and area centric designs.
8. Design a four input CMOS NAND and NOR gates with the constraint propagation delay not exceeding 10ns. Compare LVS.
9. Familiarity with Cadence Familiarization with Cadence EDA Tools. To study the main features and utilities of the tools for design and physical layout design. Report the same in practical file.
10. Design NAND NOR, XOR circuits using Cadence EDA Tools, for delay and power centric design criteria.
11. Physical design a full adder circuit using minimum number of CMOS NAND gates.
12. Design triangular wave generator using OP-Amps in SPICE.
13. Familiarization with COMSOL Multiphysics Tool and its applications for Design and study of 1D Heat Transfer with Radiation model.

Note: *The concerned Course Coordinator will prepare the actual list of experiments/problems at the start of semester based on above generic list.*

Course Outcomes

Upon successful completion of the course, the students will be able to

CO1: Identify and abstract the programming task involved for a given VLSI problem.
CO2: Design and develop programming skills for VLSI circuit design.
CO3: Trace and debug any VLSI related program.

Course Name:	**Control System**
Course Code:	**EC-411**
Course Type:	**Core**
Contact Hours/Week: **3L**	Course Credits: **03**

Course Objectives

- To discuss basic concepts of linear systems.
- To provide a basic understanding of mathematical model of linear systems.
- To introduce the fundamental concept of different control components.
- To enable the students to understand the concepts of time and frequency domain analysis.
- The students can be able to learn stability analysis.
- To discuss the concept of state variable.

Unit Number	Course Content	Lectures
UNIT-01	**Basic Concepts:** Historical Review, Definitions, Classification, Relative Merits and Demerits of Open and Closed Loop Systems.	**03L**
UNIT-02	**Mathematical Models of Control System:** Linear and Non-Linear Systems, Transfer Function, Mathematical Modeling of Electrical, Mechanical and Thermal Systems, Analogies, Block Diagrams and Signal Flow Graphs.	**07L**
UNIT-03	**Control Components:** DC Servomotor, AC Servomotor, Potentiometers, Synchronous, Stepper-Motor.	**05L**
UNIT-04	**Time and Frequency Domain Analysis:** Transient and Frequency Response of First and Second Order Systems, Correlationship Between Time and Frequency Domain Specifications, Steady-State Errors and Error Constants, Concepts and Applications of P, PD, PI and PID Types of Control.	**07L**
UNIT-05	**Stability Analysis:** Definition, Routh-Hurwitz Criterion, Root Locus Techniques, Nyquist Criterion, Bode Plots, Relative Stability, Gain Margin and Phase Margins.	**07L**
UNIT-06	**State Variable Analysis:** Introduction, Concept of State, State Variables & State Models, State Space Representation of Linear Continuous Time Systems, State Models for Linear Continuous Time Systems, State Variables and Linear Discrete Time Systems, Solution of State Equations, Concept of Controllability & Observability.	**07L**

Course Outcomes

Upon successful completion of the course, the students will be able to

CO1: Demonstrate fundamentals of (feedback) control systems.
CO2: Explain mathematical model for different systems.
CO3: Explain different control components.
CO4: Explain the relation between time and frequency domain specification and employ controllers such as P, PD, PI and PID control design.
CO5: The use and significance of the different tools for control system design and analysis such as Nyquist plots, Bode plots, and Evansplots (root locus).
CO6: Demonstrate concept of state variable and state model.

Books and References

1. Discrete-Time Control Systems by K. Ogata, Prentice Hall India Learning Pvt. Ltd.
2. An Introduction to Control Systems by K. Warwick, World Scientific Publishing Co. Pvt. Ltd.
3. Control System Fundamentals by W. S. Levine, CRC Press.
4. Modern Control Systems by R. C. Dorf and R. H. Bishop, Prentice Hall.

Course Name: **Optical Communication Systems & Networks**		
Course Code: **EC-412**		
Course Type: **Core**		
Contact Hours/Week: **3L**		Course Credits: **03**
Course Objectives • To introduce the students to various optical fibre modes, configurations and various signal degradation factors associated with optical fiber • To study about various optical sources and optical detectors and their use in the optical communication system.		
Unit Number	**Course Content**	**Lectures**
UNIT-01	**OVERVIEW :** The Electromagnetic Spectrum, Properties of Light, Dual Nature of Light Concept of A Photon, Wave Model, Characteristics of Light Waves. Concepts of Information, General Communication Systems, Evolution of Basic Fiber Optic Communication System, Benefits and Disadvantages of Fiber Optics. Transmission Windows. Transmission Through Optical Fiber, The Laws of Reflection and Refraction, Light Rays and Light Waves, Reflection of Light From Optical Surfaces, Refraction of Light From Optical Interfaces, The Numerical Aperture (NA), The Optical Fiber, Types of Fiber.	**07L**
UNIT-02	**LOSSES IN OPTICAL FIBER:** Attenuation, Material Absorption Losses, Linear and Non Linear Scattering Losses, Fiber Bend Loss, Dispersion Viz. Inter Modal Dispersion and Intra Modal Dispersion, Overall Fiber Dispersion and Polarization, Dispersion Shifted and Dispersion Flattened Fibers, Attenuation and Dispersion Limits in Fibers, Kerr Nonlinearity, Self Phase Modulation, Combined Effect of Dispersion and Self Phase Modulation	**07L**
UNIT-03	**FIBER MATERIAL, COUPLERS AND CONNECTORS**: Preparation of Optical Fiber: Liquid-Phase Techniques, Vapor Phase Deposition Techniques, Connector Principles, Fiber End Preparation, Splices, Connectors.	**06L**
UNIT-04	**OPTICAL SOURCES AND DETECTORS**: Sources: Basic Principle of Surface Emitter LED and Edge Emitter LED- Material Used Structure, Internal Quantum Efficiency and Characteristics, LASER Diode - Material Used Structure, Internal Quantum Efficiency and Characteristics, Working Principle and Characteristics of Distributed Feedback (DFB) Laser. Detectors: PIN Photodiode - Material Used, Working Principle & Characteristics, Avalanche Photodiode: - Material Used Working Principle and Characteristics.	**05L**
UNIT-05	**ADVANCED TOPICS:** Optical TDM, SCM, WDM And Hybrid Multiplexing Methods, Fiber Optic Networks, Trans receivers for Fiber-Optic Networks, Semiconductor Optical Amplifiers, Erbium Doped Fiber Amplifiers (EDFAs).	**05L**
UNIT-06	**OPTICAL NETWORKS:** Elements and Architecture of Fiber-Optic Network, SONET/SDH, ATM, IP, Optical Line Terminals (OLT), Optical Add-Drop Multiplexers, Optical Cross Connects.	**06L**
Course Outcomes Upon successful completion of the course, the students will be able to CO1: Learn the basic elements of optical fiber transmission link, fiber modes configurations and structures CO2: Understand the different kind of losses, signal distortion in optical wave guides and other signal degradation factors. CO3: Learn the fiber optical receivers such as PIN APD diodes, noise performance in photodetector, receiver operation and configuration CO4: Learn the various optical source materials, LED structures, quantum efficiency, Laser diodes CO5: Understand the optical multiplexing techniques. CO6: Understand the optical network and its architecture.		
Books and References 1. Fiber Optic Communications (Fifth Ed.) by J.C. Palais, Pearson Prentice Hall, 2005 2. Optical Fiber Communications (Third Ed.) by Gerd Keiser, McGraw-Hill, 2000 3. Optical Networks: A Practical Perspective (Third Ed.) by R Ramaswamiand and K.N. Sivarajan, Morgan Kaufman Publishers		

Course Name: **Information Theory and Coding** Course Code: **EC-611** Course Type: **Core**	
Contact Hours/Week: **4L**	Course Credits: **04**

Course Objectives

- To impart knowledge about measuring the amount of information, capacities calculation of different channels in communication systems.
- To understand the theorems and inequalities used in information and coding theory field.
- To enable the students to design the source coding algorithms for improving transmission efficiency.
- To enable the students to design the block based error control coding algorithms for improving error performance of communication systems.

Course Content

Measures of Information and Channel Capacity; Entropy, Relative Entropy and Mutual Information, Basic Inequalities: Jensen Inequality and its Physical Application), Log–Sum Inequality and its Physical Application, Fano Inequality and its Physical Application, Data Processing Theorem and its Physical Application, Consequences of the Inequalities in the Field of Information Theory. Entropy Rate and Channel Capacity; Stationary Markov Sources: Entropy Rate and Data Compression, Definition of Capacity and its Computation of Discrete Memory Less Channels (BNC, BSC, BEC, Cascaded Channels, Noiseless Channels, Noisy Typewriter), The Channel Coding Theorem and the Physical Significance of Capacity. Data Compression by Fixed–To–Variable–Length Codes; Unique Decodability and the Prefix Condition, Kraft's Inequality, Relationship of Average Codeword Length to Source Entropy, Examples of Coding Techniques: Huffman, Shannon–Fano–Elias, Lempel–Ziv and Universal. Design of Linear Block Codes; Introduction of Linear Block Codes, Syndrome and Error Detection, Minimum Distance of a Block Code, Error Detecting and Error Correcting Capability of a Block Code, Design of Encoder and Syndrome Decoder for Linear Block Codes. Design of Cyclic Codes; Description Cyclic Codes, Generator and Parity Check Matrices of Cyclic Codes, Encoding of Cyclic Codes, Syndrome Computation and Error Detection, Decoding of Cyclic Codes, Cyclic Hamming Codes. Convolutional Codes; Encoding of Convolutional Codes, Structural Properties of Convolutional Codes, Distance Properties of Convolutional Codes, Design of Encoder and Decoder for Convolutional Codes.

Course Outcomes

Upon successful completion of the course, the students will be able to

CO1: Understand the various terminologies to estimate information content in the communication system.
CO2: Apply various inequalities and quantities to evaluate the information content and entropy rate of a DMS.
CO3: Design lossless source codes for discrete memory-less source to improve the efficiency of information transmission.
CO4: Design block based error control codes for improving the error performance of information transmission systems.

Books and References

1. Elements of Information Theory by T.M. Cover and J.A. Thomas, John Wiley, 1991.
2. Error Control Coding by S. Lin and D. J. Costello, 2nd Edition, Pearson Education, 2010.
3. Information Theory and Reliable Communication by R. G. Gallager, John Wiley & Sons, 1969.

Course Name:	**Device Modeling for Circuit Simulation**
Course Code:	**EC-631**
Course Type:	**Core**
Contact Hours/Week: **4L**	Course Credits: **04**

Course Objectives

- To impart knowledge about the basics of electronics device modeling.
- Build upon the theoretical, mathematical and physical analysis of e-devices used for e-circuit simulation
- To analyse working of e-devices for proper understanding of VLSI design requirements.
- To enable the students to understand the parameters and factors that controls the behavior of the electronic devices.

Course Content

Review of semiconductor device physics, fundamentals and principles of device modeling and circuit simulation, objectives and advantages. Introduction to SPICE, AC, DC, Transient, Noise, Temperature analysis, etc. of electronic devices and their application in circuit simulation. Junction Diodes, DC, Small signal, Large signal, High frequency and noise models of diodes, junction and depletion capacitance, narrow and wide base diodes. Measurement and extraction of diode model-parameters. Modeling BJT, DC, small signal, high frequency and noise models of bipolar junction transistors. Extraction of BJT model parameters. Ebers-Moll and Gummel-poon models. MOSFETs, Types of MOSFETs, DC, small signal, high frequency and noise models of MOSFETs. MOS Capacitance model. Weak and strong inversion in MOSFETs. Threshold voltage concept. MOS Models, Level-1 and level-2 large signal MOSFET models. Introduction to BSIM models. Extraction of MOSFET model parameters. Device Scaling, Short and narrow channel MOSFETs. MOSFET channel mobility model, DIBL, charge sharing and various non-linear effects. JFET, MESFETs & HBTs, Modeling of JFET & MESFET and extraction of parameters. Principles of hetro-junction devices, HBTs, HEMT.

Course Outcomes

Upon successful completion of the course, the students will be able to:

CO1: Comprehend the insight of electronic devices so as to provide appropriate and economically viable solutions to electronics engineering community and society at large.

CO2: Identify the new state of art electronic devices models to solve the real world research problems.

CO3: Apply principles of usage of EDA tools & techniques for effective & efficient modeling of e-devices & e-circuits.

CO4: Analyse the performance of electronic devices without actual fabrication so as to deal with e-designing for practical aspects and generate interest and competence in self-directed continuing professional development.

Books and References

1. CMOS Digital Integrated Circuits-Analysis & Design, S.M. Kang & Y. Leblibici, TMH, 3rd Ed.
2. Physics of Semiconductor Devices, S.M. Sze, Wiley Pub.
3. Solid State Electronic Devices, B.G. Streetman & S. Banerjee, PHI.
4. Computer Simulation of Electronic Circuits, R. Raghuram, Wiley Eastern Ltd.
5. SPICE, Sedra and Smith.
6. Introduction to PSPICE, H.M. Rashid, PHI.

