Course Title	Course Code	Structure (I-P-C)		
Drone Technology		**3**	**2**	**4**

Pre-requisite, if any: Nil

Course Outcomes: At the end of the course, the students will be able to:

CO1	Apply the concept of Flight dynamics for building Quadcopter
CO2	Assemble and Program the Quadcopter
CO3	Perform Testing and Control operations on the Quadcopter
CO4	Implement Quadcopter for real world applications
CO5	Design and Develop the Drone

Syllabus:

Flight Dynamics of Aerial Vehicles

Definitions of Drone, UAV, RPA, Quad copters -Basic Components and Categories – Principles of Flight - Flight Maneuvers – Airframes - Creating a Frame: Materials, Different Frame Shapes – Building Airframes - Flight dynamics - Applications - Future potential - Comparison with other aerial vehicles

Hardware Anatomy of Quadcopter

Power Train – Propellers, Motors- Total Lift - Electronic Speed Controllers – Flight Battery – Radio transmitter and receiver – Flight Controller – GPS, Compass, Camera Assembling for Quad copter – Connectors, Mounting of Propellers and Powering up.

Testing And Maintenance of Quadcopter

Key Flight Safety Rules - Preflight Checklist and Flight Log Information – Flight Instructions - Repair and Maintenance: Crash analysis, Common issues, Voltage testing.

Test and troubleshoot Flight Controller Board (FCB), Electronic Speed Controller (ESC), and its associated peripherals.

Perform programming and configure the flight control board (FCB). Identify, explore, and test the interconnectivity of different peripherals with FCB. Establish connection of FCB with motor, GPS, ESC, and sensors. Configure, test, and record FCB with battery to monitor battery level and perform return to home operation Perform and carry out drone leveling using IMU sensor. Perform calibration of the compass, Lidar, and gyro sensor. The test communication link between FCB and RF transceiver. Write and upload computer code to FCB to test sensor results. Test and record data of motor connectivity with ESC. Perform motor rotation using FCB and ESC. Test signal flow into the drone to test ESC parameters on FCB to check its operation. Write and upload computer code to FCB to ESC working.

Real World Applications and Case Studies

Beneficial Drones, Aerial Photography, Mapping and Surveying, Precision Agriculture, Search and Rescue, Infrastructure Inspection, and Conservation. Case Studies: Agriculture Weed Classification, Microdrone surveillances.

Drone Technology

1. Familiarization with Drone Parts
2. Assembling of Drone
3. Preparation for Drone for Flight, making flight plan and basic drone flight training

4. Debugging and repairing of the drone
5. Operation of Drone for different Applications

Text Book(s):

1. Reg Austin "Unmanned Aircraft Systems UAV design, development and deployment", Wiley, 2010.

2. Robert C. Nelson, Flight Stability and Automatic Control, McGraw-Hill, Inc, 1998.

3. Kimon P. Valavanis, "Advances in Unmanned Aerial Vehicles: State of the Art and the Road to Autonomy", Springer, 2007

4. Paul G Fahlstrom, Thomas J Gleason, "Introduction to UAV Systems", UAV Systems, Inc, 1998

5. Dr. Armand J. Chaput, "Design of Unmanned Air Vehicle Systems", Lockheed Martin Aeronautics

Course Title	Course Code	Structure (I-P-C)		
Autonomous Systems		**3**	**2**	**4**

Pre-requisite, if any:

Course Outcomes: At the end of the course, the students will be able to:

CO1	Understand the agent systems and architecture of autonomous systems
CO2	Understand the different sensors and actuators used in Autonomous systems.
CO3	Develop the Basic Aerial Robots
CO4	Analyse and deploy different communication protocols used in Autonomous Systems
C05	Design and develop of different Autonomous Systems

Syllabus:

Introduction to Agent Systems

Introduction to Agents, Agent Architectures, and Multi-agent Systems and Society of Agents, Distributed Problem Solving and Planning, Case Study: Collaborative Robotics, Robocup

Architecture of Autonomous Systems

Degree of Autonomy, Reactive Systems, Real-time Systems, Architecture of AGV's , AUV , Drones, Tele-Operation, AR, VR applications

Classification, Modelling, and Control Aspects of Unmanned Vehicles

Discussion on different types of unmanned vehicles: ground (wheeled and legged), aerial (fixed, flapping, and rotary wings), underwater vehicles , Modelling of unmanned vehicles considering basic forces, kinematics, and dynamics, Discussion on different types of control for aerial, underwater (fins and propulsion control), ground (biped and quadruped motion control for legged robots)

Sensors and Actuators

Discussion on different types of sensors used in unmanned vehicles (proximity, IMU, magnetometers, thermal imaging, vision, LiDAR, GPS, RTK, etc.) and their characteristics, Sensor data aggregation, processing, and sensor fusion, Introduction to popular computing platforms for data processing, Different types of actuators: motors, servos, harmonic drive, linear actuators

Basic Aerial Robot Flight Concepts, Micro-aerial vehicle, Frame Rotations and Representations, Aerial robots equations of motion, State-Space Form, Time, Motion, and Trajectories, Linearization, 2-D and 3-D control of Aerial robots, PID Control, LQR control, Motion planning, Collision-free Navigation, Sensing and Estimation, Vision-based Guidance for aerial robots

Communication and Networking Protocols

Introduction to in-vehicle and vehicle to anything (V2X) communications, In-vehicle communication technologies : Bluetooth, CAIN, LIN , Vehicle to Anything communication technologies : Cellular, DSRC, MAVLink , QoS, QoE Requirements

Autonomous SystemsLaboratory

1.Implementation of guidance strategies for autonomous vehicles
2.Implementation of sensing and perception of autonomous vehicles
3.Demonstrating Application of data fusion of different sensor for Autonmous System

4.Comparison of possible architectures for autonomous systems with long response times
5.Programming heterogeneous embedded systems for autonomous applications, and
6. Analysis and verification of autonomous systems

Text Books:

1. Roland Siegwart, Illah Reza Nourbakhsh, Davide Scaramuzza(2018), Introduction to autonomous mobile robots, MIT press.
2. Gerhard Weiss ed. (2013), Multiagent System, Second Edition, MIT Press.
3. Stuart J. Russell and Peter Norwig (2019), Artificial Intelligence: A Modern Approach, 4th edition, Pearson Press
4. Spyros G. Tzafestas (2014), Introduction to Mobile Robot Control, Elsevier
5. Gerald Cook (2011), Mobile Robots: Navigation, Control and Remote Sensing, Wiley.
6. Choset, H. M., Hutchinson, S., Lynch, K. M., Kantor, G., Burgard, W., Kavraki, L. E., &Thrun, S. (2005). Principles of robot motion: theory, algorithms, and implementation. MIT press.
7. U. Ozguner, T. Acarman, Keith Redmill, (2011), Autonomous Ground Vehicles, 1st Edition, Artech House Publishers
8. Sahiba Wadoo, Pushkin Kachroo, (2011), Autonomous Underwater Vehicles: Modeling, Control Design and Simulation, 1st Edition, CRC Press
9. Kenzo Nonami et. al., (2010), Autonomous Flying Robots: Unmanned Aerial Vehicles and Micro Aerial Vehicles, 1st Edition, Springer
10. C. Sommer, F. Dressler, (2014), Vehicular Networking, 1st Edition, Cambridge University Press 5. H. Sjafrie, (2019), Introduction to Self-Driving Vehicle Technology, 1st Edition, Chapman and Hall/CRC

References and Web Resources

1. C. Venkatesan, (2014), Fundamentals of Helicopter Dynamics, 1st Edition, CRC Press
2. John D. Anderson, (2015), Introduction to Flight, 8th Edition, McGraw-Hill Education
3. Rajendra Jani, (2009), Development of an autonomous underwater vehicle - Hydrocopter - A systematic approach to effective low-cost design, manufacture and testing of underwater vehicles, 1st Edition, VDM Verlag

Course Title	Course Code	Structure (I-P-C)		
Artificial Intelligence		**3**	**0**	**3**

Pre-requisite, if any:

Course Outcomes: At the end of the course, the students will be able to:

CO1	Define and explain the concepts of artificial intelligence
CO2	Implement basic techniques in artificial intelligence
CO3	Identify the different fields of AI, including machine learning, neural networks, natural language processing, and robotics
CO4	Design, develop, and implement intelligent systems
CO5	Implementation of AI on Drone and IoT case studies

Syllabus:

Propositional logic

Search: Uninformed strategies (BFS, DFS, Dijkstra), Informed strategies (A* search, heuristic functions, hill-climbing), Adversarial search (Minimax algorithm, Alpha-beta pruning)

Predicate logic: Knowledge representation, Resolution

Rule-based systems: Natural language parsing, Context free grammar, Constraint satisfaction problems

Planning: State space search, Planning Graphs, Partial order planning, Uncertain Reasoning: Probabilistic reasoning, Bayesian Networks, Dempster-Shafer theory, Fuzzy logic

Artificial Intelligence: Probabilistic Reasoning and Knowledge Representation

Probabilistic Reasoning over time: Hidden Markov Models, Kalman Filters, Dynamic Bayesian Networks (7 lectures) Knowledge Representation: Ontological engineering, Semantic Networks, Description Logics (7 lectures)

Artificial Intelligence: Making Decisions

Making decisions: Utility theory, utility functions, decision networks, sequential decision problems, Partially Observable MDPs, Game Theory

Artificial Intelligence: Reinforcement Learning

Reinforcement Learning: Passive RL, Active RL, Generalization in RL, Policy Search, Deep Reinforcement Learning

Textbooks

1.Russel,S., and Norvig,P., (2015), Artificial Intelligence: A Modern Approach, 3rd Edition, Prentice Hall

Reference Books

1. Yang, Q. (1997), Intelligent Planning: A decomposition and abstraction based approach, Springer Verlag, Berlin Heidelber

Course Title	Course Code	Structure (I-P-C)		
Guidance, Navigation, and Control		**3**	**2**	**4**

Pre-requisite, if any: Nil

Course Outcomes: At the end of the course, the students will be able to:

CO1	Various navigation systems available and used for different applications. Like Terrestrial Radio Navigation Satellite Navigation, Radio Navigation, Long and Short Range Navigation Techniques, etc
CO2	Discussion on signal structures of navigation systems available, Global Navigation Systems, Regional Navigation Systems, and Differential Navigation systems available across the world
CO3	Concepts of Guidance and Navigation
CO4	Satellite Navigation Processing, Errors, and Geometry, Dead Reckoning, Attitude and Height Measurement, Feature Matching, and INS/GNSS Integration. Students will be provided hands-on experience on GPS, IRNSS, and GAGAN receivers along with real time signal generation and analysis in the laboratory

Syllabus

Module - I: INTRODUCTION TO NAVIGATION: What Is Navigation, Position Fixing, Dead Reckoning, Inertial Navigation, Radio and Satellite Navigation, Terrestrial Radio Navigation, Satellite Navigation, Feature Matching, The Complete Navigation System.

