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)

(July 2024)

Curriculum for Dual Degree (B.Tech. and M.Tech.) Programme

Course No.	3rd Semester	Credits	Course Type
BS/Engg	Basic Sciences	3	Discipline Core
	Engineering Courses	14	Discipline Core
	Engineering Course (Lab)	2	Discipline Core
Discipline Workshop	Basic Engineering Skills	1	Discipline Core
	Total	**20**	
Course No.	**4th Semester**	**Credits**	**Course Type**
	Engineering Course	13	Discipline Core
	Engineering Course	3	Discipline Elective
	Engineering Course (Lab)	3	Discipline Core
	LA/CA	1	Institute Elective
	HSS Course	2	Institute Core
	Total	**20**	

Second Year													
3rd Semester							4th Semester						
SN	**Code**	**Subject**	**L**	**T**	**P**	**Credits**	**SN**	**Code**	**Subject**	**L**	**T**	**P**	**Credits**
1	EC-211	Digital Electronics and Logic Design	3	0	0	3	1	EC-221	Linear Integrated Circuits	3	0	0	3
2	EC-212	Analog Electronics	3	0	0	3	2	EC-222	Analog Communication Systems	3	0	0	3
3	EC-213	Communication Theory	3	0	0	3	3	EC-223	Microprocessors and Microcontrollers	3	0	0	3
4	EC-214	VLSI Technology	3	0	0	3	4	EC-224	Electromagnetic Field Theory	3	1	0	4
5	EC-215	Network Analysis and Synthesis	2	0	0	2	5	EC-241/242/243	Discipline Elective-I	3	0	0	3
6	MA-218	Numerical Analysis and Statistics	3	0	0	3	6	EC-225	Linear Integrated Circuits Lab	0	0	2	1
7	EC-216	Digital Electronics and Logic Design Lab	0	0	2	1	7	EC-226	Analog Communication Lab	0	0	2	1
8	EC-217	Analog Electronics Lab	0	0	2	1	8	EC-227	Microprocessors and Microcontrollers Lab	0	0	2	1
9	EC-218	Electronics Workshop	0	0	2	1	9	SA-201	LA/CA (Institute Elective)	0	0	2	1
Total Hours = 23						**20**		**Total Hours = 24**					**20**

Discipline Elective-I

EC-241 Electronic Device Modeling

EC-242 Nano Technology

EC-243 Digital Arithmetic

Curriculum for Dual Degree (B.Tech. and M.Tech.) Programme

Course No.	5th Semester	Credits	Course Type
	Open Elective	3	Institute Elective
	Engineering Course	12	Discipline Core
	Engineering Course	3	Discipline Elective
	Engineering Course (Lab)	2	Discipline Core
Total		**20**	

Course No.	6th Semester	Credits	Course Type
	Engineering Course	8	Discipline Core
	Engineering Course	6	Discipline Elective
	Engineering Course	2	Stream Core
	Engineering Course (Lab)	2	Discipline Core
	HSS Course	2	Institute Core
Total		**20**	

Third Year													
5^{th} Semester							6^{th} Semester						
SN	**Code**	**Subject**	**L**	**T**	**P**	**Credits**	**SN**	**Code**	**Subject**	**L**	**T**	**P**	**Credits**
1	EC-311	Microwave Devices and Systems	3	0	0	3	1	EC-321	Digital Signal Processing	3	0	0	3
2	EC-312	Digital Communication and Systems	3	0	0	3	2	EC-322	Antenna and Wave Propagation	3	0	0	3
3	EC-313	Control Systems	3	0	0	3	3	EC-323	Electronic Measurements and Instrumentation	2	0	0	2
4	EC-314	VLSI Design	3	0	0	3	4	EC-324	Digital Signal Processing Lab	0	0	2	1
5	EC-315	Digital Communication Lab	0	0	2	1	5	EC-325	Antenna and Microwave Systems Lab	0	0	2	1
6	EC-316	VLSI Design Lab	0	0	2	1	6	EC-341/342/343	Discipline Elective-III	3	0	0	3
7	EC-351/352/353	Discipline Elective-II					7	EC-361/362/363	Discipline Elective-IV	3	0	0	3
8	EC-301/302/303/304	Open Elective	3	0	0	3	8	EC-381/382	Stream Core	2	0	0	2
			3	0	0	3	9	HS-321	Engineering Economics and Accountancy	2	0	0	2
Total Hours = 22						**20**		**Total Hours = 22**					**20**

Discipline Elective-II

EC-351 Switching & Finite Automata Theory
EC-352 Data Structures and Algorithms
EC-353 Object Oriented Programming

Discipline Elective-III

EC-341 Data Communication and Computer Networks
EC-342 Spread Spectrum and Wideband Communication
EC-343 Satellite Communication and Radar

Discipline Elective-IV

EC-361 Digital Image Processing
EC-362 Speech Processing
EC-363 Estimation and Detection Theory

Stream Core

EC-381 Hardware Description Language
EC-382 Simulation of Communication Systems

Open Elective

EC-301 Microcontroller and Embedded System
EC-302 MEMS and Sensor Design
EC-303 Communication Systems
EC-304 VLSI Design and Techniques

Note: Students opting for **Dual Degree (B.Tech. and M.Tech.) Program** shall enter a different teaching scheme after completion of the 6th Semester.

Curriculum for Dual Degree (B.Tech. and M.Tech.) Programme

Course No.	7th Semester	Credits	Course Type
	Engineering Course	6	Discipline Core
	Engineering Course (PG Core Courses)	8	PG Programme Core
	Engineering Course (PG Elective Courses)	8	PG Programme Elective
	Engineering Course (Lab)	2	Discipline Core
Summer Training	Engineering Course	2	Discipline Core
Total		**26**	
Course No.	**8th Semester**	**Credits**	**Course Type**
	Engineering Course	6	Discipline Core
	Engineering Course (PG Core Courses)	12	PG Programme Core
	Engineering Course (PG Elective Courses)	4	PG Programme Elective
	General Proficiency	2	Discipline Core
	Major Project	12	Discipline Elective
	Total	**36**	
Course No.	**9th Semester**	**Credits**	**Course Type**
EC-798	M.Tech. Dissertation*	18	Programme Elective
	Free Elective /Open Elective Course (Courses available in other Departments in the Odd semester)/ Engineering Course (PG Elective Course)	4	PG Institute Elective (Interdisciplinary Course)
	Total	**22**	
Course No.	**10th Semester**	**Credits**	**Course Type**
EC-799	M.Tech. Dissertation	18	Programme Elective
	Total	**22**	

*Students **opting for Internship** in 9th Semester shall register for **M.Tech. Dissertation** as well as **Free Elective Courses** of 04 Credits.

Fourth Year													
7th Semester							8th Semester						
SN	**Code**	**Subject**	**L**	**T**	**P**	**Credits**	**SN**	**Code**	**Subject**	**L**	**T**	**P**	**Credits**
1	EC-411	Computer Architecture and Organization	3	0	0	3	**1**	EC-421	Optical Communication Systems and Networks	3	0	0	3
2	EC-412	Wireless Communication	3	0	0	3	**2**	EC-422	Advanced Mobile Communication	3	0	0	3
3	EC-631#	Information Theory and Coding	4	0	0	4	**3**	EC-622#	Analog VLSI Design	4	0	0	4
4	EC-635#	AI and Machine Learning	4	0	0	4	**4**	EC-623#	FPGA & ASIC Design	4	0	0	4
5	EC-7MN	PG Program Elective-I	4	0	0	4	**5**	EC-643#	Modelling and Simulation of Communication Systems	4	0	0	4
6	EC-7MN	PG Program Elective-II	4	0	0	4	**6**	EC-7MN	PG Program Elective-III	4	0	0	4
7	EC-416	Industrial Training Evaluation	0	0	4	2	**7**	EC-498	General Proficiency	0	0	0	2
8	EC-417	Network Simulation Lab	1	0	2	2	**8**	EC-499	Major Project	---			12
Total Hours = 29						**26**			**Total Hours = 22**				**36**

#PG Course

Fifth Year													
9th Semester							10th Semester						
SN	**Code**	**Subject**	**L**	**T**	**P**	**Credits**	**SN**	**Code**	**Subject**	**L**	**T**	**P**	**Credits**
1	EC-798	M. Tech. Dissertation	---			18	**1**	EC-799	M. Tech. Dissertation	---			18
2		Free Elective /Open Elective Course (Courses available in other Departments in the Odd semester)/ Engineering Course (PG Elective Course)	4	0	0	4							
						22							**18**

Semester Wise Credits											
Semester	**1st**	**2nd**	**3rd**	**4th**	**5th**	**6th**	**7th**	**8th**	**9th**	**10th**	**Total**
Credits	20	20	20	20	20	20	26 (UG=10) (PG=16)	36 (UG=20) (PG=16)	22 (PG=22)	18 (PG=18)	**222 (UG=150, PG=72)**
Hours/week	24	24	23	24	22	22	27	46	4	-	**216**

List of Postgraduate (PG) Program Electives

(Courses related to VLSI Design)

PG Program Elective-I

EC-711 Characterization of Semiconductor Materials & Devices
EC-712 Nano-Electronics
EC-713 Deep Submicron VLSI Design
EC-714 Advanced Semiconductor Devices
EC-715 VLSI Test and Testability
EC-716 VLSI Interconnects
EC-717 MEMS and Micro Sensor Design
EC-718 Memory Design and Testing
EC-719 Neural Networks and Deep Learning

PG Program Elective-II

EC-720 Low Power VLSI Design
EC-721 Advanced IC Design
EC-722 IC Design for IoT Systems
EC-723 Data Converters for IC Design
EC-724 Verification of VLSI Circuits
EC-725 Reliability of VLSI Circuits
EC-726 Hardware Algorithms for VLSI
EC-727 Advanced Computer Architecture

PG Program Elective-III

EC-728 RF IC Design
EC-729 DSP Architectures
EC-730 VLSI Signal Processing
EC-731 Flexible Electronics
EC-732 Organic Electronics
EC-733 Quantum Electronics
EC-734 Magneto-electronics & Spintronics
EC-735 Numerical Optimization

List of Postgraduate (PG) Program Electives
(Courses related to Communication Systems and Networks)

PG Program Elective-I

EC-736	Advanced Digital Communication
EC-737	Advanced Optical Communication
EC-738	Soft Computing
EC-739	Wi-Fi, Bluetooth and Zigbee Technology
EC-740	Wireless Sensor Networks
EC-741	Optimization Tools and Techniques
EC-742	Applied Linear Algebra for Signal Processing, Data Analytics, and Machine Learning

PG Program Elective-II

EC-743	Electromagnetic Interference and Compatibility
EC-744	Advanced Engineering Electromagnetics
EC-745	RF and Microwave Circuit Design
EC-746	Advanced Antenna and Electromagnetic Metamaterials: Concept and Applications
EC-747	Nanophotonics and Plasmonics: Concepts and Applications
EC-748	Wavelet Transform and Applications
EC-749	mm-Wave Wireless Communication for 5G and Beyond

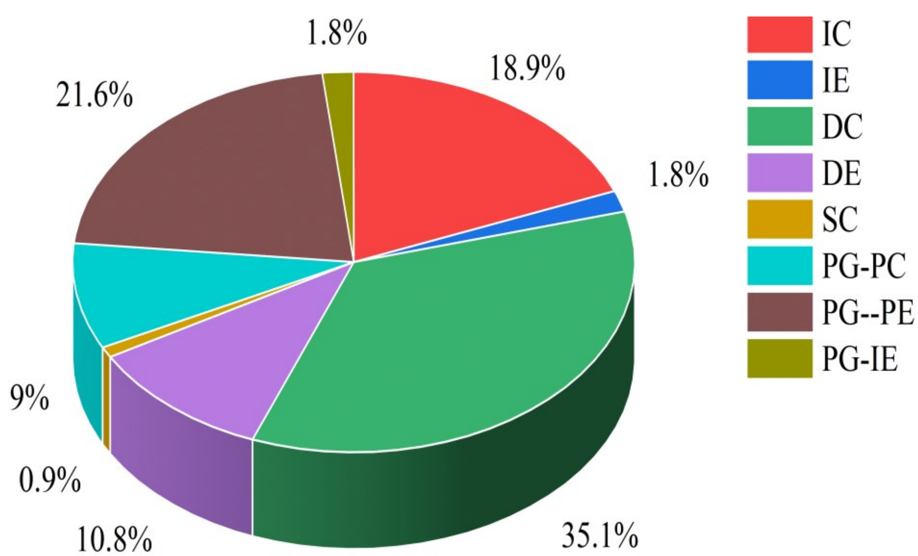
PG Program Elective-III

EC-750	Biomedical Signal Processing
EC-751	Statistical Signal Processing
EC-752	Radar Signal Processing
EC-753	Adaptive Signal Processing
EC-754	Multi-rate Signal Processing
EC-755	Advanced Spectrum Engineering
EC-756	6G and Terahertz Communication

Type of Courses and Credits in Each Semester for Dual Degree (B.Tech. and M.Tech.) Program

SEMESTERS											
Type of Courses	**1st**	**2nd**	**3rd**	**4th**	**5th**	**6th**	**7th**	**8th**	**9th**	**10th**	**Total**
IC	20	20	0	0	0	2	0	0	0	0	**42**
IE	0	0	0	1	3	0	0	0	0	0	**4**
DC	0	0	20	16	14	10	10	8	0	0	**78**
DE	0	0	0	3	3	6	0	12	0	0	**24**
SC	0	0	0	0	0	2	0	0	0	0	**2**
PG-PC	0	0	0	0	0	0	8	12	0	0	**20**
PG-PE	0	0	0	0	0	0	8	4	18	18	**48**
PG-IE	0	0	0	0	0	0	0	0	4*	0	**4**
Credits	**20**	**20**	**20**	**20**	**20**	**20**	**26**	**36**	**22**	**18**	**222**
											Total Credits = 222

*Students are free to choose any combination out of free electives, IE, and PG-DE for 4 credits.



Share of credits based on the requirement of the Dual-Degree (B.Tech. and M.Tech.) Program

Course Name:	**Digital Electronics and Logic Design**
Course Code:	**EC-211**
Course Type:	**Discipline Core**
Contact Hours/Week: **3L**	Course Credits: **03**

Course Objectives

- To impart knowledge about the concept of digital design, number system and codes.
- To introduce the fundamental concepts related to the 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, Number systems, Binary Arithmetic (Addition, Subtraction, Multiplication and Division), Diminished radix and radix complements; BCD codes, Excess-3 code, Gray code, Hamming code, Error Detection and Correction. Digital to analog converter, Analog to digital converter	**08L**
UNIT-02	**Logic Gates and Logic Families:** Digital Logic Gates, characteristics of logic families, Various Logic Families: RTL, DTL, TTL, ECL, MOS and CMOS; Working and their characteristics.	**06L**
UNIT-03	**Combinational Logic Design:** Boolean Algebra, Basic Theorems and Properties of Boolean Algebra, Representation of function in SOP and POS form, NAND and NOR implementation Minimization of Logical functions: Karnaugh- Map method, Tabulation method, VEM method, Iterative Consensus & Generalized Consensus method, Design of Combinational circuits.	**12L**
UNIT-04	**MSI and PLD Components:** Binary Adder and Subtractor; Decoders and Encoders; Multiplexers and DE-Multiplexers circuits; Programmable Read Only Memory, Programmable Logic Arrays, Programmable Array Logic; Implementation of Combinatorial Logic using these devices, Semiconductor Memories.	**06L**
UNIT-05	**Sequential Logic Design:** Introduction and Classification of Sequential circuits, Latches & Flip-flops: Excitation Table of flip-flops, Interconversion of flip-flops, Design of Synchronous & Asynchronous Sequential circuits, Registers, Counters, finite state machine	**08L**

Course Outcomes

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

CO1: Understand about the concept of digital systems.

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.
5. Digital Systems: Principles and Applications R. J. Tocci, Prentice Hall

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

Contact Hours/Week: **3L** Course Credits: **03**

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	**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, 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:	**Discipline Core**

Contact Hours/Week: **3L** Course Credits: **03**

Course Objectives

- To understand the basic components of communication systems.
- To prepare the mathematical background for communication signal analysis.
- To analyze signals in the presence of 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 Diodes 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 the 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. Principles of Communication System by Taub & Schilling, McGraw-Hill Education Publisher.
3. Communication Systems by S. Haykin, Wiley Publication.

Course Name: **VLSI Technology** Course Code: **EC-214** Course Type: **Discipline 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 package 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 to identify 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: **Network Analysis and Synthesis**

Course Code: **EC-215**

Course Type: **Discipline Core**

Contact Hours/Week: **2L** Course Credits: **02**

Course Objectives

The basic objective of this course is to introduce the fundamental theory and mathematics for the analysis of electrical circuits, frequency response and transfer function of circuits. The students will be able extend these fundamental principles into a way of thinking for problem solving in mathematics, science, and engineering.

Unit Number	Course Content	Lectures
UNIT-01	**NETWORK THEOREMS** Superposition and Reciprocity theorem, Thevenin's and Norton's theorem, Millman's theorem, maximum power transfer theorem, compensation, Tellegan's theorem, analysis of circuits using theorems.	**07L**
UNIT-02	**TRANSIENT ANALYSIS OF NETWORKS** Network elements, Transient response of R-L, R-C, R-L- C for DC and sinusoidal excitation, Initial condition, Solution using differential equation approach and Laplace transform method.	**07L**
UNIT-03	**NETWORK ANALYSIS** State variable method, Analytic and numerical solutions, Two Port Networks, Graph theoretic analysis for large scale networks, Formulation, and solution of network graph of simple networks, State space representation, Analysis using PSPICE.	**07L**
UNIT-04	**NETWORK SYNTHESIS** Network realizability, Causality and stability, Hurwitz Polynomials, Positive real functions, Properties of RC, RL & LC networks, Foster and Cauer forms of realization, Transmission zeroes, Synthesis of transfer functions.	**07L**

Course Outcomes

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

CO1: Apply different network theorems to solve complex circuit problems.

CO2: Identify the transient and steady state response of different types of circuits.

CO3: Solve network problems using graphical method.

CO4: Realize the network for a given response.

Books and References

1. Network Analysis and Synthesis by Franklin F. Kuo, Wiley; Second edition, 2006.
2. Network Analysis, by M. E. V. Valkenburg, Pearson, 3rd Edition, 2015.
3. Network and systems by D. Roy – Choudhary, New Age; Second Edition, 2013.

Course Name: **Numerical Analysis and Statistics**
Course Code: **MA-218**
Course Type: **Discipline Core**

Contact Hours/Week: **3L** Course Credits: **03**

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, and to understand the concept of approximating & interpolating polynomials and finding values of function at arbitrary point.
- To impart knowledge of various numerical techniques to solve ODE, and to incorporate the concept of probability to find the physical significance of various distribution phenomenon.