Course Name:	**Engineering Economics and Accountancy**
Course Code:	**HS-404**
Course Type:	**Core**
Contact Hours/Week: **3L**	Course Credits: **03**

Course Objectives

- To impart knowledge about the Economics and its applicability to the Engineers
- To introduce the fundamental concepts of economics
- To enable the students to understand the factors that causes the changes in economic conditions of the entrepreneur

Unit Number	Course Content	Lectures
UNIT-01	**Introduction to Engineering Economics:** Definitions, Nature, Scope and application; Difference between Micro Economics and Macro Economics; Theory of Demand & Supply: Meaning, Determinants, Law of Demand, Elasticity of demand, Demand Forecasting, Law of Supply, Equilibrium between Demand & Supply.	**06L**
UNIT-02	**Production and Cost**: Production functions, Isoquant, Least Cost combination, Laws of Returns to Scale. Economics and Diseconomies of Scale of production, Cost and Cost curves, Revenue and Revenue curve, Break even analysis.	**06L**
UNIT-03	**Costing and Appraisal:** Cost elements, Economic cost, Accounting cost, Standard cost, Actual cost, Overhead cost, Cost control, Criteria of project appraisal, Social cost benefit analysis	**05L**
UNIT-04	**Markets**: Meaning, Types of Markets, Characteristics (Perfect Competition, Monopoly, Monopolistic Competition, Oligopoly) Price and Output Determination; Product Differentiation; Selling Costs; Excess Capacity.	**05L**
UNIT-05	**Money**: Meaning, Functions, Types; Monetary Policy- Meaning, Objectives, Tools; Fiscal Policy:-Meaning, Objectives, Tools. **Banking:** Meaning, Types, Functions, Central Bank: its Functions, concepts CRR, Bank Rate, Repo Rate, Reverse Repo Rate, SLR.	**04L**
UNIT-06	**Depreciation:** Meaning of depreciation, causes, object of providing depreciation, factors affecting depreciation, Methods of Depreciation: Straight line method, Diminishing balance method, Annuity method and Sinking Fund method	**04L**
UNIT-07	**Financial Accounting:** Double entry system (concept only), Rules of Double entry system, Journal(Sub-division of Journal) , Ledger, Trial Balance Preparation of final accounts-Trading Account. Profit and Loss account, Balance Sheet.	**06L**

Course Outcomes

Upon successful completion of the course, the students will be able to

CO1: Identify the challenges of the economy as entrepreneur/manufacturer as well as consumer

CO2: Describe the economic system at the micro and macro level

CO3: Apply principles of economics and accountancy in the professional, personal and societal life

CO4: Assess the role of engineering economics and accounting in attaining economic efficiency

Books and References

1. Principles of Micro Economics by Mceachern & Kaur, Cengage Publication.
2. Managerial Economics by Craig Peterson and W. Cris Lewis, PHI Publication.
3. Modern Microeconomics by A. Koutsoyiannis, Macmillan.
4. Managerial Economics Theory and Applications by D. M. Mithani. Himalaya Publication House.
5. Fundamental of Managerial Economics Mark Hirschey, South Western Educational Publishing.
6. Engineering Economics by Degramo, Prentice Hall.
7. Financial Accounting–A Managerial Perspective by R. Narayanaswamy, PHI.
8. Introduction to Accounting by J. R. Edwards and Marriot, Sage Publication.
9. Cost Accounting by Jawahar Lal, Tata McGraw Hill.
10. Project Planning Analysis, Selection, Implementation and Review by Prasanna Chandra, Tata McGraw Hill

Course Name: **Data Communication & Computer Networks**		
Course Code: **EC-421**		
Course Type: **Core**		
Contact Hours/Week: **3L**		Course Credits: **03**
Course Objectives • To introduce basic concepts of Data communication with different models. Enumerate the physical layer, Data Link Layer, Network Layer, Transport Layer and Application Layer, explanation of the function(s) of each layer. • Understanding of switching concept and different types of switching techniques.		
Unit Number	**Course Content**	**Lectures**
UNIT-01	**Introduction to Data Communication:** Goals and Applications of Networks, Wireless Network, Interfaces and services. Reference Models: The OSI reference model, TCP/IP reference model.	**04L**
UNIT-02	**Physical Layer:** Analog and Digital, Analog Signals, Digital Signals, Analog versus Digital, Data Rate Limit, Transmission Impairments, Line Coding, Block Coding, Sampling, Transmission Mode, Modulation of Digital Data, Telephone Modems, Modulation of Analog Signal, FDM, WDM, TDM, Guided Media, Unguided Media, Switching.	**06L**
UNIT-03	**Data Link Layer:** Data Link Layer Design Issues, Services Provided to Network Layers, Framing, Error Control, Flow Control, Error Detection and Correction, Elementary Data Link Protocols, An Unrestricted Simplex Protocol, A Simplex Stop-and-Wait Protocol, Simplex Protocol for a Noisy Channel, Sliding Window Protocols, A protocol using go-back-N, A Protocol using Selective Repeat, Example Data Link Protocol-HDLC, PPP.	**06L**
UNIT-04	**Medium Access Sublayer:** Channel Allocations, Random Access, ALOHA, Carrier Sense Multiple Access Protocols, Collision Free Protocols, Limited Contention Protocols, Controlled Access, Channelization, Wired LANs: Ethernet, Wireless LANs.	**06L**
UNIT-05	**Network Layer:** Internetworks, Addressing, Routing, ARP, IP, ICMP, IPV6, Unicast Routing, Unicast Routing Protocol, Multicast Routing, Multicast Routing Protocols.	**05L**
UNIT-06	**Transport Layer:** Process to Process Delivery, User Datagram Protocol (UDP), Transmission Control Protocol (TCP), Data Traffic, Congestion, Congestion Control, Quality of Service, Techniques to Improve QOS, Integrated Services, QOS in Switched Networks	**05L**
UNIT-07	**Application Layer:** Design Issues of the Layer, Domain Name Systems, File Transfer, http, Web Documents, Virtual Terminals.	**04L**
Course Outcomes Upon successful completion of the course, the students will be able to CO1: Give the basic information of how a network can be designed, possible choice of various models for designing a network. CO2: Understand the protocol layer specific communication between two trusted entities. CO3: Analyse the possible attacks on a network to interrupt the transmission and mislead the communication between different entities. CO4: Analyse the shortest path over which data can be transmitted, able to design a routing protocol implementing security mechanisms for secure transmission of data from sender to the receiver. CO5: Understand the subject based on course work, assignments and through implementation on a specific platform CO6: Design a network topology with the available networking elements and can implement a routing protocol along with secure mechanisms ensuring the error free transmission of data.		
Books and References 1. Data Communications and Networking by Behrouz A Ferouzan, TATA McGraw Hill. 2. Data and Computer Communication by Stallings William, Pearson Education. 3. An Engineering Approach on Computer Networking by S. Keshav, Addison Welsey. 4. Introduction to Data Communications and Networking by Wayne Tomasi, Pearson. 5. Computer Networks by A.S. Tanenbaum, PHI.		

Course Name: **Modeling and Simulation of Communication System**
Course Code: **EC-622**
Course Type: **Core**

Contact Hours/Week: **4L** Course Credits: **04**

Course Objectives

- To provide a thorough introduction to modeling & simulation techniques of communication systems.
- To provide in depth knowledge of estimation of parameter measures and testing process of the communication system.
- To introduce the concept of performance evaluation of any communication system including channel models.
- To introduce the concepts of queuing theory and its relevance for design of communication systems.

Course Content

Univariate and Multivariate Models; Probability Density and Distribution Functions, Random Variables, Independence of Random Variables, Transformations Between Random Variables, Expectations and Moments, Conditional Expectation and Conditional Variance, Bi- and Multivariate Distributions, Random Processes, Covariance and Spectral Density, Application of Different Probability Models, Bounds and Approximation of Random Variables, Introduction to Simulation and Modeling: Steps in Simulation and Modeling. Simulation of Random Variables and Random Process; Properties of Random Numbers, Generation of Random Numbers, Techniques for Generating Random Numbers: Linear Congruential Method and Combined Linear Congruential Method, Validation of Random Number Generators: KS Test, Chi-Square Test, Runs Test, Autocorrelation Test. Random Variate Generators; Inverse Transform Technique for Generating Discrete Random and Continuous Random Variables (Examples for Exponential, Uniform, Triangular, Poisson, Binomial Distributed Random Variables), Acceptance–Rejection Technique for Generation of Discrete and Continuous Random Variables, Some Special Generators: Box Muller Method, Sum–of–12 Method for Generating Normally Distributed Random Variables, Validation of the Generation Methods using Goodness of Fit Tests. Estimation of Performance Measures: Quality of an Estimator, Estimator of SNR, Probability Density Functions of Analog Communication System, BER of Digital Communication Systems, Unbiased Estimation of Expected Value, Unbiased Estimation of Variance, Monte Carlo Method and Importance Sampling Method for Estimating the Integral (Crude Monte Carlo Method, Acceptance– Rejection Monte Carlo, Stratified Sampling, Importance Sampling Methods and their Performance Comparison). Queuing Models: Characteristics of Queuing Models, Queuing Notation, Long Run Performance Measures of Queuing Systems, Steady State Behavior of M/M/1 and M/M/1/N Queuing Models, Little Formula, Burke's Theorem M/G/1 Queuing Model, Embedded Markov Chain Analysis of TDM Systems, Polling, Random Access Systems.

Course Outcomes

Upon successful completion of the course, the students will be able to

CO1: Analyze, model and simulate the communication networks and systems

CO2: Generate, test and estimate parameters and performance measures used in communication systems and networks.

CO3: Apply this knowledge for detection, estimation and simulation of various communication networks

CO4: Simulate and evaluate the performance measures of queuing systems.

Books and References

1. Simulation of Communication Systems Modeling, Methodology and Techniques by M. C. Jeruchim, P. Balaban and K. S. Shanmugan, 2nd Edition, Springer, 2000.
2. Simulation Modelling and Analysis by A. M. Law and W. D. Kelton, 3rd Edition, McGraw Hill Higher Education, 2000.
3. Discrete-Event System Simulation by J. Banks, J. S. Carson II, B. L. Nelson and D. M. Nicol, 5th Edition, Pearson, 2009.

Course Name: **Analog VLSI Design** Course Code: **EC-642** Course Type: **Core**	
Contact Hours/ Week: **4L**	Course Credits: **04**

Course Objectives

- To discuss basic transistor models for the design of analog integrated circuits and to characterize them.
- To study the most important building blocks in CMOS technologies and understand their limitations.
- To study key analog circuits for signal processing, conditioning and detection in systems
- To design analog IC circuits considering practical design parameters.

Course Content

Introduction to Analog VLSI: Analog integrated circuit design, Circuit design consideration for MOS challenges in analog circuit design, Recent trends in analog VLSI circuits; Analog MOSFET Modelling: MOS transistor, Low frequency MOSFET Models, High frequency MOSFET Models, Temperature effects in MOSFET, Noise in MOSFET; Current Source, Sinks and References: MOS Diode/Active resistor, Simple current sinks and mirror, Basic current mirrors, Advance current mirror, Current and Voltage references, Bandgap references; CMOS Amplifier: Performances matrices of amplifier circuits, Common source amplifier, Common gate amplifier, Cascode amplifier, Frequency response of amplifiers and stability of amplifier; CMOS Feedback Amplifier: Feedback equation, Properties of negative feedback on amplifier design, Feedback Topology, Stability; CMOS Differential Amplifier: Differential signalling, source coupled pair, Current source load, Common mode rejection ratio, CMOS Differential amplifier with current mirror load,, Differential to single ended conversion; CMOS Operational amplifier: Block diagram of Op-amplifier, Ideal characteristics of Op-Amplifier, Design of two stage Op-Amplifier, Compensation of Op-Amplifier, Frequency response of Op-Amplifier; CMOS Comparator: Characteristic of a comparator, Two stage open loop comparator, Special purpose comparator, Regenerative comparator, High output current amplifier, High speed comparator; Introduction to Switched Capacitor Circuits: Switched capacitor circuits, Switched capacitor amplifiers, Switch capacitor integrators.

Course Outcomes

Upon successful completion of the course, the students will be able to

CO1: Identify the various design metrics of analog Design.

CO2: Describe the MOS based biasing circuits, various MOS based amplifier, Op-Amplifier, Differential amplifier.

CO3: Apply principles of design to various analog blocks.

CO4: Assess the results obtained by solving broadly defined engineering technology problems.

Books and References

1. Design of Analog CMOS Integrated Circuits by Behzad Razavi, McGraw Hill.
2. CMOS: Circuit Design, Layout and Simulation by R. Jacob Baker, Harry W. Li, and David E. Boyce, Prentice Hall of India.
3. Analog Integrated circuit Design by David A. Johns and Ken Martin, John Wiley & Sons.

Course Name: **Mobile Communication** Course Code: **EC-612** Course Type: **Core**	
Contact Hours/Week: **4L**	Course Credits: **04**

Course Objectives

- To expose the students to understand mobile radio communication principles
- To study the recent trends adopted in cellular systems
- To introduce the students to recent wireless standards.

Course Content

Basic cellular systems, Performance criteria, Uniqueness of mobile radio environment, Operation of cellular systems, Concept of frequency reuse channels, Co–channel interference reduction factor, Desired C/I from a normal case in an Omni–directional antenna system, Handoff mechanism, Cell splitting. Cell coverage for signal and traffic, Obtaining the mobile point-to-point model, Propagation over water or flat open area, Foliage loss, Propagation in near-in distance, Long–distance propagation, Obtain path loss from a point–to–point prediction model, Cell–site antenna heights and signal coverage cells. Co-channel and adjacent-channel interference in mobile communications; Co-channel interference, Design of an Omni–directional antenna system in the worst case, Design of a directional antenna system, Lowering the antenna height, Power control, Diversity receiver, Adjacent–channel interference, Near–end–far–end interference, Effect on near-end mobile units**.** Frequency management, channel assignment and handoffs; Frequency management, Frequency–spectrum utilization, Set–up channels, Definition of channel assignment, Fixed channel assignment schemes, Non fixed channel assignment schemes, Concept of handoff, Initiation of a hard handoff, Delaying a handoff, Forced handoffs, Queuing of handoffs, Power–difference handoffs, Mobile assisted handoff, Soft handoffs, Cell–site handoff only, Intersystem handoff. Multiple access techniques and digital cellular systems; Multiple access techniques for mobile communications; Global system for mobile (GSM): GSM system architecture, GSM radio subsystem, GSM channel types, Frame structure for GSM, Signal processing in GSM; GPRS; EDGE; Overview of third generation (3G) wireless networks, 4G and 5G standards.

Course Outcomes

Upon successful completion of the course, the students will be able to

CO1: Discuss the cellular system design and technical challenges.

CO2: Analyze the Mobile radio propagation, fading, diversity concepts and the channel modeling.

CO3: Analyze the design parameters, link design, smart antenna and multiple access systems.

CO4: Summarize the principles and applications of wireless systems and standards like GSM, GPRS, EDGE and 3G, 4G, 5G standards.

Books and References

1. Mobile Cellular Telecommunications: Analog and Digital Systems by W. C. Y. Lee, 2nd Edition, McGraw Hill Education, 2017.
2. Wireless Communications: Principles and Practice by T. S. Rappaport, 2nd Edition, Pearson Education India, 2010.
3. Wireless Communications and Networks: 3G and Beyond by ITI S. Misra, 2nd Edition, McGraw Hill Education, 2017.
4. Wireless Digital Communications: Modulation and Spread Spectrum Applications by K. Feher, Prentice Hall, 1995.

Course Name:	**Advanced Digital Communication**
Course Code:	**EC-701**
Course Type:	**PG Elective-I**
Contact Hours/Week: **4L**	Course Credits: **04**

Course Objectives

- To study baseband data transmission over AWGN and band-limited channels
- To study different digital modulation schemes
- To study optimum receivers for different modulation schemes for AWGN channels
- To study different techniques for carrier recovery and symbol synchronization in signal demodulation

Course Content

Baseband pulse transmission: Matched filter, Properties of matched filters, Error rate due to noise, Intersymbol interference, Nyquist's criterion for distortionless baseband binary transmission, Ideal Nyquist Channel, Raised cosine spectrum, Correlative-level coding, Duobinary signaling, Modified duobinary signaling; Signal-space analysis: Geometric representation of signals, Gram-Schmidt orthogonalization procedure, Conversion of the continuous AWGN channel into a vector channel, Statistical characterization of the correlator outputs, Likelihood functions, Coherent detection of signals in noise, Maximum likelihood decoding, Correlation receiver, Equivalence of correlation and matched filter receivers; Digital Modulation Schemes: Representation of digitally modulated signals, Memory less modulation methods, Pulse amplitude modulation, Phase modulation, Quadrature amplitude modulation, Signaling schemes with memory, Continuous-phase frequency-shift keying, Continuous-phase modulation; Optimum Receivers for AWGN Channels: Optimal detection and error probability for band-limited signaling (ASK, PSK, QAM), Optimal detection and error probability for power-limited signaling (orthogonal signaling), Optimum receiver for CPM signals, Optimum demodulation and detection of CPM; Carrier and Symbol Synchronization: Signal parameter estimation, Carrier recovery and symbol synchronization in signal demodulation, Carrier phase estimation, Maximum-likelihood carrier phase estimation, The phase-locked loop, Symbol timing estimation, Maximum-likelihood timing estimation, Joint estimation of carrier phase and symbol timing.