Module – II: NAVIGATION MATHEMATICS: Coordinate Frames, Kinematics, and the Earth: Coordinate Frames, Kinematics, Earth Surface and Gravity Models, Frame Transformations

Module – III: INERTIAL NAVIGATION: Inertial-Frame Navigation Equations, Earth-Frame Navigation Equations, Local-Navigation-Frame Navigation Equations, Navigation Equations Precision, Initialization and Alignment, INS Error Propagation, Platform INS, Horizontal-Plane Inertial Navigation, INS/GNSS Integration**.**

Module– IV: PRINCIPLES OF RADIO POSITIONING: Radio Positioning Configurations and Methods, Positioning Signals, User Equipment, Propagation, Error Sources, and Positioning Accuracy

Module– V GNSS: FUNDAMENTALS, SIGNALS, AND SATELLITES: Fundamentals of Satellite Navigation, The Systems: Global Positioning System, GLONASS, Galileo, Beidou, REGIONAL NAVIGATION SYSTEMS: Beidou and Compass, QZSS, IRNSS, GNSS INTEROPERABILITY: Frequency Compatibility, User Competition, Multistandard User Equipment Augmentation Systems, System Compatibility, GNSS Signals, Navigation Data Messages

Module – VI: ADVANCED SATELLITE NAVIGATION: Differential GNSS, Carrier-Phase Positioning, and Attitude, Poor Signal-to-Noise Environments, Multipath Mitigation, Signal Monitoring,

Module – VII: SATELLITE NAVIGATION PROCESSING, ERRORS, AND GEOMETRY: Satellite Navigation Geometry, Receiver Hardware and Antenna, Ranging Processor, Range Error Sources.

Module-VIII:GUIDANCE: Introduction to radars, Radar equation. Block Diagram and Operation, Radar Frequencies. Application of Radars, Range performance of radars, Minimum detectable signal,Noise effects, Continuous wave and Frequency modulated radars, Doppler effect, CW-radar, Isolation between transmitter and receiver. Radial velocity, CW radar applications, Frequency modulated CW radars, MIT and Pulse Doppler radars, Description of operation.

Module-IX:CONTROL: Classical linear time invariant control systems. Transfer function representations; stability; time domain characteristics. PID controller design for aerospace systems.

TEXT BOOKS:

1. Principles of GNSS, Inertial, and Multisensor Integrated Navigation Systems, Paul D. Groves Artech House, 2008 and 2013 Second Edition.
2. M .I. Skolnik: Introduction to Radar Systems, Tata McGraw-Hill, 2007.
3. M. Kayton and W. Fried: Avionics Navigation System, Wiley Interscience, 1997.
4. P. Zarchan: Tactical and Strategic Missile Guidance, AIAA, 2007.
5. N.S. Nise: Control Systems Engineering, Wiley-India, 2004.

REFERENCE BOOKS:

1. B.HofmannWollenhof, H.Lichtenegger, and J.Collins, “GPS Theory and Practice”, Springer Wien, new York, 2000.
2. Pratap Misra and Per Enge, “Global Positioning System Signals, Measurements, and Performance,” Ganga-Jamuna Press, Massachusetts, 2001.
3. Ahmed El-Rabbany, “Introduction to GPS,” Artech House, Boston, 2002.
4. Bradford W. Parkinson and James J. Spilker, “Global Positioning System: Theory and Applications,” Volume II, American Institute of Aeronautics and Astronautics, Inc., Washington, 1996.
5. B. Friedland: Control System Design, Dover, 2005.

Course Title	Course Code	Structure (I-P-C)		
Design of IoT systems		**3**	**2**	**4**

Pre-requisite, if any: Embedded Systems, Computer Networks, C programming, and microprocessor/microcontrollers

Course Outcomes: At the end of the course, the students will be able to:

CO1	Understand the networking with IoT, and its enabling technologies, and explore a young, but rich, body of exciting ideas, solutions, and paradigm shifts.
CO2	Understanding the potential of IoT devices, support for networking according to the protocol standards, and being able to program them, would be useful for real-time applications.
CO3	Develop the rapid prototypes of IoT-based embedded systems
CO4	Using sensors, cloud, and open source microcontrollers such as Arduino, Raspberry Pi, Beagle Bone Black, and Intel Edison/Galileo.
CO5	Deploying IoTs application using cloud server (Thingspeak and AWS)

Syllabus:

Introduction to IoT: Definition, Trend, IoT applications, Sensing and Actuation, IoT Devices and deployment models, Power awareness of IoT, LDO in IoT.
IoT Networking: Basic IoT Components, Interdependencies, Service Oriented Architecture.
IoT Data Protocols: MQTT, SMQTT, CoAP, XMPP, AMQP.
IoT Communication Protocols and their applications: IEEE 802.15.4, ZigBee6LoWPAN, Wireless HART, Z-Wave, ISA 100, Bluetooth, and Bluetooth low energy (BLE), NFC,RFID, WiFi for IoT communications.
Data Handling, Analytics, Data management for IoT: Data cleaning and processing, Data storage models, Searching in IoT, Deep Web Semantic Sensor Web, Semantic web data management, Real-time and Big data analytics for IoT, High-dimensional data processing, Parallel and Distributed data processing.
Interoperability in IoT: Low power Interoperability for IPV6 IoT.
Cloud-Centric IoT: Architecture, Open Challenges, Energy efficiency, QoS, QoE.
Industrial IoT (IIoT): Industrial IoT and its benefits, Future of IIoT, Challenges, Examples.
IoT System Management and Virtualization: IoT environment management over Cloud computing framework, Fog Computing paradigm for IoT with case studies, Softwarized control and virtualization technologies for IoT network and computation resource managements.
Case Studies: Sensor body-area-network, Smart cities and Smart homes, Agriculture.

IoT Network Framework: Wireless Network Fundamental for IoT communication tutorials with demonstrations and hands-on: 802.11 and 802.15.4 MAC Fundamentals, Management Operations, Security Overview, Network Core Protocols, Tizen Network Stack Architecture, Introduction, CAPI Architecture Overview, Sync/Async Operation Sequence, Interaction of Network Core Components, P2P Core Component Overview, OEM Layer, Supplicant Plugin Architecture overview.

Design of IoT systems Practice:

1. Interfacing of sensors and Actuators for IoT
2. Design and Development for IoT System
3. Experiments on different IoT Networking, Data and Communication Protocols
4. Interfacing with cloud (Thingspeak and AWS)
5. Project work related to cotemporary case study

References & Web Resources:

1. The Internet of Things: Enabling Technologies, Platforms, and Use Cases", by Eethurum Raj and Anupama C. Raman (CRC Press).

2. Internet of Things: A Hands-on Approach, by Arshdeep Bahga and Vijay Madisetti (Universities Press).

Course Title	Course Code	Structure (I-P-C)		
Mobile Communication and Networking		3	2	4

Pre-requisite, if any: Nil

Course Outcomes: At the end of the course, the students will be able to:

CO1	Analyze and apply the principles of mobile communication and networking to IoT applications.
CO2	Select the appropriate networking technology for different IoT scenarios.
CO3	Evaluate IoT architectures and protocols.
CO4	Design and deploy mobile communication and networking solutions for IoT applications.

Syllabus:

MODULE – I Cellular Mobile Wireless Networks: Systems and Design Fundamentals: Brief introduction to mobile wireless communication and systems, Description of cellular system, Cellular Structure, Frequency Reuse, Cell clustering, Capacity enhancement techniques for cellular networks, cell splitting, antenna sectoring, Co-channel and Adjacent channel interferences, Channel assignment schemes – Fixed channel, Dynamic channel and Hybrid channel, mobility management – location management and handoff management, handoff process, different types of handoff.

Characteristics of wireless channel and propagation path loss models: Different Multi-path propagation mechanisms, Multi-path effects on mobile communication, Fading, different types of fading, small and large scale fading, slow and fast fading, narrowband and wideband fading, Inter symbol interference, fast fading model, Doppler effect due to velocity of mobiles, Rayleigh envelop, free space propagation model, two ray ground reflection model, log distance path loss model, log normal shadowing model, macro and micro cell propagation models, types of base stations and mobile station antennas.