Course Content

Unit No	Course Content	Lectures
Unit-01	**Introduction to Complex Numbers:** 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..	05
Unit-02	**Functions of Complex Variable:** 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	06
Unit-03	**Interpolation:** Least square curve fit, Finite differences and difference operators, Newton's interpolation formulae, Gauss forward and backward formulae, Lagrange's interpolation.	05
Unit-04	**Numerical Integration and Differentiation:** Integration by trapezoidal and Simpson's rules 1/3 and 3/8 rule, Taylor series method, Picard's method, Euler's method, Modified Euler's method, Runge-Kutta method.	08
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.	06
Unit-06	**Probability and Statistics:** Review of probability, Conditional probability and sampling theorems, Discrete and Continuous Probability Distribution, Probability Mass & Probability Density Functions, Distribution function, Discrete and Continuous probability distributions, Binomial, Poisson and Normal distributions.	06

Course Outcomes

Upon successful completion of the course, the students 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 variables.
CO2. Identify an appropriate technique to solve the linear, non-linear equations, ordinary differential equations.
CO3. Formulate the problems on related topics and solve them analytically.
CO4. Apply the concepts of linear, non-linear equations, differential equations and complex analysis in various engineering problems.
CO5. Apply the concepts of probability theory in various engineering problems and 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 (2 nd Ed.): by J D Hoffman, CRC Press.
5. Numerical Analysis Mathematics and Scientific computing (3 rd ed.): by D. Kincaid and W. Cheney, American Mathematical Society.
6. Probability and Statistics for Engineers and Scientists by R.E. Walpole, S. L. Myers and K. Ye, Pearson.

Course Name:	**Digital Electronics and Logic Design Lab**
Course Code:	**EC-216**
Course Type:	**Discipline Core**

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

Course Objectives

- Familiarization with digital integrated circuits and equipment.
- 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 verify 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.

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-217**

Course Type: **Discipline Core**

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 may prepare the actual list of experiments/problems at the start of semester based on the 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:	**Electronic Workshop**
Course Code:	**EC-218**
Course Type:	**Discipline Core**
Contact Hours/Week: **2P**	Course Credits: **01**

Course Objectives

- To understand basic electronic components and hardware systems.
- Familiarization and hands-on with various instruments and tools used in electronic system repair and service.
- Hands-on training with familiarization, identification, testing, assembling, dismantling, fabrication and repairing electronic systems.

List of Experiments

1. Familiarization/Identification of electronic components with specification (Functionality, type, size, color coding, package, symbol, cost etc. [Active, Passive, Electrical, Electronic, Electro-mechanical, Wires, Cables, Connectors, Fuses, Switches, Relays, Crystals, Displays, Fasteners, Heat sink etc.), Pulse Code Modulation & Demodulation.
2. Drawing of electronic circuit diagrams using BIS/IEEE symbols and introduction to EDA tools, Interpret data sheets of discrete components and IC's, Estimation, and costing.
3. Familiarization/Application of testing instruments and commonly used tools and instruments such as: Multimeter, Function generator, Power supply, CRO, Soldering iron, De-soldering pump, Pliers, Cutters, Wire strippers, Screw drivers, Tweezers, Crimping tool, Hot air soldering and de-soldering station etc.
4. Testing of electronic components [Resistor, Capacitor, Diode, Transistor, UJT and JFET using multimeter.
5. Inter-connection methods and soldering practice. [Bread board, Wrapping, Crimping, Soldering - types - selection of materials and safety precautions, soldering practice in connectors and general-purpose PCB, Crimping.]
6. Printed circuit boards (PCB) [Types, Single sided, Double sided, PTH, Processing methods, Design, and fabrication of a single sided PCB for a simple circuit with manual etching (Ferric chloride) and drilling.]
7. Mini Project: Designing and assembling of any electronic circuit/system on general purpose PCB, test and show the functioning.

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 test the active and passive electronic components.

CO2: Test, assemble, dis-assemble, test and repair electronic hardware systems.

CO3: Use the electronic workshop tools efficiently and effectively.

Course Name:	**Linear Integrated Circuits**
Course Code:	**EC-221**
Course Type:	**Discipline Core**

Contact Hours/Week: **3L** Course Credits: **03**

Course Objectives

- To impart a strong foundation of IC based design.
- To introduce the various applications of operational amplifiers and their 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 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:	**Discipline Core**

Contact Hours/Week: **3L** Course Credits: **03**

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.	**08L**
UNIT-02	**AM Transmitters and Receivers AM Transmitters:** Generation of AM, Low Level and High-Level Modulation, AM Transmitter Block Diagram, AM Modulator circuits, 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.	**07L**
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.	**10L**
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.	**05L**

Course Outcomes

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

CO1: Differentiate AM and FM transmission.

CO2: To analyse 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: **Microprocessors and Microcontrollers**
Course Code: **EC-223**
Course Type: **Discipline Core**

Contact Hours/Week: **3L** Course Credits: **03**

Course Objectives

To give an in-depth understanding of the architectures of 8085 and 8051 Chips. Knowledge of this course will enable the students to design and develop 8085 and 8051 based applications in real time.

Unit Number	Course Content	Lectures
UNIT-01	**8085 ARCHITECTURE AND ORGANISATION** Introduction to Microprocessor, Microcomputer system, Microprocessor operations, Internal Architecture of 8085, System Bus, Pin description of 8085, Need and generation of control signals, types of Registers & Timing and Control Unit.	**05L**
UNIT-02	**INSTRUCTION SET OF 8085** Instruction formats, addressing Modes, Timing effect of Addressing modes, Instruction set classification, Instruction Cycle, Machine cycles, Timing diagram, Stack and Subroutine, Interrupt types, interrupt systems and polling, Interrupt control logic, Assembly language programming.	**06L**
UNIT-03	**MEMORY AND I/O DEVICES INTERFACE** Serial and Parallel communication interface, Hardware (Circuit level) description of Registers, RAM, ROM and Secondary memories, DMA controller, memory mapped I/O & I/O mapped I/O, Generating Control Signals, Interfacing 2KX8 EPROM, 2KX8 RAM, Interfacing I/O ports to 8085, Handshake Signals, Block diagram and working of PPI-8255, Interfacing 8255 to 8085 and LED Interface.	**06L**
UNIT-04	**INTRODUCTION TO 8051 MICROCONTROLLERS** Comparison of Microprocessors and Microcontrollers, Architecture of 8051, Special Function & General-Purpose Registers, Pin diagram of 8051, Instruction set, addressing modes, Role of PC and DPTR, Flags and PSW, CPU, Registers, RAM and ROM organization, Special Function Registers, I/O pins, ports and circuits, External memory, Counter and Timers, Serial Transmission, and Interrupts programming.	**06L**
UNIT-05	**TIMER / COUNTER AND SERIAL COMMUNICATION IN 8051** Timer registers - Timer0, Timer1. Configuration of TMOD, TCON registers. Timer Mode1and Mode2 programming. Counter mode. Serial communication modes and protocols, RS-232 pin configuration and connection. Serial port programming (Transmitting a character and receiving a character using serial communication) using Assembly.	**06L**
UNIT-06	**PROGRAMMING AND APPLICATIONS OF 8051** Assembly language programming, Jump Loop and Call Instructions, I/O Port Programming, Addressing Modes, Arithmetical and Logical Instructions, Stepper Motor Interfacing, DC motor interfacing, PWM generation using 805.	**05L**

Course Outcomes

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

CO1: Understand the architecture cum programming models of 8085 and 8051.

CO2: Know about the instruction set of 8085 and 8051.

CO3: Learn the use of instruction sets in Assembly language programming of 8085 and 8051. .

Books and References

1. Microprocessor Architecture, Programming & application with 8085 by Ramesh Gaonkar, Fifth Edition, Penram Publications
2. The 8051 Microcontroller and Embedded Systems" by Mohammad Ali Mazidi and Janice Gillispie Maszidi, Pearson education, 2003, ISBN- 9788131710265.
3. Microprocessors and Microcontrollers by Sunil Mathur and Jeebananda Panda, PHI.

Course Name: **Electromagnetic Field Theory**
Course Code: **EC-224**
Course Type: **Discipline 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 coordinate system, introduction to line, Surface and volume integrals, Definition of gradient, Divergent and curl of a vector and their physical significance.	**07L**
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	**08L**
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	**08L**
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	**10L**
UNIT-05	**TRANSMISSION LINE** 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.	**09L**

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 another.
CO2: Describe the force between charges and equipotential surfaces and electrostatic shielding/ screening.
CO3: Describe the magnetic field due to a current element and force on a charge particle due to magnetic field.
CO4: Describe the electromagnetic wave phenomenon and power carried by an electromagnetic wave.
CO5: Understand how the transmission line theory bridges the gap between circuit theory and field theory.

Books and References

ctromagnetics by Matthew N.O. Sadiku, Oxford University Press.
Radiating Systems by Jordan and Balmain, PHI, Second Ed.
s by William Hayt, TATA McGraw-Hill.
s, McGraw-Hill.

Course Name: **Electronics Device Modeling** Course Code: **EC-241** Course Type: **Discipline Elective-I**		
Contact Hours/Week: **3L**		Course Credits: **03**
Course Objectives ● To bring home knowledge of fundamentals of electronics devices and modeling. ● Build upon the theoretical, mathematical and physical models of electronic devices used in VLSI, for proper understanding of e-circuit design, simulation and working. ● To provide students with an opportunity to understand and practice on SPICE platform.		
Unit Number	**Course Content**	**Lectures**
UNIT-01	**Introduction to Device Modeling**: Introduction, physical significance of device modeling, various devices used in device modeling. Material used in device modeling. Trends & projections in device modeling. Fundamentals of SPICE.	**05L**
UNIT-02	**Junction Diodes**: PN junction depletion region formation, Depletion-capacitance model, Storage capacitance model, DC, small signal, large signal, high frequency model of diodes. Measurement and extraction of diode model parameters.	**10L**
UNIT-03	**MOSFETs**: MOSFET fundamentals, Types of MOSFETs, Concept of threshold voltage, Large signal behavior MOSFETs, Comparison of operating regions of Bipolar and MOS Transistors, Shichman Hodges and Level-1 MOS Models, Limitations of MOS level-1. MOS level-2 model.	**10L**
UNIT-04	**Short & Narrow Channel Effects in MOSFETs**: Velocity saturation, Mobility degradation, Weak Inversion in MOS Transistors, Narrow & Short Channel Effects in MOSFETs, namely, Drain induced barrier lowering (DIBL), Subthreshold current, Impact ionization, Charge sharing, Threshold variation with transistor dimensions, etc.	**05L**
UNIT-05	**Bipolar Junction Transistors**: DC, small signal, high frequency models of bipolar junction transistors. Ebers–Moll BJT model. Gummel–Poon BJT model. Extraction of BJT model parameters.	**05L**
UNIT-06	**Modern VLSI Devices**: Principle of hetro-junction devices, High speed compound semiconductor devices, opto devices.	**05L**
Course Outcomes Upon successful completion of the course, the students will be able to CO1:Comprehend the insight of electronic devices to provide appropriate and economically viable solutions to electronics engineering community and society at large. CO2: Identify the new state of art electronic device models to solve real-world research problems. CO3: Apply principles of usage of EDA tools & techniques for effective & efficient modeling of e-devices for e-circuits. CO4: Assess performance of electronic devices without actual fabrication 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 by S.M. Kang & Y. Leblibici, TMH. 2. Physics of Semiconductor Devices by S.M. Sze, Wiley Pub. 3. Introduction to PSPICE by H.M. Rashid, PHI. 4. Solid State Electronic Devices by B.G. Streetman & S. Baneerjee, PHI.		

Course Name: **Nano Technology** Course Code: **EC-242** Course Type: **Discipline Elective-I**		
Contact Hours/Week: **3L**		Course Credits: **03**
Course Objectives ● To acquire the knowledge of the fundamentals of Nanomaterials. ● To enable the students to get familiarize with the basic concepts of Statistical and Quantum Mechanics		
Unit Number	**Course Content**	**Lectures**
UNIT-01	**INTRODUCTION TO NANOTECHNOLOGY:** Importance of Nanotechnology-History of Nanotechnology-Opportunity at the nanoscale-length and time scale in structures-energy landscapes-Interdynamic aspects of inter molecular forces -classification based on the dimensionality- nanoparticles- nanoclusters-nanotubes-nanowires and nanodots- Semiconductor nanocrystals- carbon nanotubes- Influence of Nano structuring on Mechanical, optical, electronic, magnetic and chemical properties.	**09L**
UNIT-02	**BASICS OF QUANTUM MECHANICS:** Introduction to Quantum Mechanics – Schrodinger equation – time dependent and time independent equations – Operators and observables – Commutation relations – Hermitian operators – Expectation values of observables – Solutions of the Schrodinger equation – free particle – particle in a box – one and three dimensions – particle in a finite well – Penetration through a barrier – Tunnel effect – Single step barrier.	**09L**
UNIT-03	**TYPES OF NANOMATERIALS:** Nanoclusters, Solid solutions, Thin film, Nanocomposites (Metal Oxide and Polymer based), Core Shell Nanostructure, Buckyballs, Carbon nano tubes and, Zeolites minerals, Dendrimers, Micelles, Liposomes, Block Copolymers, Porous Materials, Metal Nanocrystals, Semiconductor nanomaterials.	**06L**
UNIT-04	**STATISTICAL DESCRIPTION OF SMALL SYSTEMS:** Quantum states and phase space, the density matrix, few examples; An ideal gas in quantum mechanical ensembles; statistics of occupation numbers. Basic concepts and thermodynamic behavior of an ideal Bose gas, Bose-Einstein condensation; Discussion of a gas of phonons(The Debye field); Thermodynamics of an ideal Fermi gas, heat capacity of a free-electron gas at low temperatures.	**09L**
UNIT-05	**ELECTRON DYNAMICS IN SOLIDS:** Free electron theory of metals, band theory of solids, Bloch theorem – tight binding approximation – Kroning – Penne model, Evolution of band structure and Fermi surface- Metals and Insulators, semiconductors - Transport properties – Mobility, Resistivity, Relaxation time, Recombination centers- Hall effects – Confinement and transport in nanostructure – Electrons in quantum wires and quantum dots– Current, reservoirs, and electron channels – conductance formula for nanostructures – quantized conductance – Local density of states- Ballistic transport – Coulomb blockade – Diffusive transport – Fock space- 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	**12L**
Course Outcomes: Upon successful completion of the course, the students will be able to C01: Understanding the insight of Nanoelectronics device physics 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 to solve real-world research problems. C03: Understanding the applications of quantum physics in semiconductor devices. C04: Identifying different devices to meet out the present design, health, safety and environmental challenges.		
Books and References: 1. A textbook of Nanoscience and Nanotechnology by Pradeep. T , McGraw Hill, 2012. 2. Introduction to Nanoelectronics: Science, Nanotechnology, Engineering & Applications by Vladimir. V. Mitin, Cambridge University Press. 3. Introduction to Quantum Mechanics by David. J. Griffiths, Pearson, 2009. 4. Introductory Quantum Mechanics by Richard. L. Liboff, R, Pearson, 2003. 5. Statistical Physics by Claudine Herman, Springer, New York, 2005. 6. Introduction to Solid State Physics by Kittel. C, Wiley India Pvt Ltd., 2007. 7. Nanomaterials Chemistry by Rao. C. N, Muller. A, Cheetham. A. K, Wiley-VCH, 2007. 8. Nanotechnology for Microelectronics and Optoelectronics by J.M. Martinez-Duart, R.J. Martin Palma, F. Agulle Rueda, Elsevier.		

Course Name: **Digital Arithmetic**
Course Code: **EC-243**
Course Type: **Discipline Elective-I**

Contact Hours/Week: **3L** Course Credits: **03**

Course Objectives:

- To impart knowledge about 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, Tradeoffs 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 Parhami, B., Oxford University Press.
2. Computer Arithmetic Algorithms by Koren, I., CRC Press.
3. Digital Arithmetic by Ercegovac, M. and Lang, T., Elsevier.
4. Verilog Digital Computer Design Algorithms into Hardware by Mark Gordon Arnold, Prentice Hall PTR.

Course Name:	**Linear Integrated Circuits Lab**
Course Code:	**EC-225**
Course Type:	**Discipline Core**

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 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 power management, signal conditioning, analog and digital communication.

Course Name: **Analog Communication Lab**
Course Code: **EC-226**
Course Type: **Discipline Core**

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

Course Objectives

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

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 may prepare the actual list of experiments/problems at the start of semester based on the 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: Analyse the performance measure of Analog Communication Systems.

Course Name: **Microprocessors and Microcontrollers Lab**
Course Code: **EC-227**
Course Type: **Discipline Core**

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 blinking.
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 the 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 tasks involved for a given problem.
CO2: Design and develop modular programming skills.
CO3: Trace and debug a program.

Course Name: **Microwave Devices and Systems**
Course Code: **EC-311**
Course Type: **Discipline Core**

Contact Hours/Week: **3L** Course Credits: **03**

Course Objectives

- Develop students' understanding of the basic concepts and theories of microwave engineering.
- Equip students with the skills and knowledge needed to design, analyse, and optimize microwave systems and devices.
- Provide students with practical experience in the use of state-of-the-art microwave test equipment.
- Develop students' ability to apply microwave engineering concepts to solve real-world problems in a range of fields.

Unit Number	Course Content	Lectures
UNIT-01	**INTRODUCTION OF MICROWAVE AND WAVEGUIDE** Need of microwave, Advantages and application of microwave signals, Frequency Allocations and Frequency Plans, Rectangular Waveguide and its Analysis, Circular Waveguide and its Analysis, Modes of Propagation, Dominant Modes, Cut-off wavelength, Mode Excitation.	**07 L**
UNIT-02	**MICROWAVE TUBES** Limitations of Conventional Tubes at Microwave Frequency, two cavity, Multi-cavity Klystron Amplifiers their Analysis, Reflex Klystron and their analysis, Basics of Magnetrons, Traveling Wave Tube, and their applications.	**07 L**
UNIT-03	**MICROWAVE DEVICES** Scattering Matrix of Microwave Waveguide Junction, Properties of Scattering Matrix, E-Plane Tee, H-plane Tee, Magic Tee, Directional Couplers, Ferrite Devices, Gyrator, Isolator, Circulators.	**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, Varactor Diodes, PIN Diode, and its applications.	**05 L**
UNIT-05	**MICROWAVE COMPONENT AND MEASUREMENT DEVICES** VSWR meter, Frequency meter, Spectrum analyzer, Network analyzer, Tunable detector, Slotted line carriage, Power meter, Phase Shifter, Matched Load, Waveguide Transition, Attenuators.	**06 L**
UNIT-06	**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.	**05 L**

Course Outcomes

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

CO1: Demonstrate an understanding of the behaviour of electromagnetic waves in waveguides.

CO2: Understand the operating principles and applications of microwave tubes.

CO3: Understand the properties and behaviour of various passive microwave devices such as waveguide junction, directional couplers, power dividers, etc.

CO4: Understand the performance of microwave components, measuring devices and solid-state devices.

CO5: Analyse the characteristics of micro-strip lines including impedance, losses, etc.

Books and References

1. Microwave Devices and Circuits by Samuel Y. Liao, Prentice-Hall, U.S.A.
2. Microwave Engineering by David M. Pozar, Wiley Publication, New Delhi.
3. Foundations for Microwave Engineering by R.E. Collins, Wiley Inter-science, New York.
4. Microwave Engineering by S. Das, Oxford University Press.

Course Name: **Digital Communication and Systems**
Course Code: **EC-312**
Course Type: **Discipline Core**
Contact Hours/Week: **3L** Course Credits: **03**

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: **Control Systems**
Course Code: **EC-313**
Course Type: **Discipline 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 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 Evans plots (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: **VLSI Design**
Course Code: **EC-314**
Course Type: **Discipline Core**
Contact Hours/Week: **3L** Course Credits: **03**

Course Objectives

- To introduce the fundamental concepts of MOSFETs and physical design of VLSI circuits.
- To impart knowledge about various CMOS VLSI Design styles.
- To design MOS memories and learn high performance VLSI design techniques.
- To enable the students to understand the parameters on which the circuit performance depends and their control strategies.