Course Outcomes

Upon successful completion of the course, the students will be able to

CO1: Understand baseband data transmission over AWGN and band-limited channels

CO2: Understand and explain different digital modulation schemes

CO3: Analyze the performance of optimum receivers for different modulation schemes for AWGN channels

CO4: Analyze different techniques for carrier recovery and symbol synchronization in signal demodulation

Books and References

1. Communication Systems by Simon Haykin, Wiley-India Edition
2. Digital Communications by John G. Proakis and Masoud Salehi, McGraw-Hill
3. Digital Communications – Fundamentals and Applications by Bernard Sklar and P. K. Ray Pearson Education
4. Modern Digital and Analog Communication Systems by B. P. Lathi and Zhi Ding, Oxford University Press
5. Principles of Communication Systems by Herbert Taub and Donald L. Schilling, McGraw-Hill

Course Name: **Soft Computing** Course Code: **EC-702** Course Type: **PG Elective-I**	
Contact Hours/Week: **4L**	Course Credits: **04**

Course Objectives

- To impart knowledge about the Artificial Neural networks and deep learning.
- To introduce the fundamental concepts relevant to ANN, Optimization techniques and genetic algorithms.

Course Content

Introduction: History of Deep Learning, Deep Learning fundamentals, Training Deep Architectures, Intermediate Representations: Sharing Features and Abstractions across Tasks, Sigmoid Neurons, Gradient Decent, Feed-forward Neural Networks, Dropout, Back-propagation.

Deep learning fundamentals: Principal component Analysis and its interpretations, Singular Value Decomposition, Greedy Layer wise Pre-training, Better activations, Better weight initialization methods, Batch Normalization, Introduction of deep learning, How deep learning works, Introduction to Tensor flow.

Deep learning Algorithms: Gradient Descent and Back-propagation, Improving deep network, Multi-Layer Neural Networks, The Challenge of Training Deep Neural Networks, Deep Generative Architectures. Mini-batches, Unstable Gradients, and Avoiding Over-fitting, Applying deep net theory to code, Introduction to convolutional neural networks for visual recognition.

Advanced Deep Architectures: RNNs, RNNs in practice, LSTMs and GRUs, LSTMs and GRUs in practice, Reinforcement Learning, Why Unsupervised Learning is Important, Training Auto Encoder.

Applications for Communication Engineering: Shortened pipeline, error detection, correction, feature extraction, modeling

Course Outcomes

Upon successful completion of the course, the students will be able to

CO1: Describe the key components of AI, Genetic algorithms and its relation and role in Communication Engineering.

CO2: Understand the alternatives to generic designs, optimization and modeling techniques

Books and References

1. Deep Learning: Methods and Applications by Li Deng and Dong Yu.
2. Neural Networks and Deep Learning by Michael Nielsen
3. Hands-On Learning with Scikit-Learn and Tensor flow by Aurelien Geron and Oreilly.
4. Pattern Recognition and Machine Learning by Christopher Bishop.
5. Deep Learning by Ian Good fellow, Yoshua Bengio and Aaron Courville, An MIT Press book

Course Name: **Optimization Tools and Techniques**	
Course Code: **EC-703**	
Course Type: **PG Elective-I**	
Contact Hours/Week: **4L**	Course Credits: **04**

Course Objectives

- To teach basics and fundamentals of optimization.
- To build upon the theoretical and mathematical models for optimization techniques.
- To provide students with an opportunity to understand and practice optimized designing.

Course Content

Single Variable Non-Linear unconstrained optimization, One dimensional Optimization methods, Uni-modal function, Elimination methods, Fibonacci method, Golden section method, Interpolation methods, Quadratic & cubic interpolation methods. Multi variable non-linear unconstrained optimization: Direct search method, Univariant method, pattern search methods, Powell's- Hook -Jeeves, Rosenbrock search methods- gradient methods, gradient of function, Steepest decent method, Fletcher Reeves method, Variable metric method. Linear Programming: Formulation, Sensitivity analysis, Change in the constraints, Cost coefficients, Coefficients of the constraints, Addition and deletion of variable, Constraints. Integer Programming: Introduction, formulation, Gomory cutting plane algorithm, Zero or one algorithm, Branch and bound method Stochastic programming, Basic concepts of probability theory, Random variables, distributions, mean, Variance, Correlation, Co–variance, Joint probability distribution, Stochastic linear, Dynamic programming. Geometric Programming: Polynomials, arithmetic, Geometric inequality, Unconstrained, Non-traditional optimization Techniques: Genetic Algorithms, Steps, Solving simple problems Comparisons of similarities and dissimilarities between traditional and non-traditional techniques, Particle Swarm Optimization.

Course Outcomes

Upon successful completion of the course, the students will be able to:
CO1: Comprehend the insight of optimization requirements for any system.
CO2: Identify the conventional and new state of the art optimization techniques.
CO3: Apply principles of usage of optimization techniques for electronic design.
CO4: Assess and analyse the performance of optimized designs.

Books and References

1. Optimization Theory & Applications by S. S. Rao, John Wiley & Sons, 1978.
2. Optimization for Engineering Design: Algorithms and Examples by K. Deb, PHI Learning Private Limited, 2012.
3. Optimization: Theory and Practice by M. C. Joshi and K. M. Moudgalya, Cambridge Alpha Science International Ltd., 2004.

Course Name: **Advanced Antenna Design** Course Code: **EC-704** Course Type: **PG Elective-I**	
Contact Hours/Week: **4L**	Course Credits: **04**

Course Objectives

- To impart knowledge about the fundamental concepts of antenna engineering.
- To introduce the basic principle relevant to wired antennas and planar antennas.
- To enable the students to understand the factors related to frequency, radiation patteren and interference.

Course Content

Introduction to Antenna, Types and Fundamental Concepts: Physical Concept of Radiation, Radiation Pattern, Near and Far-Field Regions, Reciprocity, Directivity and Gain, Effective Aperture, Polarization, Input Impedance, Efficiency, Friis Transmission Equation, Radiation Integrals and Auxiliary Potential Functions, Radiation from Wires and Loops**:** Infinitesimal Dipole, Finite-Length Dipole, Dipoles for Mobile Communication, Small Circular Loop. Aperture Antennas: Huygen's Principle, Radiation from Rectangular and Circular Apertures, Design Considerations, Babinet's Principle, Radiation from Sectoral and Pyramidal Horns, Geometrical Theory of Diffraction, Reflector Antennas. Broadband Antennas: Broadband Concept, Log-Periodic Antennas, Frequency Independent Antennas. Microstrip Antennas: Basic Characteristics of Microstrip Antennas, Feeding Methods, Methods of Analysis, Design of Rectangular and Circular Patch Antennas, Planar Antenna Miniaturization Concepts and Techniques, Circularly Polarized Patch Antenna Design Concepts and Techniques.

Antenna Arrays: Analysis of Uniformly Spaced Arrays with Uniform and Non-uniform Excitation Amplitudes, Extension to Planar Arrays. Basic Concepts of Smart Antennas: Concept and Benefits of Smart Antennas, Fixed Weight Beam Forming Basics, Adaptive Beam forming.

Course Outcomes

Upon successful completion of the course, the students will be able to

CO1: Identify the fundamental parameters of Antennas Engineering

CO2: Describe the antenna structure, antenna arrays and planar antennas at specific frequency of operation

CO3: Apply principles of radiation from the conducting surfaces and aperture surfaces at RF frequencies

CO4: Assess the numerical techniques for the analysis of the Antenna Devices

Books and References

1. Antenna Theory: Analysis and Design, C. A. Balanis, 3rd Edition, Wiley, 2005.
2. Antenna and Wave propagation, R. J. Marhefka, A. S. Khan and J. D. Kraus, 4th Edition, McGraw Higher Ed., 2010.
3. Antenna and Wave propagation, A. R. Harish and M. Sachidananda, Oxford University Press, 2007.

Course Name: **Computer Communication and Networks** Course Code: **EC-705** Course Type: **PG Elective-II**	
Contact Hours/Week: **4L**	Course Credits: **04**

Course Objectives

- To introduce basic concepts of Computer communication and Data communication along with different networks.
- Enumerate the physical layer, Data Link Layer, Network Layer, Transport Layer and Application Layer.
- Understanding of switching concept and different types of switching techniques.

Course Content

Communication model, Data Communications, Computer Communication Architecture, Standard Making Organizations. Concepts and Terminology, Asynchronous and Synchronous Data Communications, Multiplexing Techniques. Communication Networking Techniques, Circuit Switching, Packet Switching, Local Area Networks. Protocols, Layered Approach, TCP/IP Protocol Suite, System Network Architecture. The Bridge and Routing, Connectionless Internetworking, Connection Oriented Internetworking, Transport and Network Services TCP / UDP. Session Characteristics, OSI Session and Service Protocol, Presentation Concepts, Encryption and Authentication Codes, Virtual Terminal Protocols, Network Management, File Transfer and Electronic Mail. Communication Switching Techniques, Frame-Mode Bearer Service, Frame Relay Congestion Control, Synchronous Transfer Mode.

Course Outcomes

Upon successful completion of the course, the students will be able to

CO1: Give the basic information of how a network can be designed, possible choice of various models for designing a network.

CO2: Understand the various network techniques between two trusted entities.

CO3: Analyse different connection mehotodolies for a communication network.

CO4: Analyse various reference models by which data can be transmitted, able to design a routing protocol implementing security mechanisms for secure transmission of data from sender to the receiver.

CO5: Understand the various switching methodologies based on subject related on course work, assignments.

Books and References

1. Data and Computer Communications by W. Stallings, 10th Edition, Pearson Education India, 2013
2. Computer Networks by A. S. Tanenbaum and D. J. Wetherall, 5th Edition, Pearson Education India, Wiley, 2013
3. Data Communications, Computer Networks, and Open Systems, by F. Halsall, 4th Edition, Addison-Wesley, 1996

Course Name: **Wi-Fi, Bluetooth and Zigbee Technology** Course Code: **EC-706** Course Type: **PG Elective-II**	
Contact Hours/Week: **4L**	Course Credits: **04**

Course Objectives

- To understand theoretical aspects of Wi-Fi, Bluetooth and Zigbee techonolgy.
- To design and implement Wi-Fi/ Bluetooth/ Zigbee based adhoc networks.

Course Content

Wi-Fi: Architecture and Functions: WLAN Roadmap via IEEE 802.11 Family Evolutions, IEEE 802.11 Architecture, Different Physical Layers, Data Link Layer, Medium Access Control Layer, Mobility, Security, IEEE 802.11 Family and Its Derivative Standards; Bluetooth Architecture and Functions: Introduction, Architecture and Throughputs, Physical Layer and Physical Channels, Baseband Layer, Link Manager Protocol, Logical Link Control and Adaptation Protocol, RFCOMM Protocol, Service Discovery Protocol, Profiles, Host Control Interface, Bluetooth Network Encapsulation Protocol; IEEE 802.15.4 And Zigbee: General Architecture, Physical Layer, 2450 MHz Physical Layer, 868/915 MHz Physical Layer, PDU Packet Format, MAC Layer, Channel Access, Energy Detection, Active and Passive Scan, Association Procedure, Guaranteed Time Slot, Security, Frame Structures, Beacon Frame , Data Frame.

Course Outcomes

Upon successful completion of the course, the students will be able to

CO1: Use suitable principles and standards of Bluetooth, IEEE 802.15.4 and Zigbee in design and evaluation of sensor networks and wireless communication protocols for small digital transmitter/receivers.

CO2: Use the knowledge for implementation of Wi-Fi networks.

CO3: Analyzing relevant results from research literature design and implement software and system solutions for wireless embedded systems.

CO4: Demonstrate an ability to read, critically evaluate, analyse and present (verbally or in written form) the content and implications of research articles in the area.

Books and References

1. Wi-Fi™, Bluetooth™, Zigbee™ and WiMax™ by H. Labiod, H. Afifi and C. D. Santis, Springer.
2. Bluetooth Technology and Its Applications with Java and J2Me by R. A. Prathap and C. S. R. Prabhu, Prentice Hall India Learning Private Limited.
3. Bluetooth Demystified by N. J. Muller, McGraw-Hill Professional.
4. Bluetooth Application Developer's Guide by Jennifer Bray, Brain Senese, Gordon McNutt and Bill Munday, Syngress Media.

Course Name: **Wireless Sensor Networks**
Course Code: **EC-707**
Course Type: **PG Elective-II**

Contact Hours/Week: **4L** Course Credits: **04**

Course Objectives

- To impart knowledge about wireless sensor networks and its application area.
- To introduce the fundamental concepts relevant to deployment and localization of wireless sensor networks.
- To enable the students to understand the synchronization and dissemination of information using wireless sensor network about the target area.

Course Content

Introduction, Wireless Sensor Networks: The Vision, Networked Wireless Sensor Devices, Applications of Wireless Sensor Networks, Key Design Challenges, Network Deployment: Structured Versus Randomized Deployment, Network Topology, Connectivity in Geometric Random Graphs, Connectivity using Power Control, Coverage Metrics, Mobile Deployment, Localization And Time Synchronization: Key Issues, Localization Approaches, Coarse-Grained Node Localization Using Minimal Information, Fine-Grained Node Localization Using Detailed Information, Network- Wide Localization, Theoretical Analysis of Localization Techniques, Key Issues of Time Synchronization, Traditional Approaches, Fine-Grained Clock Synchronization, Coarse grained Data Synchronization, Wireless Characteristics And Medium-Access: Wireless Link Quality, Radio Energy Considerations, The SINR Capture Model For Interference, Traditional MAC Protocols, Energy Efficiency In MAC Protocols, Asynchronous Sleep Techniques, Sleep-Scheduled Techniques, and Contention-Free Protocols, Sleep-Based Topology Control and Energy-Efficient Routing: Constructing Topologies for Connectivity, Constructing Topologies for Coverage, Set Kcover Algorithms, Cross-Layer Issues, Metric-Based Approaches, Routing with Diversity, Multi-Path Routing, Lifetime-Maximizing Energy-Aware Routing Techniques, Geographic Routing, Routing to Mobile Sinks, Data-Centric Networking: Data-Centric Routing, Data-Gathering with Compression, Querying, Data-Centric Storage and Retrieval, Database Perspective on Sensor Networks, Transport Reliability and Congestion Control: Basic Mechanisms and Tunable Parameters, Reliability Guarantees, Congestion Control, Real-Time Scheduling.