MODULE – II Modern Mobile Wireless Communication Systems Evolution strategies – First Generation (1G) to Fourth Generation (4G), Personal Area Networks :PAN, Low Tier Wireless System: Cordless Telephone, Second Generation (CT2), Digital European Cordless Telecommunications (DECT), Public wide-area Wireless Networks: 1 G to 3G cellular networks , Multiple Access Technologies in cellular communication Time division multiple access (TDMA), narrowband and wideband TDMA, synchronous and asynchronous TDMA, Frequency division multiple access (FDMA), Code Division Multiple Access (CDMA), Direct sequence CDMA, spread spectrum technique, spectral efficiency of different wireless access technologies: Spectral Efficiency in FDMA system, Spectral Efficiency in TDMA system, Spectral Efficiency for DS-CDMA system, Cellular Communication Networks and Systems Second generation (2G) Network: Global system for mobile communication (GSM): Architecture and Protocols Air Interface, GSM spectrum, GSM Multiple Access Scheme, GSM Channel Organization, Traffic Channel multi-frame, Control (Signaling) Channel Multi-frame, Frames, Multi-frames, Superframes and Hyper-frames, GSM Call Set up Procedure, Location Update Procedure, Routing of a call to a Mobile Subscriber, The concept of packet data services The 2.5 G General Packet Radio Services: GPRS Networks Architecture, GPRS Interfaces and Reference Points, GPRS Mobility Management Procedures, GPRS Attachment and Detachment Procedures, Session Management and PDP Context, Data Transfer through GPRS Network and Routing, The IP Internetworking Model, Overview of CDMA systems: IS-95 Networks and 3G – The Universal

Mobile Telecommunication System (UMTS) CDMA based IS-95 Systems, forward link and reverse link for IS-95, handoff process in CDMA based IS-95 network. UMTS Network Architecture –Release 99, UMTS Interfaces, UMTS Network Evolution UMTS Release 4 and 5, UMTS FDD and TDD, UMTS Channels, Logical Channels, UMTS Time Slots

MODULE – III Wireless Local Area Networks (WLAN): IEEE 802.11 Standards and Protocols IEEE 802.11 standards, WLAN family, WLAN transmission technology, WLAN system architecture, Collision Sense Multiple Access with Collision Detection (CSMA/CD) and CSMA collision avoidance (CSMA/CA), Frequency Hopping Spread Spectra, 802.11 PHY and MAC layers, IEEE 802.11 Distributed Coordination function (DCF) and Point coordination function (PCF), Back off algorithm, Virtual carrier sense, MAC frame format. Security and QoS issues, WLAN applications, mywbut.com Wireless Broadband Networks and Access Evolution of broadband wireless, IEEE 802.16 standards : WiMAX , Spectrum Allocation, IEEE 802.16 Standard Architecture, Overview of WiMAX PHY, IEEE 802.16 MAC Layer, IEEE 802.16 Scheduling Services, Unsolicited Grant Service (UGS), Real-time Polling Service (rtPS), Non-realtime Polling Service (nrtPS), Best Effort (BE) Overview of 3G Long Term Evolution (3G LTE) for broadband wireless communication, Orthogonal Frequency Division Multiple Access (OFDMA)

MODULE – IV Mobile Internet Protocol Basic Mobile IP, Mobile IP Type-MIPV4 and MIPv6, Mobile IP: Concept, Four basic entities for MIPv4, Mobile IPv4 Operations, Registration, Tunneling, MIPv4 Reverse Tunneling, MIPv4 Triangular Routing, Configuring PDP Addresses on Mobile Station, Mobility Classification, Seamless Terminal Mobility Management, Limitations of current TCP/IP networks for mobility support, Mobility solution, Accessing External PDN through GPRS/UMTS PS Domain, Transparent Access, Use of Mobile IP for Non-transparent access, Dynamically accesses IP address from External Network.

TEXT BOOKS:

1. Wireless Networks: Applications and Protocols, T. S. Rappaport, Pearson Education
2. Wireless Communication and Networks: 3G and Beyond, I. Saha Misra, TMH Education.
3. Wireless Communications: Principles and Practice, T.S.Rappaport, PHI Learning.
4. Wireless Communications, A. Goldsmith, Cambridge University Press.

REFERENCE BOOKS:

1. Lee's Essentials of Wireless Communications, MH Prof. Med/Tech
2. Wireless Digital Communications: Modulations and Spread Spectrum Applications, K. Feher, Prentice Hall.
3. Wireless Communications and Networking, J.W.Mark and W. Zhuang, PHI.

Course Title	Course Code	Structure (I-P-C)		
Smart Sensors and Actuators		**3**	**2**	**4**

Pre-requisite, if any: Embedded Systems, Computer Networks, C programming, and microprocessor/microcontrollers

Course Aim: This course introduces the basic components of IoT and their interdependencies, deployment models, and fundamental concepts of IoT networking. This will be followed by more IoT network topics such as data and communication protocols. To have an in-depth understanding of data handling in IoT, this course has lectures on data handling, analytics, and data management for IoT devices.

Course Outcomes: At the end of the course, the students will be able to:

CO1	Interpret physical principles applied in sensors and actuators
CO2	To model and design sensors with desired physical and chemical properties
CO3	Identify various types of sensors including thermal, mechanical, electrical, electromechanical and optical sensors
CO4	To implement Actuators for different IoT Applications
CO5	To Design Signal conditioning circuits for different sensors suitable for IoT

Syllabus

Sensor characteristics:

Definitions, terminology, classification, Static vs dynamic properties of transducers, Transfer functions, Ideal and realistic transducer models, Resolution, linearization, dynamic range, detection threshold, Selectivity & sensitivity, Calibration, Errors of the experimental measurements, Noise: electronics, environmental & internal

Physical Principle of Sensing

Capacitance, Magnetism, Induction, Resistance, Piezoelectric effect, Pyroelectric effect, Hall Effect, Thermoelectric effect, Temperature and thermal properties of materials and heat transfer, Optics, Fibber optics and waveguides

Sensor Interface and Applications

Input characteristics of interface circuits, Amplifiers, Light to voltage converters, Capacitance to voltage converters, Bridge Circuits, Excitation circuits. Case Studies: Inertial Sensors, Healthcare Sensors and Smart building Sensors

Smart Sensors and Actuators:

Sensor’s with Integrated Electronics, functions of Integrated Electronics, Electrical Actuator, Piezoelectric Actuators, and Machine to machine Communication: Introduction, Node types and M2M Applications, Integration of Sensors, and Actuators for Implementation of IoT, Nanotechnology and miniaturization of sensing and Actuating devices.

Smart Sensors and Actuators Practice

1. Signal Conditioning Circuits for resistive, Capacitive and Inductive Sensor

2. Measurement of Voltage and Current in various ranges

3. Signal Conditioning Circuits for sensor which gives voltage, current and charge as output

4. Selection of signal conditioning ICs for various physical sensor

5.Design of various drivers for actuators

References

1. cv Jacob Fraden, (2010), Handbook of Modern Sensors, 5th Edition, Springer.
2. J. W. Gardner, (1996), Microsensors, Principles and Applications, 1st Edition, Wiley.
3. S. M. Sze, (1994), Semiconductor Sensors, 1st Edition, Wiley.
4. Jon. S. Wilson, “Sensor Technology Hand Book”, 2011, 1st edition, Elsevier, Netherland.
5. John G Webster, “Measurement, Instrumentation and sensor Handbook”, 2017, 2nd edition,CRC Press, Florida.

Course Title	Course Code	Structure (I-P-C)		
Internet and Wireless Networks Security		**3**	**0**	**0**

Pre-requisite, if any:

Course Outcomes: At the end of the course, the students will be able to:

CO1	Study technologies and research problems in the Internet, wireless ad hoc and sensor networks, with concentration in security related issues.
CO2	Familiarize with the issues and technologies involved in designing a wireless and mobile system that is robust against various attacks.
CO3	Have a broad knowledge of the state-of-the-art and open problems in wireless and mobile security, thus enhancing their potential to do research or pursue a career in this rapidly developing area.
CO4	Gain knowledge and understanding of the various ways in which wireless networks can be attacked and trade-offs in protecting networks.

Module-I: Wireless Network Security:

- Secure and resilient data aggregation
- Key pre-distribution and management
- Encryption and authentication
- Security in group communication
- Trust establishment and management
- Denial-of-service attacks
- Energy-aware security mechanisms

Security Issues in Mobile Communication: Mobile Communication History, Security – Wired Vs Wireless, Security Issues in Wireless and Mobile Communications, Security Requirements in Wireless and Mobile Communications, Security for Mobile Applications, Advantages and Disadvantages of Application – level Security.

Security of Device, Network, and Server Levels: Mobile Devices Security Requirements, Mobile Wireless network level Security, Server Level Security. Application Level Security in Wireless Networks: Application of WLANs, Wireless Threats, Some Vulnerabilities and Attach Methods over WLANs, Security for 1G Wi-Fi Applications, Security for 2G Wi-Fi Applications, Recent Security Schemes for Wi-Fi Applications

Application Level Security in Cellular Networks: Generations of Cellular Networks, Security Issues and attacks in cellular networks, GSM Security for applications, GPRS Security for applications, UMTS security for applications, 2G-5G security for applications, Some of Security and authentication Solutions.

Application Level Security in MANETs: MANETs, Some applications of MANETs, MANET Features, Security Challenges in MANETs, Security Attacks on MANETs, External Threats for MANET applications, Internal threats for MANET Applications, Some of the Security Solutions. Ubiquitous Computing, Need for Novel Security Schemes for UC, Security Challenges for UC, and Security Attacks on UC networks, Some of the security solutions for UC.

Module-II: Internet Security:

- Denial-of-Service Attacks
- Internet Worms
- IP Traceback
- BGP security

Reference Books:

1. Randall k. Nichols, Panos C. Lekkas : “Wireless Security Models, Threats and Solutions”, 1st Edition, Tata McGraw Hill, 2006.
2. Bruce Potter and Bob Fleck : “802.11 Security” , 1st Edition, SPD O’REILLY 2005.
3. James Kempf: “Guide to Wireless Network Security, Springer. Wireless Internet Security – Architecture and Protocols”, 1st Edition, Cambridge University Press, 2008

Course Title	Course Code	Structure (I-P-C)		
Edge, Cloud and Distributed Computing		**3**	**2**	**4**

Pre-requisite, if any: Nil

Course Aim: To teach fundamentals of Edge, Cloud and Distributed Computing for IoT

Course Outcomes: At the end of the course, the students will be able to:

CO1	Understand different computing required for IoT
CO2	Analysis and specification of different Computing.
CO3	Understanding the different architecture of computing required for IoT
CO4	Systematic Configuration of different protocols

Syllabus:

IoT and Edge Computing Definition and Use Cases Introduction to Edge Computing Scenario's and Use cases - Edge computing purpose and definition, Edge computing use cases, Edge computing hardware architectures, Edge platforms, Edge vs Fog Computing, Communication Models - Edge, Fog and M2M.

