



Jharkhand University of Technology, Ranchi
NEP-2020 based Syllabus w.e.f – 2025-26 Batch
B.Tech in Electronics and Communication Engineering

Semester- VIIth

S.No.	Course Code	Course Title	L	T	P	J	Cr	FM	Overall Pass Marks	Internal	External	Categorization
			Contact Hours per week									
PROGRAMME CORE COURSES (PCC)												
01	ECEC701	PCC-I (Computer Communication and Network Security)	3	1	0		4	100	35	30	70	
PROGRAMME ELECTIVES V, VI & VII												
02	ECEPEV701, ECEPEV702, ECEPEV703, ECEPEV704, ECEPEV705, ECEPEV706, ECEPEV707, ECEPEV708, ECEPEV709	PE-V (Any One From The Given Basket of PE-V)	3	0	0		3	100	35	30	70	
03	ECEPEVI701, ECEPEVI702, ECEPEVI703, ECEPEVI704, ECEPEVI705, ECEPEVI706, ECEPEVI707, ECEPEVI708, ECEPEVI709	PE-VI (Any One From The Given Basket of PE- VI)	3	0	0	6	3	100	35	30	70	
04	ECEPEVII701, ECEPEVII702, ECEPEVII703, ECEPEVII704, ECEPEVII705, ECEPEVII706,	PE-VII (Any One From The Given Basket of PE-VII)	3	0	0		3	100	35	30	70	

	ECEPEVII707, ECEPEVII708, ECEPEVII709, ECEPEVII710											
		OPEN ELECTIVE-II& III										
05	ECEOII701, ECEOII702, ECEOII703, ECEOII704, ECEOII705, ECEOII706, ECEOII707, ECEOII708, ECEOII709	OE-II (Any one From The Given Basket of OE-II& III)	3	0	0	3	100	35	30	70		
06	ECEOIII701, ECEOIII702, ECEOIII703, ECEOIII704, ECEOIII705, ECEOIII706, ECEOIII707, ECEOIII708, ECEOIII709	OE-III (Any one From The Given Basket of OE-II& III)	3	0	0	3	100	35	30	70		
Total			18	1	0	19	600	--	--	--		
Practical			L	T	P	Cr	FM	Overall Pass Marks	Internal	External	Categorization	
06	ECEP701	Lab-I (Microwave and Lightwave Technologies Lab)	0	0	3	1	50	25	30	20		
07	ECEP702	Lab-II (____ Computer network lab _____)	0	0	3	1	50	25	30	20		
Total			0	0	6	2	100	--	--	--		
Audit Course			L	T	P	Cr	FM	Overall Pass Marks	Internal	External	Categorization	
10	AUC701	(THROUGH NPTEL/SWAYAM) Exploring Human Values: Visions of Happiness and Perfect Society				--	100	35	30	70		
<p>Student will complete this Audit Paper of 12 weeks duration from NPTEL/SWAYAM. It is mandatory to pass this paper in order to pass this semester. Students may register on NPTEL/SWAYAM at any time from 1st to 7th semester also but the passing marks and credits will be reflected only in the 7th semester. The passing marks and certificate shall be forwarded by the institute to Controller of Examination (CoE), JUT, Ranchi timely</p>												

11	AUC702	Sports/NCC/NSS/YOGA/Painting/Music/ Classical Dance	6			--	50	25	30	20	
						Students shall participate actively in one of the activities and for Passing of the semester "Participation Certificate" in activity will be mandatory student participation shall be monitored and participation record shall be maintained at institute level. The marks obtained shall be forwarded to controller of Examination (CoE), JUT, Ranchi timely.					
Project			L	T	P	Cr	FM	Overall Pass Marks	Internal	External	Categorization
12	ECEP703	Minor Research Project	0	0	6	3	100	35	30	70	
Total			0	0	6	3	250	--	--	--	
Grand Total			18	1	6	24	950	--	--	--	

Professional Elective-V

S. No.	Course Code	Subject
01	ECEPEV701	Embedded Automotive Systems
02	ECEPEV702	Real Time Operating Systems
03	ECEPEV703	FPGA based Embedded Systems
04	ECEPEV704	Smart Antennas and Adaptive Beamforming
05	ECEPEV705	Computational Electromagnetics
06	ECEPEV706	RADAR Systems
07	ECEPEV707	Remote Sensing Systems
08	ECEPEV708	Biomedical Applications of Radio Frequency Waves
09	ECEPEV709	RFID Systems
10		

Professional Elective-VI

S. No.	Course Code	Subject
01	ECEPEVI701	Agent based Modeling
02	ECEPEVI702	Software Defined Radio Architecture
03	ECEPEVI703	Computer Vision
04	ECEPEVI704	Biomedical Signal Processing
05	ECEPEVI705	Natural Language Processing
06	ECEPEVI706	AI in Speech Signal Processing
07	ECEPEVI707	Image Processing
08	ECEPEVI708	Multirate Signal Processing and Wavelets
09	ECEPEVI709	Statistical Signal Processing
10		

Professional Elective-VII

S. No.	Course Code	Subject	S. No.	Course Code	Subject
01	ECEPEVII701	Adaptive Signal Processing	06	ECEPEVII706	Cryptography and Network Security
02	ECEPEVII702	Digital Electronics	07	ECEPEVII707	Introduction to ASIC Design
03	ECEPEVII703	Principles of Communication Systems	08	ECEPEVII708	RF Microelectronics
04	ECEPEVII704	GPU Architectures and Programming	09	ECEPEVII709	Advanced Digital Signal Processing
05	ECEPEVII705	Embedded Hardware Platforms and Programming	10	ECEPEVII710	Software Defined Radio

Open Elective-II

Open Elective-III

S. No.	Course Code	Subject	S. No.	Course Code	Subject
01	ECEOEII701	Wireless Communications- 5G Use Cases	01	ECEOEIII701	Communication Systems
02	ECEOEII702	Telecom Switching	02	ECEOEIII702	Digital IC Design
03	ECEOEII703	Speech Processing	03	ECEOEIII703	Microprocessors and Microcontrollers
04	ECEOEII704	Optimization Techniques	04	ECEOEIII704	Digital Electronics
05	ECEOEII705	CAD for IC Design	05	ECEOEIII705	Sensors and Instrumentation
06	ECEOEII706	Cloud based Technologies	06	ECEOEIII706	Device Modeling
07	ECEOEII707	Adhoc Networks	07	ECEOEIII707	Physical Design Automation
08	ECEOEII708	Biomedical Instrumentation and Signal Processing	08	ECEOEIII708	Analog IC Design
09	ECEOEII709	IPR & Cyber Laws	09	ECEOEIII709	Mixed Signal Design

10				10		
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Abbreviations: - AU-Audit Course; L: Lecture, T: Tutorial, P: Practice.

J-Self learning hours shall not be reflected in the Time table. Self-learning includes micro projects/assignments/other activities as mentioned in earlier semesters.

***Passing in the Audit Course shall be mandatory.**

Note:- Students may choose their two Professional Electives (PE-V,VI & PE-VII) & Open Elective-II & III from NPTEL/SWAYAM also on the approval of departmental academic council if that subject is not mentioned in the above basket.

Students will complete the Elective Papers (Professional or Open) of 12 weeks duration from NPTEL/SWAYAM. Student may register on NPTEL/SWAYAM at any time between 1st to 7th semester but the passing marks and credits will be reflected only in the 7th semester.

The secured percentage of marks and passing certificate of the subject shall be forwarded by the institute to Controller of Examination (CoE), JUT, Ranchi timely.

The institute will inform University Examination Session about selection of PE and OE subjects by the students also before 1st mid-semester examination of that semester.



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B.Tech, Branch-Electronics and Communication Engineering

VIIIth –Semester

S.No.	Course Code	Course Title	L	T	P	J	Cr	FM	Overall Pass Marks	Internal	External	Categorization
			Contact Hours per week									
01	ECEP801	Major Project/ Research Project/ Industrial Internship	36 Hours per week / week Total 12-16 Weeks			6	12	400	200	240	160	
Total			--	--	--		12	400	--	--	--	
Grand Total			--	--	--		12	400	--	--	--	

L: Lecture, T: Tutorial, P: Practical.

J- Self learning hours shall not be reflected in the Time table. Self-learning includes micro project/ assignment/ other activities as mentioned in earlier semester.

Semester- VIIth

PCCI-Computer Communication and Network Security

Course Code-

L:T:P-

Rationale

Course Outcomes

- Explain principles of application layer protocols
- Recognize transport layer services and infer UDP and TCP protocols
- Classify routers, IP and Routing Algorithms in network layer
- Understand the Wireless and Mobile Networks covering IEEE 802.11 Standard
- Describe Multimedia Networking and Network Management

Course Content:

Unit I

Application Layer: Principles of Network Applications: Network Application Architectures, Processes Communicating, Transport Services Available to Applications, Transport Services Provided by the Internet, Application-Layer Protocols. The Web and HTTP: Overview of HTTP, Non-persistent and Persistent Connections, HTTP Message Format, User-Server Interaction: Cookies, Web Caching, The Conditional GET, File Transfer: FTP Commands & Replies, Electronic Mail in the Internet: SMTP, Comparison with HTTP, Mail Message Format, Mail Access Protocols, DNS; The Internet's Directory Service: Services Provided by DNS, Overview of How DNS Works, DNS Records and Messages, Peer-to-Peer Applications: P2P File Distribution, Distributed Hash Tables, Socket Programming: creating Network Applications: Socket Programming with UDP, Socket Programming with TCP.

Unit II

Transport Layer : Introduction and Transport-Layer Services: Relationship Between Transport and Network Layers, Overview of the Transport Layer in the Internet, Multiplexing and Demultiplexing: Connectionless Transport: UDP,UDP Segment Structure, UDP Checksum, Principles of Reliable Data Transfer: Building a Reliable Data Transfer Protocol, Pipelined Reliable Data Transfer Protocols, Go-Back-N, Selective repeat, Connection-Oriented Transport TCP: The TCP Connection, TCP Segment Structure, RoundTrip Time Estimation and Timeout, Reliable Data Transfer, Flow Control, TCP Connection Management, Principles of Congestion Control: The Causes and the Costs of Congestion, Approaches to Congestion Control, Network-assisted congestion-control example, ATM ABR Congestion control, TCP Congestion Control: Fairness.

Unit III

The Network layer: What's Inside a Router?: Input Processing, Switching, Output Processing, Where Does Queuing Occur? Routing control plane, IPv6,A Brief foray into IP Security, Routing Algorithms: The Link-State (LS) Routing Algorithm, The Distance-Vector (DV) Routing Algorithm, Hierarchical Routing, Routing in the Internet, Intra-AS Routing in the

Internet: RIP, Intra-AS Routing in the Internet: OSPF, Inter/AS Routing: BGP, Broadcast Routing Algorithms and Multicast.

Unit IV

Network Security: Overview of Network Security: Elements of Network Security , Classification of Network Attacks , Security Methods , Symmetric-Key Cryptography : Data Encryption Standard (DES), Advanced Encryption Standard (AES) , Public-Key Cryptography : RSA Algorithm , Diffie-Hellman Key-Exchange Protocol , Authentication : Hash Function , Secure Hash Algorithm (SHA) , Digital Signatures , Firewalls and Packet Filtering , Packet Filtering , Proxy Server .

Unit V

Multimedia Networking: Properties of video, properties of Audio, Types of multimedia Network Applications, Streaming stored video: UDP Streaming, HTTP Streaming, Adaptive streaming and DASH, content distribution Networks Voice-over-IP : Limitations of the Best-Effort IP Service , Removing Jitter at the Receiver for Audio , Recovering from Packet Loss Protocols for Real-Time Conversational Applications , RTP , SIP

Textbooks:

1. . James F Kurose and Keith W Ross, Computer Networking, A Top-Down Approach, Sixth edition, Pearson, 2017 .
2. Nader F Mir, Computer and Communication Networks, 2nd Edition, Pearson, 2014.

Reference Books:

1. Behrouz A Forouzan, Data and Communications and Networking, Fifth Edition, McGraw Hill, Indian Edition
2. Larry L Peterson and Bruce S Davie, Computer Networks, fifth edition, ELSEVIER
3. Andrew S Tanenbaum, Computer Networks, fifth edition, Pearson
4. Mayank Dave, Computer Networks, Second edition, Cengage Learning

Professional Elective-V

1.Embedded Automotive Systems

Course Code-

L:T:P-

Rationale

Course Outcomes

At the end of the course, the student should be able to

CO1: understand the automotive architecture

CO2: understand the protocol functioning in the automotive network

CO3: understand the communication involved in automotive system

CO4: understand the software development process in automotive industry

Course Content:

Unit I

Automotive Architectures: Vehicle Functional Domains and Their Requirements- Functional Domains-Standardized Components, Models, and Processes- Certification Issue of Safety-Critical In-Vehicle Embedded Systems, Application of the AUTOSAR Standard: Motivation-Mainstay of AUTOSAR: AUTOSAR Architecture - Main Areas of AUTOSAR Standardization-Methodology and templates, Intelligent Vehicle Technologies: Introduction: Road Transport and Its Evolution, New Technologies, Dependability Issues, Fully Autonomous Car: Dream or Reality?.