Course Outcomes

Upon successful completion of the course, the students will be able to

CO1: Have an understanding of the principles and characteristics of wireless sensor networks.
CO2: Apply knowledge of wireless sensor networks to various application areas.
CO3: Analyse WSN protocols in terms of their energy efficiency and design new energy efficient protocols.

Books and References

1. Networking Wireless Sensors by Bhaskar Krishnamachari, Cambridge University Press.
2. Wireless Sensor Networks-An Information Processing Approach by Feng Zhao and Leonidas Guibas, Morgan Kauffman.
3. Wireless Sensor Networks-Technology, Protocols and Applications by K. Sohraby, D. Minoli and T. Znati, John Wiley & Sons.

Course Name: **Wi-Fi Telephony and VoIP**
Course Code: **EC-708**
Course Type: **PG Elective-II**

Contact Hours/Week: **4L** Course Credits: **04**

Course Objectives

- To have an accurate overview on Voice over IP QoS evaluation techniques.
- To introduce about new type of applications that can take advantage of internet network.
- To understand the medium access control protocols, and address physical layer issues.

Course Content

Conventional Telephony and Data protocols: The Evolution of the Telephone Network, Digitizing Speech, PSTN Architecture, Signaling in the Local Loop, Signaling in the Network, SS7, Call-Setup, Voice and Wireless Networks, The TCP/IP Transport Layer, Transmission Control Protocol, (TCP), User Datagram Protocol (UDP), Voice over IP: Motivation for VoIP, Challenges in VoIP, Putting Voice Over Internet, VoIP Architectures, Signaling Protocols, Media Gateway Control Protocol, Megaco/H248, H323, Session Initiation Protocol (SIP), Wireless LAN and VoWLAN Challenges: Network Architecture, 802.11 Framing, Accessing the Medium, PHY, VoWLAN, System Capacity and QoS, Packet Sizes, Packetization Overheads, DCF Overheads, Transmission Rate, Inherent Fairness Among All Nodes, PCF, Admission Control, Security, Roaming/Handoffs in 802.11, QoS and Security Issues: 802.11e, WME and “Vanilla” WLANs, Traffic Categories, Voice Data Coexistence, Achieving QoS for VoWLAN, System Capacity, Authentication in 802.1, Open System Authentication, Shared Key Authentication, Authentication and Handoffs, Confidentiality in 802.1, Data Integrity in 802.11, Loopholes in 802.11 Security, WPA, Roaming and Power Management: Types of Roaming, Roaming Issues, Roaming and Voice, Scanning Types, Scanning Strategies, Inter-ESS Roaming, The Need for Power Management, Power-Aware System Design, Implementing Power Management.

Course Outcomes

Upon successful completion of the course, the students will be able to

CO1: Explain the related term used in IP telephony for a set of facilities for managing the delivery of voice information using the Internet Protocol.
CO2: Describe H.323 and other protocols with an architectural overview of the Internet.
CO3: Apply principles and algorithms of security and authentication issues.
CO4: Analyze share key authentication and roaming and power management issues.

Books and References

1. Wi-Fi Telephony Challenges and Solutions for Voice over WLANs by Praphul Chandra and Lide, Elsevier Inc.
2. Internetworking with TCP/IP: Principles, Protocols, and Architecture by Douglas E Comer, PHI Learning.
3. Voice over IP Fundamentals by Jonathan Davidson and James Peters, Cisco Press.

Course Name: **Electromagnetic Interference & Compatibility** Course Code: **EC-709** Course Type: **PG Elective-III**	
Contact Hours/Week: **4L**	Course Credits: **04**

Course Objectives

- To familiarize with the fundamentals that are essential for electronics industry in the field of EMI / EMC
- To understand EMI sources and its measurements.
- Concept of signal integrity in ICs, conducted emissions and electromagnetic radiation susceptibility, and crosstalk and shielding.
- To understand the various techniques for electromagnetic compatibility.

Course Content

Basic Concepts Introduction and Definition of EMI and EMC with examples, Various Parameters, Sources of EMI, EMI coupling modes - CM and DM, ESD Phenomena and effects, Transient phenomena and suppression, Various issues of EMC, EMC Testing categories. Coupling Mechanism Electromagnetic field sources and Coupling paths, Coupling via the supply network, Common mode coupling, Differential mode coupling, Impedance coupling, Inductive and Capacitive coupling, Radiative coupling, Ground loop coupling, Cable related emissions and coupling. EMI Mitigation Techniques Working principle of Shielding and Murphy's Law, LF Magnetic shielding, Apertures and shielding effectiveness, Choice of Materials for H, E, and free space fields, Gasketting and sealing, PCB Level shielding, Principle of Grounding, Isolated grounds, Grounding strategies for Large systems. Standard and Regulations Need for Standards, Standards for EMI/EMC, National and International EMI Standardizing Organizations: IEC, ANSI, FCC, AS/NZS, CISPR, BSI, CENELEC, and ACEC, Electro Magnetic Emission and susceptibility standards and specifications. Measurement Methods and Instrumentation EMI Shielding effectiveness tests, Open field test, TEM cell for immunity test, Shielded chamber, Shielded anechoic chamber, EMI measuring instruments.

Course Outcomes

Upon successful completion of the course, the students will be able to

CO1: Real-world EMC design constraints and make appropriate tradeoffs to achieve the most cost-effective design that meets all requirements

CO2: Designing electronic systems that function without errors or problems related to electromagnetic compatibility.

CO3: Diagnose and solve basic electromagnetic compatibility problems.

Books and References

1. Introduction to Electromagnetic compatibility by C. R. Paul, Wiley & Sons.
2. Principles of Electromagnetic Compatibility by B. Keiser, Artech House.
3. Field Theory of Guided waves by R. E. Collin, Wiley-IEEE Press.
4. Elements of Electromagnetics by M. N. O. Sadiku, Oxford University Press.

Course Name: **RF and Microwave Circuit Design** Course Code: **EC-710** Course Type: **PG Elective-III**	
Contact Hours/Week: **4L**	Course Credits: **04**

Course Objectives

- To impart knowledge about the transmission lines theory, network analysis, planar Transmission Lines, circuits and their characterization and Ferromagnetic Components.

Course Content

Transmission Lines theory: Waves propagation in transmission line, Parameters, Concepts of propagation constant, Characteristic impedance, Reflection coefficient, Wave velocities and dispersion, Smith chart, Impedance transformers, Generator and load mismatches, Lossy transmission lines. Network analysis: S (scatter), Z, Y, ABCD and other multi-port parameters, Impedance matching and tuning. Planar Transmission Lines, Circuits and Characterization: Microstrip, strip line, Coplanar waveguide and other types of transmission lines, Microstrip discontinuities simple printed couplers, Filters, Power dividers, Directional couplers, Transmission line resonators, Microstrip antennas. Ferromagnetic Components: Basic properties, Plane wave propagation in ferrite, Ferrite isolators, Circulators, Phase shifters.

Course Outcomes

Upon successful completion of the course, the students will be able to

CO1: Apply transmission line theory

CO2: Describe and utilize different network analysis parameters for solving two or multiport networks

CO3: Design and chraterize different microwave circuits

CO4: Design and Analyze Ferromagnetic Components

Books and References

1. Microwave Engineering by D. M. Pozar, 4th Edition, Wiley, 2011.
2. Foundations of Microstrip Circuit Design by T. C. Edwards and M. B. Steer, 4th Edition, Wiley-IEEE Press, 2016.
3. Elements of Electrornagnetics by M. N. O. Sadiku, 3rd Edition, Oxford University Press, New York, 2001.

Course Name: **Advanced Engineering Electromagnetics** Course Code: **EC-711** Course Type: **PG Elective-III**	
Contact Hours/Week: **4L**	Course Credits: **04**

Course Objectives

- To impart knowledge about the propagation of electromagnetic wave and power carried by it.
- To introduce the fundamental concepts relevant to electromagnetic wave behavior at media interface and its polarization.
- To enable the students to understand the electromagnetic wave propagation in different guided media and its nature if media is confined with electric and magnetic boundaries.

Course Content

Electromagnetics: Electrostatic Problems and their solutions, Separation of variables in rectangular, Cylindrical and spherical systems, Green's functions, Maxwell's equations, Electromagnetic Waves, Time domain equivalent and its relevance, Propagation of Waves in different medias like Dielectric interface etc. under normal and oblique incidence plane waves in cylindrical system, Bessel's and Hankel's function, Scattering problems under different conditions, Wave functions in planar, Cylindrical and spherical form. Transmission Lines: Telegrapher's equation, Reflection Coefficient, VSWR, Impedance matching and techniques, Single and double stub matching, Types of transmission lines. Waveguides: Full wave analysis of different types of waveguides including solutions to TE/TM/HE modes, Parallel plate waveguide, Rectangular waveguides, Cylindrical waveguides, Dielectric slab waveguide, Cylindrical dielectric waveguide, Strip line analysis, Microstrip line as resonator structure, Quasi TEM modes in microstrip line, Discontinuities in microstrip line, Boxed microstrip line, Resonant cavities: Rectangular, Cylindrical, Dielectric resonators.

Course Outcomes:

Upon successful completion of the course, the students will be able to

CO1: Describe the concept of wireless communication and how radio wave propagates.
CO2: Describe the fundamental concept of PCB circuit design.
CO3: Describe the design of low loss and high power electromagnetic wave guides.
CO4: Design dirrent types of resonator and how to use them for filters and antennas application.

Books and References:

1. Time Harmonic Electromagnetic Fields by R. F. Harrington, Wiley-IEEE Press
2. Field Theory of Guided waves by R. E. Collin, Wiley-IEEE Press.
3. Elements of Electromagnetics by M. N. O. Sadiku, Oxford University Press.
4. Bluetooth Electromagnetism: Theory and Applications by Ashutosh and Pramanik, Prentice Hall India Learning Private Limited.

Course Name: **RF and Microwave Active Circuits** Course Code: **EC-712** Course Type: **PG Elective-III**	
Contact Hours/Week: **4L**	Course Credits: **04**

Course Objectives

- Explain the design considerations for RF active circuits.
- Model and analyze the characteristics of low noise amplifier.
- Analysis of characteristics of different RF diode.
- Analysis of different types of RF mixers.
- Design and analysis of different types of microwave oscillator.

Course Content

Two port power gains, Stability criterion, Low noise amplifier design for maximum gain, Constant gain and specific gain, Input and output matching networks using lumped element and distributed elements, Large signal scattering parameters, Design of power amplifier, Tunnel and backward diodes, GaAs Gunn effect diodes, Read diode, TRAPATT diode, Schottky barrier diodes, PIN diode, Introduction of microwave mixers, Mixer characterization, Single ended mixer, Balanced mixer, Image rejection mixer, Double balanced mixer and FET mixer, General classification, Microwave transistor oscillators, Dielectric resonator oscillators and voltage controlled oscillators.

Course Outcomes

Upon successful completion of the course, the students will be able to

CO1: Explain the performance requirements of RF active circuits.
CO2: Design and explain RF amplifier.
CO3: Explain the difference between different RF diode with its particular applications.
CO4: Understand different mixer circuits and can design for a given specifications.
CO5: Design and explain different microwave oscillator for a given specifications.

Books and References

1. Microwave Engineering by D. M. Pozar, Wiley, India
2. Microwave Transistor Amplifiers by G. Gonzalez, Prentice-Hall
3. Microwave Engineering by S. Das, Oxford University Press
4. Microwave Active Circuit Analysis and Design by C. Poole and I. Darwazeh, Elsevier
5. Fundamentals of RF and Microwave Transistor Amplifiers by I. J. Bahl, John Wiley & Sons

Course Name: **Computational Electromagnetics** Course Code: **EC-713** Course Type: **PG Elective-III**	
Contact Hours/Week: **4L**	Course Credits: **04**

Course Objectives

- Students will acquire the basic understanding different numerical methods, and integral equation solvers used for numerical characterization of electromagnetic fields and waves. They will learn how to implement these methods in 1D, 2D and 3D cases.

Course Content

Review of electromagnetic theory, introduction to computational electromagnetics, different approximations based on one-dimensional wave equation, numerical dispersion & group delay. Introduction to Maxwell's equations and Yee algorithm: Stability of explicit solution, implicit formulation and stability, Maxwell's equations in 1D, 2D, and 3D, Yee algorithm, numerical dispersion, numerical stability. Source excitation: Total-Field/Scattered-Field formulation, Waveguide source excitations. Boundary conditions, analytical absorbing boundary conditions, Perfectly matched layer media, Near field to Far field transformations. Modeling: lumped elements modeling, modeling of antennas, electromagnetic crystals and metamaterials, micro-cavity resonators.

Course Outcomes

Upon successful completion of the course, the students will be able to

CO1: Identify conventional and state-of-the-art computational electromagnetic techniques for modeling wireless communication devices, high speed electronic circuits, millimeter-wave ICs and antenna populations.

CO2: Apply electromagnetic wave theories and tools for the applications of wave propagation, radiation, scattering, and in particular, wireless communications.

CO3: Understand systematical numerical techniques and software packages for solving generalized practical electromagnetic problems.

Books and References

1. Computational Electromagnetics: The Finite-Difference Time-Domain by A. Taflove and S. C. Hagness, Artech House.
2. Electromagnetic Simulation Using The FDTD Method by D. M. Sullivan, Wiley IEEE Press.
3. Numerical Electromagnetics: The FDTD Method by U. S. Inan and R. A. Marshall, Cambridge University Press.

Course Name:	**Digital Image Processing and Pattern recognition**
Course Code:	**EC-714**
Course Type:	**PG Elective-IV**
Contact Hours/Week: **4L**	Course Credits: **04**

Course Objectives

- To understand the basics of image formation and filtering in spatial and frequency domain.
- To understand the concepts of image compression, image segmentation and morphological operation on image.
- To understand the pattern recognition and Neural Network for pattern classification.