IoT Architecture and Core IoT Modules-A connected ecosystem versus machine-to-machine versus, SCADA, The value of a network and Metcalfe's and Backstrom's laws, IoT and edge architecture, Role of an architect, Understanding Implementations with the examples-Example use case and deployment, Case study – Telemedicine palliative care, Requirements, Implementation, Use case retrospective.

Introduction- Objectives, From collaborative to the Cloud – A short history Client – Server Computing, Peer-to-Peer Computing, Distributed Computing, Collaborative Computing, Cloud Computing, Functioning of Cloud Computing, Cloud Architecture, Cloud Storage, Cloud Services, Industrial Applications. Business Values, Introduction-Objectives, Service Modeling, Infrastructure Services, Platform Services, Software Services - Software as service modes-Massively scaled software as a service- Scale of Economy, Management, and Administration. Inside Cloud Computing- Introduction- Objectives, Feeling Sensational about Organization, Making Strategy Decisions- Governance Issues- Monitoring Business Processes- IT Cost Management

Cloud Service Administration- Service Level Agreements and Monitoring- Support Services Accounting Services, Resource Management- IT Security- Performance Management Provisioning- Service Management, Untangling Software Dependencies. Cloud Computing Technology- Introduction-Objectives, Clients – Mobile – Thin – Thick, Security - Data Linkage - Offloading Work - Logging - Forensics - Development – Auditing. Network- Basic Public Internet- The Accelerated Internet- Optimised Internet Overlay- Site-to-Site VPN Cloud Providers- Cloud Consumers - Pipe Size- Redundancy, Services- Identity- Integration Mapping-Payments- Search.

Introduction to distributed computing models; Clock synchronization; Message Ordering and Group Communication; Termination Detection Algorithms; Reasoning with Knowledge; Distributed Mutual Exclusion Algorithms and Distributed Shared Memory.

Textbooks

1. Hands-On Industrial Internet of Things: Create a powerful Industrial IoT infrastructure using Industry 4.0 - by Giacomo Veneri and Antonio Capasso.

2. Mastering the FreeRTOS Real Time Kernel – a Hands On Tutorial Guide

3. Cloud Computing Bible by B. Sosinsky, Wiley India

4. Mastering Cloud Computing by R. Buyya, C. Vecchiola and S. T. Selvi, McGraw Hill 3. Cloud computing: A practical approach by A. T. Velte, TMH

5. Cloud Computing by Miller, Pearson 5. Building applications in cloud: Concept, Patterns and Projects by Moyer, Pearson

References & Web Resources:

1. Rethinking the Internet of Things: A Scalable Approach to Connecting Everything, by Francis daCosta, ISBN: 978-1-4302-5740-0, 2013

2. Architecting the Internet of Things, by Dieter Uckelmann, Mark Harrison and Florian Michahelles, ISBN: 978-3-642-19157-2, 2011 Arduino Yun", Packt Publishing, 2014.

3. IoT and Edge Computing for Architects: Implementing edge and IoT systems from sensors to clouds with communication systems, analytics, and security, 2nd Edition by Perry Lea.

Course Title	Course Code	Structure (I-P-C)		
Analog and Mixed Signal Circuit Design		**3**	**0**	**3**

Pre-requisite, if any: Analog Electronics

Course Outcomes: At the end of the course, the students will be able to:

CO1	Design and analyze complex analog integrated circuits using industry level analog IC Design tools
CO2	Design and analyze ADC and DAC using EDA tools
CO3	Design and analyze various MOSFET based arithmetic circuits.
CO4	Learn the various methods of power optimization in analog circuits.
CO5	Learn various circuits of design of Operational Amplifier

Syllabus:

Introduction: Review of single state MOS amplifiers, current mirrors, cascode current mirrors, active current mirrors, biasing techniques.

Op-amp design: Differential pair with current mirror load, single stage op-amp characteristics, single stage op-amp tradeoffs, telescopic cascode op-amp, folded cascode op-amp, two stage op-amp, fully differential single stage op-amp.

Data converter fundamentals: Analog versus digital (or discrete time) signals, converting analog signals to data signals, sample and hold circuits, sample and hold characteristics, switched capacitor circuits, DAC specifications, ADC specifications.

Data converters: DAC architectures – digital input code, R-2R ladder networks, current steering, charge scaling DACs, cyclic DAC, pipeline DAC, ADC architectures – flash ADC, 2-step flash ADC, pipeline ADC, integrating ADC, successive approximation ADC.

Phase locked loop: simple PLL, frequency/phase detectors, charge pump PLL, application as frequency multiplier.

Text Book(s):

1. Behzad Razavi, Design of Analog CMOS Integrated Circuits McGraw-Hill International Edition 2016.
2. Baker, R. Jacob, CMOS: Circuit design, Layout, and Simulation. John Wiley & Sons, 2019.

References & Web Resources:

1. Phillip E. Allen and Douglas R. Holberg, CMOS Analog Circuit Design, Oxford University Press, 2003.
2. Behzad Razavi, Fundamentals of Microelectronics, Second edition, Wiley, 2013
3. P. R. Gray, P. J. Hurst, S. H. Lewis and R. G. Meyer, Analysis And Design Of Analog Integrated Circuits, 5th edition, John Wiley & Sons, Inc., 2009.

Course Title	Course Code	Structure (I-P-C)		
Artificial Intelligence and Machine Learning		**3**	**0**	**3**

Pre-requisite, if any: Linear Algebra, Probability Theory, and Statistics

Course Outcomes: At the end of the course, the students will be able to:

CO1	Understand the applications of Linear Algebra and Probability in Machine Learning
CO2	Familiarize with traditional and modern learning paradigms with their applications in the real-world systems
CO3	Adapt human training for the development of intelligent machines
CO4	Model any real-world practical problem in a machine-learning domain
CO5	Grasp the artificial neural networks with an understanding of the modern deep-learning techniques

Syllabus:

Introduction to machine learning: learning systems, classification, clustering, regression, separability of problems; introduction to learning paradigms: supervised, unsupervised, semi supervised, active, reinforcement with examples; cross-validation; performance evaluation metrics for classification and clustering; curse of dimensionality, feature selection, reduction and expansion, computation of Eigen co-ordinates and principle component analysis.

Recognition systems and design cycle, Non-linearly separable problems: solutions through Cover's theorem with examples, parametric learning mechanisms like Maximum likelihood, expectation maximisation, aposteriori probabilities, Instance-based learning, Lazy learning with K-nearest neighbour, Eager learning with basis functions, non-parametric learning using support vector machines (SVMs).

Artificial neural networks: Analogy of biological neural network with artificial neural network; Perceptron learning; gradient descent algorithm; multi-layer perceptrons; backpropagation algorithm; activation functions, delta rule, learning curves: overfitting and underfitting of models; Hebbian learning, self-organising feature map, radial basis function neural networks.

Deep neural networks: Introduction and advent of deep learning paradigm, solutions to vanishing and exploding gradient problems, regularisation, activation functions for deep learning, deep feed forward network, convolutional neural network (CNN), pretrained CNN models, attention network, generative models like auto-encoders and adversarial learning, recurrent neural networks, problem solving through deep learning and open areas of research**.**

Text Book(s):

1. T. M. Mitchell, Machine Learning, McGraw-Hill, 1997.
2. S. Haykin, Neural Networks: A Comprehensive Foundation. Prentice-Hall of India, 2007.

Reference Book(s):

1. R. O. Duda, P.E. Hart, D. G. Stork, Pattern Classification, John Wiley, 2001
2. I. Goodfellow, Y. Bengio, and A. Courville, Deep Learning, MIT Press, 2016

Course Title	Course Code	Structure (I-P-C)		
Circuits for Electronic System Design		**3**	**0**	**3**

Pre-requisite, if any: Analog Electronics and Digital Logic Circuits

Course Outcomes: At the end of the course, the students will be able to:

CO1	Apply concepts of Analog circuits for signal conditioning, signal processing, controller circuits, and driver circuits for power electronic circuits.
CO2	Design transformer and different power sources for various applications
CO3	Understand the interface of various modules to microcontroller and learn various communication protocols
CO4	Perform descriptive error analysis for the circuits
CO5	Demonstrate key concepts in electronics circuit design, including tools, approaches, and application scenarios

Syllabus:

1. Introduction to Op-Amps: Op-amp Characteristics, Negative feedback, Gain of the Op-Amp
2. Analog Signal conditioning circuits**:** Buffering, scaling, level translation, filtering applications, Analog math circuits - arithmetic circuits, log circuits, trigonometric circuits and applications Timer circuits, pulse width modulation circuits, P, PI and PID controller circuits, protection circuits, base and gate drive circuits for power transistors, MOSFETs and IGBTs, relay and contactor drive circuits. Design and error budget analysis of signal conditioners for low level AC and DC applications. Error Analysis.
3. Power supply circuits:Board level power supply circuits to generate +/-12V, 5V, 3.3V, 1.8V. Linear regulators, low drop out regulators, charge pumps, switched mode power converters.
4. Interfacing circuits**:** A to D, D to A, A to A and D to D interfaces, serial and parallel DACs, sampling, RS-232, USB, I2C, LCD, serial memory, SPI, CAN, wireless (RF, WiFi) Ethernet, RFID, SD card, SIM card, GPS, Touchscreen interfaces.

Digital circuit essentials**:**Digital filters, moving average, numeric formats, scaling, normalizing, arithmetic, log, exponential, square root, cube root, hypotenuse, sine, 3 phase waves, PWM etc.