Unit II

Embedded Communications: A Review of Embedded Automotive Protocols: Automotive Communication Systems- In- Car Embedded Networks- Middleware Layer- Open Issues for Automotive Communication Systems, FlexRay Protocol: Introduction- FlexRay Communication- FlexRay Protocol- FlexRay Application, Dependable Automotive CAN Networks: Introduction- Data Consistency Issues- CANcentrate and ReCANcentrate-CANELy- FTT-CAN: Flexible Time-Triggered Communication on CAN- FlexCAN: A Deterministic, Flexible, and Dependable Architecture for Automotive Networks

Unit III

Embedded Software and Development Processes: Product Lines in Automotive Electronics: Introduction- Characteristics of Automotive Product Lines- Basic Terminology- Global Coordination of Automotive Product-Line Variability- Artifact-Level Variability, Reuse of Software in Automotive Electronics: A Challenge for Automotive OEMs- Requirements-Supporting the Reuse of Application Software Components in Cars- application example

Textbook(s)

Nicolas Navet, Francoise Simonot-Lion, “Automotive Embedded Systems Handbook”, Industrial Information Technology Series, CRC Press, Taylor and Francis Group,

Reference(s)

1. Ronald K Jurgen : “Automotive Electronics Hand Book”, 2nd Edition , McGraw- Hill, 1999
2. James D Halderman: “Automotive Electricity and Electronics”, PHI Publication
3. Allan Bonnick: “Automotive Computer Controlled Systems Diagnostic Tools And Technology”.Elsevier Science, 2001

2.Real Time Operating Systems

Course Code-

L:T:P-

Rationale

Course Outcomes

At the end of the course, the student should be able to

CO1: understand the basic concepts in real time systems

CO2: understand the RTOS architecture and kernel service

CO3: analyze various real-time scheduling algorithms

CO4: design and develop real time applications using RTOS

Course Content:

Syllabus

Unit I

Overview of concepts of GPOS, GPOS functionalities, Evolution of operating systems. Introduction to real-time systems, RTOS basic architecture, RTOS vs. GPOS. Architecture of OS (Monolithic, Microkernel, Layered, Exokernel and Hybrid kernel structures). POSIX Standards. RTOS Kernel services.

Unit II

Task Management -tasks, process and threads, task attributes and types, preemption-context switching, task states and transition, task control block. Introduction to real-time task scheduling, clock-driven and priority-driven scheduling, uniprocessor scheduling algorithms- RM-response time analysis, DM, EDF-processor demand analysis, Least Laxity First (LLF), and introduction to multiprocessor scheduling concepts. Blocking, deadlock, priority inversion and solutions.

Unit III

Task Communication and Synchronization - Semaphores and Mutex, Mailbox, Queue, Pipes. Timer Management, Interrupt handling, Memory Management-Cache and virtual memory, Input-Output handling. Familiarization of Free RTOS – architecture, porting, Real time applications using RTOS.

Textbook(s)

1. Jane W.S. Liu, “Real -Time Systems”, First Edition, Pearson Education, 2000.
2. Cheng, A. M. K., “Real-Time Systems: Scheduling, Analysis, and Verification”, First Edition, Wiley, 2002.
3. Richard Barry, “Mastering the FreeRTOS™ Real Time Kernel A Hands-On Tutorial Guide”, First Edition, Real Time Engineers Ltd., 2016.

Reference(s)

1. Krishna, C. M., Shin, K. G., “Real-Time Systems”, First Edition, McGraw-Hill, 2017

3.FPGA based Embedded Systems

Course Code-

L:T:P-

Rationale

Course Outcomes

At the end of the course, the student should be able to

CO1: understand the architecture and specifications of FPGA

CO2: understand synthesizable HDL modeling of digital subsystems

CO3: understand the design flow of embedded systems including design of the data path, control unit subsystems and interpreting reports

CO4: develop block-based embedded system using FPGA resources and I/O inter

Course Content:

Unit I

Introduction to FPGAs – Design flow – Circuit Fabrics – LUTs and IO Blocks – FPGA Technology overview – Digital Design for FPGAs - High Level System Architecture and Specification: Behavioural modelling and simulation – Hardware description languages.

Unit II

FPGA based embedded design flow - Design of data path and controller subsystems – FIFOs - Memory controllers – DSP blocks – FPGA Block RAMs - Case Study of RTL Design for FPGAs – Interpreting Synthesis and Implementation reports of RTL Designs - Synthesis issues.

Unit III

FPGA processor fabrics and bus interfaces – ADC interface, DAC interface, I/O interfaces - Block-based design flow – System Level synthesis from high level languages - Case study of design of FPGA based embedded systems.

Textbooks/References

1. Michael D. Ciletti, “Advanced Digital Design with Verilog HDL”, Second Edition, Pearson Higher Education, 2011.
2. Stephen Brown and Zvonko Vranesic, “Fundamental of Digital Logic with VHDL Design”, Third Edition, McGraw Hill, 2009.
3. Samir Palnitkar, “Verilog HDL, A Guide to Digital Design and Synthesis”, Second Edition, Pearson Education, 2003.
4. Wayne Wolf, “FPGA-Based System Design”, Prentice Hall India Pvt. Ltd., 2005.

4.Smart Antennas and Adaptive Beamforming

Course Code-

L:T:P-

Rationale

Course Outcomes

At the end of the course, the student should be able to

CO1: study and design different types of antenna arrays

CO2: understand types of adaptive antenna systems

CO3: comprehend spatial diversity and radio receiver techniques for smart antennas

CO4: understand and analyse different beamforming algorithms

Course Content:

Unit I

Introduction to Smart Antennas: Antenna Fundamentals, Linear Antennas, Array Fundamentals, Linear Arrays, Two element array, Uniform N-element linear array, Uniform N-element linear array, Circular Arrays, Beam steered circular arrays, Rectangular Planar Arrays.

Unit II

Adaptive Antenna System, Adaptive Beam forming, Spatial Diversity, Diversity Combining, and Sectoring, Digital Radio Receiver Techniques and Software Radios for Smart Antennas.

Unit III

Angle-of-Arrival Estimation: AOA Estimation Methods, Bartlett AOA estimate, Capon AOA estimate, Linear prediction AOA estimate, Maximum entropy AOA estimate, MUSIC AOA estimate, Root-MUSIC AOA estimate, ESPRIT AOA estimate; AI/ML role in AOA estimation. Fixed Weight Beam forming Basics, Maximum signal-to-interference ratio, Maximum likelihood, Minimum variance, Adaptive Beam forming, Least mean squares, Recursive least squares, Constant modulus, Least squares constant modulus, Conjugate gradient method.

Textbook(s)

1. Constantine A. Balanis & Panayiotis I. Ioannides, "Introduction to Smart Antennas", Morgan & Claypool Publishers' series-2007.

References(s)

1. T. K. Sarkar, Michael C. Wicks, M. Salazar-Palma, Robert J. Bonneau, "Smart Antenna", John Wiley & Sons, 2005.

2. T.S Rappaport, "Smart Antennas Adaptive Arrays Algorithms and Wireless Position Location", IEEE press 1998, PTR – PH publishers 1999.

3. Lal Chand Godara, "Smart Antennas", CRC Press, LLC-20.

5. Computational Electromagnetics

Course Code-

L:T:P-

Rationale

Course Outcomes

At the end of the course, the student should be able to

CO1: understand the concept of computational electromagnetic techniques for modeling wireless communication devices

CO2: understand the concept of finite difference method and FDTD analysis techniques

CO3: comprehend finite element analysis and method of moment techniques

CO4: apply the computational methods for solving electromagnetics problems

Course Content:

Unit I

Classification of Electromagnetic Problems, Classification of methods of analysis, mathematical frame work, Overview of Computational methods, Analytical methods and orthogonal functions.

Unit II

Finite Difference Approximations, Treatment of Interface and Boundary Conditions, Finite Difference Analysis of Guiding Structures, Pulse Propagation in a Transmission Line, Finite Difference Time Domain (FDTD) Analysis in One-Dimension, Applications of One-Dimensional FDTD Analysis, FDTD Analysis in Two-Dimensions, FDTD Analysis in Three Dimensions, Implementation of Boundary Conditions in FDTD

Unit III

Basic Steps in finite element analysis, finite element method (FEM) analysis in one dimension, FEM analysis in two dimension. Eigenvalue Analysis using method of moments (MoM), Solution of Integral Equations using MoM, Fast Multipole Solution Methods for MoM, Comparison of FDM, FDTD, FEM and MoM, selected problems in electromagnetic using modern tools.

Textbook(s)

1. Peterson, A.F, Ray, S.L. and Mittra, R., "Computational Methods for Electromagnetics", Wiley-IEEE Press.
2. Matthew N.O. Sadiku, "Numerical Techniques in Electromagnetics with MATLAB", CRC Press, 2009.
3. Ramesh Garg, Analytical and Computational methods in Electromagnetics, Artech House, INC, 2008.

References(s)

1. Karl E. Lonngren, Sava V. Savov, Randy J. Jost, "Fundamentals of Electromagnetics with MATLAB", SciTech Publishing, Inc., 2007, Second Edition.
2. JaanKiusalaas, "Numerical Methods in Engineering with Python 3", Cambridge University Press, 2

6. RADAR Systems

Course Code-

L:T:P-

Rationale

Course Outcomes

At the end of the course, the student should be able to

CO1: understand system specifications of RADAR

CO2: understand architecture of different RADAR systems

CO3: understand the concepts of RADAR receivers

CO4: understand performance of RADAR systems under noise

Course Content:

Unit I

Introduction-Nature of Radar, Maximum Unambiguous Range, Radar Waveforms, Simple form of Radar Equation, Radar Block Diagram and Operation, Radar Frequencies and Applications, Radar Equation: Prediction of Range Performance, Minimum Detectable Signal, Receiver Noise and SNR, Integration of Radar Pulses, Radar Cross Section of Targets (simple targets - sphere, cone-sphere), Transmitter Power, PRF and Range Ambiguities.

Unit II

CW and Frequency Modulated Radar : Doppler Effect, CW Radar – Block Diagram, Isolation between Transmitter and Receiver, Non-zero IF Receiver, Receiver Bandwidth Requirements, Applications of CW radar. FM-CW Radar, Range and Doppler Measurement, Block Diagram and Characteristics (Approaching/ Receding Targets), FM-CW altimeter, Measurement Errors, Multiple Frequency CW Radar.

Unit III

MTI and Pulse Doppler Radar: Introduction, Principle, MTI Radar with - Power Amplifier Transmitter and Power Oscillator Transmitter, Delay Line Cancellers – Filter Characteristics, Blind Speeds, Double Cancellation, Staggered PRFs. Range Gated Doppler Filters. MTI Radar Parameters, Limitations to MTI Performance - Non-coherent MTI, MTI vs Pulse Doppler Radar; Radar Receivers : Matched Filter Receiver – Response Characteristics and Derivation, Correlation Function and Cross-correlation Receiver, Efficiency of Non-matched Filters, Matched Filter with Non-white Noise. Noise Figure and Noise Temperature. Displays – types. Duplexers – Branch type and Balanced type, Circulators as Duplexers. Introduction to Phased Array Antennas – Basic Concepts, Radiation Pattern, Beam Steering and Beam Width changes, Series versus Parallel Feeds, Applications, Advantages and Limitations.

Textbook(s)

1. Introduction to Radar Systems – Merrill I. Skolnik, 3rd edition, Tata McGraw-Hill, 2001.

Reference(s)

1. David K. Barton, Modern Radar System Analysis, Artech House, Inc., NY 1988.
2. Brookner E, Aspects of Modern Radar, Artech House, Inc., NY 1988

7. Remote Sensing Systems

Course Code-

L:T:P-

Rationale

Course Outcomes

At the end of the course, the student should be able to

CO1: understand fundamental principles of remote sensing

CO2: understand interaction of electromagnetic radiation with homogeneous and multi-layered medium

CO3: understand the working principles of different remote sensing systems

CO4: understand the remote sensing data processing

Course Content:

Unit I

Electromagnetics basis: Electromagnetic waves, Polarization, Spectra and Fourier transform, Doppler effect, Angular distribution of radiation, Thermal radiation, diffraction, Interactions of electromagnetic radiation: Propagation through homogeneous materials, Reflection and emission from real materials, Propagation through the atmosphere Molecular absorption and scattering, Radiative transfer equation

Unit II

Remote sensing system: Spectral Imagery, VIR imaging systems, Thermal infrared imagers, Passive Microwave Systems: Microwave Radiometry, Ranging Systems: Laser profiling, Radar altimetry

Unit III

Scattering Systems: LiDAR, Microwave Scatterometry, Synthetic Aperture Radar, Data Processing: Image Processing, Classification and Segmentation, Applications of Remote Sensing Systems; AI/ML role in radar image processing.

Textbook(s)

1. W. G. Rees, "Physical Principles of Remote Sensing", Cambridge University Press; 3rd edition, 2013.

References(s)

1. R. C. Olsen, "Remote Sensing from Air and Space", SPIE Press, 2007.

2. James B. Campbell, Randolph H. Wynne, "Introduction to Remote Sensing", 5th Edition, Guilford Press, 2011

8. Biomedical Applications of Radio Frequency Waves

Course Code-

L:T:P-

Rationale

Course Outcomes

At the end of the course, the student should be able to

CO1: understand the dielectric properties of biological tissues

CO2: comprehend how biological materials interact with electromagnetic fields

CO3: understand the thermal effects on biological tissues due to electromagnetic waves

CO4: understand RF system concepts for biomedical applications

Course Content:

Unit I

Introduction: Fundamentals of electromagnetics- Electromagnetics, RF/Microwave energy, Penetration in Biological tissues and skin effect, Dielectric measurements and exposure; Environmental electromagnetic field and Bio-systems

Unit II

Electromagnetic Interaction Mechanism in Biological Materials: Bioelectricity, Tissue characterization, Thermodynamics and energy, Biological Effects: Absorption – Fundamentals, Dosimetry and SAR, Thermal considerations.

Unit III

RF Systems for Therapeutic applications: transmission lines and waveguides for medical applications; antennas; RF/Microwave ablation, Perfusion chamber, Endometrial ablation, E. M. based method for measuring blood perfusion in heart muscle, Lumen measurements of arteries using RF equipments, RF tissue Welding, Principles of computerized Tomography (CT) scan equipment.

Textbook(s)

1. V. Vorst, A Rosen and Y Kotsuka, “RF/Microwave Interaction with Biological Tissues”, John Wiley & Sons

Reference(s)

1. J Malmivuo and R Plonsey, “Bioelectromagnetism - Principles and Applications of Bioelectric and Biomagnetic Fields”, New York, Oxford University Press
2. M. Gandolfo, “Biological Effects and Dosimetry of Nonionizing Radiation: Radio Frequency and Microwave Energies”, Springer.