Course Content

Introduction: Steps in Digital Image Processing, Components of an Image Processing system, Applications. Human Eye and Image Formation; Sampling and Quantization, Basic Relationship among pixels- neighbor, connectivity, regions, boundaries, distance measures; Image Enhancement: Spatial Domain, Gray Level transformations, Histogram, Arithmetic/Logical Operations, Spatial filtering, Smoothing & Sharpening Spatial Filters; Frequency Domain- 2-D Fourier transform, Smoothing and Sharpening Frequency Domain Filtering; Convolution and Correlation Theorems; Image Restoration: Inverse filtering, Wiener filtering; Wavelets- Discrete and Continuous Wavelet Transform, Wavelet Transform in 2-D; Image Compression: Redundancies- Coding, Interpixel, Psycho visual; Fidelity, Source and Channel Encoding, Elements of Information Theory; Loss Less and Lossy Compression; Run length coding, Differential encoding, DCT, Vector quantization, entropy coding, LZW coding; Image Compression Standards-JPEG, JPEG 2000, MPEG; Video compression; Image Segmentation: Discontinuities, Edge Linking and boundary detection, Thresholding, Region Based Segmentation, Watersheds; Introduction to morphological operations; binary morphology- erosion, dilation, opening and closing operations, applications; basic gray-scale morphology operations; Feature extraction; Classification; Object recognition; Pattern Recognition: Introduction to pattern recognition, Pattern Recognition Methods, Pattern Recognition System Design, Statistical Pattern recognition – Classification, Principle, Classifier learning, Neural networks for pattern classification. The wavelet transform, Discrete-time orthogonal wavelets, continuous time orthogonal wavelet basis.

Course Outcomes

Upon successful completion of the course, the students will be able to

CO1: Understand the basic image formation model and application of image processing.
CO2: Enhancement of image in spatial and frequency domain.
CO3: Understand the Image Restoration using wavelet.
CO4: Analyse the different image compression techniques.
CO5: Understand the image segmentation and pattern recognition.

Books and References

1. Fundamentals of Digital Image processing by A. K. Jain, Pearson Education
2. Digital Image Processing by R. C. Gonzalez and R. E. Woods, Pearson Education
3. Digital Image Processing using MATLAB by R. C. Gonzalez , R. E. Woods and S. L. Eddins, Pearson Education
4. Digital Image Processing and Analysis by Chanda and Mazumdar, PHI

Course Name:	**Adaptive Signal Processing**
Course Code:	**EC-715**
Course Type:	**PG Elective-IV**
Contact Hours/Week: **4L**	Course Credits: **04**

Course Objectives

- To introduce signal processing techniques for adaptive systems.
- To understand the applications of adaptive systems in the fields of communications, radar, sonar, seismology, navigation systems and biomedical engineering.
- To study the basic principles of adaptation, various adaptive signal processing algorithms for applications like adaptive noise cancellation, interference canceling, system identification, etc.

Course Content

Linear Optimum Filtering and Adaptive Filtering, Linear Filter Structures, Adaptive Equalization, Noise Cancellation and Beam Forming. Optimum Linear Combiner and Wiener-Hopf Equations, Orthogonality Principle, Minimum Mean Square Error and Error Performance Surface, Steepest – Descent Algorithm and its Stability. LMS Algorithm and its Applications, Learning Characteristics and Convergence Behaviour, Mis-Adjustment, Normalized LMS and Affine Projection Adaptive Filters, Frequency Domain Block LMS Algorithm. Least Squares Estimation Problem and Normal Equations, Projection Operator, Exponentially Weighted RLS Algorithm, Convergence Properties of RLS Algorithm, Kalman Filter as the Basis for RLS Filter, Square-Root Adaptive Filtering and QR- RLS Algorithm, Systolic-Array Implementation of QR – RLS Algorithm. Forward and Backward Linear Prediction, Levinson-Durbin Algorithm, Lattice Predictors, Gradient-Adaptive Lattice Filtering, Least-Squares Lattice Predictor, QR-Decomposition Based Least-Squares Lattice Filters.

Course Outcomes

Upon successful completion of the course, the students will be able to

CO1: Comprehend design criteria and modeling of adaptive systems and theoretical performance evaluation.
CO2: Design a linear adaptive processor.
CO3: Apply mathematical models for error performance and stability.
CO4: Comprehend the estimation theory for linear systems and modeling algorithms.

Books and References

1. Adaptive Filter Theory by S. Haykin, Pearson Education, 2002
2. Adaptive Signal Processing by B. Widrow and S. D. Stearns, Pearson Education, 1985
3. Statistical and Adaptive Signal Processing by D. G. Manolakis, V. K. Ingle and M. S. Kogon, Artech House, 2005
4. Statistical Signal Processing: Detection, Estimation, and Time Series Analysis by L. L. Scharf, Pearson.

Course Name: **Signal Detection and Estimation Theory** Course Code: **EC-716** Course Type: **PG Elective-IV**	
Contact Hours/Week: **4L**	Course Credits: **04**

Course Objectives

- To enable the students to acquire the fundamental concepts of Signal Detection and Estimation.
- To get familiarize with different hypotheses in detection and estimation problems.
- To introduce the methods of detection and estimation of signals in white and non-white Gaussian noise.
- To familiarize with the detection of random signals.

Course Content

Introduction: Review of Gaussian Variables and Processes; Problem Formulation and Objective of Signal Detection and Signal Parameter Estimation in Discrete-Time Domain. Statistical Decision Theory: Bayesian, Min-Max, and Neyman-Pearson Decision Rules, Likelihood Ratio, Receiver Operating Characteristics, Composite Hypothesis Testing, Locally Optimum Tests, Detector Comparison Techniques, Asymptotic Relative Efficiency. Detection of Deterministic Signals: Matched Filter Detector and its Performance; Generalized Matched Filter; Detection of Sinusoid with Unknown Amplitude, Phase, Frequency and Arrival Time, Linear Model. Detection of Random Signals: Estimator-Correlator, Linear Model, General Gaussian Detection, Detection of Gaussian Random Signal with Unknown Parameters, Weak Signal Detection. Estimation of Signal Parameters :Minimum Variance Unbiased Estimation, Fisher Information Matrix, Cramer-Rao Bound, Sufficient Statistics, Minimum Statistics, Complete Statistics; Linear Models; Best Linear Unbiased Estimation; Maximum Likelihood Estimation, Invariance Principle; Estimation Efficiency; Bayesian Estimation: Philosophy, Nuisance Parameters, Risk Functions, Minimum Mean Square Error Estimation, Maximum Aposteriori Estimation.

Course Outcomes

Upon successful completion of the course, the students will be able to

CO1: Understand the basic concepts of signal detection and estimation
CO2: Understand the different hypotheses in detection and estimation problems
CO3: Understand the conceptual basics of detection and estimation of signals in white and non-white Gaussian noise
CO4: Understand the detection of random signals
CO5: Understand the time varying waveform detection and its estimation

Books and References

1. Detection, Estimation and Modulation Theory: Part I, II, and III by H. L. Van Trees, John Wiley, NY, 1968.
2. An Introduction to Signal Detection and Estimation by H. V. Poor, Springer, 2/e, 1998.
3. Fundamentals of Statistical Signal Processing: Estimation Theory by S. M. Kay, Prentice Hall PTR, 1993.
4. Fundamentals of Statistical Signal Processing: Detection Theory by S. M. Kay, Prentice Hall PTR, 1998.

Course Name: **Multi-rate Signal Processing** Course Code: **EC-717** Course Type: **PG Elective-IV**	
Contact Hours/Week: **4L**	Course Credits: **04**

Course Objectives

- To provide an in-depth treatment of both the theoretical and practical aspects of multirate signal processing.
- To provide the fundamentals of multirate, Sample rate conversion and efficient implementations using polyphase filters
- The filter bank theory and implementation, including quadrature mirror, conjugate quadrature, and cosine modulated filter banks along with their relationship to wavelet transform area also covered in this course.

Course Content

Fundamentals of Multirate systems: Introduction, Basic multirate operations, interconnection of building blocks, The polyphase representation, multistage implementation, some applications of multirate systems, special filters and filters banks. Maximally decimated filter bank: Introduction, Errors created in the QMF bank, A simple alias free QMF system, M-Channel filter bank, polyphase representation, perfect reconstruction systems, tree structure filter banks. Paraunitary Perfect Reconstruction Filter banks: Lossless Transfer matrices, filter banks properties induced by paraunitariness, Two channel FIR Paraunitary QMF banks, M –channel FIR paraunitary Filter bank. Cosine Modulated Filter Banks: The pseudo QMF bank, Design of the Pseudo QMF bank, Efficient polyphase structures, deeper properties of cosine matrices, Cosine modulated perfect reconstruction systems. Wavelet Transform and Its Relation to Multirate Filter Banks: Introduction, Short Fourier transform, The wavelet transform, Discrete-time orthogonal wavelets, continuous time orthogonal wavelet basis.

Course Outcomes

Upon successful completion of the course, the students will be able to

CO1: Understand the basic multirate operations.
CO2: Analyse the type M-channel filter bank.
CO3: Understand the perfect reconstruction filter bank.
CO4: Understand the cosine modulated filter banks.
CO5: Analyse the wavelet and its ralation to filter banks.

Books and References

1. Multirate Systems and Filter Banks by P.P. Vaidynathan, Pearson Education Inc.
2. Wavelets and filter banks by D. Strang and T. Nguyen, Wellesley-Cambridge Press.
3. Digital Signal Processing: Principles, Algorithms and Applications by J. G. Proakis and D. G. Manolakis, Pearson Education.
4. Multirate Digital Signal Processing by N. J. Fliege, John Wiley and Sons.

Course Name:	**Wavelet Transforms & Applications**
Course Code:	**EC-718**
Course Type:	**PG Elective-IV**

Contact Hours/Week: **4L** Course Credits: **04**

Course Objectives

- To introduce the concepts of inner product space.
- To equip students with various topics related to wavelet transforms and multiresolution analysis.
- To introduce time-frequency analysis and its applications.

Course Content

Inner Product Spaces: Definition of Inner Product; The Spaces L2 and l2, Convergence in L2 Versus Uniform Convergence, Schwarz and Triangle Inequalities, Orthogonality, Orthogonal Projections, Gram–Schmidt Orthogonalization, Linear Operators and their Adjoints, Least Squares and Linear Predictive Coding, Biorthogonality Fourier theory and Continuous Wavelet Transform: Introduction, Computation of Fourier Series, The Complex Form of Fourier Series, Convergence Theorems for Fourier Series, Fourier transform, Discrete time Fourier transform, Discrete Fourier transform, Short-time Fourier transform, uncertainty principle; Continuous Wavelet Transform, Inversion Formula for the Wavelet Transform, time-frequency analysis, Haar Wavelet Analysis: Haar Wavelets, The Haar Scaling Function, Basic Properties of the Haar Scaling Function, The Haar Wavelet, Haar Decomposition and Reconstruction Algorithms, Decomposition, Reconstruction, Filters and Diagrams. Multiresolution Analysis: The Multiresolution Framework, Definition and axioms, The Scaling Relation, The Associated Wavelet and Wavelet Spaces, Decomposition and Reconstruction Formulas & implementation, Iterative Procedure for Constructing the Scaling Function The Daubechies Wavelets: Daubechies' Construction, Classification, Moments, and Smoothness, Computational Issues, The Scaling Function at Dyadic Points. Other Wavelet Topics: Computational Complexity of Wavelet Algorithm, Wavelet Packets, Wavelets in Higher Dimensions, Relating Decomposition and Reconstruction, Coiflets, Symlets, Biorthogonal wavelets

Course Outcomes

Upon successful completion of the course, the students will be able to

CO1: Differentiate continuous and discrete wavelet analysis.

CO2: To analyze various methods of time-frequency analysis.

CO3: Gain the knowledge of wavelet transform, multiresolution Analysis and its applications.

Books and References

1. A First Course in Wavelets with Fourier Analysis, 2nd Edition by Albert Boggess, Francis J. Narcowich.
2. A Wavelet Tour of Signal Processing, 3rd Edition, The Sparse Way by Stephane Mallat, Academic Press, December 2008.
3. Ten Lectures on Wavelets by Ingrid Daubechies.

Course Name: **MEMS & Microsensor Design** Course Code: **EC-731** Course Type: **PG Elective-I**	
Contact Hours/Week: **4L**	Course Credits: **04**

Course Objectives

- To impart knowledge about the need and applications of microsystem in engineering.
- To introduce the fundamental concepts relevant to fabrication and machining process of MEMS sensors and actuators.
- To enable the students to understand the design issues and explore design tradeoff in various sensing and actuation mechanisms.

Course Content

Introduction to MEMS and Microsystems, Structural and Sacrificial Materials, Properties of Materials, Basic Modeling of Elements in Electrical and Mechanical systems, Sensors/transducers, Sensors Characterization and Classifications, Microactuators, Applications of MEMS, Silicon Growth, Additive Techniques: Oxidation, Physical Vapor Deposition, Chemical Vapor Deposition, Thin Film Deposition, Photolithography, Wet and Dry Etching, Bulk and Surface Micromachining, Etch Stop Technique and Microstructure, Microsterolithography LIGA, Wafer Bonding, Capacitive Sensors, Modeling of Capacitive Sensor, Capacitive Accelerometer, Parallel-Plate Actuator, Comb Drive Actuator, Piezoresistance Effect, Modeling of Piezoresistive Transducers, Piezoresistive Pressure Sensor, Piezoelectricity, Piezoactuators, Inertial Sensors, Microaccelerometer, Gyroscope, Temperature Coefficient of Resistance, Thermo-Electricity, Thermocouples, Thermal and Temperature Sensors, Heat Pump, Micromachined Thermocouple Probe, Thermal Flow Sensors, Shape Memory Alloy, Hot Arm Actuators, Properties of Light, Light Modulators, Beam Splitter, Microlens, Micromirrors, Digital Micromirror Devices, Light Detectors, Grating Light Valve, Optical Switch, Magnetic Sensing and Detection, Magnetoresistive Sensor, Magneto diodes, Magneto transistor, Pressure Sensor, and Bidirectional Microactuator.

Course Outcomes

Upon successful completion of the course, the students will be able to

CO1: Identify structural and sacrificial materials for MEMS.

CO2: Describe the fabrication steps in designing of various MEMS & Sensors parts.

CO3: Apply principles for the design of sensor and actuators.

CO4: Use MEMS for different applications in various fields of engineering.

Books and References

1. Introductory MEMS Fabrication and Applications by T. M. Adams and R. A. Layton, Springer Publications.
2. Sensors and Transducers by M. J. Usher, McMillian Hampshire.
3. MEMS by N. P. Mahalik, Tata McGraw Hill.
4. Microsensors by R. S. Muller, Howe, Senturia and Smith, IEEE Press.
5. Analysis and Design Principles of MEMS Devices by Minhang Bao, Elsevier.
6. Semiconductor Sensors by S. M. Sze, Wiley –Inderscience Publications.

Course Name: **Nano-Electronics** Course Code: **EC-732** Course Type: **PG Elective-I**	
Contact Hours/Week: **4L**	Course Credits: **04**

Course Objectives

- To make the student able to know physics of the short channel effects in Nano MOS devices and possible solutions..
- To know the scaling of transistors and other devices to smaller and smaller sizes.
- To understand the various devices in nano regime.