References & Web Resources:

1. Franco, S., Design with operational amplifiers and analog integrated circuits. Mc. Graw Hillbook Co. 1988.
2. Horowitz, P., and Hill, W., The art of electronics (2nd edition), Cambridge University Press. 1992.
3. Abraham Pressman, Keith Billings, Taylor Morey, Switching Power Supply Design, McGraw-Hill Education, 2009
4. Warwick A. Smith, ARM Microcontroller Interfacing: Hardware and Software, Elektor Electronics Publishing, 2010
5. Datasheets and Application notes of different Integrated circuits.

Course Title	Course Code	Structure (I-P-C)		
Cognitive Communication Networks		**3**	**0**	**3**

Pre-requisite, if any: Signals and Systems, Analog and Digital, Wireless Communication Techniques.

Course Outcomes: At the end of the course, the students will be able to:

CO1	Understand the Cognitive Communication and networking as per applications.
CO2	Detects the desired signal in the scrambled spectrum.
CO3	Understand algorithms for cognitive networks.
CO4	Understand the MAC protocols in cognitive networks.

Syllabus:

Introduction to Cognitive Radio: Introduction –Software Defined Radio: Architecture–Digital Signal Processor and SDR Baseband architecture – Reconfigurable Wireless Communication Systems – Digital Radio Processing –Cognitive Radio: Cognitive radio Framework – Functions – Paradigms of Cognitive Radio.

Spectrum Sensing: Introduction –Spectrum Sensing – Multiband Spectrum Sensing – Sensing Techniques – Other algorithms – Comparison – Performance Measure & Design Trade-Offs: Receiver operating characteristics – Throughput Performance measure –Fundamental limits and trade-offs.

Cooperative Spectrum Acquisition: Basics of cooperative spectrum sensing–Examples of spectrum acquisition techniques – cooperative transmission techniques – sensing strategies– Acquisition in the Presence of Interference: Chase combining HARQ –Regenerative cooperative Diversity–spectrum overlay– spectrum handoff.

MAC Protocols and Network Layer Design: Functionality of MAC protocol in spectrum access – classification –Interframe spacing and MAC challenges – QOS – Spectrum sharing in CRAHN – CRAHN models – CSMA/CA based MAC protocols for CRAHN – Routing in CRN– Centralized and Distributed protocols – Geographical Protocol.

Text Book(s):

1. Mohamed Ibnkahla, “Cooperative Cognitive Radio Networks:The complete Spectrum Cycle” I edition.
2. Ahamed Khattab, Dmitri Perkins,BagdyByoumi,“Cognitive Radio Networks from Theory to Practice " 2013th edition.

References & Web Resources:

1. Kwang-Cheng Chen and Ramjee Prasad, “Cognitive Radio Networks, Wiley Publications
2. Alexander M.Wyglinski,MaziarNekovee, ThomasHou,” Cognitive Radio Communications and Networks”. I edition.

Course Title	Course Code	Structure (I-P-C)		
Communication Protocols for Electronic System Design		**3**	**0**	**3**

Pre-requisite, if any: NIL

Course Aim: To teach fundamentals of communication protocols for designing electronic systems.

Course Outcomes: At the end of the course, the students will be able to:

CO1	Quantitative analysis of individual components of industrial data communications.
CO2	Analysis and specification of serial communication protocol standards.
CO3	Understanding the error detection, cable shielding techniques to avoid stray pickups, noise.
CO4	Systematic understanding and development of industrial communication protocols.
CO5	Implement the different communication protocols for different applications

Syllabus:

Overview: Standards, OSI model, Protocols, Physical standards, Modern instrumentation and control systems, PLCs, Smart instrumentation systems, Communication principles and modes, error detection, Transmission, UART.

Serial communication standards: Standards, serial data communication interface standards, EIA-RS232 interface standard, RS-449, RS-422, RS-423 and RS-485 standards, Troubleshooting and testing with RS-485, GPIB standard, USB interface.

Error Detection, Cabling and Electrical Noise: Errors, Types of error detection, control and correction, copper and fiber cables, sources of electrical noise, shielding, cable ducting and earthling.

Modems and Multiplexers: Synchronous and Asynchronous modes, flow control, modulation techniques, types of a modem, modem standards, terminal and statistical multiplexers.

Communication Protocols: Flow control protocols, XON/XOFF, BSC, HDLC and File transfer protocols, OSI model and layers, ASCII protocols, Modbus protocol.

Industrial Protocols: Introduction to HART protocol, Smart instrumentation, HART physical layer, HART data link layer, HART application layer, ASD_i interface, Seriplex, CANbus, Device net, Profibus, FIP bus, Fieldbus.

Local Area Networks: Circuit and packet switching, Network topologies, Media access control mechanisms, LAN standards, Ethernet protocol, Token ring protocol.

References & Web Resources:

1. Practical data communications for instrumentation and control, John Park, Steve Mackay, Edwin Wright, Elsevier Newnes Publisher, 2008.
2. Computer Networks,Andrew Tanenbaum, Prentice Hall Professional Technical Reference, 2002.

CourseTitle	CourseCode	Structure (I-P-C)		
Design of Switched Mode Power Supplies		**3**	**0**	**3**

Pre-requisite, if any: Basic Electrical and Electronics Engg., and Control System

Course Outcomes: At the end of the course, the students will be able to:

CO1	Able to do the Steady-State Analysis of DC-DC power converters
CO2	Design switched-mode DC-DC power converters
CO3	Apply corresponding control techniques
CO4	Design transformer and different power sources for various DC-DC Applications
CO5	Demonstrate proficiency with computer skills (e.g., PSPICE and MATLAB) for the analysis and design of switched mode power converters.

Syllabus:

Switching devices: Ideal and real characteristics, control, drive and protection.

Design constraints of reactive elements in Power Electronic Systems: Design of inductor, transformer and capacitors for power electronic applications, Input filter requirement.

Switching power converters: Circuit topology, operation, steady-state model, dynamic model. PWM DC - DC Converters (CCM and DCM) - operating principles, constituent elements, characteristics, comparisons and selection criteria.

Soft-switching DC - DC Converters: Zero-voltage-switching converters, zero-current switching converters, multi-resonant converters and Load resonant converters.

Pulse Width Modulated Rectifiers: Properties of ideal rectifier, realization of near ideal rectifier, control of the current waveform, single phase and three-phase converter systems incorporating ideal rectifiers and design examples.

Review of linear control theory. Closed-loop control of switching power converters. Sample designs and construction projects.

Text Books:

1. R. W. Erickson and D. Maksimovic, Fundamentals of Power Electronics, 2nd Kluwer Academic Publishers, 2000. ed.,

References:

1. Marian K. Kazimierczuk, ‘Pulse-width Modulated DC-DC Power Converters’ John Wiley & Sons Ltd., 1st Edition, 2008.

2. Philip T Krein, ‘Elements of Power Electronics’, Oxford University Press, 2nd Edition, 2012.

3. Batarseh, ‘Power Electronic Circuits’, John Wiley, 2nd Edition, 2004.

4. H. W. Whittington, B. W. Flynn, D. E. Macpherson, ‘Switched Mode Power Supplies’, John Wiley & Sons Inc., 2nd Edition, 1997.

Course Title	Course Code	Structure (I-P-C)		
Detection and Estimation Theory		**3**	**0**	**3**

Pre-requisite, if any: Signals and Systems, Random Process, Communication Systems

Course Outcomes: At the end of the course, the students will be able to:

CO1	Understand the discrete-time and continuous-time signal theory for finding unknown signal parameters.
CO2	Extract useful information from random observations in communications.
CO3	Design and analyze optimum detection schemes.
CO4	Estimate the error in wireless communication.
CO5	Understand the performance parameters in practical applications

Syllabus:

Detection Theory: Detection Theory in Signal Processing; the Detection Problem; the Mathematical Detection Problem; Hierarchy of Detection Problems; Role of Asymptotics.

Statistical Detection Theory: Neyman-Pearson Theorem , Receiver Operating Characteristics, Minimum Probability of Error, Multiple Hypothesis Testing, Minimum Bayes Risk Detector - Binary Hypothesis.

Deterministic Signal: Matched Filters – Development of Detector, Performance of Matched Filter; Multiple Signals – Binary case, Performance of Binary Case, M-ary case.

Random Signals: Estimator-Correlator – Energy Detector; Linear Model - Rayleigh Fading Sinusoid, Incoherent FSK for a Multipath Channel.

Estimation Theory: Estimation in Signal Processing; Mathematical Estimation Problem; Assessing Estimator Performance.

Minimum Variance Unbiased Estimation: Unbiased Estimators; Minimum Variance Criterion; Existence of the Minimum Variance Unbiased Estimator; Finding the Minimum Variance Unbiased Estimator. Estimator Accuracy Considerations; Cramer-Rao Lower Bound; General CRLB for Signals in AWGN.

Estimation Techniques: Linear Model, General Minimum Variance Unbiased Estimation, Best Linear Unbiased Estimators, Maximum Likelihood Estimation, Least Squares, Estimation.

Text Book(s):

1. Steven M. Kay, Fundamentals of Statistical signal processing, volume-1: Estimation theory. Prentice Hall 2011.
2. Steven M. Kay, Fundamentals of Statistical signal processing, volume-2: Detection theory, Prentice Hall 2011.

References & Web Resources:

1. Harry L. Van Trees, Detection, Estimation, and Modulation Theory, Part I, John Wiley & Sons, Inc. 2011.
2. A. Papoulis and S. Unnikrishna Pillai, Probability, Random Variables and stochastic processes, 4e. The McGraw-Hill 2010.