Unit Number	Course Content	Contact Hours
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, MOSFET parasitics. Trends & Projections in VLSI Design & Technology, Flow of VLSI Circuit Design, Scaling in MOS devices.	**06L**
UNIT-02	**VLSI Design Styles**: NMOS and CMOS Process flow, Concept of Noise Margin, Resistive MOS inverter design, voltage transfer characteristics, Inverter Threshold Voltage. Active loads and their importance, NMOS Inverter design, Critical voltages for inverter design, CMOS Inverter design and properties, CMOS Delay and Power Dissipation, Parallel & Series Equivalent circuits, Static CMOS Circuit Design.	**11L**
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 circuits. Transmission gate logic.	**06L**
UNIT-05	**MOS Memory Design**: Types of MOS memories, ROM memory design, SRAM cell design and DRAMs.	**06L**
UNIT-06	**CMOS Amplifiers**: Single stage MOS Amplifiers: Common Source amplifier, Common Gate amplifier, Common Drain amplifier. Differential Amplifier analysis. Merits and advantages of differential amplifiers.	**06L**

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: **Digital Communication Lab**
Course Code: **EC-315**
Course Type: **Discipline Core**

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 & De-multiplexing.
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: **VLSI Design Lab** Course Code: **EC-316** Course Type: **Discipline Core**	
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 softwares & 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.

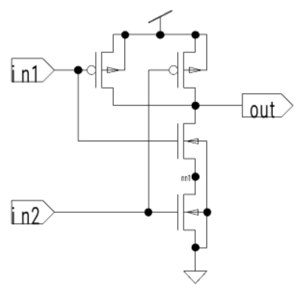


Fig.1. CMOS NAND Gate.

4. Simulate firstly minimum dimension CMOS inverter circuit using SPICE. Hence analyze and plot power and delay variations with voltage scaling, and ii) Load variations.
5. Simulate CMOS NAND, NOR and XOR circuits using SPICE. Hence analyze and plot their power and delay variations i) 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. Familiarization with Cadence or Xilinx 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 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.

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: **Switching and Finite Automata Theory**
Course Code: **EC-351**
Course Type: **Discipline Elective-II**

Contact Hours/Week: **3L** Course Credits: **03**

Course Objectives

- Understand the basics of threshold logic, effect of hazards on digital circuits and techniques of fault detection.
- Explain finite state model and minimization techniques.
- Know the structure of sequential machines, and state identification.
- Understand the concept of fault detection experiments.

Unit Number	Course Content	Lectures
UNIT-01	**Threshold Logic:** Introductory Concepts: Threshold element, capabilities and limitations of threshold logic, Elementary Properties, Synthesis of Threshold networks: Unate functions, Identification and realization of threshold functions, The map as a tool in synthesizing threshold networks.	**08L**
UNIT-02	**Reliable Design and Fault Diagnosis:** Hazards, static hazards, Design of Hazard-free Switching Circuits, Fault detection in combinational circuits, Fault detection in combinational circuits: The faults, The Fault Table, Covering the fault table, Fault location experiments: Preset experiments, Adaptive experiments, Boolean differences, Fault detection by path sensitizing.	**08L**
UNIT-03	Sequential Machines: Capabilities, Minimization and Transformation the Finite state model and definitions, capabilities and limitations of finite state machines, State equivalence and machine minimization: k-equivalence, The minimization Procedure, Machine equivalence, Simplification of incompletely specified machines.	**08L**
UNIT-04	Structure of Sequential Machines: Introductory example, State assignment using partitions: closed partitions, The lattice of closed partitions, Reduction of output dependency, Input dependence and autonomous clocks, Covers and generation of closed partitions by state splitting: Covers, The implication graph, An application of state splitting to parallel decomposition.	**08L**
UNIT-05	State–Identification and Fault Detection Experiments: Experiments, Homing experiments, Distinguishing experiments, Machine identification, Fault detection experiments, Design of diagnosable machines, Second algorithm for the design of fault detection experiments.	**08 L**

Course Outcomes

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

CO1: Explain the concept of threshold logic.
CO2: Understand the effect of hazards on digital circuits and fault detection and analysis.
CO3: Define the concepts of finite state model.
CO4: Analyze the structure of sequential machine.
CO5: Explain methods of state identification and fault detection experiments.

Books and References

1. Switching and Finite Automata Theory – Zvi Kohavi, McGraw Hill, 2nd edition.
2. Fault Tolerant and Fault Testable Hardware Design - Parag K Lala, Prentice Hall Inc.
3. Digital Circuits and Logic Design. - Charles Roth Jr, Larry L. Kinney, Cengage Learning.

Course Name: **Data Structures and Algorithms**
Course Code: **EC-352**
Course Type: **Discipline Elective-II**

Contact Hours/Week: **3L** Course Credits: **03**

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	Lectures
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.	**07L**
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	**07L**
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.	**06L**
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.	**06L**

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, and binary search trees.
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 and 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: **Object Oriented Programming**
Course Code: **EC-353**
Course Type: **Discipline Elective-II**

Contact Hours/Week: **3L** Course Credits: **03**

Course Objectives

- To impart knowledge about the concept of Object Oriented programming.
- To introduce the fundamental concepts relevant to Arrays, Pointers and Functions, Classes, Objects, etc.
- To enable the students to understand the standard library, exception handling, streams and files

Unit Number	Course Content	Contact Hours
UNIT-01	**Concepts of Object-Oriented Programming:** Object Oriented Programming Paradigm, Basic concepts of OOPs, Benefits of OOPs, and Introduction to object oriented design and development, Design steps, Design example, Object oriented languages, Comparison of structured and object-oriented programming languages.	**06L**
UNIT-02	**Arrays, Pointers and Functions:** Arrays, Storage of arrays in memory, Initializing Arrays, Multi-Dimensional Arrays, Pointers, accessing array elements through pointers, passing pointers as function arguments, Arrays of pointers, Pointers to pointers, Functions, Arguments, Inline functions, Function Overloading Polymorphism.	**06L**
UNIT-03	**Classes and Objects:** Data types, operators, expressions, control structures, arrays, strings, Classes and objects, access specifiers, constructors, destructors, operator overloading, type conversion. Storage classes: Fixed vs. Automatic declaration, Scope, Global variables, register specifier, Dynamic memory allocation.	**07L**
UNIT-04	**Inheritance:** Inheritance, single Inheritance, Multiple Inheritance, Multi-level inheritance, hierarchical inheritance, hybrid inheritance, Virtual functions. Streams and Files: Opening and closing a file, File pointers and their manipulations, Sequential Input and output operations, multi-file programs, Random Access, command line argument, string class, Date class, Array class, List class, Queue class, User defined class, Generic Class.	**07L**
UNIT-05	**Exception Handling and Graphics:** List of exceptions, catching exception, handling exception. Text Mode, Graphics mode functions, Rectangles, and Lines, Polygons and Inheritance, Sound and Motion, Text in Graphics Mode. Standard Template Library: Standard Template Library, Overview of Standard Template Library, Containers, Algorithms, Iterators, Other STL Elements, Container Classes, General Theory of Operation, Vectors.	**10L**

Course Outcomes

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

CO1: Understand the concept of object oriented paradigm and programming.
CO2: Apply the concept of polymorphism and inheritance.
CO3: Implement exception handling and templates.
CO4: Handling of files and streams during programming.

Books and References

1. Object Oriented programming with C++ by E. Balagurusamy, Tata McGraw Hill.
2. The C++ programming Language by Bjarne Strustrup, Addison Wesley.
3. Object Oriented Analysis and Design with Applications by Grady Booch, Addison Wesley.
4. The Complete Reference Visual C++ by Chris H. Pappas and William H. Murray, Tata McGraw Hill.
5. C++ Primer by S. B. Lippman, Josee Lajoie and Barbara E. Moo, Pearson Education.

Course Name: **Microcontroller and Embedded System** Course Code: **EC-301** Course Type: **Open Elective**		
Contact Hours/Week: **3L**		Course Credits: **03**
Course Objectives ● To discuss the microcontroller architecture, programming techniques, interrupts timers and assembly language. ● The concepts of ARM architecture and real-time operating system. ● To provide theoretical knowledge enabling integration of hardware and software in microcontroller-based applications. ● 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 and Characteristics of Embedded Systems, Hardware and Software Co-Design, RISC Vs CISC, MCS-51 Family Overview, Architecture, Pin Diagram, Addressing Modes, Instruction Set, Instruction Types and applications of 8051 in ASIC and FPGA designs.	**05L**
UNIT-02	**PROGRAMMING** Assembly Programming, Timer Registers, Timer Modes, Overflow Flags, System clock, 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, Multitasking 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** Introduction to 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	**INTRODUCTION TO ARM ARCHITECTURE** Introduction to ARM architecture family, Syntax, Addressing modes and operands, Memory access instructions. Logical, Shift and Arithmetic operations, Stack, Functions and control flow, Macros and Directives, Thumb and arm instruction differences, Development with Keil and Mbed, Applications like IoT and machine learning with cortex-M.	**04L**
Course Outcomes Upon successful completion of the course, the students will be able to CO1: Develop the assembly codes for the microcontrollers. CO2: Understand the functional role of embedded systems in real time. 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. 5. Real-Time Operating Systems for ARM Cortex-M Microcontrollers, Vol. 3 (2nd Ed.) by Jonathan W. Valvano, Create Space.		

Course Name: **MEMS and Sensor Design**
Course Code: **EC-302**
Course Type: **Open Elective**

Contact Hours/Week: **3L** Course Credits: **03**

Course Objectives

- To impart knowledge about the need and applications of microsystems 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.
- To enable the students to design and analysis MEMS technology-based devices

Unit Number	Course Content	Lectures
UNIT-01	**Introduction:** Introduction to MEMS and Microsystems, MEMS Classification, MEMS versus Microelectronics, Applications of MEMS in Various Industries, Some Examples of Microsensors, Microactuators, and Microsystems, Classification of Sensors, Scaling Laws in miniaturization, Materials for MEMS	**05L**
UNIT-02	**MEMS Fabrication:** Structure of Silicon, Single Crystal Growth Techniques, Photolithography, Oxidation, Diffusion, Ion Implantation, Physical Vapor Deposition, Chemical Vapor Deposition, Surface Micromachining, Bulk Micromachining, Overview of Etching, Isotropic and Anisotropic Etching, Wet Etchants, Etch Stop Techniques, , Dry Etching, Micro- stereolithography, LIGA, SLIGA, Wafer Bonding	**12L**
UNIT-03	**Mechanical microsensors and Microactuators**: Basic Modeling Elements in Mechanical, Electrical and Thermal Systems, Types of Beams: Fixed-Free (Cantilevers), Fixed-Fixed (Bridges), Fixed-Guided beams, Electrostatic sensing and Actuation: Parallel plate capacitor, Applications of parallel plate capacitors: Inertial sensor, Pressure sensor, Flow sensor, Parallel plate Actuators, Piezoresistive Sensors: Origin and Expressions of Piezoresisitivity, Piezoresistive Materials and design of Piezoresistive Sensors, Piezoelectric effect, Piezoelectric materials, Design of Piezoelectric Principle based Sensors and Actuators	**12L**
UNIT-04	**Thermal and Magnetic microsensors:** Thermal Sensing and Actuation: Sensors and Actuators based on Thermal Expansion, Thermocouples, Thermoresistors, Shape Memory Alloy, Applications: Inertial sensors, Flow sensors, Infrared sensors, Magnetic material for MEMS, magnetic sensing, and detection, Magnetoresistive sensors, hall effect, magnetodiode, megnetotransitors, MEMS magnetic sensors	**05L**
UNIT-05	**RF-MEMS:** MEMS devices for RF Applications: High-Q Capacitors, Inductors, Switching devices and their Applications in RF Circuits, Mechanical, Electromechanical and Electromagnetic modelling	**06L**

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 various MEMS devices.

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. MEMS and Microsystems design and manufacture by Tai-Ran Hsu, Tata McGraw Hill.
2. MEMS by N. P. Mahalik, Tata McGraw Hill.
3. Foundations of MEMS by Chang Liu, Pearson Prentice Hall.
4. Sensors and Transducers by M. J. Usher, McMillian Hampshire.
5. Analysis and Design Principles of MEMS Devices by Minhang Bao, Elsevier.
6. Fundamentals of Microfabrication by M. Madou, CRC Press
7. Microsensors by R.S. Muller, Howe, Senturia and Smith, IEEE Press.
8. Semiconductor Sensors by S. M. Sze, Wiley–Inderscience Publications.

Course Name: **Communication Systems**
Course Code: **EC-303**
Course Type: **Open Elective**

Contact Hours/Week: **3L** Course Credits: **03**

Course Objectives

- To introduce students to the principles and applications of communication systems
- To provide students with an understanding of analog, digital and pulse communication techniques
- To familiarize students with modulation and demodulation techniques
- To introduce students to multiplexing and error correction codes
- To provide students with an understanding of the basic concepts of information theory, noise, and channel capacity

Unit Number	Course Content	Lectures
UNIT-01	**Introduction to Communication Systems** Definition and scope of communication systems, Communication channels and media, Basic block diagram of communication systems, Signal Representation and Analysis, Time and frequency domain representation of signals, Analog and digital signals, Fourier series and Fourier transform.	**05L**
UNIT-02	**Modulation and multiplexing techniques** Amplitude modulation (AM), Frequency modulation (FM), Phase modulation (PM), Digital modulation techniques (ASK, FSK, PSK, QAM), Pulse modulation schemes: pulse amplitude modulation (PAM), pulse position modulation (PPM), pulse width modulation (PWM), pulse code modulation (PCM), delta modulation (DM), and adaptive delta modulation (ADM). Frequency division multiplexing (FDM), Time division multiplexing (TDM), Code division multiplexing (CDM).	**08L**
UNIT-03	**Analog and Digital radio receivers** Types of analog radio receivers: Superheterodyne, TRF (Tuned Radio Frequency), and Regenerative, Demodulation Techniques: Amplitude Modulation (AM) and Frequency Modulation (FM), Sensitivity and Selectivity of Radio Receivers, Noise in Radio Receivers Automatic Gain Control (AGC) in Radio Receivers, Applications of analog radio receivers, Types of digital radio receivers: Direct Conversion, Superheterodyne, and Software Defined Radio (SDR), Demodulation Techniques: Amplitude Shift Keying (ASK), Frequency Shift Keying (FSK), Phase Shift Keying (PSK), and Quadrature Amplitude Modulation (QAM).	**08L**
UNIT-04	**Channel Capacity and Coding** Introduction to information theory, Entropy and information content, Source coding, Channel capacity, introduction to error correction codes, Linear block codes, Convolutional codes, Shannon's channel capacity theorem.	**05L**
UNIT-05	**Recent Communication Systems** 5G Communication Systems, Satellite Communication Systems, Cognitive Radio Systems, Internet of Things (IoT) Communication Systems.	**05 L**

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

CO1: Understand the basic building blocks of communication systems, including modulation techniques and transmission media.

CO2: Understand the principles of digital signal processing and its application to communication systems, including techniques for signal filtering, modulation, and demodulation.

CO3: Understand the source and channel encoding principles used in the communication systems.

CO4: Understand the emerging communication technologies, including 5G, Internet of Things (IoT), and Cognitive radio systems.

Books and References

1. "Communication Systems Engineering" by John G. Proakis and Masoud Salehi.
2. “Communication Systems, 3rd edition” by Simon Haykin.

Course Name: **VLSI Design and Techniques**	
Course Code: **EC-304**	
Course Type: **Open Elective**	
Contact Hours/Week: **3L**	Course Credits: **03**

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 to 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.	**06L**
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.	**06L**
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: **Digital Signal Processing**
Course Code: **EC-321**
Course Type: **Discipline Core**

Contact Hours/Week: **3L** Course Credits: **03**

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 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.

Course Name: **Antenna and Wave Propagation**
Course Code: **EC-322**
Course Type: **Discipline 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:** Recap of Maxwell's equations and wave equations, Retarded potentials, Vector potential A for an electric current source J, Radiation phenomenon from an oscillation dipole, Infinitesimal Dipole Antenna, Small dipole, Half wave dipole and quarter wave monopole antenna and its radiation characteristics.	**08L**
UNIT-02	**Antenna Fundamentals:** Radiation Pattern, Radiation Power Density, Radiation Intensity, Beamwidth, Directivity, Antenna Efficiency, Gain, Beam Efficiency, Bandwidth, Polarization, Input Impedance, Antenna Vector Effective Length and Equivalent Areas, Maximum Directivity and Maximum Effective Area, Friis Transmission Equation and Radar Range Equation	**08L**
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	**09L**
UNIT-04	**Special Antennas:** Basics of Loop antennas, Folded dipole antennas, Yagi-Uda antenna, Horn antennas, Helical antennas, Microstrip Patch antennas and its feeding techniques.	**08L**
UNIT-05	**Wave Propagation:** 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. Ionosphere Propagation: ionosphere structure, Effective characteristics of the various layers of ionosphere, Reflection and Refraction of waves by ionosphere, Space Wave Propagation: Space wave range, Troposphere waves-reflection, Refraction, Duct propagation, Troposphere propagation link.	**09L**

Course Outcomes

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

CO1: Understand the mechanism of radiation and will be able to Identify basic antenna parameters.

CO2: Design and analyse wire antennas.

CO3: Design and analyse antenna arrays.

CO4: Analyse 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.

Course Name: **Electronic Measurements and Instrumentation**
Course Code: **EC-323**
Course Type: **Discipline Core**

Contact Hours/Week: **2L** Course Credits: **02**

Course Objectives

- To introduce the various methods of instrumentation and parameters
- To impart knowledge about the various AC and DC measurement instruments
- To enable the students to understand the various types and transducers

Unit Number	Course Content	Lectures
UNIT-01	**Instrumentation Scheme & Characteristics:** Definition, Application and Methods of Measurements, Instrument Classification, Functional Elements of an instrument, Input Output Configuration of Measuring Instruments, Methods of Correction for Interfering and Modifying Inputs, Standards, Calibration, Accuracy, Precision, Loading Effects, Selection of Instruments, Measurement Systems–Static and Dynamic Characteristics, Zero Order, First Order and Second Order Systems and their Response	**07L**
UNIT-02	**Error analysis:** Types of Errors, Methods of Error Analysis, Uncertainty Analysis, Statistical Analysis, Gaussian Error Distribution, Rejection of Data, Method of Least Square, Curve Fitting, Graphical Analysis, General Consideration in Data Analysis	**07L**
UNIT-03	**DC & AC Measurement:** Analog Ammeter, Voltmeter and Ohmmeters, PMMC, Moving Iron, Electro-dynamometer, Electrostatic, Ohmmeter, Digital type voltmeter, AC Voltmeter using Rectifier, True RMS Voltmeter, Digital VOM Meter	**05L**
UNIT-04	**Transducers:** Principles, Classification, Guidelines for Selection, Requirements, Types and Application of Transducers, Resistance, Capacitance, Inductance Transducers, Potentiometer, Strain Gauges, LVDT, Piezo Electric Transducers, Resistance Thermometers, Thermocouples, Thermistors, Photosensitive Device, Capacitive Transducer, Hall Effect Transducers, Pyroelectric Sensors, Thermo Sensors using Semiconductor Devices, Thermal Radiation Sensor, Measurement of Force, Pressure, Velocity, Humidity, Moisture, Speed, Proximity and Displacement	**08L**

Course Outcomes

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

CO1: Describe basic principles of instrumentations and measurements associated with engineering, design, and the general technology applications.