Course Content

Introduction to Nanoelectronics: Physical and Technological Limitations of Microelectronics, Transitioning from Microelectronics to Nanoelectronics, MOS Scaling Theory- Issues in Scaling MOS Transistors, Short Channel Effects; Free Electron Theory & The New Ohm's Law: Why Electrons flow, Classical free electron theory, Sommerfeld's theory, The quantum of conductance, Coulomb blockade, Towards Ohm's law, The Elastic Resistor: Conductance of an Elastic Resistor, Elastic Resistor- Heat dissipation; Materials for nanoelectronics: Semiconductor heterostructures, Lattice-matched and pseudomorphic heterostructures ,Inorganic nanowires, Organic semiconductors , Carbon nanomaterials: nanotubes and fullerenes, Graphene; Ballistic and Diffusive Transport: Ballistic and Diffusive Transfer Times, Channels for Conduction Conductivity, Conductivity: E(p) or E(k) Relations, Counting States, Drude Formula, Quantized Conductance, Electron Density –Conductivity; Electron transport in semiconductors and nanostructures: Time and length scales of the electrons in solids, Statistics of the electrons in solids and nanostructures, Fermi statistics for electrons, the density of states of electrons in nanostructures, Electron transport in nanostructures. Electrons in traditional low-dimensional structures: Electrons in quantum wells: Single modulation-doped heterojunctions, Numerical analysis of a single heterojunction, Control of charge transfer, Electrons in quantum wires, Electron transport in quantum wires, Electrons in quantum dots; Nanostructure devices: Introduction, MODFETS, heterojunction bipolar transistors, Resonant-tunneling diodes, Field-effect transistors, Single-electron-transfer devices, Potential-effect transistors, Carbon Nanotube Transistors, Semiconductor Nanowire FETs etc.

Course Outcomes

Upon successful completion of the course, the students will be able to

CO1: Understanding the insight of Nanoelectronics device Physics so as to provide appropriate and economical viable solution to electronic engineering community and society at large.

CO2: Identifying different techniques to improve the state of art electronic device so as to solve the real world research problems.

CO3: Understanding the applications of quantum physics in Semiconductor Devices.

CO4: Identifying different devices so as to meet out the present design, health, safety and environmental challenges

Books and References

1. Fundamentals of Nanoelectronics by George W. Hanson, Pearson Education.
2. Nanoelectronics and Nanosystems: From Transistors to Molecular and Quantum Devices by Karl Goser, Springer.
3. Introduction to Nanoelectronics: Science, Nanotechnology, Engineering & Applications by Vladimir. V. Mitin, Cambridge University Press.
4. Introduction to Nano Science and Technology by S.M. Lindsay, World Scientific
5. Lessons from Nanoscience: A Lecture Note Series by Supriyo Dutta, World Scientific.
6. Quantum Transport- Atom to Transistor by Supriyo Dutta, Cambridge University Press.
7. Nanotechnology for Microelectronics and optoelectronics by J.M. Martinez-Duart, R.J. Martin Palma, F. Agulle Rueda, Elsevier.

Course Name: **Deep Learning & AI for VLSI** Course Code: **EC-733** Course Type: **PG Elective-I**	
Contact Hours/Week: **4L**	Course Credits: **04**

Course Objectives

- To impart knowledge about the Artificial Neural networks and deep learning.
- To introduce the fundamental concepts relevant to ANN architectures and deep learning algorithms.
- To understand the applications and use cases of Deep Learning architectures for VLSI circuits and design automation.

Course Content

Introduction: History of Deep Learning, Deep Learning fundamentals, Training Deep Architectures, Intermediate Representations: Sharing Features and Abstractions across Tasks, Sigmoid Neurons, Gradient Decent, Feed-forward Neural Networks, Dropout, Back-propagation.

Deep learning with Tensor flow: Principal component Analysis and its interpretations, Singular Value Decomposition, Greedy Layer wise Pre-training, Better activations, Better weight initialization methods, Batch Normalization, Introduction of deep learning, How deep learning works, Introduction to Tensor flow.

Deep learning Algorithms: Gradient Descent and Back-propagation, Improving deep network, Multi-Layer Neural Networks, The Challenge of Training Deep Neural Networks, Deep Generative Architectures. Mini-batches, Unstable Gradients, and Avoiding Over-fitting, Applying deep net theory to code, Introduction to convolutional neural networks for visual recognition.

Advanced Deep Architectures: RNNs, RNNs in practice, LSTMs and GRUs, LSTMs and GRUs in practice, Reinforcement Learning, Why Unsupervised Learning is Important, Training Auto Encoder.

Applications of Deep learning in VLSI: Chip design, test generation, chip testing, diagnosis and debug, characterization.

Course Outcomes

Upon successful completion of the course, the students will be able to

CO1: Describe the key components of AI field and its relation and role in computer science.

CO2: Build custom architectures from scratch

CO3: To be able to apply appropriate architectures for solving, modeling, optimizing and automizing VLSI design related options.

Books and References

1. Deep Learning: Methods and Applications by Li Deng and Dong Yu.
2. Neural Networks and Deep Learning by Michael Nielsen.
3. Hands-On Learning with Scikit-Learn and Tensor flow by Aurelien Geron, Oreilly.
4. Pattern Recognition and Machine Learning by Christopher Bishop.
5. Deep Learning by Ian Goodfellow and Yoshua Bengio and Aaron Courville, An MIT Press Book.

Course Name:	**Deep Submicron VLSI Design Issues**
Course Code:	**EC-734**
Course Type:	**PG Elective-I**
Contact Hours/Week: **4L**	Course Credits: **04**

Course Objectives

- To teach fundamentals of deep submicron (DSM) technologies in VLSI.
- To give an insight into the various non-ideal effects in DSM.
- To provide remedial measures for various issues in DSM VLSI design.

Course Content

Evolution of the structure of MOSFETs, the structure of deep-submicron MOSFETs (0.25-μm to 0.13-μm), compare to the structure of the conventional MOSFETs (2.0-μm to 0.5-μm), evolution of the MOSFET gate stack and contact structure, gate dielectric materials in deep-submicron MOSFETs, doping-concentration profiles of the MOSFET channel, evolution of the drain structure of MOSFETs. Deep-submicron CMOS structures, Substrate issues for deep-submicron CMOS, well formation in deep-submicron CMOS, dual-doped poly in deep-submicron CMOS, shallow trench isolation for deep-submicron CMOS, silicon-on-insulator (SOI) technology. 300-mm Silicon Wafers, 300-mm silicon crystal growth, grown-in silicon defects, formation of crystal-originated-particles (cops), the oxygen-stacking-fault ring (OSF-ring), mitigating effects of cops by use of post-crystal-growth annealing, high pull speed silicon, from ingot to finished wafer, slicing, etching, & polishing, specifications of silicon wafers for VLSI. Gate Dielectrics, Thin Gate Oxides, required characteristics of gate dielectrics for deep-submicron MOSFETs, the structure of thermally grown SiO_2 and the properties of the Si/SiO_2 interface, Dielectric breakdown in silicon dioxide films trapped in SiO_2, Leakage currents in SiO_2 films (tunneling phenomena), Manufacturing thin gate oxides, High-k dielectrics and low-k dielectrics. The Structure of Deep-Submicron MOSFETs, well-formation in deep-submicron CMOS, Super-steep retrograde channel (SSR) profiles Source/drain engineering in deep-submicron CMOS, Anti-punch-through structures in deep-submicron CMOS. Advanced Lithography and Chemical Mechanical Polishing (CMP) Deep-submicron resists, Chemically-amplified deep-UV resists for optical lithography, chemically-amplified deep-UV resists for optical lithography, anti-reflective coating (arcs), photoresist processing systems. Optics and hardware, Excimer laser deep-UV light sources, exposure tools for DUV lithography, resolution enhancement technologies (RETS), mask error factor (MEF or MEEF), non-optical (or next generation) lithographic technologies (NGL) Mechanisms of CMP, CMP equipment, cleaning issues in CMP, miscellaneous issues in CMP. Shallow Trench Isolation (STI), Shallow trench isolation for CMOS, details of the process flow to form a baseline shallow-trench-isolation (STI) structure, issues and characteristics of MOSFETs fabricated with STI.

Course Outcomes

Upon successful completion of the course, the students will be able to:

CO1: Comprehend the insight of deep submicron (DSM) VLSI design.
CO2: Identify the non-ideal issues and remedial solutions for these.
CO3: Assess and analyse the performance of DSM VLSI designs.

Books and References

1. Silicon Processing for the VLSI Era: Deep-Submicron Process Technology by Stanley Wolf, Lattice Pr, 2002.
2. Deep-Submicron CMOS ICs: From Basics to ASICs by Harry Veendrick, Kluwer Academic, 2000.

Course Name:	**Characterization of Semiconductor Materials & Devices**
Course Code:	**EC-735**
Course Type:	**PG Elective-II**
Contact Hours/Week: **4L**	Course Credits: **04**

Course Objectives

- To impart knowledge about properties of various semiconductor materials.
- To introduce the semiconductor physics behind the materials
- To enable the students to understand the design of semiconductor devices using electronic materials
- To understand how various semiconductor devices behave and how to optimize them

Course Content

Introduction to Electronic Materials, Crystal structure, Band theory, Carrier concentration at thermal equilibrium, Density of states, Fermi energy, Ionization impurity in semiconductors, Quantum aspect of semiconductors, Carrier transport, Random motion, Drift and diffusion, Excess carriers Injection level, Lifetime, Direct and indirect semiconductors, Measurement of Semiconductor Properties, Procedure for analyzing semiconductor devices, Basic equations and approximations, Characteristics and energy band diagrams of PN Junction diodes, Schottky barrier diode, Bipolar Junction Transistor, Field Effect Transistors, Optoelectronic Devices ; LED,PIN Photodetector, Semiconductor LASER

Course Outcomes

Upon successful completion of the course, the students will be able to

CO1: Identify various Materials useful in designing Semiconductor Devices

CO2: Understand the semiconductor physics of the material

CO3: Apply different material characteristics for designing of Semiconductor devices

CO4: Understand the theoretical concepts of various semiconductor devices and their applications

Books and References

1. Physics of Semiconductor Devices by S. M. Sze, Wiley Publication
2. Semiconductor Materials and Devices by M. S. Tyagi, Wiley Publication
3. Solid State Electronics Devices by B. G. Streetman, Prentice Hall
4. Semiconductor Devices by Kanaan Kano, Prentice Hall

Course Name: **CMOS RF Circuit Design**
Course Code: **EC-736**
Course Type: **PG Elective-II**

Contact Hours/Week: **4L** Course Credits: **04**

Course Objectives

- To impart knowledge about the RF circuit design and Wireless Technology.
- To introduce the fundamental concepts of RF modulation along with RF testing.
- To enable the students to understand the behavior of BJT and MOSFET at RF frequencies.

Course Content

Introduction to RF design and Wireless Technology: Design and applications, Complexity and choice of Technology, Basic concepts in RF design, Nonlinearly and time Variance, Inter-symbol interference, Random processes and noise, Sensitivity and dynamic range, Conversion of gains and distortion, RF Modulation: Analog and digital modulation of RF circuits, Comparison of various techniques for power efficiency, Coherent and non-coherent detection, Mobile RF communication and basics of Multiple Access techniques, Receiver and Transmitter architectures, Direct conversion and two-step transmitters, RF Testing: RF testing for heterodyne, Homodyne, Image reject, Direct IF and sub sampled receivers, BJT and MOSFET Behavior at RF Frequencies: BJT and MOSFET behavior at RF frequencies, Modeling of the transistors and SPICE model, Noise performance and limitations of devices, Integrated parasitic elements at high frequencies and their monolithic implementation, RF Circuits Design: Overview of RF Filter design, Active RF components & modeling, Matching and Biasing Networks. Basic blocks in RF systems and their VLSI implementation, Low noise Amplifier design in various technologies, Design of Mixers at GHz frequency range, Various mixers working and implementation. Oscillators- Basic topologies VCO and definition of phase noise, Noise power and trade off. Resonator VCO designs, Quadrature and single sideband generators. Radio frequency Synthesizers- PLLS, Various RF synthesizer architectures and frequency dividers, Power Amplifier design, Liberalization techniques, Design issues in integrated RF filters.

Course Outcomes

Upon successful completion of the course, the students will be able to

CO1: Understand the basic concepts of RF design, behavior of passive components and RF modulation
CO2: Realize the behavior of BJT and MOSFET parameters at RF range
CO3: Design high frequency amplifiers
CO4: Explain the biasing and referencing in devices at RF range
CO5: Design RF circuits and explain RF synthesizers

Books and References

1. Design of CMOS RF Integrated Circuits by Thomas H. Lee, Cambridge University Press 1998
2. RF Microelectronics by B. Razavi, PHI, 1998
3. CMOS Circuit Design, Layout and Simulation by R. Jacob Baker, H.W. Li, D.E. Boyce, PHI, 1998
4. Mixed Analog and Digital Devices and Technology by Y. P. Tsividis, TMH, 1996

Course Name:	**VLSI Test & Testability**
Course Code:	**EC-737**
Course Type:	**PG Elective-II**

Contact Hours/Week: **4L** Course Credits: **04**

Course Objectives

- To impart knowledge about the basics of testing techniques for VLSI circuits and Test Economics
- To introduce the fundamental concepts of Design for Testability.
- To enable the students to generate the test patterns.

Course Content

Basics of Testing And Fault Modeling: Introduction to Testing, Test process and ATE, Faults in digital circuits, Modeling of faults, Logical Fault Models, Fault detection, Fault location, Fault dominance, Logic Simulation, Types of simulation, Delay models, Gate level Event-driven simulation. Test Generation For Combinational and Sequential Circuits: Logic simulation and fault simulation, Testability measures, Test generation for combinational logic circuits, Testable combinational logic circuit design, Test generation for sequential circuits, design of testable sequential circuits. Design For Testability Design for Testability: Ad-hoc design, Generic scan based design, Classical scan based design – System level DFT approaches, Memory test. Self-Test and Test Algorithms Built-In Self-Test: Test pattern generation for BIST, Circular BIST, BIST Architectures, Testable Memory Design, Test algorithms, Test generation for Embedded RAMs, Logic BIST and EDT, Boundary Scan, System test and core test. Fault Diagnosis Logic Level Diagnosis: Diagnosis by UUT reduction, Fault Diagnosis for Combinational Circuits, Self-checking design, System Level Diagnosis.

Course Outcomes

Upon successful completion of the course, the students will be able to

CO1: Apply the concepts in testing which can help them design a better yield in IC design.

CO2: Tackle the problems associated with testing of integrated circuits at earlier design levels so as to significantly reduce the testing costs.