Course Title	Course Code	Structure (I-P-C)		
Digital Image Processing		**3**	**2**	**4**

Pre-requisite, if any: Digital Signal Processing

Course Outcomes: At the end of the course, the students will be able to:

CO1	Analyse the properties of various images
CO2	Manipulate the operations between the images
CO3	Transform the given images
CO4	Detect the objects in the images
CO5	Enhance the resolution of the images

Syllabus:

Theory

1. Digital Image Fundamentals: elements of visual perception, image acquisition and display, image sampling and quantization, pixel relationship, arithmetic operations between images and super resolution (4 hours)

2. Image Transformation and Enhancement: geometric transformation, intensity transformation, spatial domain filtering, DFT, DCT, KLT and frequency domain filtering (8 hours)

3. Image and Video coding: run length coding, Huffman coding, compression using DCT, H.264/MPEG-4 advanced video coding (4 hours)

4. Image Restoration and Reconstruction: models for image degradation and restoration process, Wieners' filter, principles of Computed Tomography (CT), Image reconstruction from projections using inverse Radon transform and binary image reconstruction using network flow (6 hours)

5. Color Image Processing: color models, pseudo and full-color image processing, smoothing and sharpening in color images and segmentation based on color (4 hours)

6. Morphological Image Processing: erosion and dilation, opening and closing, boundary extraction, hole filling, connected component extraction, thinning and thickening, and grayscale morphology (6 hours)

7. Image Segmentation: point, line and edge detection, Hough transform, thresholding using Otsu's method, region based segmentation, watershed segmentation algorithm and graph-cut based segmentation (7 hours)

8. Representation, Description and Recognition of Objects: chain codes, polygonal approximation approaches, signatures, boundary segments, boundary descriptors, regional descriptors, recognition based on decision–theoretic methods, matching shape numbers and string matching (7 hours)

Text Book(s):

1. Rafael C. Gonzalez and Richard E. Woods, "Digital Image Processing", Pearson Education, 3rd Edition, 2009

References & Web Resources:

1. William K Pratt, "Digital Image Processing", John Willey, 4th edition, 2006.
2. A.K. Jain, "Fundamentals of Digital Image Processing", Prentice Hall of India, 1995.
3. Rafael C. Gonzalez, Richard E. Woods, and Steven L. Eddins, "Digital Image Processing using MATLAB", Pearson Education, 2nd Edition, 2009.
4. B. Chanda and D. Dutta Majumder, "Digital Image Processing and Analysis", Prentice Hall of India, 2008

CourseTitle	CourseCode	Structure(I-P-C)		
Electrical Drives		**1**	**3**	**3**

Pre-requisite,ifany: BasicElectricalandElectronicsEngineering

CourseOutcomes: Atthe endofthe course,thestudentswillbeableto:

CO1	Understandhowpowerelectronicconvertersandinvertersoperate.
CO2	Possessanunderstandingoffeedbackcontroltheory.
CO3	Analyze andcomparetheperformanceofDCandACmachines.
CO4	Designcontrolalgorithmsforelectricdriveswhichachievetheregulation oftorque, speed,or position inthe abovemachines.

Syllabus:

Experiments conducted in this course bring out the basic concepts of different types ofelectricalmachinesand theirperformance.

Experimentsareconductedtointroducetheconceptofcontrolofconventionalelectri cmotors such as DC motor, AC Induction motor and also special machines such as Steppermotor, Permanentmagnetbrushless motors,Servo motor.

Speed-Torquecharacteristicsofvarious typesofloadanddrivemotors arealsodiscussed.

The working principle of various power electronic converters is also studied by conductingexperiments.

References & Web Resources:

1. R.Krishnan,“ElectricMotorDrives:Modeling,Analysis,andControl,”Pre nticeHall, 2001.
2. .Mohan,“ElectricDrives:AnIntegrativeApproach,”MNPERE,2001.

Course Title	Course Code	Structure (I-P-C)		
Electromagnetic Interference and Compatibility		**3**	**0**	**3**

Pre-requisite, if any: Electromagnetic Waves and Transmission Lines

Course Outcomes: At the end of the course, the students will be able to:

CO1	Gain knowledge to understand the concept of EMI / EMC related to product design.
CO2	Understand the various standards of EMI/EMC.
CO3	Diagnose and solve various electromagnetic compatibility problems.
CO4	Understand the sources of EMI and various coupling methods.
CO5	Learn the various methods of doing the pre-compliance measurement techniques.

Syllabus:

Introduction to EMI and EMC: Various EMC requirements and standards-Need for EMC and its importance in electronic product design - sources of EMI - few case studies on EMC.

Conducted and radiated emission: power supply line filters-common mode and differential mode current-common mode choke-switched mode power supplies.

Shielding techniques: shielding effectiveness-shield behaviour for the electric and magnetic field - aperture-seams-conductive gaskets- conductive coatings.

Grounding techniques: signal ground-single point and multi-point grounding-system ground common impedance coupling -common mode choke-Digital circuit power distribution and grounding.

Contact protection: arc and glow discharge-contact protection network for inductive loads-C, RC, RCD protection circuit- inductive kickback.

RF and transient immunity: transient protection network- RFI mitigation filter-power line disturbance- ESD- human body model- ESD protection in system design.

PCB design for EMC compliance: PCB layout and stack up- multi-layerPCB objectives Return path discontinuities-mixed signal PCB layout.

EMC pre-compliance measurement: conducted and radiated emission test-LISN- Anechoic chamber.

Text Book(s):

1. H. W. Ott, Electromagnetic Compatibility Engineering, 2nd edition, John Wiley & Sons, 2011, ISBN: 9781118210659.
2. C. R. Paul, Introduction to Electromagnetic Compatibility, 2nd edition, Wiley India, 2010, ISBN: 9788126528752.

References & Web Resources:

1. K. L. Kaiser, Electromagnetic Compatibility Handbook, 1st edition, CRC Press, 2005. ISBN: 9780849320873.

Course Title	Course Code	Structure (I-P-C)		
MIMO Communication Systems		**3**	**0**	**3**

Pre-requisite, if any: Signals and Systems, Analog and Digital Communications, and Wireless Communication.

Course Outcomes: At the end of the course, the students will be able to:

CO1	Understand the concept of MIMO communication techniques, Channel Capacity, MIMO algorithms.
CO2	Understand power allocation strategies for practical MIMO systems.
CO3	Design algorithms of MIMO to improve the bit rate.
CO4	Understand MIMO in 5G communication.
CO5	Understand the MIMO reception in various channel conditions

Syllabus:

Introduction: Diversity-multiplexing trade-off, transmit diversity schemes, advantages and applications of MIMO systems.

Analytical MIMO channel models: Uncorrelated, fully correlated, separately correlated and keyhole MIMO fading models, parallel decomposition of MIMO channel.

Power allocation in MIMO systems:Uniform, adaptive and near optimal power allocation.

MIMO channel capacity: Capacity for deterministic and random MIMO channels, Capacity of i.i.d., separately correlated and keyhole Rayleigh fading MIMO channels.

Space-Time codes: Advantages, code design criteria, Alamouti space-time codes, SER analysis of Alamouti space-time code over fading channels, Space-time block codes, Space-time trellis codes, Performance analysis of Space-time codes over separately correlated MIMO channel, Space-time turbo codes.

MIMO detection: ML, ZF, MMSE, ZF-SIC, MMSE-SIC, LR based detection.

Advances in MIMO wireless communications: Spatial modulation, MIMO based cooperative communication and cognitive radio, multiuser MIMO, cognitive-femtocells and large MIMO systems for 5G wireless.

Text Book(s):

1. R. S. Kshetrimayum, Fundamentals of MIMO Wireless Communications, Cambridge University Press, 2017.
2. A. Chokhalingam and B. S. Rajan, Large MIMO systems, Cambridge University Press, 2014.

References & Web Resources:

1. B. Kumbhani and R. S. Kshetrimayum, MIMO Wireless Communications over Generalized Fading Channels, CRC Press, 2017
2. T. L. Marzetta, E. G. Larsson, H. Yang and H. Q. Ngo, Fundamentals of Massive
3. MIMO, Cambridge University Press, 2016.

Course Title	Course Code	Structure (I-P-C)

Numerical Techniques in Electromagnetics		3	0	3

Pre-requisite, if any: Electromagnetic Waves and Transmission Lines

Course Outcomes: At the end of the course, the students will be able to:

CO1	Understand how to computational solve different structures using Maxwell equations.
CO2	Understand various computational techniques and their pros and cons.
CO3	Understand which software works best in terms of speed, and accuracy for analysing a given structure
CO4	Develop codes to analyze the EM structures.
CO5	Gain knowledge need to develop EM simulation software tools

Syllabus:

Review of vector calculus, Overview of computational electromagnetics, Review of Maxwell's equations.
Analytical techniques in Electromagnetics.
Finite Difference Time Domain methods: Analysis, convergence, accuracy and numerical dispersion, incorporating dielectric and dispersive materials, absorbing boundary conditions, perfectly matched layers (PML), sources.

Moment Methods: Integral equations (EFIE,MFIE), Green's Functions, MOM.

Finite element methods: Formulation and Absorbing boundary conditions (FEM).

Applications of computational electromagnetic: Specific Absorption Rate, Radar RCS, Periodic structures, Eddy current calculations, capacitance and inductance calculations, Microwave inverse imaging, Antenna radiation problems, Calculating the modes of a waveguide structure using the integral equation method.

Text Book(s):

1. Numerical Techniques in Electromagnetic, Second Edition Hardcover – Import, 12 July 2000, by Matthew N.O. Sadiku
2. Analytical and Computational Methods in Electromagnetic, Artech House Electromagnetic Analysis, 30 September 2008, by Ramesh Garg, Raj Mittra

References & Web Resources:

1. Computational Electromagnetics for RF and Microwave Engineering, 28 October 2010, by David B. Davidson
2. Advanced Engineering Electromagnetics Paperback - 8 October 2008, by Constantine A. Balanis
3. Computational Methods for Electromagnetics: 4 (IEEE Press Series on Electromagnetic Wave Theory) Hardcover – Import, 12 December 1997, by Andrew F. Peterson, Scott L. Ray, Raj Mittra

CourseTitle	CourseCode	Structure(I-P-C)		
PowerElectronics		**3**	**0**	**3**

Pre-requisite,ifany: Electronic Devices

CourseOutcomes: Atthe endofthe course,thestudentswillbeableto:

CO1	Understand basic operation of various power semiconductor devices andpassive components
CO2	Understandthebasicprinciple ofswitchingcircuits.
CO3	DesignAC/DCrectifier,DC/DCconverterandDC/ACinvertercircuits.
CO4	Understandtherolepowerelectronicsplayintheimprovementofenergyusage,efficiencyandthedevelopmentofrenewableenergytechnologies.
CO5	Design different power converters

Syllabus:

Introduction topowerelectronics; applicationsandroleofpowerelectronics.