CO2: Use and calibrate common errors in instruments and their analysis.

CO3: Selecting appropriate sensors, instruments, display devices and analyzers for the task under consideration.

CO4: Understanding various transducers available, their operating principles, strengths, and weaknesses.

Books and References

1. Modern Electronic Instrumentation and Measurement Techniques by A.D. Helfrick and W.D. Cooper, Prentice Hall.
2. Instruments and Measurements by C.N. Herrick, Mc Graw Hill.
3. Electrical and Electronic Measurements and Instrumentation by A. K Sawhney, Dhanpat Rai Publishing.

Course Name: **Digital Signal Processing Lab**
Course Code: **EC-324**
Course Type: **Discipline Core**

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

Course Objectives

- To understand the fundamentals of digital signal processing, including discrete-time signals and systems, sampling and quantization, and digital filter design.
- To gain hands-on experience with MATLAB and other DSP tools for signal generation, analysis, and processing.
- To undertake a project on a specific DSP application and develop a prototype system using DSP hardware and software tools.
- To develop critical thinking and problem-solving skills through laboratory assignments and project work, and to enhance technical writing and presentation skills through lab reports and project presentations.

1. Demonstrate the Nyquist-Shannon sampling theorem and perform sampling and reconstruction of analog signals using different sampling rates and reconstruction filters.
2. Generate and analyze different types of fundamental signals such as sinusoidal, square wave, triangular wave, sawtooth wave, and noise signals. Perform frequency analysis using Fourier transform and windowing techniques.
3. Perform linear convolution, correlation and circular convolution of signals using MATLAB.
4. Perform Z-transform of signals using MATLAB and analyse the important properties of Z-transform.
5. Perform discrete Fourier transform (DFT) of signals using MATLAB and analyze the frequency domain characteristics of the signals.
6. Implement FFT (fast Fourier transform) algorithm to reduce the computation complexity in MATLAB.
7. Design and implement different types of digital filters such as low-pass, high-pass, band-pass, and band-stop filters using FIR (finite impulse response) and IIR (infinite impulse response) filter structures.
8. Image Processing: Perform image processing operations such as image filtering, edge detection, and image compression using MATLAB. Implement image codecs such as JPEG and MPEG.
9. DSP Hardware Implementation: Implement DSP algorithms on hardware platforms such as DSP kits (TMS320C6713 Processor Kits).
10. Project Work: Undertake a project on a specific DSP application such as digital audio processing, speech recognition, or image processing. Develop a prototype system using DSP hardware and software tools and present a report and demonstration of the project.

Note: The concerned Course Coordinator may 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

1. have a good understanding of basic DSP concepts, including sampling, filtering, frequency analysis, and time-domain analysis.
2. be proficient in using DSP tools, such as MATLAB, Simulink, or other software platforms for designing, simulating, and analyzing DSP systems.
3. be able to implement DSP algorithms in software or hardware, depending on the focus of the lab. They should be able to design, simulate, and test DSP algorithms for various applications.
4. have hands-on experience with DSP hardware, such as digital signal processors or field-programmable gate arrays (FPGAs). They should be able to program and configure DSP hardware for specific applications.

Course Name: **Antenna and Microwave Systems Lab**

Course Code: **EC-325**

Course Type: **Discipline Core**

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

To Study the Microwave Components, Sources and Different Types of Loads at X Band Setup.
To Study the Characteristics of Reflex Klystron Oscillator and Determine its Mechanical and Electronics Tuning Range.
To Study the V-I Characteristics of Gunn Diode and Determine its Negative Resistance.
To Determine the Insertion Loss Parameter and Isolation Parameter of a Ferrite Based Isolator and Circulators.
To Measure the Frequency in a Rectangular Waveguide and Demonstrate the Relationship among the Frequency, Free Space Wavelength and Guide Wavelength.
To Study the Characteristics of Various Tees, i.e., E-Plane Tee, H-Plane Tee and Magic Tees.
To Measure the Coupling and Directivity of a 3 dB, 10 dB and 20 dB Directional Couplers.
To Measure the Low, Medium, and High VSWR of DUT Using Slotted Lines Section.
To Measure the Unknown Impedances using Smith Chart.
To Measure of VSWR, Insertion Loss, Attenuation of Fixed and Variable Attenuators.
To Plot the Radiation Pattern of a Pyramidal Horn Antenna and determine its Gain and Beam width.
To Study the working of Vector Network Analyzer (VNA) and its applications.
To Study the *E*-and *H*- field of a Rectangular Waveguide using HFSS/ CST.

Note: The concerned Course Coordinator may 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 basic requirements of microwave components and sources in real time applications.

CO2: Identify a practical approach for testing and measurement of microwave devices in real environment.

CO3: Design any analyse microwave device and components using software.

Course Name: **Engineering Economics and Accountancy**
Course Code: **HS-321**
Course Type: **Institute Core**

Contact Hours/Week: **2L** Course Credits: **02**

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 Microeconomics 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 professional, personal, and societal life.
CO4: Assess the role of engineering economics and accounting in attaining economic efficiency.

Books and References

1. Principles of Microeconomics by Mceachern & Kaur, Cengage Publication.
2. Managerial Economics by Craig Peterson & 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 by 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 and Computer Networks**
Course Code: **EC-341**
Course Type: **Discipline Elective-III**

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.	**07L**
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.	**05L**
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.	**07L**
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	**05L**
UNIT-05	**Network Layer:** Internetworks, Addressing, Routing, ARP, IP, ICMP, IPV6, Unicast Routing, Unicast Routing Protocol, Multicast Routing, Multicast Routing Protocols	**04L**
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	**08L**
UNIT-07	**Application Layer:** Design Issues of the Layer, Domain Name Systems, File Transfer, http, Web Documents, Virtual Terminals.	**05**

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, McGraw Hill Education.
2. Data and Computer Communication by Stallings William, Pearson Education.
3. Computer Networks by A.S. Tanenbaum, Pearson Education.
4. An Engineering Approach on Computer Networking by S. Keshav, Addison Welsey.
5. Introduction to Data Communications and Networking by Wayne Tomasi, Pearson.

Course Name:	**Spread Spectrum and Wideband Communication**
Course Code:	**EC-342**
Course Type:	**Discipline Elective-III**

Contact Hours/Week: **3L** Course Credits: **03**

Course Objectives

- To impart knowledge about the basic spread spectrum techniques that are used in CDMA based cellular communication systems, including direct sequence spread spectrum and frequency-hopped spread spectrum.
- To introduce the fundamental mathematical concepts relevant to design aspects of the PN sequence generators.
- To enable the students to understand the factors that affect the practical implementation of IS-95, 3G,4G and 5G systems.

Unit Number	Course Content	Lectures
UNIT-01	**Introduction:** Concept of Multiple Access Systems, Narrowband and Broadband Systems, Advantages of Spread Spectrum Systems.	**02L**
UNIT-02	**Principles of Direct Spread Spectrum:** Direct Spectrum System: Definition and Concepts, Spreading Sequences and Waveforms, Random Binary Sequence, Shift-Register Sequences, Periodic Auto Correlations, Polynomials over The Binary Field, Systems with PSK Modulation, Power Spectral Density of DSS-CDMA, Pulsed Interference, De-Spreading with Matched Filter.	**10L**
UNIT-03	**Spreading Code Acquisition and Tracking:** Initial Code Acquisition, Acquisition Strategy: Serial Search, Parallel Search, Multi-Dwell Detection, False Alarm and Miss Probability for Matched Filter Receiver, False Alarm and Miss Probability for Radiometer, Mean Overall Acquisition Time for Serial Search.	**06L**
UNIT-04	**Performance of Spread Spectrum System:** Link Performance of Direct Sequence Spread Spectrum CDMA In (I) Additive White Noise Channel (Ii) Multipath Fading Channel. Concept of Rake Receiver, Performance of RAKE Receiver in Multipath Fading.	**06L**
UNIT-05	**Frequency Hoped Systems:** Concepts and Characteristics, Modulations, MFSK, Hybrid Systems, Frequency Synthesizers, Direct Frequency Synthesizer, Digital Frequency Synthesizer, Indirect Frequency Synthesizers.	**06L**
UNIT-06	**Spread Spectrum and Wide-band systems:** CDMA-IS-95: Forward link Channels, Reverse link Channels, Overview of 3G, 4G and 5G Systems. Ultra-wideband communication: definition, features and applications.	**06L**

Course Outcomes

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

CO1: Identify spread spectrum techniques that are used in CDMA based cellular communication systems, including direct sequence spread spectrum and frequency-hopped spread spectrum.
CO2: Apply the principles of linear algebra to design PN sequence generators.
CO3: Analyze the performance of CDMA systems in various wireless Channel.
CO4: Assess the practical implementation of IS-95, 3G,4G and 5G systems.

Books and References

1. Principles of Spread Spectrum Communication Systems by Don Torrieri, Springer Science & Business Media, Inc.
2. CDMA: Principles of Spread Spectrum Communication by Andrew J. Viterbi, Addison- Wesley Publishing Company.
3. Introduction to CDMA Wireless Communications by Mosa Ali Abu-Rgheff, Elsevier Academic Press.
4. Code Division Multiple Access-CDMA by R. Michael Buehrer, Morgan & Claypool Publishers Series.
5. CDMA Systems Engineering Handbook by Jhong S. Lee and Leonard E. Miller, Artech House Publishers.
6. IS-95 CDMA and CDMA-2000 by Vijay K Garg, Pearson Education.
7. OFDM for Wireless Communications Systems by Ramjee Prasad, Artech House, Inc.

Course Name: **Satellite Communication and Radar**
Course Code: **EC-343**
Course Type: **Discipline Elective-III**

Contact Hours/Week: **3L** Course Credits: **03**

Course Objectives

- To impart knowledge about the Orbital Mechanism, satellites and satellite system, satellite link design.
- To introduce the basic functioning of a radar system and to make the students understand this by taking a specific example of MTI and PULSE Doppler radar.

Unit Number	Course Content	Lectures
UNIT-01	**Orbital Mechanics:** Overview of Satellite Communications, Satellite orbit and orbital equations, Kepler's laws of planetary motion, Locating satellite in the orbit, Locating satellite with respect to earth, Orbital Elements, Look Angle Determination, Orbital Perturbations, Orbit Determination, Space Launch Vehicles and Rockets, Placing Satellites Into Geostationary Orbit, Orbital Effects in Communications Systems Performance	**08L**
UNIT-02	**Satellites:** Satellite subsystems, Attitude and orbit control system, Telemetry tracking command and monitoring, Power system, communication subsystem, Satellite antennas	**07L**
UNIT-03	**Satellite Link Design:** Transmission Theory, System Noise Temperature and G/T Ratio, Design of Downlinks, Ku-Band GEO Satellite Systems, Uplink Design, Design for Specified CNR: Combining CNR and C/I Values in Satellite Links, System Design for Specific Performance	**08L**
UNIT-04	**Introduction to Radar System:** Introduction to Radar, Applications of Radar, Radar Frequencies, Working Principle of Radar, Radar block diagram, Simple form of Radar Equation, Minimum detectable signal, Range to a target, Pulse repetition frequency and range ambiguities. Radar System: Maximum radar range, Detection of Signals in Noise, Receiver noise and SNR, Integration of radar pulse, Radar cross section of targets, RADAR detection, Range & Doppler measurements, tracking.	**10L**
UNIT-05	**MTI and Pulse Doppler Radar:** Concept of Doppler Effect, Introduction to Doppler and MTI Radar, Doppler frequency shift, CW Doppler radar, MTI radar, Delay line cancellers, Staggered PRF, pulse Doppler radar, FM-CW radar, Tacking Radar, Sequential lobing, Conical Scan, Monopulse, Acquisition, Comparison of Track, Radar Transmitter/Receiver.	**09L**

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

CO1: Understand the orbital and functional principles of satellite communication systems.

CO2: Architect, interpret, and select appropriate technologies for implementation of specified satellite communication systems.

CO3: Analyze and evaluate a satellite link and suggest enhancements to improve the link performance.

CO4: Understand the basic working of RADAR, Doppler shift.

CO5: Understand the working of a MTI, Pulse Doppler Radar and Tracking radar.

Books and References

1. Satellite Communications by Timothy Pratt and Jeremy E., Willey.
2. Satellite Communications by Dennis Roddy, Tata McGraw Hill.
3. Digital Satellite Communications by Tri. T. Ha, Tata McGraw Hill.
4. Introduction to Radar Systems by Skolnik, Tata McGraw Hill.
5. Radar Handbook by Skolnik, McGraw-Hill
6. Radar Principles by Peyton Z. Peebles, John Wiley and Sons (2004).
7. Radar Foundation for Imaging & Advanced Concepts by R.J Sullivan, PHI, 2004

Course Name: **Digital Image Processing**
Course Code: **EC-361**
Course Type: **Discipline Elective-IV**

Contact Hours/Week: **3L** Course Credits: **03**

Course Objectives

- To understand the basics of image formation
- To understand image enhancement in spatial and frequency domain.
- To understand the concepts of image compression, image segmentation and morphological operation on image.

Unit Number	Course Content	Lectures
UNIT-0 1	**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.	06
UNIT -02	**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.	08
UNIT -03	**Image Restoration:** Image degradation/restoration process, noise models, restoration in the presence of noise only-spatial filtering, periodic noise reduction by frequency domain filtering, Linear, Position-Invariant Degradation, Estimating the Degradation Function, Inverse filtering, Wiener Filtering, Constrained Least Square Filtering, Geometric filter, Geometric Transformation.	08
UNIT -04	**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.	08
UNIT -05	**Image Segmentation:** Discontinuities, Edge Linking and boundary detection, Thresholding, Region Based Segmentation, Segmentation by Morphological Watersheds; binary morphology- erosion, dilation, opening and closing operations, Hit-or-Miss Transform, some basic morphological algorithms.	08

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

CO4: Analyse the different image compression techniques.

CO5: Understand the image segmentation and morphological operations

Books and References

1. Digital Image Processing- R. C. Gonzalez and R. E. Woods, Pearson Education
2. Fundamentals of Digital Image processing- A. K. Jain, Pearson Education
3. Digital Image Processing using MATLAB- R. C. Gonzalez , R. E. Woods and S. L Eddins, Pearson Education.
4. Digital Image Processing and Analysis- Chanda and Mazumdar, PHI
5. N.J. Fliege, "Multirate Digital Signal Processing", John Wiley and Sons.

Course Name: **Speech Processing**
Course Code: **EC-362**
Course Type: **Discipline Elective-IV**

Contact Hours/Week: **3L** Course Credits: **03**

Course Objectives:

- To introduce speech production and related parameters of speech.
- To show the computation and use of techniques such as short time Fourier transform, linear predictive coefficients and other coefficients in the analysis of speech.
- To understand different speech modeling procedures such as Markov and their implementation issues.

Unit Number	Course Content	Lectures
UNIT-01	**BASIC CONCEPTS:** Speech Fundamentals: Articulatory Phonetics Production and Classification of Speech Sounds; Acoustic Phonetics Acoustics of speech production; Review of Digital Signal Processing concepts; Short-Time Fourier Transform, Filter-Bank and LPC Methods.	**07L**
UNIT-02	**SPEECH ANALYSIS**: Features, Feature Extraction and Pattern Comparison Techniques: Speech distortion measures– mathematical and perceptual – Log–Spectral Distance, Cepstral Distances, Weighted Cepstral Distances and Filtering, Likelihood Distortions, Spectral Distortion using a Warped Frequency Scale, LPC, PLP and MFCC Coefficients, Time Alignment and Normalization – Dynamic Time Warping, Multiple Time – Alignment Paths.	**07L**
UNIT-03	**SPEECH MODELING:** Hidden Markov Models: Markov Processes, HMMs – Evaluation, Optimal State Sequence – Viterbi Search, Baum-Welch Parameter Re-estimation, Implementation issues.	**09L**
UNIT-04	**SPEECH RECOGNITION:** Large Vocabulary Continuous Speech Recognition: Architecture of a large vocabulary continuous speech recognition system – acoustics and language models – n-grams, context dependent sub-word units; Applications and present status.	**09L**
UNIT-05	**SPEECH SYNTHESIS:** Text-to-Speech Synthesis: Concatenative and waveform synthesis methods, sub-word units for TTS, intelligibility and naturalness – role of prosody, Applications and present status.	**08L**

Course Outcomes

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

CO1: Model speech production system and describe the fundamentals of speech.

CO2: Extract and compare different speech parameters.

CO3: Choose an appropriate statistical speech model for a given application.

CO4: Design a speech recognition system.

CO5: Use different speech synthesis techniques.

Books and References

1. Lawrence Rabiner and Biing-Hwang Juang, “Fundamentals of Speech Recognition”, Pearson Education, 2003.
2. Daniel Jurafsky and James H Martin, “Speech and Language Processing – An Introduction to Natural Language Processing, Computational Linguistics, and Speech Recognition”, Pearson Education, 2002.
3. Frederick Jelinek, “Statistical Methods of Speech Recognition”, MIT Press, 1997.

Course Name: **Estimation and Detection Theory**
Course Code: **EC-363**
Course Type: **Discipline Elective-IV**

Contact Hours/Week: **3L** Course Credits: **03**

Course Objectives

- To enable the students to acquire the fundamental concepts of Signal Detection and Estimation.
- To get familiarized 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.

Unit Number	Course Content	Lectures
UNIT-01	Review of Probability, Random variables, random processes, filtered random processes, Ensemble averages, correlation, covariance, power spectrum, cross power spectrum, Ergodicity, time averages, biased & unbiased estimators, consistent estimators. Problem Formulation and Objective of Signal Detection and Signal Parameter Estimation in Discrete-Time Domain.	07L
UNIT-02	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.	07L
UNIT-03	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.	07L
UNIT-04	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.	07L
UNIT-05	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.	07L
UNIT-06	Bayesian Estimation: Philosophy, Nuisance Parameters, Risk Functions, Minimum Mean Square Error Estimation, Maximum aposteriori estimation	07L

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 Gaussian noise.
CO4: Understand the detection of random signals.
CO5: Understand the time varying waveform detection and its estimation.

Books and References

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

Course Name: **Hardware Description Language**
Course Code: **EC-381**
Course Type: **Stream Core**

Contact Hours/Week: **2L** Course Credits: **02**

Course Objectives

- To impart knowledge about the Hardware Description Language based design approach.
- To Understand different modeling techniques used in HDL.
- The ability to code and simulate any digital function in HDL.