CO3: Identify the design for testability methods for combinational & sequential CMOS circuits

Books and References

1. Digital Systems and Testable Design by M. Abramovici, M. A. Breuer and A. D. Friedman, Jaico Publishing House.
2. Essentials of Electronic Testing for Digital, Memory and Mixed-Signal VLSI Circuits by M. L. Bushnell and V. D. Agrawal, Kluwer Academic Publishers.
3. Digital Circuit Testing and Testability by P. K. Lala, Academic Press, 2002.
4. Design Test for Digital IC's and Embedded Core Systems by A. L. Crouch, Prentice Hall International.

Course Name: **VLSI Interconnects** Course Code: **EC-738** Course Type: **PG Elective-II**	
Contact Hours/Week: **4L**	Course Credits: **04**

Course Objectives

- To impart knowledge about the importance of electrical on-chip interconnects in modern VLSI circuits
- To introduce the various equivalent circuit models of interconnects and their comparison
- To understand the short-channel model of CMOS repeater driving interconnect and its analysis
- To enable the students to understand the advanced interconnect techniques

Course Content

Interconnect Parameters, resistance, inductance, and capacitance, RC Delays, lumped RC Model, distributed RC Model, transmission line model, SPICE wire models, gate and interconnect delay, CMOS repeater: static and dynamic behavior, switching threshold, noise margins, computing the capacitances, propagation delay, first order analysis, propagation delay from a design perspective. Driving interconnects for optimum speed and power, short channel model of CMOS repeater, transient analysis of an RC loaded CMOS repeater, delay analysis, analytical power expressions: dynamic power, short circuit power, resistive power dissipation, CMOS repeater insertion: analytical expressions for delay and power of a repeater chain driving an RC load. Advanced interconnect techniques**:** reduced-swing circuits, current mode transmission techniques. Crosstalk, theoretical basis and circuit level modeling of crosstalk, energy dissipation due to crosstalk, model for energy calculation of two coupled lines, contribution of driver and interconnect to dissipated energy, crosstalk effects in logic VLSI circuits, static circuits, dynamic circuits and various remedies.

Course Outcomes

Upon successful completion of the course, the students will be able to

CO1: Develop the ability to analyze and design electrical interconnect using equivalent circuit models
CO2: Understand the use of CMOS repeater to predict delay and power in interconnects
CO3: Describe the design trade-offs in driver-interconnect-load system
CO4: Design crosstalk and delay aware repeater driven interconnect system using advanced signaling techniques

Books and References

1. Analysis and Design of Digital Integrated Circuits – A Design Perspective by Jan M. Rabaey, Tata Mc-Graw Hill.
2. Interconnection Noise in VLSI Circuits by F. Moll and M. Roca, Kluwer Academic Publishers.
3. Introduction to VLSI Circuits and Systems by J. P. Uymera, Wiley Student Edition.
4. CMOS Digital Integrated Circuits – Analysis and Design by S. M. Kang and L. Yusuf, Tata Mc-Graw Hill.

Course Name: **Low Power VLSI Design** Course Code: **EC-739** Course Type: **PG Elective-III**	
Contact Hours/Week: **4L**	Course Credits: **04**

Course Objectives

- To impart knowledge about the dominant sources of power dissipation in VLSI circuits.
- To introduce the fundamental concepts for optimization of power at all design levels: technology, circuit, logic, and architectural level.
- To enable the students to aware of power estimation by various means.

Course Content

Need for Low Power VLSI Chips, Sources of Power Dissipation in CMOS Devices, Dynamic Power Dissipation in CMOS, Static Power Dissipation, Low Power Figure of Merits, Impact of Technology Scaling, Device Innovation and Channel Engineering, Simulation Power Analysis- SPICE Circuit Simulators, Gate Level Logic Simulation, Capacitive Power Estimation, Static State Power, Gate Level Capacitance Estimation, Architecture Level Analysis, Data Correlation Analysis in DSP Systems. Monte Carlo Simulation, Probabilistic Power Analysis- Random Logic Signals, Probability and Frequency, Probabilistic Power Analysis Techniques, Low Power Circuit and Logic Design, Transistor and Gate Sizing, Multi Stage Logic Design, Reduced Voltage Swing, Circuit Techniques for Leakage Power Reduction, Transistor Stacking, Supply Voltage Scaling Techniques, DTCMOS, MTCMOS, Network Restructure and Reorganization, Flip Flops and Latches Design, Gated Clock Flip Flop, Double Edge Triggered Flip Flop, Low Power Digital Cell Library, Gate Reorganization, Signal Gating, Logic Encoding, State Machine Encoding, Pre-Computation Logic, Adiabatic Logic, Low Power Arithmetic Components, Low Power Architecture and Systems, Power and Performance Management , Low Power Stand By Modes, Switching Activity Reduction, Parallel and Pipelining Architecture with Voltage Reduction, Flow Graph Transformation, Architectural Trade-Offs for Power, Power Dissipation In Clock Distribution, Single Driver Vs Distributed Buffers, Zero Skew Vs Tolerable Skew, and Clock Distribution Network.

Course Outcomes

Upon successful completion of the course, the students will be able to

CO1: Identify sources of power dissipation in VLSI systems.
CO2: Analyze various techniques for dynamic and leakage power reduction at various level of abstraction.
CO3: Design arithmetic circuits, latches and flip flops with different logic styles.
CO4: Understand the concepts of probability and random logic signals for estimation of capacitance and power Dissipation.

Books and References

1. Practical Low Power Digital VLSI Design by Gary K. Yeap, Kluwer Academic Press.
2. Low-Power CMOS VLSI Circuit Design by Kaushik Roy, Sharat Prasad, Wiley.
3. Low Power VLSI CMOS Circuit Design by A. Bellamour, and M. I. Elmasri, Kluwer Academic Press.
4. Low Power Design Methodologies by Rabaey and Pedram, Kluwer Academic Press.
5. Low-Voltage Low-Power VLSI subsystems by Kiat-Seng Yeo and Kaushik Roy, Tata McGraw-Hill.
6. Low Power Digital CMOS Design by Anantha P. Chandrakasan and Robert W. Brodersen, Kluwer Academic Press.

Course Name: **Advanced Semiconductor Devices** Course Code: **EC-740** Course Type: **PG Elective-III**	
Contact Hours/Week: **4L**	Course Credits: **04**

Course Objectives

- To teach about various advanced semiconductor devices.
- To build upon the theoretical and mathematical models for working and behavior of the advanced semiconductor devices.
- To understand and practice designing of VLSI circuits with advanced devices.

Course Content

Review of semiconductors fundamentals, semiconductor materials and their properties, band structure modification by alloys, carrier transport in semiconductors, scattering, defects, phonons, mobility, excess carriers in semiconductor, reverse recovery time. Junctions and interfaces, description of p-n junction, action, abrupt junction, example of an abrupt junction, linearly graded Junction. Ideal diode model, real diodes, temperature dependence of current-voltage (I-V) characteristics, high level injection effects, example of diodes. Description of breakdown mechanism, Zener and Avalanche breakdown in p-n junctions. Majority carrier diodes, Tunnel diode, backward diode, Schottky barrier diode, Ohmic contacts, heterojunctions. Microwave diodes, Varactor diode, p-i-n Diode, IMPATT diode, TRAPATT diode, BARITT diode, transferred electron devices. Optoelectronic devices &nano-electronics, solar cell, photo detectors, light emitting diodes, semiconductor lasers. Nano devices, material and classification, issues in scaling MOS transistors, transport in nano-MOSFET, carbon nanotubes (CNTs). Metal semiconductor field effect transistors, basic types of MESFETs, models for I-V characteristics of short channel MESFETs, high frequency performance, MESFETs structures. MOS transistors and charge coupled devices, basic structures and the operating principle, I-V characteristics, short- channel effects, charge coupled devices.

Course Outcomes

Upon successful completion of the course, the students will be able to:
CO1: Identify the conventional and new state of the art semiconductor devices.
CO2: Apply the theoretical and mathematical models of the advanced devices for usage in electronic design.
CO3: Assess and analyse the performance of advanced semiconductor devices and circuits.

Books and References

1. Advanced Theory of Semiconductor Devices by Karl Hess, Wiley-IEEE Press, 1999.
2. Physics of Semiconductors and Their Heterostructures by Jasprit Singh, McGraw-Hill Education, 1993.
3. Advanced Semiconductor Fundamentals by Robert F. Pierret, Prentice Hall, 2002.
4. Fundamentals of Modern VLSI Devices by Y. Taur and T. Ning, Cambridge University Press, 2013.

Course Name: **Advanced IC Design** Course Code: **EC-741** Course Type: **PG Elective-III**	
Contact Hours/Week: **4L**	Course Credits: **04**

Course Objectives

- To impart strong foundation of IC based design.
- To introduce the various applications of operational amplifiers and its integration with other devices.
- To learn biomedical application of op-amp design and other related applications.

Course Content

Operational Amplifier Design using CMOS as well as Bipolar technologies. Linear and non-linear applications of operational amplifiers. Active filters, response characteristics of Butter worth, Chebyshev and causal filters. Design and analysis of higher order filters of all types. Design of Super Buffer Circuits for driving large capacitive loads. Design and analysis CMOS Schmitt trigger circuit. Comparators and their characteristics zero crossing detector, voltage limiters, absolute value detectors, sample and hold circuit. Biomedical applications of instrumentation amplifier. Design and analysis of multi-vibrator circuits using transistors, Op-Amps and 555 Timer. Design and analysis of oscillator circuits using transistors and Op-Amps. Phase shift, Wien Bridge and quadrature oscillators. Square wave, triangular wave, saw tooth wave generators and voltage controlled oscillator. Differential and Feedback Amplifiers and their analysis.

Course Outcomes

Upon successful completion of this course students will be able to :

CO1: Understand and design the advanced ICs using op-amp and perform operations and their troubleshooting

CO2: To learn how to detect, amplify, store, create and manipulate signals using operational amplifiers

CO3: To design and analyze the responses of IC based designed circuits in the area of power management, signal conditioning, analog and digital communication

CO4: To develop IC based projects in the above areas.

Books and References

1. CMOS Analog Circuit Design by P. E. Allen and D. R. Holberg
2. CMOS Digital Integrated Circuits-Analysis & Design by S. M. Kang & Y. Leblebici, Tata McGraw Hill
3. Design of Analog CMOS Integrated Circuits by B. Razavi, Tata McGraw Hill

Course Name:	**Embedded System Design**
Course Code:	**EC-742**
Course Type:	**PG Elective-III**

Contact Hours/Week: **4L** Course Credits: **04**

Course Objectives

- To familiarize the students with the basic design concepts for designing an embedded systems
- To be able to design the embedded system for any use case

`Course Content

Typical Embedded System: Core of the Embedded System, Memory, Sensors and Actuators, Communication Interface, Embedded Firmware, Other System Components.

Characteristics and Quality Attributes of Embedded Systems: Hardware Software Co-Design and Program Modeling: Fundamental Issues in Hardware Software Co-Design, Computational Models in Embedded Design, Introduction to Unified Modeling Language, Hardware Software Trade-offs.

Embedded Hardware Design and Development: EDA Tools, How to Use EDA Tool, Schematic Design – Place wire, Bus , port, junction, creating part numbers, Design Rules check, Bill of materials, Netlist creation, PCB Layout Design – Building blocks, Component placement, PCB track routing.

ARM -32 bit Microcontroller family: Architecture of ARM Cortex M3 –General Purpose Registers, Stack Pointer, Link Register, Program Counter, Special Register,. Nested Vector Interrupt Controller. Interrupt behavior of ARM Cortex M3. Exceptions Programming. Advanced Programming Features. Memory Protection. Debug Architecture. Embedded Firmware Design and Development, Design Approaches, Embedded Firmware Development Languages.

Real-Time Operating System (RTOS) based Embedded System Design: Operating System Basics, Types of OS, Tasks, Process and Threads, Multiprocessing and Multitasking, Task Scheduling, Threads, Processes and Scheduling: Putting them altogether, Task Communication, Task Synchronization, Device Drivers, How to Choose an RTOS, Integrated Development Environment (IDE), Types of Files Generated on Cross compilation, Disassembler/ELD Compiler, Simulators, Emulators and Debugging, Target Hardware Debugging, Boundary Scan.

Course Outcomes

Upon successful completion of the course, the students will be able to

CO1: Define a real life problem in terms of technical specification of relevant embedded system.

CO2: Understand the processor and memory and to learn different types of I/O Devices, timer and counting devices.

CO3: Design the embedded system as per the specification and can understand the importance of Hardware-Software Co-design in an Embedded System

Books and References

1. Introduction to Embedded Systems by K. V. Shibu, Tata McGraw Hill Education Private Limited, 2009
2. The Definitive Guide to the ARM Cortex-M3 by Joseph Yiu, Newnes, (Elsevier), 2008.
3. Embedded Systems – A contemporary Design Tool by James K Peckol, John Wiley, 2008.
4. Specification and Design of Embedded Systems by D. Gajski, F. Vahid, S. Narayan and J. Gong, Prentice Hall.
5. Hardware Software Co-design: Principles and Practice by J. Syaunstrup and W. Wolf, Kluwer Academic Publishers.

Course Name: **SoC And FPGA Based Design** Course Code: **EC-743** Course Type: **PG Elective-IV**	
Contact Hours/Week: **4L**	Course Credits: **04**

Course Objectives

- To give the student an understanding of issues and tools related to FPGA design and implementation.
- To give the student an understanding of basics of System on Chip and Platform based design.
- To impart knowledge about the System-level and SoC design methodologies and tools.

Course Content

Types of ASICs: Types of ASICs, VLSI Design flow, Programmable ASICs, Antifuse, SRAM, EPROM, EEPROM based ASICs. Programmable ASIC logic cells and I/O cells. Programmable interconnects. Latest Version, FPGAs and CPLDs and Soft-core processors. Design Specification and Resource Scoping: Trade off issues at System Level: Optimization with regard to speed, area and power, asynchronous and low power system design. ASIC physical design issues, System Partitioning, Power Dissipation, and Partitioning Methods. SoC Block-Based Design: System-On-Chip Design, SoC Design Flow, Platform-based and IP based SoC Designs, Basic Concepts of Bus-Based Communication Architectures, On-Chip Communication Architecture Standards, Low-Power SoC Design, Performance Evaluation Methods for Multiprocessor System-on-Chip Design. FPGA Design Environment: Introduction, Scripting Environment, Interaction with Version Control Software, A Regression Test System, Common Tools in the FPGA Design Environment, Challenges that FPGAs Create for Board Design, Engineering Roles and Responsibilities, FPGA Engineers, Design Flows for Creating the FPGA Pinout, Board Design Check List for a Successful FPGA Pin-Out. Power Analysis and RTL Design: Introduction, Power Basic, Key Factors in Accurate Power Estimation, Power Estimation Early in the Design Cycle, Simulation Based Power Estimation, Best Practices for Power Estimation, Recommendations for Engineers with an ASIC Design Background, Writing Effective HDL, Analyzing the RTL Design. The Hardware/Software considerations: Introduction, Software Interface, Definition of Register Address Map, Use of the Register Address Map, Hardware/Software Co-Design and Verification, High performance algorithms for ASICS/ SoCs as case studies – Canonic Signed Digit Arithmetic, Distributed Arithmetic.