9 RFID Systems

Course Code-

L:T:P-

Rationale

Course Outcomes

At the end of the course, the student should be able to

CO1: understand physical principles of RFID components

CO2: understand protocol standards used in RFID systems

CO2: understand system design and evaluation from component and network specifications

CO4: understand broad potential applications of RFID systems

Course Content:

Unit I

Introduction to RFID – Comparison with other identification systems – Operating and physical principles. Types of tags – Passive, active, semi-passive, security issues, memory capacity – Radio regulatory issues and frequency ranges.

Unit II

Communication principles, coding, modulation and demodulation – Data integrity multiple access procedures – Anticollision procedures – Security issues and solutions. Hardware architecture of Tags and readers – Transponder design – memory- Sensors. Reader RF interface-control unit – Middleware – Near field communications. Comparison of successful RFID standards.

Unit III

Case studies – Smart cards – Public transport – Payment systems – NFC Applications – Electronic passport – Ski Tickets – Access control – Online and offline Systems – Intelligent infrastructure – Healthcare management – Supply chain and transport systems – Container transport animal identification – Stock keeping – Product lifecycle monitoring – Industrial and medical applications.

Textbook(s)

1. M. Bolic, D. Simplot and I. Stojmenovic, “RFID Systems: Research Trends and Challenges”, 2010.
2. Klaus Finkenzeller, “RFID Handbook – Fundamentals and applications in contact less smart cards, radio frequency identification and near-field communication”, 3rd edition, Wiley 2010.

Reference(s)

1. Curty, Declercq, Dehollain and Joehl, “Design and Optimization of passive UHF RFID Systems”, Springer, 2007.

2. V.D. Daniel, A. Puglia and M. Puglia, "RFID: A Guide to Radio Frequency Identification", Wiley, 2007

Professional Elective-VI

1.Agent based Modeling

Course Code-

L:T:P-

Rationale

Course Outcomes

At the end of the course, the student should be able to

CO1: apply the concepts of data mining for designing a simple agent based model

CO2: analyze and formulate an agent-based solution

CO3: design a simple multi-agent system model to solve complex engineering problems

CO4: implement artificial agents using agent based modeling software

Course content:

Unit-I

Introduction to Agents – Features - Classification of agents. Multi Agent Systems (MAS) and properties – Agent communication ontology - Agent communication languages. Internal structure of MAS: Shell – Reasoning engine-MAS development methodology - Agent behavior - Agent action - Knowledge diffusion in MAS – Application level –behavior level and evolutionary agent communities.

Unit II

Data mining techniques for intelligent Agents - Association rule mining – A priori, DHP, DIC, κ -Profile- Clustering – Kmeans, PAM, EM, Classification- ID 3, C4.5, CLS, σ -FLNMap Evolutionary algorithms-Genetic Algorithm, Particle Swarm optimisation-Ant Colony Optimization.

Unit III

Applying data mining to agents - Study of available agent-based modeling software NetLogo- Implementation of agentbased models using NetLogo- Case studies - Application level - behavior level and evolutionary agent communities.

Textbook(s)

1. A. L. Symeonidis, P. A. Mitkas, “Agent Intelligence through Data Mining”, Springer, 2005.
2. Uri Wilensky, William Rand, “An Introduction to Agent-Based Modeling”, MIT Press, 2015.

Reference(s)

1. M. Mohammadian, “Intelligent Agents for Data Mining and Information Retrieval,” Idea Group Publishing, 2003

2. D. L. Poole, A. K. Mackworth, “Artificial Intelligence: Foundations of Computational Agents,” Cambridge University Press, 2010.

2. Software Defined Radio Architecture

Course Code-

L:T:P-

Rationale

Course Outcomes

At the end of the course, the student should be able to

CO1: understand baseband processing techniques including multi-rate systems

CO2: understand Multi-standard radio systems

CO3: understand the integration of baseband techniques with radio systems

CO4: analyze the performance of baseband techniques for SDR

Course Content:

Unit I

Introduction to wireless communication systems – Baseband signal processing – overview of wireless digital communication – Digital modulation and demodulations techniques: transmitter for complex PAM – symbol mapping – pulse shaping – wireless channel: source and channel coding schemes – channel impairments techniques: time and frequency offset corrections - Signal processing with passband signals – Multi-rate signal processing – down sampling – up sampling – polyphase structure – changing the sampling rate – Digital generation of signals – Analog to Digital (ADC) and Digital to Analog (DAC) conversion architectures.

Unit II

Software Communication Architecture: Operating environments - operating scenarios - general requirements and services – Devices and device manager - Hardware Architecture: General Purpose Processor (GPP) based SDR – FPGA based SDR – Multi-channel SDR – Software Centric SDR platform – RF front end architecture – Development tools – Digital hardware choices – Case studies: SPEAKeasy – Joint Tactical Radio Systems (JTRS) – Spectrumware.

Unit III

Applications of SDR: Cognitive Radio: architecture – Dynamic spectrum access – OpenBTS – OpenLTE – WiFi Transceiver – Zigbee Transceiver – Military communication – deep space communication – Video streaming applications – satellite signal reception – HAM radio communication – MIMO-OFDM communication system.

Textbook(s)

1. Bard, John, and Vincent J. Kovarik Jr. Software defined radio: the software communications architecture. John Wiley & Sons, 2007.
2. Reed, Jeffrey Hugh. Software radio: a modern approach to radio engineering. Prentice Hall Professional, 2002.

References(s)

- [1] www.gnuradio.org

[2] <https://in.mathworks.com/discovery/sdr.html>

[3] <https://www.ni.com>

3. Computer Vision

Course Code-

L:T:P-

Rationale

Course Outcomes

At the end of the course, the student should be able to

CO1: Understand the basics concepts of image formation models.

CO2: Understand the various feature extraction models.

CO3: Understand and apply the calibration and geometry models.

CO4: Use simulation tools to develop applications using computer vision techniques

Course Content :

Unit I

Image Formation: Geometric image formation, Photometric image formation - Camera Models and Calibration: Camera Projection Models – Orthographic, Affine, Perspective, Projective models. Projective Geometry, Transformation of 2D and 3D, Internal Parameters, Feature Detection and Matching – points and patches, edges, lines, Feature-Based Alignment - 2D, 3D feature based alignment, pose estimation, Image Stitching, Dense motion estimation – Optical flow - layered motion, parametric motion, Structure from Motion.

Unit II

Local Feature Detectors and Descriptors: Hessian corner detector, Harris Corner Detector, LOG detector, DOG detector, SIFT, PCA-SIFT, GLOH, SURF, HOG, Pyramidal HOG, PHOW-Calibration Methods: Linear, Direct, Indirect and Multiplane methods - Pose Estimation.

Unit III

Stereo and Multi-view Geometry: Epipolar Geometry, Rectification and Issues related to Stereo, General Stereo with E Matrix Estimation, Stratification for 2 Cameras, Extensions to Multiple Cameras, Self-Calibration with Multiple Cameras, 3D reconstruction of cameras and structures, Three View Geometry.

Textbook(s)

1. Forsyth and Ponce, “Computer Vision – A Modern Approach”, Second Edition, Prentice Hall, 2011.
2. Richard Szeliski, “Computer Vision: Algorithms and Applications”, Springer, 2011.

Reference(s)

1. Olivier Faugeras, “Three Dimensional Computer Vision”, MIT Press, 1993.
2. Emanuele Trucco and Alessandro Verri, “Introductory Techniques for 3-D Computer Vision”, Prentice Hall, 1998.

4. Biomedical Signal Processing Transmission

Course Code-

L:T:P-

Rationale

Course Outcomes

At the end of the course, the student should be able to

CO1: understand techniques for various levels of tasks in biomedical signal analysis

CO2: adopt appropriate algorithms according to the nature of the signal and acquisition characteristics

CO3: develop contemporary algorithms to address complex problems

CO4: implement biomedical signal processing algorithms using appropriate tools

Course Content:

Unit I

Introduction to Biomedical Signals- Action Potential and Its Generation- Origin and Waveform Characteristics of Basic Biomedical Signals - Electrocardiogram (ECG), Electroencephalogram (EEG), Electromyogram (EMG), Phonocardiogram (PCG), Electroneurogram (ENG), Event-Related Potentials (ERPS), Electrogastrogram (EGG)- Objectives of Biomedical Signal Analysis, Difficulties in Biomedical Signal Analysis, Computer-Aided Diagnosis

Unit II

Cardiological and Neurological signal Analysis-Data Acquisition- ECG signals -Basic electrocardiography, ECG lead systems, ECG signal characteristics- Filtering for Removal of Artifacts in ECG – Algorithms for QRS Detection – Morphological Analysis of ECG, Arrhythmia analysis-Heart sounds and Murmurs- Data acquisition -EEG Rhythms –Waves and Transients – Correlation Analysis of EEG Channels.

Unit III

Data Compression Techniques: Turning point algorithm, AZTEC algorithm, Fan algorithm, Huffman coding, data reduction algorithms; The Fourier transform, Correlation, Convolution, Power spectrum estimation, Frequency domain analysis of the ECG – Applications. – Adaptive noise canceller – cancellation of 50 Hz signal in ECG – Cancellation of maternal ECG in foetal electrocardiography– Muscle artifact (noise) Cancellation from EEG signals.

Textbook(s)

1. Rangaraj M Rangayyan “Biomedical Signal Analysis – A case study approach” IEEE press series in biomedical engineering, First Edition, 2002.
2. Willis J Tompkins, “Biomedical Digital Signal Processing”, Prentice Hall India Private Limited, First Edition, 2006.

Reference(s)

1. Reddy, D.C, "Biomedical signal processing: principles and techniques". McGraw-Hill, 2005
2. Begg R, Palaniswami M and Lai D T H, "Computational Intelligence in Biomedical Engineering", CRC Press, 2007.

5.Natural Language Processing

Course Code-

L:T:P-

Rationale

Course Outcomes

At the end of the course, the student should be able to

CO1: Generate word representation to solve NLP problems

CO2: Implement machine learning models for NLP

CO3: Implement sequence-to-sequence models for NLP

CO4: Assess NLP models using various evaluation metrics

Course Content:

Unit I

Computational linguistics- Introduction, syntax, semantics, morphology, collocation and other NLP problems. Word representation: One-hot encoding, Bag-of-Words (BoW) Dictionary: Term Frequency – Inverse Document Frequency (TFIDF), Embedding: Word2vec, Glove and Fasttext

Unit II

Language Model-n-gram, Sequences and sequential data: Part-of-Speech tagging-HMM and CRF, Named Entity Recognition, Dependency parsing. Evaluation metrics for NLP models- Precision, Recall, F score, ROUGE, BLEU scores and Visualization

Unit III

Machine learning and deep learning for NLP, Sequence to sequence modelling (Encoder decoder), Attention mechanism, Transformer Networks – BERT, A brief introduction to Reinforcement learning for NLP. NLP application introduction- Sentiment Analysis, Machine translation, Question Answering, Text summarization.

Textbook(s)

1. Christopher Manning and Hinrich Schütze, ‘Foundations of Statistical Natural Language Processing’, MIT press, 1999
2. Daniel Jurafsky, James H Martin, ‘Speech and language processing’ ,Prentice Hall, 2008

Reference(s)

1. Steven Bird, Ewan Klein and Edward Loper, ‘Natural Language Processing with Python’, O'Reilly Media, Inc.", 2009.
2. Douglas O'Shaughnessy, ‘Speech Communication’, University Press, 2001

6.AI in Speech Signal Processing

Course Code-

L:T:P-

Rationale

Course Outcomes

At the end of the course, the student should be able to

CO1: explain the acoustics of speech production and perception

CO2: differentiate the characteristics of different speech sounds

CO3: analyse the time-domain and frequency-domain features of the speech signal

CO4: realize various algorithms on AI-based speech modeling

Course Content:

Unit I

Overview of Speech Processing Systems, Speech Production, Speech Perception, Speech Signal Characteristics- Stationarity, Non-stationarity, Properties of speech sounds – Elements of language -Phonemes – Vowels – Consonants- Fricatives- Stops.

Unit II

Short-time processing of speech -Windows – Rectangular, Hamming, Hanning-Time Domain parameters: Pitch, Short-time energy of speech, Zero crossing rate, Autocorrelation - Frequency domain parameters: Feature extraction for speechprocessing: Short term Fourier transform –Mel frequency cepstral coefficients (MFCC), Linear Prediction Analysis

Unit III

Basic applications in speech modelling - Speech Recognition- Basic speech models- Hidden Markov models (HMM) for acoustic modelling, Observation probability and model parameters - HMM as probabilistic automata - Viterbi algorithm, Deep neural network models: RNN, LSTM, DBN used for speech modelling, Speech synthesis: Linguistic processing - Acoustic processing - Text preprocessing - Grapheme to phoneme conversion – Rule based and decision tree approaches - Syntactic prosodic analysis - Prosodic analysis - Speech signal modelling - Speaker recognition introduction – popular approaches-Applications for speech based AI

Textbook(s)

1. Thomas F Quatieri, 'Discrete Time Speech Signal Processing', Pearson Education Inc., 2004
2. L. Rabiner, R. W. Schafer, 'Theory and applications of digital speech processing', Pearson Education India,2010

Reference(s)

1. L. Rabiner, Biing-Hwang Juang and B. Yegnanarayana, 'Fundamentals of Speech Recognition', Pearson Education Inc, 2008.
2. Douglas O'Shaughnessy, 'Speech Communication', University Press, 2001

7. Image Processing

Course Code-

L:T:P-

Rationale

Course Outcomes

At the end of the course, the student should be able to

CO1: understand the basic mathematical concepts used in image processing.

CO2: analyze different techniques adapted for image enhancement in spatial and frequency domain.