Unit Number	Course Content	Contact Hours
UNIT-01	**Introduction:** Introduction and levels of abstraction, Modeling and Hierarchical design concepts, Languages, Compilation & Simulation, concurrency, Logic value system, Role of CAD Tools in the VLSI design process.	**05L**
UNIT-02	**Language concepts:** Lexical conventions, Data types, modules and ports, Behavioral modeling, Dataflow modeling, Structural modelling.	**08L**
UNIT-03	**RTL Design:** Control & Data partitioning, Synthesis concepts, Non-synthesizable constructs, Operators, Expressions, Conditional statements, Post synthesis simulation.	**07L**
UNIT-04	**Advanced language concepts:** 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.	**08L**
UNIT-05	**Hardware modules:** Boolean equations, Encoders, Decoders, Multiplexers, Cascaded multiplexers, Adders, Serial adders, Comparators, Multipliers, Divider, Sorters, Shifters, Static and dynamic memories, Mealy & Moore finite state machine, Vending machines.	**05L**
UNIT-06	**Advanced design concepts:** FPGA architecture, Static timing analysis, Synchronization, Metastability, Verification methods, Implementation on FPGA, PLA based design.	**06L**

Course Outcomes

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

CO1: Design digital circuits in HDL.

CO2: Verify behavioral and RTL models.

CO3: Synthesize and simulate RTL design to standard cell libraries and FPGAs.

Books and References

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

Course Name: **Simulation of Communication Systems** Course Code: **EC-382** Course Type: **Stream Core**	
Contact Hours/Week: **2L**	Course Credits: **02**

Course Objectives

- This course introduces simulating communication systems using MATLAB and Python.
- Understand the basics of communication systems, including signal modulation, demodulation, channel impairments, and error correction techniques.
- Develop skills in MATLAB and Python programming for numerical computation and data analysis.
- Learn how to model and simulate various communication systems, including analog and digital modulation, synchronization, channel coding, and demodulation.
- Analyze the performance of simulated systems under different channel conditions and noise levels.
- Gain experience in presenting and interpreting simulation results.

Unit Number	Course Content	Lectures
UNIT-01	Introduction to Communication Systems and Programming Essentials : Overview of communication systems, Signal representation and analysis, Analog modulation and demodulation techniques, Digital modulation and demodulation techniques, Channel impairments and noise Introduction to MATLAB and Python Data types, variables, operators, and control flow Functions, modules, and packages Numerical computations and data analysis, Plotting and visualization.	**08L**
UNIT-02	Communication System Modeling and simulation in MATLAB: Modeling of signal sources and modulators. Channel modeling and noise generation, simulating analog modulation schemes (AM, FM, PM), Simulating digital modulation schemes (PSK, QAM), Performance analysis of simulated systems.	**08L**
UNIT-03	Communication System Modeling in Python: Implementing similar simulations using Python libraries (NumPy, SciPy, Matplotlib), Object-oriented programming for complex system modeling, Advanced signal processing techniques in Python.	**08L**
UNIT-04	Advanced Topics: Channel coding and decoding techniques, Synchronization methods, MIMO systems, Introduction to software-defined radio (SDR).	**06L**

Course Outcomes

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

CO1: Explain the basic concepts of modeling and simulation and their role in communication system engineering.

CO2: Simulate communication systems including modulators, filters, demodulators, channels, equalizers, and encoders and decoders.

CO3: Apply simulation and modeling methodologies to solve real-world communication system problems.

CO4: Interpret simulation results and use them to make informed decisions about communication system design and implementation

Books and References

1. "Simulation of Communication Systems" by Michel C. Jeruchim, Philip Balaban, Sam Shanmugan.
2. Simon Haykin, "Communication Systems", Wiley.

Course Name: **Computer Architecture and Organization**
Course Code: **EC-411**
Course Type: **Discipline Core**

Contact Hours/Week: **3L** Course Credits: **03**

Course Objectives

- To conceptualize the basics of organizational and architectural issues of a digital computer
- To analyze processor performance improvement using instruction level parallelism.
- To study various data transfer techniques in digital computer.

Unit Number	Course Content	Lectures
UNIT-01	**Basics of Computer Architecture**: Codes, Number System, Logic gates, Flip flops, Registers, Counters, Multiplexer, Demultiplexer, Decoder, Encoder etc., Register transfer, Bus & memory transfer, Logic micro operations, and Shift micro operation.	**05L**
UNIT-02	**Basic Computer Organization:** Instruction codes, Computer instructions, Timing & control, Instruction Cycles, Memory reference instruction, Input/output and Interrupts, Complete computer description & design of basic computer.	**07L**
UNIT-03	**ARM Processor Fundamentals:** AR M core data flow model, Architecture, ARM General Purpose Register set, Exceptions, Interrupts, Vector Table, ARM processors family.	**08L**
UNIT-04	**Central Processing Unit:** General register organization, Stack organization, Instruction format, Data transfer & manipulation, Program control, RISC, CISC, Addition & subtraction, Multiplication Algorithms, Division algorithms, Peripheral devices, I/O interface Data transfer schemes, Program control, Interrupt, DMA transfer, I/O processor.	**07L**
UNIT-05	**Memory Unit**: Memory hierarchy, Processor vs. memory speed, High-speed memories, Cache memory, Associative memory, Interleave, Virtual memory, Memory management.	**05L**
UNIT-06	**Introduction to Parallel Processing:** Pipelining, Characteristics of multiprocessors, Interconnection structures, Inter-processor arbitration, Inter-processor communication & synchronization.	**04L**

Course Outcomes

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

CO1: Identify and compare different methods for computer I/O mechanisms.

CO2: Categorize memory organization and explain the function of each element of a memory hierarchy.

CO3: Demonstrate control unit operations and conceptualize instruction level parallelism.

Books and References

1. Computer System Architecture by Morris M. Mano and Yu Dong, Prentice Hall.
2. Computer Architecture A Quantitative Approach by J. L. Hennessy, D. A. Patterson and D. Goldberg, 3 rd ARM Edition.
3. Computer Architecture and Organization by J. P. Hayes, McGraw Hill.
4. System Architecture: Software and Hardware Concepts by W. E. Leigh and D. L. Ali, South Wester Publishing.

Course Name: **Wireless Communication**
Course Code: **EC-412**
Course Type: **Discipline Core**

Contact Hours/Week: **3L** Course Credits: **03**

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.	**02L**
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.	**09L**
UNIT-03	**PROPAGATION MODELS** Free space propagation model, Two-ray ground reflection model, Distance power loss, Macro-cell propagation model, Micro-cell propagation model, Shadowing model, Multipath effects in mobile communication, Models for multipath reception.	**08L**
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.	**09L**
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.	**09L**

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 Publications.
2. Wireless Communications and Networks: 3G and beyond by Iti Saha Misra, Tata McGraw Hill Publications.
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: **Information Theory and Coding**
Course Code: **EC-631**
Course Type: **PG Program 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 the 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.

Unit Number	Course Content	Lectures
UNIT-01	**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.	**05L**
UNIT-02	**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.	**04L**
UNIT-03	**Data Compression:** 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.	**07L**
UNIT-04	**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.	**07L**
UNIT-05	**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.	**07L**
UNIT-06	**Convolutional Codes**: Encoding of Convolutional Codes, Structural Properties of Convolutional Codes, Distance Properties of Convolutional Codes, Design of Encoder and Decoder for Convolutional Codes.	**06L**

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 discrete memory-less source.
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, Pearson Education, 2010.
3. Information Theory and Reliable Communication by R. G. Gallager, John Wiley & Sons, 1969.

Course Name:	**AI and Machine Learning**
Course Code:	**EC-635**
Course Type:	**PG Program Core**

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

Course Objectives: The objective of this course is to develop artificial intelligence and machine learning techniques for solving various real-life problems.

Course Content

The Foundations of Artificial Intelligence. The History of Artificial Intelligence, Risks and Benefits of AI, Performance Measures of Classification, Bayesian Decision Theory, Bayesian Belief Networks, Parameter Estimation and Maximum Likelihood Estimation, Dimensionality Problem and Principal Component Analysis (PCA), Linear Discriminant Analysis.
Linear Regression, Decision Tree Classifiers, Overfitting, Notion of Training, Validation and Testing, Ensemble Classifiers, Support Vector Machine (SVM), K-means clustering, Logistic Regression, Kernels (with SVM), Hidden Markov Model (HMM). Models of a Neuron, Multilayer Perceptron (MLP), Back Propagation Learning, Role of Loss Functions and Optimization, Gradient Descent, MLP for Classification and Regression. Unsupervised Learning with Deep Network, Autoencoders, Convolutional Neural Network (CNN), Building blocks of CNN, Transfer Learning, Recurrent Neural Networks (RNN), Effective training in Deep Network- early stopping, Dropout, Batch Normalization, Instance Normalization, Group Normalization. Generative Adversarial Networks (GAN) - Fundamentals and Applications, Classical Supervised Tasks with Deep Networks, CNN and RNN for Signal Classification, Convolutional Networks for Image Segmentation, Networks for Image Denoising, Object Detection

Course Outcomes

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

CO1: Understand the fundamentals of artificial intelligence and machine learning.
CO2: Understand the concepts of selected machine learning algorithms.
CO3: Understand the concepts of neural network learning.
CO4: Understand the concepts of deep neural networks.

Books and References

1. Marc Peter Deisenroth, A. Aldo Faisal, Cheng Soon Ong, “Mathematics for Machine Learning”, Cambridge University Press.
2. Ian Goodfellow, Yoshua Bengio, and Aaron Courville, “Deep Learning”, MIT Press Ltd, Illustrated edition.
3. Richard O. Duda, Peter E. Hart, David G. Stork, “Pattern Classification”, John Wiley & Sons Inc.

Course Name: **Network Simulation Lab**
Course Code: **EC-417**
Course Type: **Discipline Core**

Contact Hours/Week: **1L & 2P** Course Credits: **02**

Course Objectives

- To provide skills for modeling and simulation of communication systems & networks on MatLab platform.
- To provide skills for writing MatLab programs and use communication and signal processing toolboxes.

List of Experiments

1. Familiarity with MatLab communication and signal processing toolbox.
2. Programs to generate uniformly distributed random variables between [0, 1] using Linear Congruential Generator.
3. Programs to generate discrete random variables based on inverse transform technique.
4. Programs to generate continuous random variables based on inverse transform technique.
5. Programs to generate discrete random variables based on acceptance rejection technique.
6. Programs to generate continuous random variables based on acceptance rejection technique.
7. Programs to validate random variable generators based on KS test.
8. Programs to validate random variable generators based on Chi square test.
9. Programs to validate independence of random variable generators based on Runs test.
10. Programs to validate independence of random variable generators based on Autocorrelation test.
11. Programs to use Monte Carlo techniques to estimate parameters of quantities used in communication system.
12. Programs to implement parameters and performance measures used in communication system design.
13. Designing the digital communication system to evaluate BER vs. SNR performance.
14. Simulation of spread-spectrum techniques (DS-CDMA, FH-CDMA) and comparison of their performance in a multipath fading channel.
15. Implementation and analysis of Carrier Sense Multiple Access (CSMA) and Carrier Sense Multiple Access with Collision Detection (CSMA/CD) protocols in a network.

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 simulation model design of communication systems.
CO2: Design and develop modular programming skills on MatLab platform.
CO3: Trace, debug and validate simulation models.
CO4: Able to implement the algorithms required for discrete event simulation.
CO5: Able to implement the validation tests for discrete event simulation models.

Course Name: **Optical Communication Systems and Networks**
Course Code: **EC-421**
Course Type: **Discipline Core**

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

Course Objectives

- To introduce the students to various optical fiber 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), Introduction to Free Space Optical and Visible Light Communications.	**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:

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.
CO4: Learn the various optical source materials, LED structures, quantum efficiency, Laser diodes
CO5: Understand the optical multiplexing techniques, 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:	**Advanced Mobile Communication**
Course Code:	**EC-422**
Course Type:	**Discipline Core**

Contact Hours/Week: **3L** Course Credits: **03**

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, McGraw Hill Education.
2. Wireless Communications: Principles and Practice by T. S. Rappaport, Pearson Education India
3. Wireless Communications and Networks: 3G and Beyond by ITI S. Misra, McGraw Hill Education.
4. Wireless Digital Communications: Modulation and Spread Spectrum Applications by K. Feher, Prentice Hall.

Course Name: **Analog VLSI Design**
Course Code: **EC-622**
Course Type: **PG Program 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

Analog integrated circuit design, Circuit design consideration for MOS challenges in analog circuit design, 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 & Son

Course Name: **FPGA and ASIC Design**
Course Code: **EC-623**
Course Type: **PG Program Core**

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

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

Course Name:	**Modeling and Simulation of Communication Systems**
Course Code:	**EC-643**
Course Type:	**PG Program 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: **Characterization of Semiconductor Materials & Devices** Course Code: **EC-711** Course Type: **PG Program Elective-I**	
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

Various Semiconductor materials and their advantages & disadvantages applied to VLSI and Nano-electronics Crystal structure, Band theory, Carrier concentration at thermal equilibrium, Density of states, Fermi energy, Ionization of impurity in semiconductor, Quantum aspect of semiconductors. Scattering of carrier in semiconductors, Low field effect in semiconductor, very high field effect in semiconductor, Carrier transport phenomena, Charge injection and quasi equilibrium, Generation and recombination of electron and holes and Basic equation for semiconductor device operation. Resistivity, conductivity, and Band gap of Semiconductor materials. Procedure for analyzing semiconductor devices, Basic equations and approximations, Characteristics, and energy band diagrams of PN Junction diodes-step and graded junction, Schottky barrier diode, Ohmic contact, Insulator-semiconductor junction. Electronic properties of compound Semiconductor materials, Optoelectronic Devices; LED, PIN Photodetector, Semiconductor laser, Microwave Devices.

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: **Nano-Electronics**
Course Code: **EC-712**
Course Type: **PG Program Elective-I**

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

Course Objectives

- Understand nanotechnology and its impact on the electronics industry and different types of nanomaterials and their properties.
- Learn principles of quantum mechanics and design quantum dot-based devices.
- Gain knowledge of carbon-based nanomaterials and design carbon-based nanoelectronic devices.
- Gain knowledge of semiconductor nanomaterials and design semiconductor nanoelectronic devices.
- Understand emerging trends in Nano electronics and critically evaluate challenges and opportunities in scaling down devices to the nanoscale, and their potential impact on various industries.

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. Effect Of Temperature: The Elastic Resistor: Conductance of an Elastic Resistor, Elastic Resistor- Semiconductor heterostructures, Lattice-matched and pseudomorphic heterostructures, Inorganic nanowires, Organic semiconductors, Carbon nanomaterials: nanotubes and fullerenes, Graphene. Materials For Nanoelectronics: Semiconductors, Crystal lattices: bonding in crystals, Electron energy bands, Semiconductor heterostructures, Lattice-matched and pseudomorphic heterostructures, Inorganic nanowires, Organic semiconductors , Carbon nanomaterials: nanotubes and fullerenes fabrication of nanostructures Crystal growth, Nanolithography, Clusters and nanocrystals, Nanotube growth,- Characterization of nanostructures. 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: Demonstrate knowledge of nanotechnology and its impact on the electronics industry and different types of nanomaterials and their properties.

CO2: Design semiconductor nanoelectronic devices using knowledge of semiconductor nanomaterials and fabrication technique.

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.
3. Introduction to Nano Science and Technology by S.M. Lindsay, World Scientific.
4. Lessons from Nanoscience: A Lecture Note Series, By Supriyo Dutta, World Scientific.
5. Quantum Transport- Atom to Transistor, By Supriyo Dutta, Cambridge University Press.
6. Nanotechnology for Microelectronics and optoelectronics, By J.M. Martinez-Duart, R. J. Martin Palma, F. Agulle Rueda, Elsevier.

Course Name:	**Deep Submicron VLSI Design**
Course Code:	**EC-713**
Course Type:	**PG Program 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 SiO2 and the properties of the Si/SiO2 interface, Dielectric breakdown in silicon dioxide films trapped in SiO2, Leakage currents in SiO2 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 analyze 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.
2. Deep-Submicron CMOS ICs: From Basics to ASICs by Harry Veendrick, Kluwer Academic.

Course Name:	**Advanced Semiconductor Devices**
Course Code:	**EC-714**
Course Type:	**PG Program Elective-I**

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 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: **VLSI Test and Testability**

Course Code: **EC-715**

Course Type: **PG Program Elective-I**

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 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-716** Course Type: **PG Program Elective-I**	
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: **MEMS and Micro Sensor Design**
Course Code: **EC-717**
Course Type: **PG Program 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 Microactuators.

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.

Course Name: **Memory Design and Testing**
Course Code: **EC-718**
Course Type: **PG Program Elective-I**

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

Course Objectives

- To use modelling of the various semiconductor devices for digital VLSI circuit design.
- To comprehend static and dynamic CMOS logic circuits.
- To learn MOS Memory design.
- To build upon the theoretical, mathematical and physical analysis of digital VLSI circuits, for proper understanding of concept, working, analysis and design.
- To analyze the designed digital circuits and their verification.

Course Content

Types and principles of MOSFETs, Introduction to large signal MOS models (long channel) for digital design. MOS Inverters, Static and Dynamic characteristics, Resistive, Depletion and Enhancement load NMOS inverters, the basic CMOS inverter, voltage transfer characteristics, logic threshold, Noise margins. Dynamic behavior, transition time, Propagation Delay, Power Consumption. MOS Circuit Layout & Simulation, Stick diagrams, Layout design rules, MOS device layout, Transistor layout, Inverter layout, CMOS-circuits layout & simulation, Circuit Compaction, Euler's Rule, Circuit extraction and post-layout simulation. Combinational MOS Logic Design, Static MOS design, Complementary MOS, Ratioed logic, Pass Transistor logic, Complex logic circuits, DSL, DCVSL, Transmission gate logic. Dynamic MOS design, Dynamic logic families and their performance. MOS Memory design, Design of ROM, SRAM and DRAM cells. Sequential MOS Logic Design, Static and dynamic latches, flip flops & registers, CMOS Schmitt trigger, Monostable sequential and Astable circuits, adders and multiplier circuits. VLSI Interconnects, Interconnect delays, Cross-talks. Introduction to low power design, Input and Output Interface circuits. BiCMOS Logic Circuits, Introduction, Basic BiCMOS Circuit behavior, Switching Delay in BiCMOS Logic circuits.

Course Outcomes

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

CO1: Classify ICs, static and dynamic VLSI design techniques.
CO2: Design any CMOS digital VLSI combinatorial and sequential circuits.
CO3: Design, analyze and verify digital logic circuits and MOS memories as well as Physical layout designing of circiuts.
CO4: Model the CMOS circuits with equivalent parameters.
CO5: Build upon the theoretical & mathematical models using design principles, for proper understanding of VLSI circuits.

Books and References

1. CMOS Digital Integrated Circuits-Analysis & Design by S.M. Kang & Y. Leblibici, TMH.
2. Digital Integrated Circuits Design by J.M. Rabey, Pearson Education.
3. Principles of CMOS VLSI Design: A System Perspective by NHE Weste & K. Eshraghian, McGraw Hill Pub.
4. Solid State Electronic Devices by B.G. Streetman & S. Baneerjee, PHI.
5. CMOS Logic Circuit Design by Uyemera, Springer India Pvt. Ltd. New Delhi.
6. Introduction to VLSI by Eshraghian & Pucknell, PHI.
7. Analysis & Design of Digital Integrated Circuits by David A. Hodges, Horace G. Jackson, R. Saleh, McGraw Hill.
8. Introduction to PSPICE by H.M. Rashid, PHI.

Course Name: **Neural Networks and Deep Learning**

Course Code: **EC-719**

Course Type: **PG Program Elective-I**

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

Course Objectives: The objective of this course is to develop neural networks and deep learning models for solving various real-life problems.