Course Outcomes

Upon successful completion of the course, the students will be able to

CO1: Demonstrate VLSI tool-flow and appreciate FPGA architecture.
CO2: Understand the basics of system on chip and on chip communication architectures.
CO3: Understand the issues involved in ASIC design, including technology choice, design management, tool-flow.

Books and References

1. Embedded System Design: Modeling, Synthesis, Verification by D. Gajski, S. Abdi, A. Gerstlauer, G. Schirner, Springer, 2009.
2. Synthesis and Optimization of Digital Circuits by G. De Micheli, McGraw-Hill, 1994.
3. EDA for IC System Design, Verification, and Testing by Louis Scheffer, Luciano Lavagno, and Grant Martin.
4. Verilog Digital Computer Design by Mark Gordon Arnold.

Course Name: **Hardware Algorithms for VLSI** Course Code: **EC-744** Course Type: **PG Elective-IV**	
Contact Hours/Week: **4L**	Course Credits: **04**

Course Objectives

- To impart knowledge about the computer arithmetic algorithms, including different techniques enabling enhanced throughput and low power.
- To understand algorithms techniques to hardware implementation of various arithmetic operations.

Course Content

Numbers and Arithmetic: Review of Number systems, their encoding and basic arithmetic operations, Class of Fixed-Radix Number Systems, Unconventional fixed-point number systems, Representing Signed Numbers, Negative-radix number Systems, Redundant Number Systems, Residue Number Systems.

Algorithms for Fast Addition: Basic Addition and Counting, Bit-serial and ripple-carry adders, Addition of a constant: counters, Manchester carry chains and adders, Carry-Look-ahead Adders, Carry determination as prefix computation, Alternative parallel prefix networks, VLSI implementation aspects, Variations in Fast Adders, Simple carry-skip and Carry-select adders, Hybrid adder designs, Optimizations in fast adders, Multi-Operand Addition, Wallace and Dadda trees, Parallel counters, Generalized parallel counters, Adding multiple signed numbers.

High-Speed Multiplication: Basic Multiplication Schemes, Shift/add multiplication algorithms, Programmed multiplication, Basic hardware multipliers, Multiplication of signed numbers, Multiplication by constants, Preview of fast multipliers, High-Radix Multipliers, Modified Booth's recoding, Tree and Array Multipliers, Variations in Multipliers, VLSI layout considerations.

Fast Division and Division Through Multiplication: Basic Division Schemes, Shift/subtract division algorithms, Programmed division, Restoring hardware dividers, Non-restoring and signed division, Division by constants, Preview of fast dividers, High-Radix Dividers, Variations in Dividers, Combined multiply/divide units, Division by Convergence, Hardware implementation.

Real Arithmetic: Representing the Real Numbers, Floating-point arithmetic, The ANSI/IEEE floating point standard, Exceptions and other features, Floating-point arithmetic operations, Rounding schemes, Logarithmic number systems, Floating-point adders, Barrel-shifter design, Leading-zeros/ones counting, Floating-point multipliers, Floating-point dividers, Arithmetic Errors and Error Control.

Implementation Topics: Computing algorithms, Exponentiation, Approximating functions, Merged arithmetic, Arithmetic by Table Lookup, Trade-offs in cost, speed, and accuracy. High-Throughput Arithmetic, Low-Power Arithmetic, Fault-Tolerant Arithmetic, Emerging Trends, Impact of Hardware Technology.

Course Outcomes

Upon successful completion of the course, the students will be able to

CO1: Understand hardware implementation of various algorithms

CO2: Learn to apply tradeoffs and multiple implementations and architectures

CO3: Know the use cases of various algorithms and their considerations

Books and References

1. Computer Arithmetic: Algorithms and Hardware Design by B. Parhami, Oxford University Press (2000).
2. Computer Arithmetic Algorithms, 2nd Edition by I. Koren, Uni Press (2005).
3. Digital Arithmetic by M. Ercegovac and T. Lang, Elsevier (2005).
4. Verilog Digital Computer Design: Algorithms into Hardware by Mark Gordon Arnold.

Course Name: **Digital ASIC Design**
Course Code: **EC-745**
Course Type: **PG Elective-IV**
Contact Hours/Week: **4L** Course Credits: **04**

Course Objectives

- To prepare the student to be an ASIC and FPGA based Chip design engineer
- To give the student an understanding of issues and tools related to ASIC/FPGA design and implementation.
- To give the student an understanding of High performance algorithms.

Course Content

Introduction: ASIC and FPGA devices, ASIC and FPGA Design flows, Top-Down and Bottom-Up design methodologies, Hardware Description Languages, Design Automation Tools, HDL Support for Synthesis.
Language concepts: Design Entity, Declaration statements, concurrent statements, sequential statements, data types, data objects, expressions, operands, if-else, for-loop, case statements, synthesis equivalents and constraints.
Modelling Combinational Circuits: Control & Data partitioning, Synthesis concepts, non-synthesizable constructs, operators, expressions, conditional statements, post synthesis simulation, basic test bench, Logic and arithmetic equations, multiplexers, encoders, decoders, comparators, adders, subtractors, multipliers, ALUs, synthesis constraints.
Modelling sequential circuits: Latches and Flip-flops, counters, mealy and Moore FSM, shifters, sequential adders, multipliers and dividers. Blocking and non-blocking statements, Static timing analysis, Procedures and timing control, procedural blocks, loops, Tasks and functions, Test bench modeling techniques, Path delay modeling, Timing analysis, User defined primitives, compiler directives, and system tasks, Implementation on FPGA. Unsigned integer, signed integer, fixed point, floating point arithmetic, Asynchronous considerations. Memory design: synchronous and asynchronous, single, dual and multi-port, Error detection and correction, compiler directives.
Design Considerations: Hardware and software processor options, SoC design considerations and implementation, I/O interfacing, Bus architectures, Serial and parallel data transmission, Handling interrupts and timers, Accelerators, DSP Blocks, Area, Power and Timing constraints, Scripting languages.

Course Outcomes

Upon successful completion of the course, the students will be able to

CO1: Understand the algorithms used for ASIC construction.
CO2: Design chip using the Full Custom Design Flow and Tool.
CO3: Understand the basics of System on Chip and on chip communication architectures appreciate high performance algorithms for ASICs.

Books and References

1. The Designer's Guide to VHDL, 2nd Edition by Peter J. Ashenden, Morgan Kaufmann Publishers, 2001.
2. A Verilog HDL Primer by J. Bhasker, Star Galaxy Press, 1996.
3. Verilog HDL: A Guide to Digital Design and Synthesis by Samir Palnitkar, Prentice Hall, 1996.
4. The Complete Verilog Book by Vivek Sagdeo, Kluwer Academic Publishers.
5. HDL Chip Design: A Practical guide for Designing, Synthesizing and Simulating ASICs and FPGAs using VHDL or Verilog by Douglas J. Smith, Doone Pubns, 1996.
6. VHDL Coding Styles and Methodologies by Ben Cohen, Kluwer Academic Publishers, 1999.
7. A VHDL Primer by J. Bhasker, Prentice Hall, 1998.

Course Name: **Verification of VLSI Circuits** Course Code: **EC-746** Course Type: **PG Elective-III**	
Contact Hours/Week: **4L**	Course Credits: **04**

Course Objectives

- To impart knowledge about the verification of VLSI circuits.
- To introduce the concepts of Verification techniques, UML and considerations
- To demonstrate the hardware acceleration and emulation techniques

Course Content

Design and Verification Languages Stephen A. Edwards: Introduction, History, Design Languages, Verification Languages.
Digital Simulation: Introduction, Event-Vs Process-Oriented Simulation, Logic Simulation Methods and Algorithms, Impact of Languages on Logic simulation, Logic Simulation Techniques, Impact of HVLs on simulation, Summary.
Using Transactional-Level Models in a SoC Design Flow: Introduction, Overview of the System-to-RTL Design Flow, TLM — View for the Design Flow, TLM Modeling Application Programming Interface, Example of a Multimedia Platform, Design Flow Automation, Conclusion.
Hardware Acceleration and Emulation: Introduction, Emulator Architecture Overview, Design Modeling, Debugging, Use Models, The Value of In-Circuit Emulation, Considerations for Successful Emulation, Summary.
Formal Property Verification: Introduction, Formal Property Verification Methods and Technologies, Software Formal Verification, Summary.

Course Outcomes

Upon successful completion of the course, the students will be able to

CO1: Able to Verify digital circuits for design errors

CO2: Understand the constrains and corner cases

CO3: Utilize techniques and technology for efficient circuit verification

Books and References

1. EDA for IC System Design, Verification, and Testing by Louis Scheffer, Luciano Lavagno, and Grant Martin.
2. Verification Techniques for System-Level Design by M. Fujita, I. Ghosh, and M. Prasad, Morgan Kaufmann, 2005.
3. Formal Verification: An Essential Toolkit for Modern VLSI Design by Erik Seligman, Morgan Kaufmann.

Course Name:	**MEMS Design**
Course Code:	**EC-370**
Course Type:	**Open Elective – I**
Contact Hours/Week: **3L**	Course Credits: **03**

Course Objectives

- To impart knowledge about the need and applications of microsystem in engineering.
- To introduce the fundamental concepts relevant to fabrication and machining process of MEMS sensors and actuators.
- To enable the students to understand the various sensing and actuation mechanisms.

Unit Number	Course Content	Lectures
UNIT-01	**Introduction:**Introduction to MEMS and Microsystems, MEMS Materials, Structural and Sacrificial Materials, Properties of Silicon, Polymers, Ceramics, and Composites, Basic Modeling of Elements in Electrical and Mechanical Systems, Sensors/Transducers, Sensors Characterization and Classifications, Microactuators, Application of MEMS	**04L**
UNIT-02	**MEMS Fabrication:** Silicon Growth, Additive Techniques: Oxidation, Physical Vapor Deposition, Chemical Vapor Deposition, Thin Film Deposition, Photolithography, Etching, Bulk and Surface Micromachining, Etch Stop Technique and Microstructure, Microstereolithography LIGA, and Wafer Bonding	**10L**
UNIT-03	**Mechanical Sensors and Actuators:** Beam and Cantilever, Capacitive Sensors, Modeling a Capacitive Sensor, Capacitive Accelerometer, Pressure Sensors, Piezoresistance Effect and Its Modeling, Piezoresistive Sensor, Flow Measurement, Piezoelectricity, Piezoactuators, Inertial Sensors, Micro accelerometer, MEMS Gyroscope, and Parallel-Plate Actuator.	**08L**
UNIT-04	**Thermal Sensors:** Need and Classification, Temperature Coefficient of Resistance, Thermo-Electricity, Thermocouples, Thermal and Temperature Sensors, Heat Pump, Gas sensors, Micromachined Thermocouple Probe, Thermo-resistive Sensor, Thermal Flow Sensors, Pyroelectricity, Shape Memory Alloy, and Thermal Actuators	**08L**
UNIT-05	**Micro-opto-electromechanical Systems:** Properties of Light, Light Modulators, Beam Splitter, Microlens, Micromirrors, Digital Micromirror Devices, Light Detectors, Grating Light Valve, and Optical Switch	**06L**

Course Outcomes

Upon successful completion of the course, the students will be able to

CO1: Identify structural and sacrificial materials for MEMS.
CO2: Describethe fabrication steps in designing of various MEMS parts.
CO3: Apply principles for the design of Sensor and actuators.
CO4: Apply MEMS for different applications in various fields of engineering.

Books and References

1. Introductory MEMS Fabrication and Applications by T. M. Adams and R. A. Layton, Springer Publications.
2. Sensors and Transducers by M. J. Usher, McMillian Hampshire.
3. MEMS by N. P. Mahalik, Tata McGraw Hill.
4. Microsensors by R.S. Muller, Howe, Senturia and Smith, IEEE Press.
5. Analysis and Design Principles of MEMS Devices by Minhang Bao, Elsevier.
6. Semiconductor Sensors by S. M. Sze, Willy –Interscience Publications.

Course Name:	**Microcontroller and its Applications**		
Course Code:	**EC- 380**		
Course Type:	**Open Elective - II**		
Contact Hours/Week: **3L**			Course Credits: **03**
Course Objectives • To impart knowledge about the architecture and instruction set of typical 8-bit microprocessor . • To introduce the fundamental concepts relevant to, Assembly Language, Timers, Interrupts. • To learn to make use of computer for real world applications			
Unit Number	**Course Content**		**Contact Hours**
UNIT-01	**Introduction to Microprocessors:** History and Evolution, types of microprocessors, Microcomputer Programming Languages, Microcomputer Architecture, Pipelining, Clocking, Intel 8085 Microprocessor, Register Architecture, Bus Organization, ALU, Control section, ISA of 8085, Instruction format, Addressing modes, Types of Instructions.		**06L**
UNIT-02	**Assembly Language Programming and Timing Diagram:** Assembly language programming in 8051, Macros, Labels and Directives, Microprocessor timings, Micro instructions, Instruction cycle, Machine cycles, T-states, State transition diagrams, Timing diagram for different machine cycles, Memory and I/O interface.		**08L**
UNIT-03	**Basic Function Blocks:** Instruction Set, Instruction Usage Examples, implementation of various structures like loop, switch, functions, subroutines.		**09L**
UNIT-04	**Interrupts and Serial Data Transfer:** Interrupts in 8051, Serial interrupts, RST instructions, Issues in implementing interrupts, Multiple interrupts and priorities, Daisy chaining, Interrupt handling in 8051, Enabling, Disabling & masking of interrupts.		**07L**
UNIT-05	**Applications:** Low power sensor networks, LEDs 7 segment, LCD, and ADCs, Defining Buses and Protocols, Embedded Computing		**06L**
Course Outcomes Upon successful completion of the course, the students will be able to CO1: Understand the architecture of 8051 CO2: Impart the knowledge about the instruction set and program components CO3: Understand the basic idea about the practical applications			
Books and References 1. The 8051 Microcontroller and Embedded Systems by Mazidi Muhammad Ali, Pearson Publications, Second Ed. 2. The Definitive Guide to ARM Cortex-M3 processors by Joseph Yiu, Newnes Publication Third Ed. 3. Computer Systems: An Embedded Approach by Ian Vince McLoughlin, McGraw-Hill Education. 4. 8051 Microcontroller by Scott MacKenzie, Parson Publications, 4th Ed.			