CO3: understand different morphological operations on images.

CO4: implement various image processing techniques

Course Content:

Unit I

Image processing- Introduction- Different types of images- Visual perception, Image sensing and Acquisition, Quantization, Sampling, Revision of Mathematical concepts for image processing, Image negatives, Log transformations, Histogram processing, Spatial filter: smoothing and Sharpening, Discrete Fourier transform, properties of 2-D DFT, Image smoothing and Sharpening in Fourier domain, Image restoration- Inverse filter, Weiner filter, Constrained Least squares filter.

Unit II

Morphological Image Analysis: Erosion, Dilation, Opening, Closing, Hit or Miss transformation, Application of Morphological operations- Boundary detection, Region filling, Connected components, Convex hull, Shape thinning and thickening, Skeletonization, Edge Detection: Gradient and Laplacian based edge detection, Diffusion based edge detection: Isotropic and anisotropic diffusion.

Unit III

Image segmentation: Thresholding, region-based Morphological Watersheds, Bayesian-based image segmentation, Image Compression: Spatial and Temporal redundancy, Basic image compression models, compression standards, basic compression methods: Huffman coding, Run-length coding, Block transform coding, Predictive coding.

Textbook(s)

1. Rafael C Gonzalez and Richard E Woods, "Digital Image Processing", Pearson Education, New Delhi, 2009.
2. Anil K Jain, "Fundamentals of Digital Image Processing", Prentice Hall of India, New Delhi, 2010.

Reference(s)

1. William K Pratt, "Digital Image Processing", Wiley, 2010.

2. John W. Woods, "Multidimensional Signal, Image, and Video Processing and Coding", Academic Publisher, 2012.

8.Multirate Signal Processing and Wavelets

Course Code-

L:T:P-

Rationale

Course Outcomes

At the end of the course, the student should be able to

CO1: understand Time-frequency decomposition of signals

CO2: understand Multi-rate filtering and filter banks

CO3: understand Multi-resolution analysis and its connection to filter banks

CO4: demonstrate the applications of multi-rate signal processing and wavelets

Course Content:

Unit-I

Fundamentals of multi-rate digital signal processing, Up sampling, down sampling, interpolation, decimation, Polyphase decomposition, Multi-stage Interpolation and Decimation systems, Two-channel quadrature-mirror filter bank, Perfect reconstruction of two-channel FIR filter banks.

Unit-II

Introduction to wavelets, Vector Space-Functions and function spaces, Continuous-time Fourier Transforms, Short time Fourier transforms, the uncertainty principle and time-frequency tiling, Discrete wavelet transforms, Scaling and Wavelet Functions, Filter Banks- Legendre Polynomials – Recurrence Formula – Laplace’s Integral Formula – Design of Orthogonal Wavelet Systems.

Unit III

Bi-orthogonal Wavelet – Introduction to Lifting Scheme – Dealing with Signal Boundaries – Multi Wavelet – Frequency Domain Approach-Applications of Wavelets- Data Compression, De-noising, Edge Detection, Object Isolation, Audio Coding, Communication Applications, Channel Coding, Speckle Removal, Image Fusion, Filter Design, Image Compression, AI based compression technique.

Textbook(s)

1. P.P Vaidyanathan “Multi-rate systems and filter banks”, Prentice Hall India, 1993
2. Soman K. P. and Ramachandran K. I., “Insight into Wavelets from Theory to Practice”, Prentice Hall, third edition, 2010.

Reference(s)

1. J.G Proakis and D GManolakis. “Digital signal processing: principles algorithms and applications”, Pearson, 2014.

2. Stephane Mallat “A Wavelet Tour of Signal Processing: The Sparse Way”, Academic Press
Elsevier 200

9.Statistical Signal Processing

Course Code-

L:T:P-

Rationale

Course Outcomes

At the end of the course, the student should be able to

CO1: understand discrete-time random processes and various signal models

CO2: analyze and develop algorithms for linear filtering and adaptive filtering

CO3: understand spectral estimators and design solution for estimation problems

CO4: formulate and apply frequency estimation algorithms

Course Content:

Unit I

Random processes- Gaussian Processes-Stationary processes- Autocovariance and Autocorrelation matrices, - Ergodicity - White noise - Power spectrum, Autoregressive moving average processes- Signal Modeling - The Least Squares method - Autocorrelation method - Covariance method - Autoregressive moving average mode

Unit I

Optimum Signal Estimation-Linear Mean Square Error Estimation-Optimum FIR and IIR filters- Linear Prediction- Fundamentals of Order Recursive Algorithms- Order-Recursive Algorithms for Optimum FIR Filters- Levinson-Durbin Recursion- Lattice filters - Wiener filtering-Least Squares FIR Filter

Unit III

Spectrum Estimation: Nonparametric methods – Periodogram - Barlett's method - Welch's method, Blackman and Tukey method of smoothing periodogram. Parametric methods- Autoregressive spectrum estimation - Moving average spectrum estimation - Frequency estimation - Eigen decomposition of Autocorrelation matrix - Detection of Harmonic signals - Pisarenko's method - MUSIC algorithm.

Textbook(s)

1. D.G Manolakis, Vinay K Ingle, Stephen M Kogon, "Statistical and Adaptive Signal Processing: Spectral Estimation, Signal Modeling, Adaptive Filtering, and Array Processing", Artech House , 2005
2. Steven Kay, Fundamentals of Statistical Signal Processing, Vol I: Estimation Theory, Vol II: Detection Theory, Prentice Hall, 1993/1998.

Reference(s)

1. Boaz Porat, "Digital Processing of Random Signals: Theory and Methods", Dover Books on Electrical Engineering, First Ed. 2008
2. Monson H. Hayes, Statistical Digital Signal Processing and Modelling, John Wiley, 1996.

Professional Elective-VII

1.Adaptive Signal Processing

Course Code-

L:T:P-

Rationale

Course Outcomes

At the end of the course, the student should be able to

CO1: understand spectral estimators and design solution for estimation problems.

CO2: design filter to meet performance requirements derived from various real life applications

CO3: develop algorithms for the design of filters to track variations of non-stationary random process

CO4: demonstrate the applications of adaptive filters.

Course content:

Unit I

Discrete time stochastic processes - Power spectral density – properties- Autocorrelation and covariance structures of discrete time random processes- Eigen-analysis of autocorrelation matrices-Spectrum Estimation - Non-parametric methods - Estimators and its performance analysis - periodogram estimators - signal modeling - parameter estimation using Yule- Walker Method.

Unit II

Newton's method - Steepest descent method –Convergence analysis — Least Mean Square (LMS) filter– Convergence – Excess mean square error -Leaky LMS - Normalized LMS – Recursive least squares (RLS) algorithm for adaptive filtering of stationary process- Matrix inversion – Comparison with LMS – RLS for quasi-stationary signals- Exponentially weighted RLS- Sliding window RLS – RLS algorithm for array processing

Unit III

Kalman Filtering - Statistical filtering for non-stationary signals - Principles – Initialization and tracking – Scalar and vector Kalman filter – Extended Kalman filter algorithm- Unscented Kalman filter algorithm-Applications in signal processing – Adaptive equalization-Adaptive Noise Cancellation- Time varying channel estimation – Radar tracking.

Textbook(s)

1. Simon O. Haykin, “Adaptive Filter Theory”, 5 th Edition, Pearson Education Limited, 2014.
2. Dimitris G. Manolakis, Vinay K. Ingle, Stephen M. Kogon, “Statistical and Adaptive Signal Processing: Spectral Estimation, Signal Modeling, Adaptive Filtering, and Array Processing”, McGraw-Hill, 2005.

Reference(s)

1. Monson H.Hayes, "Statistical Digital Signal Processing and Modeling", John Wiley and Sons, Inc., Singapore, 2002.
2. Sopcles J. Orfanidis, "Optimum Signal Processing", McGraw Hill, 2007.

2.Digital Electronics

Course Code-

L:T:P-

Rationale

Course Outcomes

CO1:Design combinational and sequential digital circuits, represent logic functions in multiple forms understanding the advantages and disadvantages of each.

CO-2: Understanding of CMOS transistors to realize digital logic circuits, understand basic characteristics of logic gates.

CO-3: Understand the principle of operation and design of a wide range of electronic circuits and memories RAM and ROM.

CO4: Understand how convert signals from analog to digital and digital to analog
Understand how convert signals from analog to digital and digital to analog

Course Content:

Unit I

conversions, complements of numbers, weighted and non-weighted codes, error detecting and correcting codes. Boolean algebra, postulates and switching algebra, completely and incompletely specified switching functions, minimization of Boolean functions using Karnaugh map and Quine Mc-Cluskey methods- their limitations.

Unit II

Logic Families: Introduction to Logic Gates- AND, OR, Ex-OR, NAND, NOR, Characteristic parameters, TTL logic, CMOS logic families, Implementation of Basic gates using TTL & CMOS logic.

Combinational Logic: Principles and practices, Logic design of combinational circuits code conversion, parity generation and checking, multiplexers, de-multiplexers, encoders, decoders, buffers, tri-state buffers.

Unit III

Sequential Logic: Study of Flip-Flops (SR, JK, T, D, MS), FSM's, Counter, Universal shift registers, Full adders. RAM, ROM (Cell Structures and Organization on Chip)

Unit IV

Data Conversion & Study of IC's: Concepts of D/A conversion, A/D conversion using the basic circuits. Study of Basic Gate IC's –AND, NAND, OR, NOR, NOT, Ex-OR, Building Block IC's – MUX, Decoder, Adder, Flip-Flops (SR, JK, T, D, Master-Slave).

Text Books:

1. S Salivahanan, Linear Integrated Circuits TATA MC GrawHill.
2. Jain R.P, "Modern Digital Electronics", Tata Mc GrawHill, 2003, Third edition.
3. Floyd T.L., "Digital Fundamentals ", Prentice Hall, 2006, 9 th Edition.

Reference Books:

1. Anil K. Mani: Digital Electronics-Principles and Integrated Circuits, Wiley-India, 2007.
2. Herbert Taub, Schilling: Digital Integrated Electronics, TATA MC Graw Hill, 2008.

3. Principles of Communication Systems

Course Code-

L:T:P-

Rationale

Course Outcomes

CO1: Understand different modulation and demodulation schemes for analog communication

CO2: Design analog communication systems to meet desired application requirements

CO3: Evaluate fundamental communication system parameters, such as bandwidth, power, signal to quantization noise ratio etc.

CO4: Elucidate design trade-offs and performance of communications system

Course Content:

Unit I

Signal Analysis: Communication Process, Sources of Information, Communication Channels, Modulation Process, Types of Communication, Random Process, Gaussian Process, Correlation Function, Power Spectral Density.

Unit II

Noise Analysis: External Noise, Internal Noise, White Noise, Narrow Band Noise, Noise Figure, Noise Bandwidth, Noise Temperature.

Unit III

Amplitude (Linear) Modulation: Linear Modulation Schemes, Generation of AM, Envelope Detector, Coherent Detection.

Unit IV

Angle (Exponential) Modulation: Types of Angle Modulation, Relation between FM and PM, Narrow Band FM, Wideband FM, Principles of FM Demodulation.

Pulse Modulation: Sampling Process, PAM, PWM, PPM, Quantization, PCM, TDM, Digital Multiplexer Hierarchy.

Unit V

Information Theory: Uncertainty, Information, Entropy, Source Coding Theorem, Data Compaction, Mutual information, Channel Capacity, Information Capacity Theorem .

Text Books:

1. S. Haykin, Communication Systems, Fourth Edition, John Wiley & Sons, Singapore, 2001.
2. B.P. Lathi, Modern Digital & Analog Communication Systems, Oxford University Press, Chennai, 1998, 3rd Edn.

Reference Books:

1. Leon W.Couch II., Digital and Analog Communication Systems, Pearson Education inc., New Delhi, 2001, Sixth Edition.

2. A Bruce Carlson, PB Crilly, JC Rutledge, Communication Systems, MGH, New York, 2002, Fourth Edition.

4.Sensors and Instrumentation

Course Code-

L:T:P-

Rationale

Course Outcomes

CO1: Understand the working of different sensors and transducers

CO2: Understand various measurements using the sensors

CO3: Understand the components of a virtual instrumentation systems

CO4: Explore different data acquisition methods

Course Content:

Unit I

Sensors & Transducer: Definition, Classification & selection of sensors, Measurement of displacement using Potentiometer, LVDT & Optical Encoder, Proximity sensors: Inductive & Capacitive, Use of proximity sensor as accelerometer and vibration sensor, Flow Sensors: Ultrasonic & Laser, Level Sensors: Ultrasonic & Capacitive.

Unit II

Measurements: Principles of Measurement: Static Characteristics, Error in Measurement, Types of Static Error Measurement of force using strain gauge, Measurement of pressure using LVDT based diaphragm & piezoelectric sensor. Measurement of temperature using Thermistor, Thermocouple & RTD, Concept of thermal imaging, Measurement of position using Hall effect sensors.

Unit III

Virtual Instrumentation: Graphical programming techniques, Data types, Advantage of Virtual Instrumentation techniques, Concept of WHILE & FOR loops, Arrays, Clusters & graphs, Structures: Case, Sequence & Formula nodes, need of software-based instruments for industrial automation.

Unit IV

Data Acquisition Methods: Basic block diagram, Analog and Digital IO, Counters, Timers, Types of ADC: successive approximation and sigma-delta, Types of DAC: Weighted Resistor and R-2R Ladder type. HVAC and BAC Protocols.

Unit V

Intelligent Sensors: General Structure of smart sensors & its components, Characteristic of smart sensors: Self calibration, Self-testing & self-communicating, Application of smart sensors: Automatic robot control & automobile engine control. Actuators.