Introductiontopowersemiconductordevices,operatingcharacteristicsofPowerDiode,SCR,Power BJT, PowerMOSFET andIGBT;DrivercircuitsandSnubbercircuits.

Introduction to AC/DC rectifiers, principle of operation of phase controlled rectifiers, singlephaseandthreephaseAC-DClinecommutatedconverters,dualconverter,andintroductiontounitypowerfactorconverters. Applications: DCmotordrivesandBattery chargers.

Introduction to DC/DC converters, Principle of operation of DC/DC (Buck, Boost, Buck-Boost, Cuk, Fly-back and Forward) converters. Applications: Power supply, DC motor drivesand SMPS.

Introductionto DC/AC inverters, PWMtechniques, Principleof operationof single phaseand three phase DC-AC inverters, Applications: AC motor drives, UPS, active filters, CFL,renewable power generation,inductionanddielectricheating.

Text Book:

1. N.Mohan,T.Undeland,andW.Robbins,“PowerElectronics:Converters,Applications, andDesign,”3rdEdition,Wiley,2003.
2. M.Rashid,“PowerElectronics:Circuits,Devices&Applications,”Prentice Hall,3rdEdition,2003.

References & Web Resources:

1. J.P.Agrawal,“PowerElectronic Systems:TheoryandDesign,”Pearson,2013.
2. Batarseh,“PowerElectronicCircuits,”JohnWiley,2004.2.R.W.EricksonandD.Maksimovic,“Fundamentals ofPowerElectronics,”2ndEdition,Springer,2001.
3. R.W.EricksonandD.Maksimovic,“FundamentalsofPowerElectronics,” 2ndEdition,Springer,2001.

Course Title	Course Code	Structure (I-P-C)		
Reliable Digital Communication System Design		**3**	**0**	**3**

Pre-requisite, if any: Communication Systems, Digital Logic Design

Course Outcomes: At the end of the course, the students will be able to:

CO1	Learn the functional behaviour of various cryptography, intrusion detection, and error correction algorithms.
CO2	Learn to develop hardware architectures of various cryptography, intrusion detection, and error correction algorithms.
CO3	Develop the countermeasure prototypes of adversary attacks
CO4	Develop the crypto co-processors using FPGA.
CO5	Understand the algorithms of cryptography.

Syllabus:

Information theory, Entropy, Properties of Entropy

Goals of Relilable Digital Communication: first level of defense (integrity, confidentiality, authenticity, and availability) and second level of defense (resilience to attacks).

Galois Field Arithmetic: Introduction to Group, Ring, and Fields, Prime/Polynomial field representation, Irreducible polynomial, primitive polynomial, minimal polynomial, Galois field addition, LSB first/MSB first/Montgomery Galois field multiplication architectures-bit serial, bit parallel, digit serial, systolic, and scalable architectures, Modular exponentiators-Square-multiply algorithm and Montgomery Ladder algorithm, Extended Euclidean algorithm/Fermat's little theorem based multiplicative inverse architectures.

Symmetric Encryption/Decryption Architectures: DES, 3-DES, and AES (fully folded, parameterized parallel, and fully parallel architectures).

Asymmetric Encryption/Decryption Architectures: ECC (right-to-left, left-to-right, Montgomery based scalar multiplication in affine/projective co-ordinates) and RSA.

HASH architectures: SHA512 and SHA3.

Key exchange protocols: Diffie Helmen, Elgamal, Neuro crypto key exchange protocol.

Authentication schemes: Yang Shieh and EijiOkamato.

Pseudo random number generators, Stream ciphers.

Physical unclonable functions: RO PUF, larger decoder memory based PUF, and XOR PUF.

Intrusion Detection: Universal HASH functions, Cuckoo hashing, and Bloom filter.

Error detection codes: CRC, LRC, and parity check, Error correction codes-Hamming, BCH, Reed Solomon, LDPC, Convolutional, Turbo product, and concatenated codes,
Hardware/software co-design analogous between ASIC/FPGA/hardware-software co-designs, need for crypto accelerators (or coprocessors), and hardware/software partitioning based AES/ECC architectures.

Side channel analysis: Power attack, Bit masking, and Cache template attack.

Text Book(s):

1. Doug R. Stinson , Cryptography Theory and Practice, Third Edition, CRC Press, 2006.
2. Shu Lin and Daniel J Castello, Error Control Coding, Second Edition, Printice Hall, 2004.
3. Haykin, An Introduction to Analog and Digital Communications, wiley Vol 2, 2008.

References & Web Resources:

1. A. J. Menezes, P. C. van Oorshot, and S. A. Vanstone, Handbook of Applied Cryptography, CRC Press, 1996.
2. Jonathan Katz and Yehuda Lindell, Introduction to Modern Cryptography, CRC Press, 2015.
3. Debdeep Mukhopadhyay and Rajat Subhra Chakraborty, Hardware Security: Design, Threats and Safeguards, CRC Press, 2014.

Course Title	Course Code	Structure (I-P-C)		
RF and Microwave Integrated Circuits		**3**	**0**	**3**

Pre-requisite, if any: Electromagnetic Waves and Transmission Lines,and Analog Electronics

Course Outcomes: At the end of the course, the students will be able to:

CO1	Understand the differences in designing low frequency ICs, RFICs, and MMICs.
CO2	Analyse high frequency filters, couplers, amplifier, oscillators and mixer circuits.
CO3	Design high frequency filters, couplers, amplifiers.
CO4	Develop RFICs.
CO5	Develop MMICs.

Syllabus:

Electromagnetic Theory Review: Maxwell's Equations, Fields in Media and Boundary Conditions, The Wave Equation, General Plane Wave Solutions, Energy and Power, Transmission lines and waveguide solutions.

Transmission Line Theory: The Lumped-Element Circuit Model for a Transmission Line, Field Analysis of Transmission Lines, The Terminated Lossless Transmission Line, The Smith Chart, The Quarter-Wave Transformer, Generator and Load Mismatches, Lossy Transmission Lines, Transients on Transmission Lines.

Microwave Network Analysis: Impedance and Equivalent Voltages and Currents, Impedance and Admittance Matrices, The Scattering Matrix, The Transmission (ABCD) Matrix.

Impedance matching and tuning, Microwave filter design.

Noise and nonlinear distortion, active rf and microwave devices.

Microwave Power Amplifier, Low Noise Amplifier, Oscillator and Mixer Design.

Introduction to microwave systems.

Text Book(s):

1. David M Pozar, Microwave Engineering, 4th Edition, Wiley, 2013.
2. Behzad Razavi, RF Microelectronics, 2nd Edition, Pearson, 2011.

References & Web Resources:

1. Robert E Collin, Foundations for Microwave Engineering, 2nd Edition, Wiley, 2007.
2. I.D. Robertson , S. Lucyszyn, RFIC and MMIC Design and Technology: 13 (Materials, Circuits and Devices), Institution of Engineering and Technology, 2001.

Course Title	Course Code	Structure (I-P-C)		
Satellite Communication		**3**	**0**	**3**

Pre-requisite, if any: Signals and Systems, Analog and Digital, Wireless Communication Techniques.

Course Outcomes: At the end of the course, the students will be able to:

CO1	Understand the satellite communication.
CO2	Understand the orbits and space of satellite communication.
CO3	Understand the optical communication.
CO4	Develop the packet switched networks.
CO5	Understand the importance of Optical technology in space applications

Syllabus:

OVERVIEW OF SATELLITE SYSTEMS, ORBITS AND LAUNCHING METHODS: Introduction, Frequency Allocations for Satellite Services, Intelsat, U. S. Domsats Polar Orbiting Satellites, Problems, Kepler's First Law, Kepler's Second Law, Kepler's Third Law, Definitions of Terms for Earth-orbiting Satellites, Orbital Elements, Apogee and Perigee Heights, Orbital Perturbations, Effects of a Non-spherical Earth, Atmospheric Drag, Inclined Orbits, Calendars, Universal Time, Julian Dates, Sidereal Time, The Orbital Plane, The Geocentric, Equatorial Coordinate System, Earth Station Referred to the IJK Frame, The Top centric-Horizon Co-ordinate System, The Sub-satellite Point, Predicting Satellite Position.

GEOSTATIONARY ORBIT & SPACE SEGMENT: Introduction, Antenna Look Angels, The Polar Mount Antenna , Limits of Visibility , Near Geostationary Orbits, Earth Eclipse of Satellite, Sun Transit Outage, Launching Orbits, Problems, Power Supply, Attitude Control, Spinning Satellite Stabilization, Momentum Wheel Stabilization, Station Keeping, Thermal Control, TT&C Subsystem , Transponders, Wideband Receiver, Input De-multiplexer, Power Amplifier, Antenna Subsystem, Morelos, Anik-E, Advanced Tiros-N Spacecraft.

OPTICAL NETWORK ARCHITECTURES: Introduction to Optical Networks; Layered Architecture- Spectrum partitioning, Network Nodes, Network Access Stations, Overlay Processor, Logical network overlays, Connection Management and Control; Static and Wavelength Routed Networks; Linear Light wave networks; Logically Routed Networks; Traffic Grooming; The Optical Control Plane- Architecture, Interfaces, Functions; Generalized Multiprotocol Label Switching – MPLS network and protocol stack, Link management, Routing and Signaling in GMPLS.