Course Content

Models of a Neuron, Multilayer Perceptron (MLP), Backpropagation: Computing Gradients w.r.t. the Output Units, Backpropagation: Computing Gradients w.r.t. Hidden Units, Role of Loss Functions and Optimization, Gradient Descent, MLP for Classification and Regression. Unsupervised Learning with Deep Network, Autoencoders, Link between PCA and Autoencoders, Regularization in autoencoders, Denoising Autoencoders, Sparse Autoencoders, Variational Autoencoder, Convolutional Neural Network (CNN), Building blocks of CNN, Transfer Learning, Recurrent Neural Networks (RNN), LSTM Networks. Effective training in Deep Network- early stopping, Dropout, Batch Normalization, Instance Normalization, Group Normalization. Revisiting Momentum Optimizer, RMSProp, Adam. Recent Trends in Deep Learning Architectures, Residual Network, Skip Connection Network, Fully Connected CNN etc. Generative Modeling with DL, Generative Adversarial Networks (GAN) - Fundamentals and Applications, Classical Supervised Tasks with Deep Networks, CNN and RNN for Signal Classification, Convolutional Networks for Image Segmentation, Networks for Image Denoising, Object Detection.

Course Outcomes:

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

CO1: Understand the concepts of neural network learning.

CO2: Understand the concepts of autoencoders.

CO3: Understand the concepts of CNN and RNN.

CO4: Understand the concepts of generative adversarial networks.

Books and References:

1. Ian Goodfellow, Yoshua Bengio, and Aaron Courville, “Deep Learning”, MIT Press Ltd, Illustrated edition.
2. Richard O. Duda, Peter E. Hart, David G. Stork, “Pattern Classification”, John Wiley & Sons Inc.

Course Name: **Low Power VLSI Design**
Course Code: **EC-720**
Course Type: **PG Program Elective-II**

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

Introduction: Need for Low Power VLSI Chips, Sources of Power Dissipation in Digital Integrated Circuits, Physics of Power Dissipation in CMOS Devices, Dynamic Dissipation in CMOS, Leakage Power Dissipation, Low Power Figure of Merits, Impact of Technology Scaling, Device Innovation and Channel Engineering

Power Estimation: Simulation Power Analysis: SPICE Circuit Simulators, Gate Level Logic Simulation, Capacitive Power Estimation, Static State Power, Gate Level Capacitance Estimation, Data Correlation Analysis in DSP Systems, Monte Carlo Simulation, Probabilistic Power Analysis: Random Logic Signals, Probability and Frequency, and Probabilistic Power Analysis Techniques

Low Power Circuit Level Design: Circuit Level Transistor and Gate Sizing, Circuit Techniques for Leakage Power Reduction, Transistor Stacking, Supply Voltage Scaling Techniques, DTCMOS, MTCMOS, Network Restructure and Reorganization, Flip Flops and Latches Design, and Low Power Digital Cell Library

Low Power Logic Level Design: Gate Reorganization, Multistage Logic Design, Signal Gating, Logic Encoding, State Machine Encoding, and Pre-Computation Logic

Low Power Architecture and System Level Design: Power and Performance Management, Switching Activity Reduction, Parallel Architecture with Voltage Reduction, and Flow Graph Transformation.

Special Techniques: Low Power Clock Distribution, Single Driver vs Distributed Buffers, Various Clock Distribution Networks, Power Reduction in Clock Networks, Low Power Bus, CMOS Floating Nodes, and Adiabatic Logic.

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 circuit and logic design techniques for dynamic and leakage power reduction.

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.

CO5: Understand power management through architectural level techniques.

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, and 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 J. M. Rabaey and M. Pedram, Kluwer Academic Press.
5. Low-Voltage Low-Power VLSI subsystems by Kait-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 IC Design** Course Code: **EC-721** Course Type: **PG Program Elective-II**	
Contact Hours/Week: **4L**	Course Credits: **04**

Course Objectives

- To impart a strong foundation of IC based design.
- To introduce the various applications of operational amplifiers and their 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 of CMOS Schmitt trigger circuit. Comparators and their characteristics zero crossing detector, voltage limiters, and 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

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 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. TMH 2004
3. Design of Analog CMOS Integrated Circuits by B. Razavi. Tata McGraw Hill, 2005.

Course Name: **IC Design for IoT Systems** Course Code: **EC-722** Course Type: **PG Program Elective-II**	
Contact Hours/Week: **4L**	Course Credits: **04**

Course Objectives

- To provide students with good depth of knowledge of Designing IC based IOT Systems for various application.

Course Content

Introduction to Embedded and IOT Systems: Definition, Examples and components of embedded Systems, Classification of an Embedded system. Architecture of Embedded system. General purpose computers vs embedded system, Embedded System Design Process, Various Embedded cores controller. Embedded system with IOT connectivity.
Hardware/Software Co-design for Embedded Systems: Microcontrollers for embedded systems, 32-bit RISC Architectures for embedded Design, ARM architectural details, The ARM programmer's model, ARM development tools, ARM microcontroller programming in C, Peripheral Interfacing with ARM, Basic Wire and Wireless Protocols like, UART, I2C, SPI, PLCC, Bluetooth, WiFi, Zig-Bee and LoRa for IoT applications. Embedded Operating Systems: Operating system requirements for Embedded systems, Fundamentals of Real Time Operating System (RTOS), Operating system services, Process, Task and Thread, System calls, Timer and Event Function, Memory management, File and I/O subsystem management, Device Management, Device drivers and It's Programming for Embedded platform. OS based Software development: Programming in higher level languages on embedded OS platform, Communication protocols and it's applications , Embedded Systems with Internet of Things (IoT) and Cloud support.
Introduction to IOT based Embedded Systems: Basic architecture of an IoT based Embedded Systems., Embedded Hardware for IoT applications, like Raspberry Pi, Arduino, and ARM development board, IoT Cloud Platform and IoT client applications on mobile phones. Case Studies of Embedded Systems: Embedded application development through ARM based development boards, Development of mini-Project on new version of Operating systems and development board.

Course Outcomes

Upon successful completion of the course, the students will be able to
CO1: Acquire the knowledge of theory and practice related to IC Design of IoT System.
CO2: Identify, formulate and solve engineering problems by using Embedded Systems with IoT.
CO3: Implement real field problem by gained knowledge of Embedded Systems with IoT capability

Books and References

1. Muhammad Ali Mazidi, Shujen Chen, Sepehr Naimi, Sarmad Naimi, "Embedded Programming Using C Language", 1st Edition, Freescale ARM Cortex-M.
2. Rajkamal, "Embedded System: Architecture, Programming and Design", TMH3.
3. Dr. Ovidiu Vermesan, Peter Friess, "Internet of Things: Converging Technologies for Smart Environments and Integrated Ecosystems", River Publisher.

Course Name: **Data Converters for IC Design**
Course Code: **EC-723**
Course Type: **PG Program Elective-II**

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

Course Objectives

- Introduce students to the fundamentals of VLSI signal processing and expose them to examples of applications.
- Design and optimize VLSI architectures for basic DSP algorithms.
- Design and optimize VLSI architectures for basic DSP algorithms.

Course Content

The functions and applications of D/A and A/D converters. Ideal DACs and ADCs: operation, specifications, metrics. Converter non-idealities: offset and gain error, DNL, INL, non-monotonicity, missing codes, SNR, DR, SFDR, etc. DAC architectures: decoder-type, binary, thermometer, hybrid DACs. DAC circuit structures: R-string and R-ladder circuits, current-steering, charger distribution, hybrid, segmented DACs. ADC architectures: integrating, successive approximation and algorithmic, pipelined, time-interleaved, sub ranging and two-step, interpolating, folding and flash ADCs. ADC circuits: resistor-string, charge-redistribution, current steering, hybrid, folding/interpolating circuits. Operational principles of delta-sigma (D-S) DACs and ADCs. Main architectures for the realization of D-S DACs and ADCs. Circuit realization and non-idealities of D-S data converters.

Course Outcomes

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

CO1: Understand the fundamentals of sampling and the translation of signals from digital to analog and analog to digital domains.

CO2: Know the basic circuits unique to data converters and how they impact design.

CO3: Have designed your own digital-to-analog converter as well as ADCs.

Books and References

Analog Integrated Circuit Design, by D. Johns and K. Martin, Wiley, 1997 or second ed. by T. Carusone, D. Johns and K. Martin, Wiley, 2012.

2. Data Conversion System Design, by B. Razavi, IEEE Press, 1995.

3. Understanding Delta-Sigma Data Converters, by R. Schreier and G.C. Temes, IEEE Press/Wiley, 2004.

4. Data Converters, F. Maloberti, Springer 2007.

5. Analog-to-Digital Conversion, M. Pelgrom, second ed., Springer, 2013.

Course Name: **Verification of VLSI Circuits**

Course Code: **EC-724**

Course Type: **PG Program Elective-II**

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 this course students will be able to :

CO1: Able to verify digital circuits for design errors.

CO2: Understand the constraints 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.
3. Formal Verification: An Essential Toolkit for Modern VLSI Design by Erik Seligman, Morgan Kaufmann.

Course Name: **Reliability of VLSI Circuits**
Course Code: **EC-725**
Course Type: **PG Program Elective-II**

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

Course Objectives

To acquaint the students with state-of-the-art circuit performance and reliability models of VLSI circuits.

Course Content

Nanoscale MOSFET Characteristics: Quasi-ballistic I-V characteristics, terminal capacitances of transistors considering quantum effects, parasitic resistances in nanoscale MOSFETs.

Delay and Timing Models: Classical delay models of logic gates, logic gate delay models for nano-regime CMOS technologies, timing parameters of sequential circuit elements, access-time of CMOS memories, impact of process/temperature/supply-voltage variations on timing parameters.

Power Consumption: Models for dynamic power, short circuit power and leakage power of CMOS circuits, full-chip power estimation techniques, impact of process/temperature variations on power consumption.

Reliability of CMOS Circuits: Circuit performance considering NBTI/PBTI, oxide breakdown, random telegraph noise, radiation damage.

Analog Circuit Performance Parameters: Impact of parasitic effects, process/temperature variation, device reliability effects.

Course Outcomes

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

CO1: Understand the Nanoscale MOSFET Characteristics.

CO2: Apply the concepts of Delay and Timing Models.

CO3: Understand the concepts of power consumption and Reliability of CMOS Circuits.

CO4: Familiarize with the Analog Circuit Performance Parameters.

Books and References

1. Yuan Taur and T. Ning, “Fundamentals of Modern VLSI Devices,” Cambridge University Press.
2. Jan M. Rabaey, Anantha Chandrakasan, Borivoje Nikolic, “Digital Integrated Circuits: A Design Perspective,” Prentice Hall
3. Behzad Razavi, “Design of Analog CMOS Integrated Circuits”, Tata McGraw-Hill.

Course Name:	**Hardware Algorithms for VLSI**
Course Code:	**EC-726**
Course Type:	**PG Programme Elective-II**
Contact Hours/Week: **4L**	Course Credits: **04**

Course Objectives

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

Course Name: **Advanced Computer Architecture**

Course Code: **EC-727**

Course Type: **PG Program Elective-II**

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

Course Objectives

- Impart knowledge about the quantitative principles of computer architecture.
- Introduce the fundamental concepts relevant to analyze the ILP and associated hazards.
- Enable the students to understand superscalar, vector and VLIW styles of computing for various applications.

Course Content

Introduction: review of basic computer architecture, quantitative techniques in computer design, measuring and reporting performance. CISC and RISC processors. Pipelining: Basic concepts, instruction and arithmetic pipeline, data hazards, control hazards, and structural. Hazards, techniques for handling hazards. Exception handling: Pipeline optimization techniques. Compiler techniques for improving. Performance. Hierarchical memory technology: Inclusion, Coherence, and locality properties. Cache memory organizations: Techniques for reducing cache misses; Virtual memory organization, mapping and management techniques, memory replacement policies. Instruction-level parallelism: basic concepts, techniques for increasing ILP, superscalar, super pipelined and VLIW processor architectures. Array and vector processors. Multiprocessor architecture: taxonomy of parallel architectures. Centralized shared-memory architecture: synchronization, memory consistency, interconnection networks. Distributed shared-memory architecture. Cluster computers. Non von Neumann architectures: data flow computers, reduction computer architectures, systolic architectures.

Course Outcomes

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

CO1: Understand quantitative principles of computer architecture.

CO2: Understand and analyse the ILP and associated hazards.

CO3: Design memory hierarchies for better performance.

CO4: Identify superscalar, vector and VLIW styles of computing for various applications.

Books and References

1. Computer Organization and Design: A Hardware/Software Interface by John L. Hennessy and David A. Patterson, Morgan Kaufmann.
2. Computer Architecture: A Quantitative Approach by John L. Hennessy and David A. Patterson, Morgan Kaufmann.
3. Advanced Computer Architecture: Parallelism, Scalability, Programmability by Kai Hwang, McGraw-Hill.

Course Name: **RF IC Design**
Course Code: **EC-728**
Course Type: **PG Program Elective-III**

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

Course Objectives

- To develop the foundation for IC design for radio frequency applications, specific to MOS integrated circuits.
- To impart knowledge about Characteristics of Passive and Active IC Components at RF Frequencies such as Low Noise Amplifier Design, Mixers, and Oscillators.

Course Content

Overview of RF and Wireless Technology, Units in RF design, Time variance, Nonlinearity, Effect of nonlinearity, Noise, Sensitivity and Dynamic Range, Passive RLC Networks**:** Parallel and Series RLC Networks, Other resonant RLC Networks, RLC Networks as Impedance Transformers, Interconnects, Resistors, Capacitors, Inductors, Transformers, Transmission lines, General Considerations, Nonlinear systems as Mixers, Multiplier-based Mixers, Single-Balanced and Double-Balanced Mixers, Passive Mixers, Active Mixers General Considerations for LNA, LNA Topologies: Common-Source Stage with Inductive load, Common-Source Stage with Resistive Feedback, Common-Gate Stage, Basic topologies, VCO, Describing functions, Resonators, Negative resistance oscillators, Heterodyne Receivers, Direct-Conversion Receivers, Image Reject Receivers, Transmitter Architectures MEMS devices for RF Applications: SPST, SPDT devices, High-Q Capacitors, Inductors and their Applications in RF Circuits.

Course Outcomes

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

CO1: Understand the Characteristics of Passive IC Components at RF Frequencies.
CO2: Design LNA for RF IC Circuits.
CO3: Design Mixers for RF IC Circuits
CO4: Understand the transceiver architectures.
CO5: Design oscillators as a part of the RF IC circuit.
CO6: Understanding the MEMS Devices for RF Applications

Books and References

1. RF Microelectronics by Behzad Razavi, Pearson Education India.
2. The Design of CMOS Radio-Frequency Integrated Circuits by Thomas H. Lee, Cambridge University Press.
3. Integrated Circuits for Wireless Communications by A.A. Abidi, P.R. Gray and R.G. Meyer, IEEE Press.
4. RF Circuit Design, Theory and Applications by R. Ludwig and P. Bretchko, Pearson.
5. RF MEMS: Theory, Design, and Technology by G.M. Rebeiz, Wiley.

Course Name: **DSP Architectures**
Course Code: **EC-729**
Course Type: **PG Program Elective-III**

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

Course Objectives

- To give an exposure to the various fixed point & a floating point DSP architectures and to develop applications using these processors.

Course Content

Difference between DSP and other microprocessor architectures. An overview of Motorola and Analog Device DSPs. TMS320C54X fixed point and TMS320C3X floating point DSP architectures, CPU, memory, buses, and peripherals. Addressing modes, instruction sets, control operations, interrupts. Repeat operations. Pipeline operation. Pipeline conflicts and programming concepts. Interfacing, serial interface, parallel interface, DMA operations, A/D and D/A converter interfaces. DSP tools. DSP applications. MAC, filter design, implementation of DFT, echo cancellation, spectrum analyzer. Speech and video processing. Architecture of other DSPs.

Course Outcomes

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

CO1: Recognize the fundamentals of fixed- and floating-point architectures of various DSPs.
CO2: Learn the architecture details and instruction sets of fixed- and floating-point DSPs.
CO3: Infer about the control instructions, interrupts, and pipeline operations.
CO4: Illustrate the features of on-chip peripheral devices and their interfacing along with its programming details.
CO5: Analyze and learn to implement the signal processing algorithms in DSPs.
CO6: Learn the DSP programming tools and use them for applications.
CO7: Design and implement signal processing modules in DSPs.

Books and References

1. B. Venkataramani & M. Bhaskar, Digital Signal Processor, Architecture, Programming and Applications (2/e), McGraw-Hill, 2010.
2. S. Srinivasan & Avtar Singh, Digital Signal Processing, Implementations using DSP Microprocessors with Examples from TMS320C54X, Brooks/Cole, 2004.

Course Name: **VLSI Signal Processing**
Course Code: **EC-730**
Course Type: **PG Programme Elective-III**

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

Course Objectives

- Introduce students to the fundamentals of VLSI signal processing and expose them to examples of applications.
- Design and optimize VLSI architectures for basic DSP algorithms.
- Design and optimize VLSI architectures for basic DSP algorithms.

Course Content

Pipelining and Parallel Processing: Introduction, Pipelining of FIR Digital Filters, Parallel Processing. Pipelining and Parallel Processing for Low Power. Retiming: Introduction, Definition and Properties, Solving System of Inequalities, Retiming Techniques. Algorithms for Unfolding, Properties of Unfolding, Critical Path, Unfolding and Retiming Application of Unfolding. Introduction to Folding Transformation, Register Minimization Techniques, Register Minimization in Folded Architectures, Folding in Multirate Systems. Systolic Architecture Design: Introduction, Systolic Array Design Methodology, FIR Systolic Arrays, Selection of Scheduling Vector, Matrix Multiplication and 2D Systolic Array Design, Systolic Design for Space Representations Containing Delays. Fast Convolution: Introduction, Cook, Toom Algorithm, Winogard Algorithm, Iterated Convolution, Cyclic Convolution, Design of Fast Convolution Algorithm by Inspection.

Course Outcomes

Upon successful completion of the course, the students will be able to
CO1: Understand VLSI design methodology for signal processing systems.
CO2: Familiarization with VLSI algorithms and architectures for DSP.
CO3: Be able to implement basic architectures for DSP using CAD tools.

Books and References

1. Keshab K. Parhi. VLSI Digital Signal Processing Systems, Wiley-Inter Sciences,1999
2. Mohammed Ismail, Terri, Fiez, Analog VLSI Signal and Information Processing, McGraw Hill, 1994.
3. Kung. S.Y., H.J. While house T. Kailath, VLSI and Modern Signal processing, Prentice Hall, 1985.
4. Jose E. France, Yannis Tsividis, Design of Analog Digital VLSI Circuits for Telecommunications and Signal Processing' Prentice Hall, 1994.

Course Name: **Flexible Electronics**
Course Code: **EC-731**
Course Type: **PG Programme Elective-III**

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

Course Objectives

- To give exposure to the various organic semiconductor devices.
- To give an exposure to the various flexible electronic devices.

Course Content

Organic Semiconductors, Electronic Transitions, Excitons, and Energy transfer; Charge generation and recombination mechanisms; Polaron and Disorder models for charge transport; Space charge and Trap limited currents; Charge injection at metal/organic interface. Inorganics, Nanomaterials, Active Materials, Barrier films, Stretchable and twistable interconnects. Modeling and Reliability, Lamination and molding, Ink-Jet printing, Flexible Display, Actuators, Medical Applications.