Text Books:

1. DVS Murthy, Transducers and Instrumentation, PHI, 2013 2nd Edition.
2. D Patranabis, Sensors and Transducers, PHI, 2013, 2nd Edition

3. S. Gupta, J.P. Gupta, PC interfacing for Data Acquisition & Process Control, Instrument Society of America, 1994, 2nd edition .
4. Gary Johnson / Lab VIEW Graphical Programing / McGraw Hill 1997, II Edition

Reference Books:

1. Arun K. Ghosh, Introduction to measurements and Instrumentation, PHI, 2012, 4th Edition.
2. A.D. Helfrick and W.D. Cooper, Modern Electronic Instrumentation & Measurement Techniques, PHI – 2001.
3. Hermann K.P. Neubert, “Instrument Transducers” 2012, Oxford University Press, 2012, 2nd Edition

4.GPU Architectures and Programming

Course Code-

L:T:P-

Rationale

Course Outcomes

CO1: Understand working proficiency with CUDA, algorithmic GPU programming and parallel computing

CO2: Comprehend with classic scientific computing algorithms and problems

CO3: Optimize GPU code and debug GPU code

CO4: Analyze architecture specific details like memory access coalescing, shared memory usage, GPU thread scheduling

Course Content:

Unit I

GPU architectures: Introduction to the ideas of parallelism and the GPU programming model
CPU vs GPU Parallelizing algorithms on paper, First CUDA program

Unit II

CUDA programming: Hardware of Graphics Processing Units and parallel communication patterns, Brief on GPU architecture, Basics of CUDA C, Floating point precision and support on GPUs

Unit III

Parallel primitives and algorithms on GPU: The CUDA programming language will be mastered while learning how to implement these algorithms., Matrix Operations, Stencil – Image Blurring, Filters, Gauss-Jacobi-Finite difference updates for PDEs, Histogram, binning 1, Reduce – Maximum and Minimum – Summation, Prefix-sum (Scan) Algorithm – Radix Sort, Generating Cumulative Distributions , Complex algorithms – N-body solutions

Unit IV

Optimizing GPU Applications: Coalesced Memory Transactions, Grid Blocks, Thread Blocks, domain decomposition, Asynchronous Kernels and Multistreaming Possible Items: Libraries on GPU, cuBLAS

Text Books:

1. GPUs for Graphics: OpenGL 4.0 Shading Language Cookbook, 2nd ed.
2. Jason Sanders, Edward Kandrot, CUDA by Example: An Introduction to General-Purpose GPU Programming, Publisher: Addison-Wesley Professional

5.Embedded Hardware Platforms and Programming

Course Code-

L:T:P-

Rationale

Course Outcomes

CO1 Understand the embedded system design challenges

CO2: Familiarize with the ARM processor architecture and programming

CO3: Understand the various communication interfaces and protocols

CO4: Explore the various hardware platforms for AI& ML applications

CO5: Develop the software drivers for embedded hardware components and communication protocols

Course Content:

Unit I

Introduction to Embedded Systems: Embedded systems Overview, Characteristics of embedded computing applications. Design Challenges, Common Design Metrics, Embedded systems Design flow. Processor Technology, IC Technology, Trade-offs.

Unit II

Introduction to ARM Processors: Introduction to ARM processors, Evolution of ARM processors, pipeline organization, ARM Processor cores and CPU cores. Introduction to ARM Cortex-M Processors, ARM Cortex-M4 processor 's architecture, Programmer's model, Special registers, Operation Modes, Memory map, Memory access attributes and overview of Interrupts and exceptions. Keil Microcontroller Development Kit for ARM, Typical program compilation flow, Sample arithmetic and logical assembly language programs

Unit III

Embedded Systems Interfacing: Serial Peripheral Interface (SPI), Inter-Integrated Circuit (I2C), RS-232, USB, CAN, IrDA, Bluetooth, Zigbee, AMBA bus protocols.

Unit IV

Embedded hardware platforms: Introduction and specifications of hardware SBC platforms for AI and ML applications: Raspberry Pi 4, Jetson Nano, Jetson Xavier NX, Jetson AGX Xavier, Google Coral, Rock Pi, Beagle Bone AI and PYNQ boards.

UnitV

Programming on Embedded hardware platforms: Board setup, installation of libraries, and application code development in Python, C and C++ on different embedded hardware platforms.

Text Books:

1. Joseph Yiu, The Definitive Guide to ARM Cortex-M3 and Cortex-M4 Processors, Newnes Publications; 2013, 3rd edition.
2. Ata Elahi-Trever Arjeski, ARM Assembly language with hardware experimentl, Springer Int. Publishing, 2015.

3. Santanu Chattopadhyaya, —Embedded System Desig, 2023, PHI, 2nd Edition.
4. Articles on Embedded hardware platforms and programming.

Reference Books:

1. Wrox, — Professional Embedded ARM Development
2. William hohl and Christoper Hinds, —ARM assembly language fundamentals and Techniques|CRC,2015, 2nd edition.

6. Machine Learning Algorithms and Applications

Course Code-

L:T:P-

Rationale

Course Outcomes

CO1: Design and implement machine learning solutions to regression, classification, and clustering problems

CO2: Appreciate the underlying mathematical relationships within and across Machine Learning algorithms and the paradigms of supervised and un-supervised learning

CO3: Apply the algorithms to a real-world problem, optimize the models learned and report on the expected accuracy that can be achieved by applying the models

CO4: Build and train deep neural networks and identify key architecture parameters

CO5: Implement deep learning algorithms and solve real-world problems

Course Content:

Unit I

Linear Regression: Basics of linear regression, its assumptions, limitations and industry applications. Least square based and Gradient Descent Based Regression, Multiple linear regression, Polynomial regression.

Unit II

Logistic Regression: Univariate and Multivariate Logistic Regression for classification ML. Implementation in Python, evaluation metrics and industry applications are covered.

Unit III

Classification Algorithms : classification algorithms, Naive Bayes: the basics of Bayes Theorem, Naive Bayes classifier and implementation in a Spam-Ham classifier, K-Nearest Neighbours Computational geometry; Voronoi Diagrams, Delaunay Triangulations, K-Nearest Neighbour algorithm; Wilson editing and triangulations

Unit IV

Support Vector Machine: the SVM algorithm, its working, kernels and implementation. , Tree Models: Basics of Tree models, their structure, splitting techniques, pruning and ensembles to form Random Forests are covered here.

Unit V

Unsupervised Learning-Clustering: Distance measures, Different clustering methods (Distance, Density, Hierarchical), Iterative distance-based clustering; K-Means Clustering Algorithm and Image Quantization, basics of Principal Component Analysis its working and implementation in Python.

Unit VI

Introduction to Neural Networks: The Intuition of Neural Networks, Activation Functions in Neural Networks, Fully Connected Layer and Back Propagation, Image Classification, Loss Functions, Optimization and Regularization: Overfitting and Capacity, Cross Validation, Feature, Selection, Regularization, Hyperparameters

Convolutional Neural Networks: The CNN, its structure, layers and working. Implementation of CNN using Keras, Image classification and hyper-parameter tuning

Learning Resources:

Text Books:

1. Christopher Bishop, Pattern Recognition and Machine Learning, Springer 2006
2. M.Gopal, Applied Machine Learning, Mc Graw Hill education, 2018

Reference Books:

1. Gareth James, Daniel

Open Elective-II

Wireless Communications- 5G Use Cases

Course Code-

L:T:P-

Rationale

Course Outcome

By the end of this course, students will be able to:

CO1: Explain the evolution of wireless technologies from 1G to 5G and identify the requirements and use cases of 5G communication systems.

CO2: Analyze the radio access technologies, spectrum utilization, propagation characteristics, and advanced antenna techniques used in 5G.

CO3: Describe the 5G core network architecture, protocols, network slicing, and edge/cloud integration for supporting diverse applications.

CO4: Evaluate 5G deployment models and apply knowledge of 5G to practical use cases such as smart cities, autonomous vehicles, healthcare, and IoT.

CO5: Assess challenges, security concerns, and explore future research directions in Beyond 5G (B5G) and 6G communication systems.

Unit I

Introduction to Wireless Communications – Evolution from 1G to 5G, Key requirements of 5G, 5G Architecture: gNodeB, 5G Core, RAN, Edge and Cloud, Fundamental 5G Use Cases: Enhanced Mobile Broadband (eMBB), Ultra-Reliable Low Latency Communications (URLLC), Massive Machine Type Communications (mMTC), Application Scenarios: Industry 4.0, Smart Cities, Healthcare, Autonomous Vehicles, IoT.

Unit II

5G New Radio (NR) – Frame structure, numerology, subcarrier spacing, carriers, bandwidth parts (BWP), Spectrum for 5G: Sub-6 GHz, mmWave and their challenges, Propagation models, Path loss, fading and Doppler effects in 5G, Massive MIMO, Beamforming and Small Cell deployment strategies.

Unit III

5G Core Network – Service-based architecture, Control plane and User plane separation, Protocols in 5G, Mobile Edge Computing (MEC), Cloud RAN (C-RAN), Network Slicing:

Architecture, Management and Applications, Quality of Service (QoS), Latency and Reliability considerations.

Unit IV

Deployment Models and Use Case Implementations – Urban, Dense Urban, Rural, Indoor and High-mobility deployments, Smart Factory and Industry 4.0, V2X and Autonomous Driving, Remote Healthcare and Telemedicine, Smart Home and Building Automation, IoT sensor networks, Performance metrics: throughput, spectral efficiency, latency, reliability, mobility support.

Unit V

Challenges, Security and Future Trends – Coverage and capacity trade-offs, Spectrum allocation and regulatory issues, Energy efficiency, Interference management, Security concerns in 5G: privacy, signalling attacks, edge and slice security, Future directions: Beyond 5G (B5G) and 6G, AI/ML in wireless communications, Reconfigurable Intelligent Surfaces (RIS), Terahertz communication and Integrated Sensing and Communication (ISAC).

Textbooks

1. T.S. Rappaport, Y. Xing, G.R. MacCartney, A.F. Molisch, E. Mellios and J. Zhang – *Wireless Communications: Principles and Practice (5G & Beyond)*, Pearson, 2nd Edition, 2021.
2. Afif Osseiran, José F. Monserrat, Patrick Marsch – *5G Mobile and Wireless Communications Technology*, Cambridge University Press, 2016.
3. S. Kumar, P. Garg – *5G NR: Architecture, Technology, Implementation and Operation of 3GPP New Radio Standards*, McGraw Hill Education, 2021.

References

1. Theodore S. Rappaport – *Wireless Communications: Principles and Practice*, Pearson Education, 2nd Edition, 2010.
2. Erik Dahlman, Stefan Parkvall, and Johan Sköld – *5G NR: The Next Generation Wireless Access Technology*, Academic Press, 2018.
3. Amitabha Ghosh, Rapeepat Ratasuk – *Essentials of LTE and LTE-A*, Cambridge University Press, 2014 (for transition to 5G understanding).
4. ITU & 3GPP Technical Specifications on 5G NR and 5G Core (for advanced study and research references).

5. F. Boccardi, R.W. Heath Jr., A. Lozano, T.L. Marzetta, and P. Popovski – “Five Disruptive Technology Directions for 5G,” *IEEE Communications Magazine*, Feb. 2014.

Telecom Switching

Course Code-

L:T:P-

Rationale

Course Outcome

By the end of this course, students will be able to:

CO1: Explain the fundamentals and evolution of telecommunication switching systems from electromechanical to digital.

CO2: Analyze the architecture and operation of circuit switching, crossbar, SPC, and digital switching systems.

CO3: Apply concepts of time and space switching, multiplexing, and blocking probability in designing switching networks.

CO4: Interpret signaling techniques and protocols including SS7, SIP, and VoIP signaling in telecommunication networks.

CO5: Evaluate modern switching technologies such as softswitches, IMS, MPLS, and switching in NGN/5G environments.

Unit I

Introduction to Telecommunication Systems: Evolution of telecommunications, Overview of switching systems, Circuit switching vs. Packet switching, Basics of analog and digital exchanges, Switching hierarchy and signaling concepts.

Unit II

Telephony Switching Systems: Strowger (step-by-step) system, Crossbar switching system – architecture and working, Electronic switching systems, Stored Program Control (SPC) exchanges, Reliability and availability considerations.

Unit III

Digital Switching: Digital transmission and multiplexing, Time-division multiplexing (TDM) and space-division switching, Time-space-time (TST) architecture, Digital cross-connect systems (DCS), Switching network design and blocking probability.

Unit IV

Signaling Systems: Signaling techniques – in-channel, common channel signaling (CCS), CCS7/SS7 protocol stack, Call setup, routing and teardown, Numbering and addressing, Signaling in mobile and VoIP systems, Next-generation signaling protocols (SIP, H.323).

Unit V

Modern Switching and Networks: Softswitch architecture, IP Multimedia Subsystem (IMS), Next Generation Networks (NGN), ATM switching, MPLS and packet-based switching, Telecom switching in 4G/5G networks, Cloud and virtualized switching, Trends in telecom switching.

Textbooks

1. Thiagarajan Viswanathan – *Telecommunication Switching Systems and Networks*, PHI Learning.
2. J.E. Flood – *Telecommunications Switching, Traffic and Networks*, Pearson Education.
3. Syed Riffat Hayat – *Telecommunication Switching and Networks*, McGraw Hill Education.

References

1. A. Ghosh and R. Mallik – *Telecommunication Switching and Networks*, Prentice Hall.
2. J. Bellamy – *Digital Telephony*, Wiley, 3rd Edition.
3. William Stallings – *ISDN and Broadband ISDN with Frame Relay and ATM*, Pearson.
4. ITU-T Recommendations on SS7 and NGN.
5. M. Naghshineh and M. Schwartz – “Distributed Call Admission Control for QoS in Wireless Networks,” *IEEE Journal on Selected Areas in Communications*.

3 Speech Processing

Course Code-

L:T:P-

Rationale

Course Outcome

By the end of this course, students will be able to:

CO1: Explain the fundamentals of speech production, perception, and acoustic characteristics of speech signals.

CO2: Apply short-time analysis and spectral techniques for feature extraction from speech signals.

CO3: Compare and implement different speech coding and compression techniques for efficient transmission.

CO4: Design basic speech recognition and synthesis systems using classical and statistical models.

CO5: Analyze advanced applications of speech processing including speaker recognition, speech enhancement, and AI-driven speech technologies

Unit I

Introduction to Speech Processing: Nature of speech signal, Speech production mechanism – articulatory and acoustic phonetics, Acoustic theory of speech production, Speech sounds and phonemes, Time and frequency domain representation of speech, Speech signal characteristics – pitch, formants, harmonics.

Unit II

Speech Analysis Techniques: Short-time energy, zero-crossing rate, short-time Fourier analysis, Linear Predictive Coding (LPC), Cepstral analysis, Mel-frequency cepstral coefficients (MFCC), Perceptual Linear Prediction (PLP), Speech feature extraction methods.

Unit III

Speech Coding and Compression: Speech coding principles, Waveform coding (PCM, ADPCM, DM), Vocoders (channel, formant and LPC vocoders), CELP coding, Speech compression standards (G.711, G.729, AMR).

Unit IV

Speech Recognition and Synthesis: Automatic Speech Recognition (ASR) – template matching, Dynamic Time Warping (DTW), Hidden Markov Models (HMM), Neural network-based ASR, Speech synthesis – formant synthesis, concatenative synthesis, text-to-speech systems (TTS), Evaluation metrics.

Unit V

Applications and Advanced Topics: Speaker recognition – identification and verification, Emotion recognition from speech, Speech enhancement – noise reduction, echo cancellation, Beamforming and microphone arrays, Applications in voice assistants, biometrics, healthcare, human-computer interaction, Recent trends in deep learning for speech processing.

Textbooks

1. Lawrence Rabiner and Ronald Schafer – *Digital Processing of Speech Signals*, Pearson Education.
2. Thomas F. Quatieri – *Discrete-Time Speech Signal Processing: Principles and Practice*, Pearson.
3. Ben Gold, Nelson Morgan, and Dan Ellis – *Speech and Audio Signal Processing*, Wiley.

References

1. Xuedong Huang, Alex Acero, and Hsiao-Wuen Hon – *Spoken Language Processing: A Guide to Theory, Algorithm, and System Development*, Prentice Hall.
2. Sadaoki Furui – *Digital Speech Processing, Synthesis, and Recognition*, CRC Press.
3. Ian McLoughlin – *Applied Speech and Audio Processing with Matlab Examples*, Cambridge University Press.
4. IEEE Transactions on Audio, Speech, and Language Processing (for research papers).
5. ITU/3GPP standards for speech coding (G.711, G.729, AMR).

Optimization Techniques

Course Outcomes (COs)

By the end of this course, students will be able to:

CO1: Explain the fundamentals of optimization problems, their classifications, and applications in engineering and science.

CO2: Formulate and solve linear programming problems using graphical and simplex methods.

CO3: Apply unconstrained and constrained nonlinear optimization techniques to practical problems.

CO4: Analyze and implement dynamic programming and integer programming approaches for discrete optimization.

CO5: Evaluate advanced optimization methods such as evolutionary algorithms, stochastic search, and multi-objective optimization for real-world problems.

Course Content (Syllabus in 5 Units)

Unit I

Introduction: Definition of optimization, Classification of optimization problems, Applications of optimization in engineering, science, and industry, Classical optimization techniques, Single and multivariable optimization without constraints, Optimality criteria.

Unit II

Linear Programming (LP): Formulation of LP problems, Graphical solution, Simplex method, Big-M method, Two-phase method, Duality in LP, Dual simplex method, Sensitivity analysis, Applications of LP.

Unit III

Nonlinear Programming (NLP): Unconstrained optimization – Gradient methods, Newton's method, Conjugate gradient method; Constrained optimization – Lagrangian method, Karush-Kuhn-Tucker (KKT) conditions, Penalty and barrier methods.

Unit IV

Dynamic Programming (DP) and Integer Programming (IP): Bellman's principle of optimality, Recursive equations, Applications of DP to shortest path, resource allocation, and scheduling problems; Integer programming – branch and bound method, cutting plane method, applications.

Unit V

Advanced Optimization Techniques: Evolutionary algorithms – Genetic Algorithms, Particle Swarm Optimization, Ant Colony Optimization; Simulated Annealing; Multi-objective optimization; Recent trends and applications in machine learning, civil, electrical, and environmental engineering.

References

Textbooks

S.S. Rao – Engineering Optimization: Theory and Practice, New Age International, 4th Edition.

Hamdy A. Taha – Operations Research: An Introduction, Pearson, 10th Edition.

Kalyanmoy Deb – Optimization for Engineering Design: Algorithms and Examples, PHI Learning.

Additional References

Singiresu S. Rao – Optimization Theory and Applications, Wiley Eastern.

Edwin K.P. Chong, Stanislaw H. Zak – An Introduction to Optimization, Wiley, 4th Edition.

Ravindran, Phillips, and Solberg – Operations Research: Principles and Practice, Wiley.

Belegundu, A.D. and Chandrupatla, T.R. – Optimization Concepts and Applications in Engineering, Cambridge University Press.

CAD for IC Design

Course Outcomes (COs)

By the end of this course, students will be able to:

CO1: Explain the fundamentals of CAD tools and their role in IC design and VLSI systems.

CO2: Apply simulation and synthesis techniques for digital and analog IC design.

CO3: Analyze algorithms for partitioning, floorplanning, placement, and routing in physical design.

CO4: Evaluate CAD methodologies for timing analysis, power optimization, and verification of ICs.

CO5: Demonstrate use of CAD tools for IC design through case studies and understand trends in EDA (Electronic Design Automation).

Course Content

Unit I

Introduction to CAD for VLSI: Need for CAD tools in IC design, VLSI design flow, Design styles (full-custom, semi-custom, standard cell, FPGA, SoC), Overview of CAD tools: front-end and back-end design.

Unit II

Logic and Circuit Simulation: Switch-level and gate-level simulation, Timing simulation, Delay models, Logic synthesis, Technology mapping, Circuit simulation methods – SPICE, mixed-signal simulation, Event-driven simulation.

Unit III

Physical Design Automation: Partitioning – Kernighan–Lin algorithm, floorplanning, Placement techniques – min-cut, simulated annealing, force-directed placement; Routing – global routing, channel routing, switchbox routing; Clock tree synthesis.

Unit IV

Design Verification and Testability: Design rule checking (DRC), Layout versus schematic (LVS) verification, Timing verification, Static timing analysis, Fault models, Automatic Test Pattern Generation (ATPG), Built-in self-test (BIST), Design for Testability (DFT).

Unit V

Advanced Topics in CAD: Power optimization techniques, Low-power design methodologies, Signal integrity, Electromigration, EDA tools for FPGA and SoC design, Hardware description languages (VHDL/Verilog) in CAD flow, Current trends in EDA and CAD applications in emerging technologies.

Textbooks

1. S. M. Sait and H. Youssef – *VLSI Physical Design Automation: Theory and Practice*, World Scientific.
2. N. Weste, D. Harris, and A. Banerjee – *CMOS VLSI Design: A Circuits and Systems Perspective*, Pearson.
3. M. Sarrafzadeh and C.K. Wong – *An Introduction to VLSI Physical Design*, McGraw-Hill.

References

1. C. L. Liu – *Elements of VLSI Design*, Tata McGraw-Hill.
2. Wayne Wolf – *Modern VLSI Design: IP-Based Design*, Pearson.
3. John P. Uyemura – *Introduction to VLSI Circuits and Systems*, Wiley.
4. IEEE Transactions on CAD of Integrated Circuits and Systems (for research references).
5. Tutorials and user manuals of EDA tools (Cadence, Synopsys, Mentor Graphics).

Cloud based Technologies

Course Outcomes (COs)

By the end of this course, students will be able to:

CO1: Explain the fundamentals of cloud computing, service models, and deployment architectures.

CO2: Apply virtualization technologies and resource management techniques for cloud infrastructure.

CO3: Analyze cloud platforms and services such as AWS, Microsoft Azure, and Google Cloud.

CO4: Evaluate issues of security, privacy, and compliance in cloud environments.

CO5: Demonstrate cloud application development and deployment using modern tools and frameworks.

Course Content (5 Units)

Unit I – Introduction to Cloud Computing

Definition and characteristics of cloud computing, Evolution of cloud computing, Service models (IaaS, PaaS, SaaS), Deployment models (public, private, hybrid, community), Cloud architecture, Advantages and challenges of cloud adoption.

Unit II – Virtualization and Cloud Infrastructure

Virtualization concepts – machine, storage, and network virtualization; Hypervisors – types and examples; Resource management; Data centers and cloud infrastructure; Cloud resource provisioning and elasticity.

Unit III – Cloud Services and Platforms

Overview of cloud service providers – Amazon Web Services (AWS), Microsoft Azure, Google Cloud Platform; Cloud storage systems; Cloud databases; Serverless computing and Function-as-a-Service (FaaS); Containerization (Docker, Kubernetes).

Unit IV – Cloud Security and Management

Cloud security fundamentals – identity and access management, authentication, authorization; Threats and vulnerabilities; Encryption and key management; Privacy and compliance (GDPR, HIPAA); Service Level Agreements (SLAs); Monitoring and performance management.

Unit V – Emerging Trends and Applications

Edge and fog computing; Cloud-native development and microservices; Big data analytics on cloud; AI/ML in cloud; Internet of Things (IoT) integration with cloud; Case studies of cloud applications in business, healthcare, and scientific research.

Textbooks

1. Rajkumar Buyya, James Broberg, Andrzej Goscinski – *Cloud Computing: Principles and Paradigms*, Wiley.
2. Kai Hwang, Geoffrey C. Fox, Jack J. Dongarra – *Distributed and Cloud Computing: From Parallel Processing to the Internet of Things*, Morgan Kaufmann.
3. Thomas Erl – *Cloud Computing: Concepts, Technology & Architecture*, Pearson.

References

1. Ronald L. Krutz, Russell Dean Vines – *Cloud Security: A Comprehensive Guide to Secure Cloud Computing*, Wiley.
2. Arshdeep Bahga, Vijay Madisetti – *Cloud Computing: A Hands-On Approach*, Universities Press.
3. Michael Miller – *Cloud Computing: Web-Based Applications That Change the Way You Work and Collaborate Online*, Pearson.
4. Online Documentation of AWS, Microsoft Azure, Google Cloud.
5. Research papers from IEEE Transactions on Cloud Computing.

Adhoc Networks

Course Outcomes (COs)

By the end of this course, students will be able to:

CO1: Describe the fundamentals, characteristics, and architectures of Adhoc networks.

CO2: Analyze medium access control (MAC) protocols and routing strategies in Adhoc environments.

CO3: Evaluate transport layer and security issues in Adhoc networks.

CO4: Apply knowledge of energy management, QoS, and cross-layer design in different Adhoc scenarios.

CO5: Explore applications of MANETs, VANETs, and WSNs in real-world domains.

Course Content (5 Units)

Unit I – Introduction to Adhoc Networks

Definition and characteristics of Adhoc networks; Comparison with cellular and infrastructure-based networks; Types of Adhoc networks – MANETs, VANETs, WSNs; Design challenges and applications.

Unit II – MAC Protocols for Adhoc Networks

Issues in designing a MAC protocol for Adhoc networks; Classification of MAC protocols – contention-based, contention-free, hybrid protocols; Examples: IEEE 802.11, CSMA/CA, MACA, MACAW; Performance considerations.

Unit III – Routing Protocols

Routing challenges in Adhoc networks; Proactive routing protocols (DSDV, OLSR), Reactive routing protocols (AODV, DSR, TORA), Hybrid routing protocols (ZRP); Position-based routing; QoS-aware routing.

Unit IV – Transport Layer and Security

Transport layer issues in Adhoc networks; TCP over Adhoc; Congestion and flow control; Security issues in Adhoc networks – attacks (black hole, wormhole, sybil, DoS), key management, authentication; Security solutions and intrusion detection systems.

Unit V – Advanced Topics and Applications

Energy management in Adhoc networks; Cross-layer design; QoS support; Applications – disaster recovery, military communication, vehicular networks, IoT and sensor networks; Future research trends in Adhoc and mesh networking.

Textbooks

1. C. Siva Ram Murthy, B.S. Manoj – *Ad Hoc Wireless Networks: Architectures and Protocols*, Pearson.
2. Charles E. Perkins – *Ad Hoc Networking*, Addison-Wesley.
3. Stefano Basagni, Marco Conti, Silvia Giordano, Ivan Stojmenovic – *Mobile Ad Hoc Networking: Cutting Edge Directions*, Wiley.

References

1. Mohammad Ilyas – *The Handbook of Ad Hoc Wireless Networks*, CRC Press.
2. George Aggelou – *Mobile Ad Hoc Networks: From Wireless LANs to 4G Networks*, McGraw Hill.
3. IEEE Journals: *IEEE Transactions on Mobile Computing*, *IEEE Transactions on Wireless Communications*.
4. Research articles from ACM SIGMOBILE.

Biomedical Instrumentation and Signal Processing

Course Outcomes (COs)

By the end of this course, students will be able to:

CO1: Understand the principles of biomedical instrumentation and physiological measurements.

CO2: Apply knowledge of transducers, electrodes, and biosensors for bio-signal acquisition.

CO3: Analyze biomedical signals using digital signal processing techniques.

CO4: Evaluate biomedical devices for diagnostics, monitoring, and therapeutic applications.

CO5: Explore emerging biomedical technologies such as imaging, wearable devices, and telemedicine.

Course Content (5 Units)

Unit I – Introduction to Biomedical Instrumentation

Overview of biomedical engineering and instrumentation; Bioelectric signals – ECG, EEG, EMG, EOG; Physiological systems of the body; Generalized medical instrumentation system; Classification of biomedical instruments; Characteristics of biomedical signals.