Course Outcomes

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

CO1: Understand the fundamental aspects of the field of flexible electronics and analyze its wide range of applications and impact on society.

CO2: Apply knowledge from interdisciplinary areas of math and science into the FE systems, integrating various disciplines such as biology, chemistry, physics, and engineering.

CO3: Identify the terminology, equipment, and design methodology used in the fabrication, and characterization of FE systems.

CO4: Recognize and discuss the societal and economical significance of FE systems applications, including benefits and potential risks.

Books and References

1. Suganuma Katsuaki, Introduction to Printed Electronics, Springer, 2014
2. Stergios Logothetidis, Handbook of Flexible Organic Electronics - Materials, Manufacturing, and Applications, 1st Ed., Woodhead Publishing, 2014.
3. Eugenio Cantatore, Applications of Organic and Printed Electronics: A Technology Enabled Revolution, Springer, 2012.

Course Name: **Organic Electronics**
Course Code: **EC-732**
Course Type: **PG Program Elective-III**

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

Course Objectives

- To give exposure to the various organic semiconductor devices.
- To give exposure about organic deposition techniques.

Course Content

Introduction to organic semiconductor devices; Electronic Transitions, Excitons, and Energy transfer; Charge generation and recombination mechanisms; Polaron and Disorder models for charge transport; Space charge and Trap limited currents; Charge injection at metal/organic interface; Organic light emitting diodes (OLEDs); Bilayer, Bulk-heterojunction, Inverted, and Tandem organic photovoltaic (OPV) devices; Carrier loss mechanisms in OPVs; Nanomorphology; Hybrid Perovskite solar cells and LEDs; Top and bottom contact organic thin film transistors (OTFTs); Display driver circuits; Operating principles of organic lasers and memory devices; Device degradation mechanisms and Stability testing methods; Organic thin film deposition techniques and Overview of various printing technologies.

Course Outcomes:

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

CO1: Recognize the fundamentals of organic semiconductor devices.

CO2: Learn the charge generation and recombination mechanisms.

CO3: Infer about the organic light emitting diodes (OLEDs).

CO4: Learn about organic thin film deposition techniques and overview of various printing technologies.

Books and References

1. Suganuma Katsuaki, Introduction to Printed Electronics, Springer, 2014.
2. Stergios Logothetidis, Handbook of Flexible Organic Electronics - Materials, Manufacturing, and Applications, 1st Ed., Woodhead Publishing, 2014.
3. Eugenio Cantatore, Applications of Organic and Printed Electronics: A Technology Enabled Revolution, Springer, 2012.
4. Wolfgang Brütting and Chihaya Adachi, Physics of Organic Semiconductors, 2nd Ed., Wiley-VCH, 2012.
5. Anna Köhler and Heinz Bässler, Electronics Processes in Organic Semiconductors - An Introduction, 1st Ed., Wiley-VCH, 2015.

Course Name: **Quantum Electronics**

Course Code: **EC-733**

Course Type: **PG Program Elective-III**

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

Course Objectives:

- The goal of this course is to introduce the quantum mechanical concept.
- To understand the operation of current nanoelectronics and nanophotonics as well as next generation quantum information processing technologies.
- To learn the fundamentals of quantum cryptography.

Course Content

Maxwell's Equations of Isotropic Media, Electromagnetic Waves and Interfaces, Mirrors, Interferometers and Thin-Film Structures, Gaussian Beams and Paraxial Wave Equation, Ray Optics and Optical Systems, Optical Resonators
Integrated Optics: Waveguides, Coupled Mode Theory, Optical Fibers, Anisotropic, Media: Crystal Optics and Polarization
Quantum Nature of Light and Matter, Schrödinger Equation and Stationary States, Harmonic Oscillator and Hydrogen Atom, Wave Mechanics. Dirac Formalism and Matrix Mechanics, Harmonic Oscillator Revisited, Coherent States,
Interaction of Light and Mater the Two-Level Atom: Rabi-Oscillations, Density Matrix, Energy and Phase Relaxation, Rate Equations, Dispersion, Absorption and Gain. Optical Amplifiers and Lasers, Homogenous and inhomogeneous Broadening and Related Effects, Q-Switching and Mode Locking, Electro- and Acousto-Optic Modulation

Course Outcomes:

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

CO1: Students will understand new physical effects.

CO2: Understand the operation of current Nano electronics and Nano photonics.

CO3: Learn quantum teleportation for processing quantum information.

CO4: Understand basic principles of quantum cryptography.

Books and References:

1. Quantum Electronics by A. Yariv, John-Willey.
2. Optical Electronics by A. K. Ghatak, Cambridge University Press.
3. Laser Fundamentals by T. Silfvast William, Cambridge University Press.

Course Name: **Magneto-electronics & Spintronics**
Course Code: **EC-734**
Course Type: **PG Program Elective-III**

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

Course Objectives

- To provide students with the necessary knowledge, skills and tools to contribute to the development of Magneto-electronics & Spintronics

Course Content

Fundamentals of magnetism, Fundamentals of Semiconductor, Basic Principles of Electrical and Magnetic transport, Magnetic-Nonmagnetic multilayer-structures, Ferromagnetic Semiconductors, Half-metallic Ferromagnets. Anisotropic Magnetoresistance (AMR), Giant Magnetoresistance (GMR), Colossal Magnetoresistance (CMR). Spin-valve, Spin-diode, Spin-LED, Spin-transistor, Spin-FET, Magnetic Random Access Memory (MRAM). Magneto-logic Gates (magnetic AND, OR, NAND, NOR), Read-head of Computer Hard Disk.

Course Outcomes

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

CO1: Demonstrate knowledge of the fundamentals of magnetism.
CO2: Demonstrate knowledge of the AMR, GMR, and CMR.
CO3: Demonstrate knowledge of the magnetic random-access memory (MRAM).
CO5: Demonstrate knowledge of the magneto-logic gates.

Books and References

1. Fundamentals of Magnetism and Spintronics, by Atowar Rahman, Zobra Books, 2022.
2. Spintronics, Fundamentals and Applications, by Puja Dey, Jitendra Nath Roy, Springer, 2021

Course Name:	**Numerical Optimization**
Course Code:	**EC-735**
Course Type:	**PG Program Elective-III**

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

Course Objectives

- To impart knowledge about the principles of optimization techniques.
- To introduce the fundamental concepts relevant to classical optimization methods, linear programming, nonlinear programming and dynamic programming.
- To enable the students to understand the factors that causes the different optimization methods to provide different solutions for the same mathematical problem.

Course Content

Introduction: Historical Development; Engineering applications of Optimization; Art of Modeling; Objective function; Constraints and Constraint surface; Formulation of design problems as mathematical programming problems; Classification of optimization problems based on nature of constraints, structure of the problem, deterministic nature of variables, separability of functions and number of objective functions.

Linear Programming: Standard form of linear programming (LP) problem; Canonical form of LP problem; Assumptions in LP Models; Elementary operations; Graphical method for two variable optimization problem; Examples; Motivation of simplex method, Simplex algorithm and construction of simplex tableau; Simplex criterion; Minimization versus maximization problems; simplex method with artificial variables.

Optimization using Calculus: Stationary points - maxima, minima and saddle points; Functions of single and two variables; Global Optimum; Convexity and concavity of functions of one and two variables; Optimization of function of one variable and multiple variables; Gradient vectors; Examples; Optimization of function of multiple variables subject to equality constraints; Lagrangian function; Optimization of function of multiple variables subject to inequality constraints; Hessian matrix formulation; Eigen values; Kuhn-Tucker Conditions; Examples.

Nonlinear programming: One dimensional minimization method, elimination, sequential and descent methods, unconstrained optimization techniques, Direct search methods, Descent methods, 2nd order methods, quasi-newton method, Constrained optimization, Indirect methods, exterior penalty function, interior penalty function, geometric viewpoint, augmented Lagrange multiplier. Dynamic Programming: Sequential optimization; Representation of multistage decision process; Types of multistage decision problems; Concept of sub optimization and the principle of optimality; Recursive equations – Forward and backward recursions; Computational procedure in dynamic programming (DP); Discrete versus continuous dynamic programming; Multiple state variables; curse of dimensionality in DP, application example.

Course Outcomes

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

CO1: Identify different types of optimization techniques and problems.

CO2: Describe techniques like calculus based classical optimization, linear programming, nonlinear programming, dynamic Programming.

CO3: Apply principles and techniques described in CO2 to solve sample mathematical and practical optimization problems.

CO4: Assess the results obtained by applying optimization techniques to solve mathematical programming problems.

Books and References

1. Introduction to optimization by Pablo Pedregal, Publisher, Springer.
2. Numerical optimization with applications by Suresh Chandera, Jaydeva, Aparna Mehta, Narosa.
3. An Introduction to optimization by Edvin K.P. Chong, and Stanislaw H. Zak Publisher, John Wiley.
4. Engineering optimization Theory and Practice by Singiresu S. Rao, New Age International Publisher.

Course Name: **Advanced Digital Communication**
Course Code: **EC-736**
Course Type: **PG Program 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, Memoryless 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 bandlimited 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:	**Advanced Optical Communication**
Course Code:	**EC-737**
Course Type:	**PG Program Elective-I**
Contact Hours/Week: **4L**	Course Credits: **04**

Course Objectives

- To introduce the students to various concepts of advanced optical communication systems.

Course Content

Correlation properties and power density spectrum of shot noise process; Laser phase noise modeling and Lorentzian power spectrum of lasers; Coherent optical communication systems: Homodyne and heterodyne detection schemes, BER analyses - super-quantum and shot noise limits for homodyne PSK, Synchronous and asynchronous FSK, Impact of finite laser linewidth on BER, Polarization control and diversity schemes, Frequency alignment schemes; Review of optical amplifiers - Semiconductor amplifiers, Erbium-doped fibre amplifiers (EDFAs) and Raman amplifiers, Analytical modeling of gain saturation in EDFAs, Gain equalization in EDFAs, ASE noise in EDFAs, Amplifier cascades, Amplifier spacing penalty; BER analysis of lightpaths in WDM backbones in presence of ASE noise and switch crosstalks; Optical duobinary modulation: Spectral efficiency, Basic scheme, BER analysis, Impact of fibre nonlinearities; Error detection and correction in optical links: Reed-Solomon codes, Interleaving; Pulse propagation in optical fibres: Propagation of chirped Gaussian pulse, Concept of nonlinear polarization, Nonlinear effects on pulse propagation, Soliton pulse propagation; Optical time division multiplexing techniques; Optical phase-locked loops.

Course Outcomes

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

CO1: Learn the Coherent optical communication systems.

CO2: Learn the concept of optical amplifiers.

CO3: Learn Error detection and correction in optical links.

CO3: Understand the optical multiplexing techniques.

CO4: Understand the concept of optical nonlinear polarization.

Books and References:

1. Cvijetic, Milorad, and Ivan Djordjevic. *Advanced optical communication systems and networks*. Artech House, 2013.
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:	**Soft Computing**
Course Code:	**EC-738**
Course Type:	**PG Program Elective-I**

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

Course Objectives

- To impart knowledge about 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 their 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: **Wi-Fi, Bluetooth and ZigBee Technology**
Course Code: **EC-739**
Course Type: **PG Program Elective-I**

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

Course Objectives

- To understand theoretical aspects of Wi-Fi, Bluetooth and Zigbee technology.
- To design and implement Wi-Fi/ Bluetooth/ Zigbee based ad hoc 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-740**
Course Type: **PG Program Elective-I**

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

Course Objectives

- To impart knowledge about wireless sensor networks and their application areas.
- 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 K-cover 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: Understand 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:	**Optimization Tools and Techniques**
Course Code:	**EC-741**
Course Type:	**PG Program 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: **Applied Linear Algebra for Signal Processing, Data Analytics and Machine Learning**
Course Code: **EC-742**
Course Type: **PG Program Elective-I**

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

Course Objectives

- To introduce all the basic and advanced concepts in Linear Algebra with a strong focus on applications. Linear Algebra is one of the fundamental tools that has.
- To introduce applications of Linear Algebra in diverse fields such as Machine Learning, Data Analytics, Signal Processing, Wireless Communication, Operations Research, Control and Finance.
- To learn about the novel cutting edge applications of linear algebra in various fields such as Machine Learning, Data Analytics, Signal Processing, Wireless Communication.

Course Content

Introduction to vectors, properties and applications, Introduction to matrices and Applications Circuits, Graphs, Social Networks, Traffic flow, Eigenvalue decomposition, properties and Applications Principal component analysis (PCA), Eigen faces for facial recognition. Singular value decomposition (SVD) and Applications Beamforming in MIMO, Dimensionality reduction, Rate maximization in wireless, MUSIC algorithm, Linear regression and Least Squares. Applications: System identification, linear regression, Support vector machines (SVM), kernel SVMs, Optimal linear MMSE estimation. Applications MMSE Receiver, Market prediction and forecasting, ARMA models. Data analytics: Recommender systems, user rating prediction, Structure of FFT/ IFFT matrices, properties, System model for OFDM/ SC-FDMA, Signal processing in OFDM systems. Modeling of Dynamical systems Examples, Solution of autonomous linear dynamical systems (LDS), solution of with inputs and outputs, Unsupervised learning: Centroid based clustering, probabilistic model-based clustering and EM algorithm, Linear perceptron. Training a perceptron stochastic gradient. Compressive sensing, orthogonal matching pursuit for sparse signal estimation. Discrete time Markov chains Applications: supply chain management, forecasting, Operations research resource and inventory management.

Course Outcomes

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

CO1: Understand the basic of Linear Algebra

CO2: Understand applications of Linear Algebra in diverse fields such as Machine Learning, Data Analytics, Signal Processing, Wireless Communication, Operations Research, Control and Finance

Books and References

1. Introduction to Linear Algebra: Gilbert Strang.
2. Fundamentals of Wireless Communication. David Tse, Pramod Viswanath.
3. Hands-On Machine Learning with Scikit-Learn, Keras, and TensorFlow: Concepts, Tools, and Techniques to Build Intelligent Systems, Third Edition by Aurélien Géron Shroff/O'Reilly Publisher.

Course Name: **Electromagnetic Interference & Compatibility**
Course Code: **EC-743**
Course Type: **PG Program Elective-II**

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

Course Name: **Advanced Engineering Electromagnetics** Course Code: **EC-744** Course Type: **PG Program Elective-II**	
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 behaviour 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 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. Full wave analysis of different types of waveguides including solutions to TE/TM/HE modes, Parallel plate waveguide, 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: Cylindrical, and 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, R. F. Harrington, Wiley-IEEE Press
2. Field Theory of Guided waves, R. E. Collin, Wiley-IEEE Press.
3. Elements of Electromagnetics, M. N. O. Sadiku, Oxford University Press.
4. Bluetooth Electromagnetism: Theory and Applications, Ashutosh and Pramanik, Prentice Hall India Learning Private Limited.

Course Name: **RF and Microwave Circuit Design**
Course Code: **EC-745**
Course Type: **PG Program Elective-II**

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

Course Objectives

- To understand theoretical aspects of transmission line, network analysis, filters, couplers low noise amplifier and power amplifier.
- To understand use of Smith Chart for high frequency circuit design.
- To design filters, couplers, power dividers, low noise amplifier and power amplifiers.

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. Printed couplers, Filters, Power dividers, Directional couplers, Transmission line resonators. 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, Introduction of microwave mixers, Mixer characterization, Microwave transistor oscillators.

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: Explain the performance requirements of RF active circuits.
CO5: Explain RF amplifier and mixer.
CO6: Explain microwave oscillator.

Books and References

1. Microwave Engineering, D. M. Pozar, 4th Edition, Wiley, 2011.
2. Foundations of Microstrip Circuit Design, T. C. Edwards and M. B. Steer, 4th Edition, Wiley-IEEE Press, 2016.
3. Elements of Electrornagnetics, M. N. O. Sadiku, 3rd Edition, Oxford University Press, New York, 2001.
4. Microwave Active Circuit Analysis and Design, C. Poole and I. Darwazeh, Elsevier
5. Fundamentals of RF and Microwave Transistor Amplifiers, I. J. Bahl, John Wiley & Sons

Course Name: **Advanced Antenna and Electromagnetic Metamaterials: Concept and Applications**
Course Code: **EC-746**
Course Type: **PG Programme Elective-II**

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

Course Objectives

- To impart knowledge about the advanced concepts of antenna engineering.
- To introduce the design principle relevant to Advanced Antennas for different applications.
- To enable the students to understand the concept of Electromagnetic Metamaterials.
- To introduce the design principle relevant to Metamaterials for various applications.

Course Content

Definitions & Preliminary Information: Application areas of Antennas, Maxwell's Equations and Boundary conditions, Wave Equations, Infinitesimal (Hertzian) Dipoles, Monopoles, Inverted-F Antennas. Aperture-type and Microstrip Antennas: Radiation from apertures, aperture distribution, Transmission line and Cavity model for patch antennas, circularly polarized microstrip antenna, Microstrip patch and printed dipole arrays. Advanced Antennas: Travelling wave and Broadband Antennas, Frequency Independent Antennas, Antenna Miniaturization, and Fractal Antennas, Smart Antennas: Concept and Benefits of Smart Antennas, MIMO Antenna configurations, Pattern and polarization diversity, Mutual coupling reduction techniques, correlation coefficients, Massive MIMO system design. Metamaterials Background and Spatial Metamaterials: General Historical perspective and idea of Metamaterials (MTMs), Plane-wave propagation in simple medium, Dispersive model for the dielectric permittivity, Phase velocity and group velocity. Spatial Metamaterials: Metamaterials and homogenization procedure, Split-ring resonator media, Media with negative permittivity and permeability: theory and properties, Origins of negative refraction and other properties. Different Metamaterials and applications: Transmission Line Metamaterials: Ideal Homogeneous CRLH TLs (Composite Right-Left Handed Transmission Lines), LC Network Implementation and distributed 1D CRLH Structures, Conversion from Transmission Line to constitutive Parameters, Negative and Zeroth-Order Resonators. Meta-surface concepts: Artificial High-Impedance Surface design, EBG (Electromagnetic Bandgap Structures), Gain-enhancement in antennas using MTM, Miniaturization using MTM, Design of FSS Radomes for EMI Shielding and Absorbers, Beam-steering using Intelligent Reflecting Surfaces (IRS).

Course Outcomes

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

CO1: Describe the antenna design principle for advanced antennas.

CO3: Apply principles of radiation from the conducting surfaces and aperture surfaces at RF frequencies and assess the numerical techniques for the analysis of the antennas.

CO4: Describe the need for metamaterials and their design principle.

CO5: Apply and design different metamaterials for specific applications.

Books and References

1. Field and Wave Electromagnetics, D. K. Cheng, Pearson Education Asia Ltd, Second Edition, 2006.
2. Antenna Theory: Analysis and Design, C. A. Balanis, John Wiley, Fourth Edition, 2016.
3. Antenna Theory and Design, W. L. Stutzman and G. A. Thiele, John Wiley & Sons Inc, 1981.
4. Antennas, J. D. Karus, McGraw Hill, 1988
5. Microstrip antennas, I. J. Bahl and P. Bhartia, Artech house, 1980.
6. Electromagnetic Metamaterials: Transmission Line Theory and Microwave Applications, The Engineering Approach, C. Caloz and T. Itoh, John Wiley & Sons, Inc., Hoboken, New Jersey, 2006.
7. Physics and Applications of Negative Refractive Index Materials, S. A. Ramakrishna and T. M. Grzegorczyk, CRC Press, Taylor & Francis Group and SPIE Press, 2009.
8. Negative Refraction Metamaterials: Fundamental Principles and Applications, G. V. Eleftheriades and K. G. Balmain Copyright: IEEE, John Wiley & Sons, Inc., Hoboken, New Jersey, 2005.

Course Name: **Nanophotonics and Plasmonics: Concept and Applications**
Course Code: **EC-747**
Course Type: **PG Program Elective-II**

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

Course Objectives

This course explains the concepts and applications of Nanophotonic and plasmonics for future communication devices. It focuses on the Photonic Crystals, Nanophotonics in metals, and Transmission through apertures and films, Simulation and Design of different photonic and plasmonics components.

Course Content

Introduction to Photonics: Electromagnetic waves; light; Maxwell equations; Wave equation; Modes, laser sources, semiconductor quantum wells, photo detectors, quantum dots, nanowires, Dielectric optical waveguides, directional coupler, Machzehnder interferometer, Optical microresonators etc. Photonic Crystals: Photonic bandgap (PGB). PBG structures, wave propagation, Construction methods, Applications: wave guides and photonic crystals fibres, optical microcavities, Photonic VLSI. Nanophotonics in metals: Electromagnetics of Metals, Electromagnetic Wave Propagation, Dielectric function and dispersion, Surface Plasmon polaritons, Single and multilayer systems, Exaction of surface Plasmon, plasmonic waveguides and resonators, localized surface plasmons, Nanoantennas. Metamaterials and Negative Index at Optical Frequencies. Transmission through apertures and films: Theory of Diffraction by Sub-Wavelength Aperture, Extraordinary Transmission, Directional Emission via Exit Surface Patterning, Localized Surface Plasmons and Light Transmission Through Single Apertures, Emerging Applications of Extraordinary Transmission, Transmission of Light Through a Film Without Apertures. Simulation and Design: Optical microresonators, guiding bending and splitting of light through photonic crystals, microcavity based MUX and DEMUX, photonic crystal fiber, plasmonic waveguides and resonators, Nanoantennas, Extraordinary transmission, Bull's eye structures, Metamaterials.

Course Outcomes

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

CO1: Understand the basics of photonics.

CO2: Understand the photonic crystals and their application.

CO3: Understand the interaction of light with metal.

CO4: Understand and analyse the transmission through apertures and films.

CO5: Design and analyse the different photonics and plasmonic components for different applications.

Books and References

1. Fundamentals and Applications, Stefen A. Maer, Springer 2007.
2. Nanophotonics with Surface Plasmon, Vladimir M. Salaev, Part II, 2006, Photonic Spectra.
3. Photonic crystals: Molding the flow of light, J.D. Joannopoulos, 2nd Edition, 2008 Princeton University Press
4. Integrated Photonics: fundamentals, G. Lifante, Wiley.

Course Name: **Wavelet Transform and Applications**
Course Code: **EC-748**
Course Type: **PG Program Elective-II**

Contact Hours/Week: **4L** Course Credits: **0**4

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:	**mm-Wave Wireless Communication for 5G and Beyond**
Course Code:	**EC-749**
Course Type:	**PG Program Elective-II**

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

Course Objectives

- Learning the basics of past, present, and future standards and trends of mobile communications.
- Providing a basic understanding of the key technologies and enablers of 5G and beyond 5G communication systems.
- Be familiar with terminologies such as massive MIMO, mm-Wave, NOMA, wireless powered communications, machine learning for wireless communications, etc.
- Developing an analytical capability for solving various problems of next generation wireless communications.

Course Content

Transmitter-Receiver Structure of Advanced Communication System, Wireless Channel–A ray tracing model, Understanding of various channel related parameter statistics. Narrow band and broadband aspect, RMS Delay spread & Doppler Effect on channel, Time Varying Model, Doppler Impact on coherence BW. Introduction to time series, AR,ARMA,MA process, Doppler with AR process model, Coherence time and parameter summery, Basic ISI channel, Channel estimation and Equalizer, Precoder and MIMO, Basics of mm-wave spectrum Angle of arrival and angle of departure, 3D concepts, AoA, AoD , mm-Wave channel model with RX beaming, mm-Wave channel model with RX beaming, mm-wave channel model, mm-Wave channel model, Basics of Beamforming, Single Antenna beamforming, Concept of antenna many fold vector, 3D Concept of antenna many fold vector, Different Geometry of antenna from electrical point of view, Basics of Beamforming pattern, SISO Beamforming, MIMO Beamforming, Structural implementation of MIMO Beamforming, Different Level of Beamforming, MIMO Beamforming in Transmitter side, MIMO Beamforming in Receiver side, MIMO Beamforming in Receiver side, Mathematical description of MIMO Beamforming Equalizer based detector, Parameter to be designed in MIMO Beamforming, OFDM Data Model, OFDM Data model General OFDM, OFDM spectrum and CFO, MIMO OFDM structure , MIMO OFDM decode and beamforming, Design parameter estimation, CFO and other impairment and their effects, MU System, Multi User Hybrid beam and impairment and analysis

Course Outcomes

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

CO1: Distinguish and understand the major cellular communication standards and wireless communications networks.

CO2: Understand the concepts of mm-Wave Wireless Communication for 5G and Beyond.

CO3: Understand the concepts of Beamforming, MIMO and OFDM.

CO4: Describe different technologies of 5G and beyond 5G communications

CO5: Apply the basic understanding to solve the existing problems of next-generation communications

CO6: Identify the state-of-the-art problems and apply the basic knowledge for finding out the required solutions.

Books and References

1. Fundamentals of Wireless Communication. David Tse, Pramod Viswanath, Cambridge University Press.
2. Wireless Communications by Andrea Goldsmith, Cambridge University Press.
3. Principles of Modern Wireless Communications Systems - Aditya Jagannatham, McGraw Hill Education.

Course Name: **Biomedical Signal Processing**
Course Code: **EC-750**
Course Type: **PG Program Elective-III**

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

Course Objectives

- To study the origin and process of acquisition of principal bioelectric signals like ECG, EEG, EMG etc.
- To understand the background material required for processing of the biomedical signals.
- To understand the utility of biomedical signals for disease diagnosis like ECG for Cardiovascular diseases and EEG for sleep disorders.
- To explore the utility of bioelectrical signals for developing other application.

Course Content

Introduction: Genesis and significance of bioelectric potentials, ECG, EEG, EMG and their monitoring and measurement, spectral analysis, digital and analog filtering, correlation and estimation techniques, AR/ARMA models, adaptive filters. ECG: Pre-processing, measurements of amplitude and time intervals, classification, QRS detection, ST segment analysis, baseline wander removal, waveform recognition, morphological studies and rhythm analysis, automated diagnosis based on decision theory ECT compression, evoked potential estimation. EEG: Evoked responses, epilepsy detection, spike detection, averaging techniques, removal of artifacts by averaging and adaptive algorithms, pattern recognition of alpha, beta, theta and delta waves in EEG waves, sleep stages. EMG: Wave pattern studies, biofeedback, zero crossing, integrated EMG, time frequency methods, and wavelets in biomedical signal processing.

Course Outcomes

Upon successful completion of the course, the students will be able to
CO1: Understand the acquisition methods for collecting ECG, EEG and EMG signals.
CO2: Develop mathematical models for analysis of biomedical signals.
CO3: Identify the characteristic points in an ECG waveform and understand their relevance.
CO4: Understand the EEG and EMG signal analysis and apply them to develop practical applications like BCI, prosthetic limbs.

Books and References

1. Biomedical Signal Analysis by R.M. Rangayyan, Wiley.
2. Biomedical Signal Processing: Principles and techniques by D.C. Reddy, Tata McGraw Hill, New Delhi.
3. Biomedical Signal Processing by Willis J Tompkins, Prentice Hall.
4. Bioelectrical Signal Processing in Cardiac & Neurological Applications by L. Sörnmo, Elsevier.

Course Name: **Statistical Signal Processing** Course Code: **EC-751** Course Type: **PG Program Elective-III**
Contact Hours/Week: **4L** Course Credits: **04**
Course Objectives: • To develop the ability to process discrete random signals. • To study the algorithms for modeling of stochastic signals. • To study the basic classical and Bayesian estimation techniques. • To familiarize with non-parametric and parametric spectrum estimation techniques.
Course Content
Introduction: Signal Processing methods, Review of Probability Theory, Random Variables and Stochastic Processes. Random Signal Analysis: Discrete random signals, Spectral representation of discrete random signals, filtering random processes, Random signal models AR, MA and ARMA. Power spectrum and phase of the signal generating system, Least squares method, Padé approximation, Prony's method, finite data records, stochastic models, Levinson-Durbin recursion; Schur recursion; Levinson recursion. Spectrum Estimation: Nonparametric methods, minimum-variance spectrum estimation, maximum entropy method, parametric methods, frequency estimation, principal components spectrum estimation. Estimation Theory: Estimation of moments, classical and Bayesian estimation. MAP, ML, MMSE, and MAVE estimators for model parameters and signal. Cramer-Rao Bound on the minimum estimator variance. Introduction to Hidden Markov Models, Noise and Distortion.
Course Outcomes Upon successful completion of the course, the students will be able to CO1: Apply the principles of random processes for analysis of linear systems. CO2: Model random signals and appreciate its utility in signal interpolation, signal prediction and signal compression. CO3: Implement estimation techniques on signal processing problems and acquire ability to estimate parameters using them. CO4: Understand the non-parametric and parametric spectrum estimation techniques.
Books and References 1. Probability, Random Variables and Stochastic Processes by A. Papoulis, McGraw Hill. 2. Statistical Digital Signal Processing and Modelling by Monson H. Hayes, John Wiley & Sons Inc. 3. Fundamentals of Statistical Signal Processing, Volume I: Estimation Theory by Steven M. Kay, Prentice Hall, USA. 4. Advanced Digital Signal Processing and Noise Reduction by Saeed V. Vaseghi, John Wiley & Sons, Ltd, Singapore. 5. Statistical and Adaptive Signal Processing by Dimitris G. Manolakis, Vinay K. Ingle and Stephen M. Kogan, McGraw Hill. 6. Detection, Estimation and Modulation Theory, Part 1 and 2 by Harry L. Van Trees, John Wiley & Sons Inc. 7. Optimal and Adaptive Signal Processing by Peter M. Clarkson, CRC Press London.

Course Name: **Radar Signal Processing**
Course Code: **EC-752**
Course Type: **PG Program Elective-III**

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

Course Objectives

- To introduce the students to the concepts of radar signal processing.
- Analyze radar waveforms for specific applications.
- Develop skills in radar signal detection and processing.

Course Content

Introduction to radar systems, History and applications of radar, Basic radar function, Radar classifications, elements of pulsed radar, The radar equation, A preview of basic radar signal processing.
Signal models, Components of a radar signal, Amplitude models, Clutter, Noise model and signal-to-noise ratio, Jamming, Frequency models: the Doppler shift, spatial models.
Sampling and quantization of pulsed radar signals, Domains and criteria for sampling radar signals, Sampling in the fast time dimension, Sampling in slow time: selecting the pulse repetition interval, Sampling the Doppler spectrum.
Radar waveforms, Introduction, The waveform matched filter, Matched filtering of moving targets, The radar ambiguity function, The pulse burst waveform, frequency-modulated pulse compression waveforms, The stepped frequency waveform, Phase-modulated pulse compression waveforms, Costas frequency codes.
Doppler processing, Alternate forms of the Doppler spectrum, Moving target indication (MTI), Pulse Doppler processing, Dwell-to-dwell stagger, Additional Doppler processing issues, Clutter mapping and the moving target detector.
Detection of radar signals in noise: detection fundamentals, detection criteria, Threshold detection in coherent systems, Threshold detection of radar signals, binary integration, CFAR detection, CA CFAR, Additional CFAR topics.

Course Outcomes

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

CO1: Understand the radar signal processing fundamentals, including signal models, clutter characteristics, and Doppler processing techniques.
CO2: Design radar waveforms tailored to specific applications, optimizing radar performance in various scenarios.
CO3: Demonstrate proficiency in radar signal detection and processing techniques, including threshold detection, CFAR algorithms, and Doppler processing, enabling accurate target detection and tracking.
CO4: Develop problem-solving skills in radar signal processing, enabling them to analyze complex radar signal scenarios and apply appropriate techniques to address challenges effectively, contributing to improved radar system design and operation.

Books and References:

1. Fundamentals of Radar Signal Processing by Mark A. Richards, McGraw-Hill, 2005.
2. Adaptive Radar Signal Processing by Simon Haykin, John Wiley & Sons, 2006.
3. Introduction to Radar Systems by Skolnik, M.I., 2nd Ed., McGraw-Hill, 1997.

Course Name: **Adaptive Signal Processing** Course Code: **EC-753** Course Type: **PG Program Elective-III**	
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, Haykin, S., Pearson Education. 2002
2. Adaptive Signal Processing, Widrow, B. and Stearns, S.D., Pearson Education, 1985
3. Statistical and Adaptive Signal Processing, Manolakis, D.G., Ingle, V.K. and Kogon, M.S., Artech House, 2005
4. Statistical Signal Processing: Detection, Estimation, and Time Series Analysis by Scharf, L.L., Pearson.

Course Name: **Multi-rate Signal Processing**
Course Code: **EC-754**
Course Type: **PG Program Elective-III**

Contact Hours/Week: 4**L** 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 transforms, 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, P. P .Vaidynathan, Pearson Education Inc.
2. Wavelets and filter banks, D. Strang and T. Nguyen, Wellesley-Cambridge Press.
3. Digital Signal Processing: Principles, Algorithms and Applications, J. G. Proakis and D. G. Manolakis, Pearson Education.
4. Multirate Digital Signal Processing, N.J. Fliege, John Wiley and Sons.

Course Name: **Advanced Spectrum Engineering**
Course Code: **EC-755**
Course Type: **PG Program Elective-III**

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

Course Objectives

- To impart knowledge about the basic spread spectrum techniques that are used in CDMA based cellular communication systems, including direct sequence spread spectrum and frequency-hopped spread spectrum.
- To introduce the fundamental mathematical concepts relevant to design aspects of the PN sequence generators.
- To enable the students to understand the factors that affect the practical implementation of IS-95, CDMA-2000 and WCDMA systems.

Course Content

Introduction: Concept of Multiple Access Systems, Narrowband and Broadband Systems, Advantages of Spread Spectrum Systems. Principles of Direct Spread Spectrum: Direct Spectrum System: Definition and Concepts, Spreading Sequences and Waveforms, Random Binary Sequence, Shift-Register Sequences, Periodic Auto Correlations, Polynomials over The Binary Field, Systems with PSK Modulation, Power Spectral Density of DSS-CDMA, Pulsed Interference, De-Spreading with Matched Filter. Spreading Code Acquisition and Tracking: Initial Code Acquisition, Acquisition Strategy: Serial Search, Parallel Search, Multi-Dwell Detection, False Alarm and Miss Probability for Matched Filter Receiver, False Alarm and Miss Probability for Radiometer, Mean Overall Acquisition Time for Serial Search. Performance of Spread Spectrum System: Link Performance of Direct Sequence Spread Spectrum CDMA In (I) Additive White Noise Channel (Ii) Multipath Fading Channel. Concept of Rake Receiver, Performance of RAKE Receiver in Multipath Fading. Frequency Hoped Systems: Concepts and Characteristics, Modulations, MFSK, Hybrid Systems, Frequency Synthesizers, Direct Frequency Synthesizer, Digital Frequency Synthesizer, Indirect Frequency Synthesizers. CDMA systems: CDMA-IS-95: Forward link Channels, Reverse link Channels, Power Controls and Handoff Procedure in IS-95, Overview of CDMA based 3G Systems (CDMA-2000 and WCDMA).

Course Outcomes

Upon successful completion of the course, the students will be able to
CO1: Identify spread spectrum techniques that are used in CDMA based cellular communication systems, including direct sequence spread spectrum and frequency-hopped spread spectrum.
CO2: Apply the principles of linear algebra to design PN sequence generators.
CO3: Analyze the performance of CDMA systems in various wireless Channels.
CO4: Assess the practical implementation of IS-95, CDMA-2000 and WCDMA systems.

Books and References

1. Principles of Spread Spectrum Communication Systems by Don Torrieri, Springer Science & Business Media, Inc.
2. CDMA: Principles of Spread Spectrum Communication by Andrew J. Viterbi, Addison- Wesley Publishing Company.
3. Introduction to CDMA Wireless Communications by Mosa Ali Abu-Rgheff, Elsevier Academic Press.
4. Code Division Multiple Access-CDMA by R. Michael Buehrer, Morgan & Claypool Publishers Series.
5. CDMA Systems Engineering Handbook by Jhong S. Lee and Leonard E. Miller, Artech House Publishers.
6. IS-95 CDMA and CDMA-2000 by Vijay K Garg, Pearson Education.
7. OFDM for Wireless Communications Systems by Ramjee Prasad, Artech House, Inc.

Course Name: **6G and Terahertz Communication**
Course Code: **EC-756**
Course Type: **PG Program Elective-III**

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

Course Objectives

- To provide students with the necessary knowledge, skills and tools to contribute to the development of 6G wireless communication networks in the THz band.

Course Content

Introduction to the Terahertz Band, Properties of Terahertz Radiation, Applications in Communications and Sensing at the Macro and Nano Scales, Terahertz Device Technologies, Technology Pathways to Terahertz Front-ends Electronics, Photonics, Plasmonics, Antenna Systems, Antenna, Antenna Arrays and Reflect-arrays, Lenses and Metasurfaces, Ultra-broadband Digital Back-ends, Experimental Testbeds for Terahertz Communications Research, Terahertz Wave Propagation and Channel, modelling, Indoors/Outdoors, Line-of-sight Propagation, Non-line-of-sight Propagation, Multi-path Propagation, Extreme Environments, Intra-body Terahertz Propagation, Satellite Terahertz Propagation, Terahertz Communications and Signal Processing, Modulation, Multi-user Interference. Channel Coding and Error Control, Physical Layer Security, Ultra-massive MIMO, Terahertz Network Architecture and Protocol Stack, Medium Access Control, Neighbor Discovery, Relaying Routing, Regularization and standardization, Coexistence of Passive and Active Services above 100 GHz, Early standardization efforts: IEEE 802.15.3d.

Course Outcomes

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

CO1: Demonstrate knowledge of the main differences between THz communication networks and traditional wireless networks at lower (microwave, millimeter-wave) and higher (infrared, visible) frequency bands.
CO2: Identify and describe the main technologies at the basis of THz transceivers and antennas.
CO3: Design and numerically simulate utilizing finite-element-methods radiating ultra-directional antenna systems at THz frequencies.
CO4: Demonstrate knowledge of the main phenomena affecting the propagation of THz signals.
CO5: Interpret experimental data sets, including channel measurements and transmitted/received data traces.

Books and References

1. Handbook of Research on Design, Deployment, Automation, and Testing Strategies for 6G Mobile Core Network by "Senbagavalli G., T. Kavitha, Aruna Ramalingam, Velvizhi V. A.", IGI Global, 2022.
2. 6G Wireless Communications and Mobile Networking by "Xianzhong Xie, Bo Rong, Michel Kadoch", Bentham Books, 2021.