Unit II – Biomedical Sensors and Transducers

Biopotential electrodes – surface, needle, microelectrodes; Sensors for pressure, temperature, blood flow, respiration; Optical and chemical biosensors; Smart sensors; Noise and interference in biomedical measurements.

Unit III – Signal Acquisition and Conditioning

Instrumentation amplifiers, isolation amplifiers; Filters – low-pass, high-pass, band-pass, notch; Analog-to-digital conversion; Data acquisition systems (DAQ); Sampling theorem and aliasing; Real-time acquisition of biomedical signals.

Unit IV – Biomedical Signal Processing

Introduction to digital signal processing of bio-signals; Time-domain and frequency-domain analysis; Fourier Transform, Power Spectral Density (PSD); Digital filters – FIR, IIR; Adaptive filters; Feature extraction from ECG, EEG, EMG; Noise removal techniques.

Unit V – Applications and Emerging Trends

Medical imaging systems – X-ray, CT, MRI, Ultrasound, PET; Biomedical devices – pacemakers, defibrillators, dialysis machines; Wearable health monitoring systems; Telemedicine and IoT in healthcare; Recent advances in biomedical signal analysis (AI/ML applications).

Textbooks

1. R.S. Khandpur – *Handbook of Biomedical Instrumentation*, McGraw Hill.
2. Leslie Cromwell, Fred J. Weibell, Erich A. Pfeiffer – *Biomedical Instrumentation and Measurements*, Pearson.
3. Rangaraj M. Rangayyan – *Biomedical Signal Analysis: A Case Study Approach*, Wiley.

References

1. John G. Webster – *Medical Instrumentation: Application and Design*, Wiley.
2. D.C. Reddy – *Biomedical Signal Processing: Principles and Techniques*, McGraw Hill.
3. Willis J. Tompkins – *Biomedical Digital Signal Processing*, Prentice Hall.
4. IEEE Transactions on Biomedical Engineering, IEEE Transactions on Medical Imaging.
5. Latest research from Elsevier – *Biomedical Signal Processing and Control*.

IPR & Cyber Laws

Course Outcomes (COs)

By the end of this course, students will be able to:

CO1: Explain the fundamentals and importance of Intellectual Property Rights in innovation and research.

CO2: Differentiate between patents, copyrights, trademarks, geographical indications, and trade secrets.

CO3: Analyze cyber laws, IT Act provisions, and their role in preventing cybercrimes.

CO4: Evaluate ethical and legal issues in digital transactions, e-commerce, and data protection.

CO5: Apply IPR and cyber law knowledge to case studies, research, and industry practices.

Course Content (5 Units)

Unit I – Introduction to IPR

Definition, scope, and importance of IPR; Categories of IPR; International frameworks (WIPO, WTO-TRIPS); Role of IPR in R&D and innovation; Case studies of IPR in science and technology.

Unit II – Patents and Related Rights

Concept of patents, patentable and non-patentable inventions; Patent application process in India; PCT (Patent Cooperation Treaty); Rights and obligations of patent holders; Infringement and remedies; Case laws on patents.

Unit III – Copyrights, Trademarks, and Other IPs

Copyright: definition, rights, ownership, duration, infringement; Trademarks: types, registration, rights, infringement; Geographical Indications (GIs); Industrial designs; Trade secrets and unfair competition.

Unit IV – Cyber Laws and IT Act

Overview of cyber law in India; IT Act 2000 and amendments; Legal recognition of electronic documents; Digital signature and e-governance; Cybercrime and offenses (hacking, phishing, identity theft, cyberstalking, ransomware); Role of CERT-In.

Unit V – Emerging Issues and Case Studies

Data protection and privacy laws (GDPR, Indian Personal Data Protection Bill); Cybersecurity frameworks; Intellectual property in digital media and software; E-commerce and digital contracts; Case studies on cybercrimes, plagiarism, and digital piracy.

Textbooks

1. Deborah E. Bouchoux – *Intellectual Property: The Law of Trademarks, Copyrights, Patents, and Trade Secrets*, Cengage.
2. V.K. Ahuja – *Law Relating to Intellectual Property Rights*, LexisNexis.
3. Vakul Sharma – *Information Technology Law and Practice*, Universal Law Publishing.

References

1. P. Narayanan – *Intellectual Property Law*, Eastern Law House.
2. Rodney D. Ryder – *Guide to Cyber Laws*, Wadhwa & Co.
3. Arun Bhansali – *Cyber Laws Simplified*, McGraw Hill.
4. Justice Yatindra Singh – *Cyber Laws*, Universal Law Publishing.
5. Journals: *Journal of Intellectual Property Rights (CSIR-NIScPR)*, *Indian Journal of Law and Technology*.

Communication Systems

Course Outcomes (COs)

By the end of this course, students will be able to:

CO1: Explain the fundamental principles and components of communication systems.

CO2: Analyze different types of analog modulation and demodulation techniques.

CO3: Apply digital modulation and coding techniques for data transmission.

CO4: Evaluate the impact of noise and channel impairments on communication systems.

CO5: Explore modern communication technologies such as optical, satellite, and wireless systems.

Course Content (5 Units)

Unit I – Introduction to Communication Systems

Elements of communication system – transmitter, channel, receiver; Signal types – deterministic, random; Noise sources and classification; Performance metrics – SNR, BER, channel capacity (Shannon's theorem).

Unit II – Analog Communication

Amplitude modulation (AM), Double Sideband (DSB), Single Sideband (SSB), Vestigial Sideband (VSB); Frequency modulation (FM) and Phase modulation (PM); Demodulation techniques; Superheterodyne receivers; Applications of analog communication.

Unit III – Digital Communication

Pulse modulation techniques – PAM, PWM, PPM, PCM, Delta modulation; Baseband transmission; Digital modulation schemes – ASK, FSK, PSK, QAM; Error detection and correction – linear block codes, cyclic codes, convolutional codes.

Unit IV – Noise and Information Theory

Types of noise – thermal, shot, transit-time; Noise figure and noise temperature; Signal-to-noise ratio (SNR) analysis in AM, FM, and digital systems; Entropy, mutual information; Source coding; Channel capacity and coding theorem.

Unit V – Advanced Communication Systems

Wireless communication basics – cellular concepts, frequency reuse, path loss; Optical communication – principles, optical fiber, multiplexing; Satellite communication – orbital aspects, link design; Emerging technologies – 4G/5G, IoT, MIMO systems.

Textbooks

1. Simon Haykin – *Communication Systems*, Wiley.
2. B.P. Lathi – *Modern Digital and Analog Communication Systems*, Oxford University Press.
3. Taub & Schilling – *Principles of Communication Systems*, McGraw Hill.

References

1. John G. Proakis, Masoud Salehi – *Communication Systems Engineering*, Pearson.
2. Dennis Roddy, John Coolen – *Electronic Communications*, Pearson.
3. H. P. Hsu – *Schaum's Outline of Analog and Digital Communications*, McGraw Hill.
4. Leon W. Couch – *Digital and Analog Communication Systems*, Pearson.
5. IEEE Transactions on Communications & Journals on Emerging Communication Technologies.

Digital IC Design

Course Outcomes (COs)

By the end of this course, students will be able to:

CO1: Explain the principles of MOS transistor operation and CMOS technology.

CO2: Design and analyze combinational and sequential logic circuits using CMOS logic.

CO3: Apply design methodologies for optimization in terms of power, performance, and area.

CO4: Evaluate testing, verification, and reliability issues in digital IC design.

CO5: Explore advanced topics such as memory design, FPGA/ASIC implementation, and low-power VLSI design.

Course Content (5 Units)

Unit I – Introduction to Digital IC Design

Overview of digital ICs; Design flow; MOS transistor theory – I-V characteristics, threshold voltage, scaling; CMOS process technology; Layout design rules; Stick diagrams and mask layout.

Unit II – CMOS Logic Circuits

Static CMOS logic – inverter, NAND, NOR, complex gates; Switching characteristics; Dynamic CMOS logic – domino logic, pass-transistor logic; Sequential circuits – latches, flip-flops; Timing issues – setup/hold time, clock skew.

Unit III – Design Methodologies and Optimization

Design styles – standard cell, full-custom, semi-custom, FPGA; Power consumption in CMOS circuits – static, dynamic, leakage power; Low-power design techniques; Design metrics – delay, power, area (PPA optimization).

Unit IV – Testing and Verification

Design for testability (DFT); Fault models – stuck-at, bridging, delay faults; Scan chains, BIST (Built-In Self-Test); Timing analysis; Formal verification, simulation, and emulation techniques.

Unit V – Advanced Topics and Applications

Memory circuits – SRAM, DRAM, non-volatile memories; Programmable logic devices (PLDs), FPGA and ASIC design flow; Emerging trends – FinFET, SOI technology, 3D ICs; Applications in processors, AI accelerators, and IoT hardware.

Textbooks

1. Jan M. Rabaey, Anantha Chandrakasan, Borivoje Nikolic – *Digital Integrated Circuits: A Design Perspective*, Pearson.
2. Sung-Mo (Steve) Kang, Yusuf Leblebici – *CMOS Digital Integrated Circuits: Analysis and Design*, McGraw Hill.
3. Neil H.E. Weste, David Harris – *CMOS VLSI Design: A Circuits and Systems Perspective*, Pearson.

References

1. John P. Uyemura – *Introduction to VLSI Circuits and Systems*, Wiley.
2. Wayne Wolf – *Modern VLSI Design: System-on-Chip Design*, Pearson.
3. M. Morris Mano, Michael Ciletti – *Digital Design*, Pearson.
4. IEEE Transactions on VLSI Systems, IEEE Design & Test Journals.
5. Research articles on low-power VLSI and advanced CMOS technologies.

Microprocessors and Microcontrollers

Course Outcomes (COs)

By the end of this course, students will be able to:

CO1: Explain the architecture and functioning of microprocessors and microcontrollers.

CO2: Write assembly language programs for microprocessors (8085/8086) and microcontrollers (8051).

CO3: Interface microprocessors/microcontrollers with memory and I/O devices.

CO4: Analyze timing diagrams, interrupts, and serial/parallel communication methods.

CO5: Apply knowledge of microcontrollers in embedded system design and real-world applications.

Course Content (5 Units)

Unit I – Introduction to Microprocessors

Evolution of microprocessors; 8085/8086 microprocessor architecture – ALU, registers, buses, addressing modes; Instruction set of 8085/8086; Assembly language programming basics.

Unit II – Microprocessor Interfacing

Memory interfacing (RAM, ROM, EPROM); I/O interfacing; Interrupt structure of 8085/8086; Direct Memory Access (DMA); Programmable peripheral devices (8255 PPI, 8253 PIT, 8259 PIC, 8279 keyboard/display controller).

Unit III – Introduction to Microcontrollers

8051 microcontroller architecture – CPU, I/O ports, memory organization, timers, interrupts, serial communication; Instruction set and assembly programming of 8051; Applications of microcontrollers.

Unit IV – Interfacing and Applications of Microcontrollers

Interfacing with LEDs, switches, seven-segment displays, LCDs; ADC/DAC interfacing; Stepper and DC motor interfacing; Serial communication (UART, SPI, I2C); Real-time application examples.

Unit V – Advanced Microcontrollers and Embedded Applications

Overview of ARM-based microcontrollers; Comparison of RISC vs. CISC; Embedded system design using microcontrollers; Case studies – IoT applications, automotive electronics, robotics, consumer electronics.

Textbooks

1. Ramesh S. Gaonkar – *Microprocessor Architecture, Programming and Applications with 8085*, Penram International.
2. Muhammad Ali Mazidi, Janice Gillispie Mazidi – *The 8051 Microcontroller and Embedded Systems*, Pearson.
3. Kenneth J. Ayala – *The 8051 Microcontroller*, Cengage.

References

1. Douglas V. Hall – *Microprocessors and Interfacing: Programming and Hardware*, McGraw Hill.
2. A.K. Ray, K.M. Bhurchandi – *Advanced Microprocessors and Peripherals*, McGraw Hill.
3. Krishna Kant – *Microprocessors and Microcontrollers: Architecture, Programming and System Design*, PHI.
4. Steve Furber – *ARM System-on-Chip Architecture*, Pearson.
5. IEEE Transactions on Embedded Systems and Microelectronics Journals.

Digital Electronics

Course Outcomes (COs)

By the end of this course, students will be able to:

CO1: Apply number systems and Boolean algebra for digital circuit design.

CO2: Analyze and design combinational logic circuits using basic logic gates.

CO3: Design and implement sequential circuits such as counters, registers, and flip-flops.

CO4: Explain the operation of memory devices, ADCs, DACs, and programmable logic devices.

CO5: Apply digital circuit concepts in real-world applications and system design.

Course Content (5 Units)

Unit I – Number Systems and Boolean Algebra

Number systems (binary, octal, decimal, hexadecimal); Binary arithmetic; Complements (1's and 2's); Codes (BCD, Gray, Excess-3, ASCII); Logic gates; Boolean algebra – laws, theorems, and simplification; Karnaugh maps.

Unit II – Combinational Logic Circuits

Design of combinational circuits; Half adder, Full adder, Subtractor; Multiplexers, Demultiplexers, Encoders, Decoders; Magnitude comparators; Implementation of Boolean functions using MUX/DEMUX.

Unit III – Sequential Logic Circuits

Latches (SR, D); Flip-Flops (JK, T, D, Master-Slave); Excitation tables; Counters (asynchronous, synchronous, up/down); Shift registers (serial-in serial-out, serial-in parallel-out, parallel-in serial-out, parallel-in parallel-out).

Unit IV – Memory and Programmable Devices

Classification of memories – ROM, RAM, PROM, EPROM, EEPROM, Flash; Basics of ADC and DAC; Programmable Logic Devices – PLA, PAL, FPGA; Applications of digital memory.

Unit V – Logic Families and Applications

Logic families – TTL, CMOS; Characteristics (fan-in, fan-out, power dissipation, propagation delay, noise margin); Interfacing TTL and CMOS; Introduction to digital system applications – digital clocks, calculators, display systems, embedded controllers.

Textbooks

1. M. Morris Mano – *Digital Design*, Pearson.
2. Thomas L. Floyd – *Digital Fundamentals*, Pearson.
3. A. Anand Kumar – *Fundamentals of Digital Circuits*, PHI.

References

1. R.P. Jain – *Modern Digital Electronics*, McGraw Hill.
2. William Gothmann – *Digital Electronics: An Introduction to Theory and Practice*, PHI.
3. Charles H. Roth Jr. – *Fundamentals of Logic Design*, Cengage.
4. Malvino & Leach – *Digital Principles and Applications*, McGraw Hill.
5. IEEE Transactions on Digital Systems and VLSI Design.

Sensors and Instrumentation

Course Outcomes (COs)

By the end of this course, students will be able to:

CO1: Understand the principles and characteristics of sensors and transducers.

CO2: Classify and select appropriate sensors for physical, chemical, and biological parameters.

CO3: Analyze signal conditioning circuits and interfacing techniques.

CO4: Explain the working of measurement systems and their error analysis.

CO5: Apply sensor and instrumentation concepts in real-world engineering applications.

Course Content (5 Units)

Unit I – Fundamentals of Measurement and Sensors

Introduction to measurement systems; Generalized configuration; Static and dynamic characteristics; Classification of errors; Calibration. Basics of sensors and transducers – principle of operation, classification, selection criteria.

Unit II – Mechanical and Displacement Sensors

Strain gauges; Force, torque, and pressure measurement – elastic and piezoelectric sensors; Displacement measurement – LVDT, RVDT, capacitive and inductive transducers; Vibration and acceleration sensors (accelerometers, gyroscopes).

Unit III – Temperature, Flow, and Level Sensors

Temperature measurement – RTD, thermistors, thermocouples, semiconductor sensors; Flow measurement – venturimeter, orifice, rotameter, hot-wire anemometer, ultrasonic flow sensors; Level measurement – float, capacitive, ultrasonic, radar-based sensors.

Unit IV – Signal Conditioning and Data Acquisition

Amplifiers (instrumentation amplifier, chopper amplifier); Filters (active and passive); ADC and DAC; Data acquisition systems; Noise reduction techniques; Digital signal processing for sensor outputs; Interfacing sensors with microcontrollers.

Unit V – Advanced Sensors and Applications

Optical sensors (fiber optic, photodiodes, LDR, IR); Chemical and biosensors (pH sensor, gas sensors, glucose sensors); Smart sensors and MEMS sensors; Sensor networks and IoT integration; Applications in robotics, biomedical, automotive, aerospace, and environmental monitoring.

Textbooks

1. A.K. Sawhney – *Electrical and Electronic Measurements and Instrumentation*, Dhanpat Rai & Sons.
2. John G. Webster – *Measurement, Instrumentation and Sensors Handbook*, CRC Press.
3. R. S. Khandpur – *Handbook of Biomedical Instrumentation*, McGraw Hill.

References

1. Doebelin E.O. – *Measurement Systems: Application and Design*, McGraw Hill.
2. D. Patranabis – *Principles of Electronic Instrumentation*, PHI.
3. Ian R. Sinclair – *Sensors and Transducers*, Elsevier.
4. Bela G. Liptak – *Instrumentation Engineers' Handbook*, CRC Press.
5. IEEE Sensors Journal, Elsevier's *Sensors and Actuators*.

Device Modeling

Course Outcomes (COs)

By the end of this course, students will be able to:

CO1: Explain the fundamentals of semiconductor physics and carrier transport.

CO2: Derive and analyze mathematical models for basic electronic devices (diodes, BJTs, MOSFETs).

CO3: Compare different device models such as large-signal, small-signal, and charge-control models.

CO4: Apply device modeling techniques for VLSI and circuit simulation.

CO5: Evaluate the limitations of classical models and explore emerging device models (nanoelectronics).

Course Content (5 Units)

Unit I – Fundamentals of Device Physics

Semiconductor fundamentals – energy bands, carrier concentration, drift and diffusion currents, continuity equation; Generation and recombination; Poisson's equation; Semiconductor junctions – depletion approximation, built-in potential, junction capacitance.

Unit II – Diode Modeling

Ideal diode equation; Current-voltage (I–V) characteristics; Static and dynamic resistance; Charge storage effects; Diode capacitances; High-frequency diode models; SPICE models for diodes; Applications in rectifiers and clippers.

Unit III – Bipolar Junction Transistor (BJT) Modeling

BJT operation – transport model; Large-signal models (Ebers-Moll, Gummel-Poon); Small-signal hybrid-pi model; Charge-control models; High-frequency and switching models; Temperature effects; Applications in amplifiers and switching circuits.

Unit IV – MOSFET Modeling

MOS structure and threshold voltage; I–V characteristics – linear, saturation, and sub-threshold regions; Small-signal models; Capacitances and charge-sharing models; Short-channel effects; High-frequency MOSFET models; SPICE MOSFET models; Applications in CMOS circuits.

Unit V – Advanced and Emerging Device Models

Modeling of JFETs, MESFETs, HEMTs; Scaling effects in devices; Noise models in semiconductor devices; Advanced compact models for VLSI design (BSIM); Emerging device models – FinFET, CNTFET, TFET; Nano-device modeling and future trends.

Textbooks

1. Yannis Tsividis – *Operation and Modeling of the MOS Transistor*, Oxford University Press.
2. Massobrio & Antognetti – *Semiconductor Device Modeling with SPICE*, McGraw Hill.
3. Robert Pierret – *Semiconductor Device Fundamentals*, Pearson.

References

1. Ben G. Streetman & Sanjay Banerjee – *Solid State Electronic Devices*, Pearson.
2. Donald A. Neamen – *Semiconductor Physics and Devices*, McGraw Hill.
3. C.T. Sah – *Fundamentals of Solid-State Electronics*, World Scientific.
4. Taur & Ning – *Fundamentals of Modern VLSI Devices*, Cambridge University Press.
5. IEEE Transactions on Electron Devices, IEEE Journal on Modeling and Simulation.

Physical Design Automation

Course Outcomes (COs)

By the end of this course, students will be able to:

CO1: Explain the fundamentals and flow of physical design in VLSI systems.

CO2: Apply algorithms for partitioning, floorplanning, and placement of ICs.

CO3: Analyze routing strategies and design rule constraints for chip layouts.

CO4: Evaluate timing, power, and signal integrity issues in physical design.

CO5: Utilize CAD tools for physical design automation and optimization in ICs.

Course Content (5 Units)

Unit I – Introduction to Physical Design Automation

Overview of VLSI design flow; Design abstraction levels; Physical design automation steps; Design rules and manufacturability; Metrics for area, delay, and power; Role of CAD tools.

Unit II – Partitioning, Floorplanning, and Placement

Partitioning algorithms – min-cut, KL, FM; Floorplanning concepts – objectives, constraints, hierarchical and non-hierarchical floorplanning; Placement algorithms – simulated annealing, force-directed, analytical placement; Wirelength and area optimization.

Unit III – Routing Techniques

Routing types – global vs. detailed routing; Maze routing, line-probe, and Steiner tree routing; Layer assignment and via minimization; Congestion analysis; Timing-driven routing; Clock routing strategies.

Unit IV – Timing, Power, and Signal Integrity

Static timing analysis; Timing constraints, critical path identification; Crosstalk and noise; Power analysis – dynamic and static power; Power-driven placement and routing; Methods for improving signal integrity and reliability.

Unit V – CAD Tools and Emerging Trends

Physical verification – DRC, LVS, ERC; Design for Test (DFT) considerations; Layout compaction and optimization; Introduction to EDA tools – Cadence, Synopsys, Mentor Graphics; Advanced trends – 3D ICs, FinFET layout challenges, machine learning in physical design.

Textbooks

1. Sadiq M. Sait, Habib Youssef – *VLSI Physical Design Automation: Theory and Practice*, World Scientific.
2. Naveed Shervani – *Algorithms for VLSI Physical Design Automation*, Springer.
3. Andrew B. Kahng, Jens Lienig, Igor L. Markov – *VLSI Physical Design: From Graph Partitioning to Timing Closure*, Springer.

References

1. David M. Bray – *Electronic Design Automation for IC Implementation, Circuit Design, and Process Technology*, Wiley.
2. Laung-Terng Wang, Chih-Hsiang Hsu – *VLSI Physical Design Automation: Theory and Practice*, Springer.
3. Igor L. Markov – *Electronic Design Automation for Integrated Circuits Handbook*, CRC Press.
4. IEEE Transactions on CAD of Integrated Circuits and Systems, Journal of VLSI Design.
5. Research papers on modern placement, routing, and timing optimization algorithms.

Analog IC Design

Course Outcomes (COs)

By the end of this course, students will be able to:

CO1: Understand the fundamentals of MOS and bipolar devices and their applications in analog ICs.

CO2: Design and analyze analog amplifiers including differential, operational, and current-mode circuits.

CO3: Apply frequency response and feedback concepts to improve analog circuit performance.

CO4: Design analog building blocks like current mirrors, voltage references, and oscillators.

CO5: Explore advanced analog IC design techniques and practical design considerations in modern VLSI systems.

Course Content (5 Units)

Unit I – Basics of Analog ICs and Device Fundamentals

Overview of analog ICs; MOS and BJT devices; Small-signal and large-signal models; Current-voltage relationships; Device parameters; Matching and layout considerations in analog design.

Unit II – Analog Amplifiers

MOS and BJT amplifiers; Differential amplifiers; Single-ended and fully differential designs; Common-mode rejection ratio (CMRR); Gain, input/output resistance; Frequency response and bandwidth considerations.

Unit III – Feedback and Stability

Concepts of negative and positive feedback; Feedback topologies; Stability analysis – Bode plots, phase margin, gain margin; Compensation techniques; Effect of feedback on input/output resistance, noise, and distortion.

Unit IV – Analog Circuit Building Blocks

Current mirrors and sources; Active loads; Voltage references; Operational amplifiers – design, characterization, and applications; Oscillators – RC, LC, and crystal oscillators; Filters – active filters, OTA-C filters.

Unit V – Advanced Analog IC Design

Switched-capacitor circuits; Low-noise design techniques; Low-power analog design; Layout considerations; Introduction to mixed-signal IC design; Applications in communication, biomedical, and sensor interfacing.

Textbooks

1. Behzad Razavi – *Design of Analog CMOS Integrated Circuits*, McGraw Hill.
2. Paul R. Gray, Paul J. Hurst, Stephen H. Lewis, Robert G. Meyer – *Analysis and Design of Analog Integrated Circuits*, Wiley.
3. David A. Johns, Ken Martin – *Analog Integrated Circuit Design*, Wiley.

References

1. Franco Maloberti – *Design of Analog CMOS Integrated Circuits*, McGraw Hill.
2. R. Jacob Baker – *CMOS Circuit Design, Layout, and Simulation*, Wiley.
3. Sergio Franco – *Design with Operational Amplifiers and Analog Integrated Circuits*, McGraw Hill.
4. IEEE Transactions on Circuits and Systems, Journal of Analog Integrated Circuits.
5. Research articles on low-power, high-speed analog IC design.

Mixed Signal Design

Course Outcomes (COs)

By the end of this course, students will be able to:

CO1: Understand the fundamentals of mixed-signal systems and their applications.

CO2: Analyze and design data converters (ADC and DAC) with different architectures.

CO3: Apply mixed-signal circuit design principles including sample-and-hold, switched-capacitor, and current-mode circuits.

CO4: Evaluate timing, noise, and distortion issues in mixed-signal ICs.

CO5: Explore system-level integration and design of modern mixed-signal applications such as communication and sensor interfaces.

Course Content (5 Units)

Unit I – Introduction to Mixed-Signal Systems

Overview of mixed-signal design; Importance and applications; System-level specifications; Noise, linearity, and dynamic range; Timing and synchronization issues; Challenges in integration of analog and digital circuits.

Unit II – Digital-to-Analog Converters (DACs)

DAC fundamentals; Weighted resistor DAC; R-2R ladder DAC; Current steering DAC; Accuracy, resolution, linearity, monotonicity; Applications in signal generation and control systems.

Unit III – Analog-to-Digital Converters (ADCs)

ADC fundamentals; Types – Flash, Successive Approximation (SAR), Sigma-Delta, Pipelined ADC; Resolution, sampling rate, linearity, SNR; Comparator design; Applications in data acquisition and communication.

Unit IV – Mixed-Signal Circuit Techniques

Sample-and-hold circuits; Switched-capacitor circuits; Current-mode circuits; Mixed-signal timing issues – clock jitter, phase noise; Noise analysis and mitigation; Layout considerations for mixed-signal ICs.

Unit V – System-Level Design and Applications

Integration of ADCs, DACs, and digital processing blocks; PLLs, data converters, and mixed-signal subsystems; Mixed-signal verification and testing; Case studies – communication systems, biomedical signal acquisition, sensor interfaces, IoT devices.

Textbooks

1. R. Jacob Baker – *CMOS Mixed-Signal Circuit Design*, Wiley.
2. Behzad Razavi – *Design of Analog CMOS Integrated Circuits* (Chapters on mixed-signal design), McGraw Hill.
3. Sergio Franco – *Design with Operational Amplifiers and Analog Integrated Circuits*, McGraw Hill.

References

1. Philip E. Allen, Douglas R. Holberg – *CMOS Analog Circuit Design*, Oxford University Press.
2. Thomas H. Lee – *The Design of CMOS Radio-Frequency Integrated Circuits*, Cambridge University Press (for mixed-signal applications).
3. IEEE Transactions on Circuits and Systems, IEEE Journal of Solid-State Circuits.
4. Research papers on high-speed ADC/DAC design, low-power mixed-signal ICs, and sensor interfaces.
5. Design manuals and datasheets from Cadence and Synopsys for mixed-signal IC design tools.