OPTICAL PACKET SWITCHED NETWORKS: Network Architectures- Unbuffered Networks, Buffering Strategies; OPS enabling technologies, Test beds; Optical Burst Switching, Switching protocols, Contention Resolution, Optical Label Switching, OLS network test beds, Control and Management – Network management functions, Configuration management, Performance management, Fault management, Optical safety, Service interface; network Survivability- Protection in SONET / SDH and IP Networks, Optical layer Protection, Interworking between layers.

FREE SPACE OPTICAL COMMUNICATION: Analog and digital FSOC data link, atmospheric attenuation, scattering, scintillation index, beam wandering, beam wave front aberration, adaptive optics, active optics, deformable mirror control, RoFSO, atmospheric channel models, estimation of refractive index, modulation and demodulation techniques, error control techniques.

Text Book(s):

1. Satellite Communications, Dennis Roddy, McGraw-Hill Publication Third edition2001
2. Satellite Communications – Timothy Pratt, Charles Bostian and Jeremy Allnutt, WSE, Wiley Publications, 2nd Edition, 2003.

References & Web Resources:

1. Timothy Pratt – Charles Bostian& Jeremy Allmuti, Satellite Communications, John Willy & Sons (Asia) Pvt. Ltd. 2004
2. Wilbur L. Pritchars Henri G. SuyderHond Robert A. Nelson, Satellite Communication Systems Engineering, Pearson Education Ltd., Second edition 2003.
3. Satellite Communications: Design Principles – M. Richharia, BS Publications, 2nd Edition, 2003.
4. J. Gower, "Optical Communication System", Prentice Hall of India, 2001
5. Rajiv Ramaswami, "Optical Networks ", Second Edition, Elsevier, 2004.
6. Satellite Communications Engineering – Wilbur L. Pritchard, Robert A Nelson and Henri G. Suyderhoud, 2nd Edition, Pearson Publications, 2003.
7. Optical Fiber Communication – John M. Senior – Pearson Education – Second Edition. 2007
8. Optical Fiber Communication – Gerd Keiser – McGraw Hill – Third Edition. 2000

CourseTitle	CourseCode	Structure(I-P-C)		
Sensing and Instrumentation		**1**	**3**	**3**

Pre-requisite, if any: Nil

CourseOutcomes: Atthe endofthe course,thestudentswillbeableto:

CO1	Buildsystemswhichwouldsensethedifferentphysicalsignal
CO2	Processthesignalsintherequiredanalogordigitalformats
CO3	Calibratesensorsaccordingtherequiredapplications.
CO4	Understandthecharacteristicsoftransducers.

Syllabus:

Transducers, transducer sensing and functions, Passive and active – Resistance, inductanceand capacitance,Strain Gauges, Hall Effect sensors, Opticalsensors.

Measurementofnon-electricalquantitiessuchasdisplacement,velocity,acceleration,pressure, force, flow and temperature, calibration of sensors, Data acquisition and detectiontechniques, Signalconversion, PC-based Instrumentation System.

Practiceincludesexperimentsfromfollowingtopics:

Signal generation – Instrumentation amplifiers – Signal conversion and processing –CharacteristicsofTransducers-Calibrationofsensors–Measurementofphysicalquantities.

Text Book(s):

1. AlanS.Morris,MeasurementandInstrumentationPrinciples,Elsevier,2001.
2. Sawhney. A. K, Course in Electrical & Electronics Measurement &Instrumentation, DhanpatRai, 2007.

References & Web Resources:

1. Howard Austerlitz,Dataacquisitiontechniquesusing PCs, AcademicPress, 2ndEd.2002.
2. BruceMihura,LabVIEWforDataAcquisition(NationalInstrumentsVirtualInstrumentation Series), PrenticeHall,2001.

CourseTitle	CourseCode	Structure(I-P-C)		
Signal and Power Integrity		**3**	**0**	**3**

Pre-requisite, if any: Nil

CourseOutcomes: Atthe endofthe course,thestudentswillbeableto:

CO1	Understand the design guidelines to be followed in PCB design and IC packagingto prevent Signal and Power Integrity issues.
CO2	Analyze the physical structure and dimensions of the PCB elements and fit an appropriate circuit model.
CO3	Analyze the measured voltages and currents in the PCB and find the causes of the signal integrity issues.
CO4	Analyze the measured voltages and currents in the PCB and find the causes of the power integrity issues.
CO5	Design an optimal layout for a PCB to avoid signal and power integrity issues.

Syllabus:

Signal Integrity Is in Your Future: What Are Signal Integrity, Power Integrity, and Electromagnetic Compatibility?, Signal-Integrity Effects on One Net, Cross Talk, Rail-Collapse Noise, Electromagnetic Interference (EMI, Two Important Signal-Integrity Generalizations, Trends in Electronic Products, The Need for a New Design Methodology, A New Product Design Methodology.

Time and Frequency Domains: The Time Domain, Sine Waves in the Frequency Domain, Shorter Time to a Solution in the Frequency Domain, Sine-Wave Features, The Spectrum of a Repetitive Signal, The Spectrum of an Ideal Square Wave, Frequency Domain to the Time Domain, Effect of Bandwidth on Rise Time, Bandwidth and Rise Time, Bandwidth of Real Signals, Bandwidth and Clock Frequency, Bandwidth of a Measurement, Bandwidth of a Model, Bandwidth of an Interconnect.

Impedance and Electrical Models, The Physical Basis of Resistance, Capacitance, Inductance, and Transmissions lines.

Transmission Lines and Reflections, Lossy Lines, Rise-Time Degradation, and Material Properties, Cross Talk in Transmission Lines.

Differential Pairs and Differential Impedance, S-Parameters for Signal-Integrity Applications, The Power Distribution Network (PDN)

Text Book(s):

1. Bogatin, Eric. Signal and power integrity-simplified. Pearson Education, 2010.

References & Web Resources:

1. Johnson, Howard, Howard W. Johnson, and Martin Graham. High-speed signal propagation: advanced black magic. Prentice Hall Professional, 2003.
2. Johnson, Howard W., and Martin Graham. High-speed digital design: a handbook of black magic. Vol. 155. Englewood Cliffs, NJ: Prentice Hall, 1993.

Course Title	Course Code	Structure (I-P-C)		
Software Defined Radio		**3**	**0**	**3**

Pre-requisite, if any: Signals and Systems, Analog and Digital, Wireless Communication Techniques.

Course Outcomes: At the end of the course, the students will be able to:

CO1	Understand the SDR, CR, and their applications.
CO2	Understand the signal processing architectures used in the SDR.
CO3	Develop the FPGA based SDR.
CO4	Develop microcontroller based SDR.

Syllabus:

INTRODUCTION TO SDR: What is Software-Defined Radio, The Requirement for Software-Defined Radio, Legacy Systems, The Benefits of Multi-standard Terminals, Economies of Scale, Global Roaming, Service Upgrading, Adaptive Modulation and Coding, Operational Requirements, Key Requirements, Reconfiguration Mechanisms, , Handset Model, New Base-Station and Network, Architectures, Separation of Digital and RF, Tower-Top Mounting, BTS Hoteling, Smart Antenna Systems, Smart Antenna System Architectures, Power Consumption Issues, Calibration Issues, Projects and Sources of Information on Software Defined Radio.

BASIC ARCHITECTURE OF A SOFTWARE DEFINED RADIO: Software Defined Radio Architectures, Ideal Software Defined Radio Architecture, Required Hardware Specifications, Digital Aspects of a Software Defined Radio, Digital Hardware, Alternative Digital Processing Options for BTS Applications, Alternative Digital Processing Options for Handset Applications, Current Technology Limitations, A/D Signal-to-Noise Ratio and Power 343 Consumption, Derivation of Minimum Power Consumption, Power Consumption Examples, ADC Performance Trends, Impact of Superconducting Technologies on Future SDR Systems.

SIGNAL PROCESSING DEVICES AND ARCHITECTURES: General Purpose Processors, Digital Signal Processors, Field Programmable Gate Arrays, Specialized Processing Units, Tilera Tile Processor, Application-Specific Integrated Circuits, Hybrid Solutions, Choosing a DSP Solution. GPP-Based SDR, Non real time Radios, High-Throughput GPP-Based SDR, FPGA-Based SDR, Separate Configurations, Multi-Waveform Configuration, Partial Reconfiguration, Host Interface, Memory-Mapped Interface to Hardware, Packet Interface, Architecture for FPGA-Based SDR, Configuration, Data Flow, Advanced Bus Architectures, Parallelizing for Higher Throughput, Hybrid and Multi-FPGA Architectures, Hardware Acceleration, Software Considerations, Multiple HA and Resource Sharing, Multi-Channel SDR.

COGNITIVE RADIO : TECHNIQUES AND SIGNAL PROCESSING:History and background, Communication policy and Spectrum Management, Cognitive radio cycle, Cognitive radio architecture, SDR architecture for cognitive radio, Spectrum sensing Single node sensing: energy detection, cyclostationary and wavelet based sensing- problem formulation and performance analysis based on probability of detection vs SNR. Cooperative sensing: different fusion rules, wideband spectrum sensing- problem formulation and performance analysis based on probability of detection vs SNR.

COGNITIVE RADIO: HARDWARE AND APPLICATIONS: Spectrum allocation models. Spectrum handoff, Cognitive radio performance analysis. Hardware platforms for Cognitive radio (USRP, WARP), details of USRP board, Applications of Cognitive radio.

Text Book(s):

1. "RF and Baseband Techniques for Software Defined Radio" Peter B. Kenington, ARTECH HOUSE, INC © 2005.
2. "Implementing Software Defined Radio", Eugene Grayver, Springer, New York Heidelberg Dordrecht London, ISBN 978-1-4419-9332-8 (eBook) 2013.

References & Web Resources:

1. "Cognitive Radio Technology", by Bruce A. Fette, Elsevier, ISBN 10: 0-7506-7952-2, 2006.
2. "Cognitive Radio, Software Defined Radio and Adaptive Wireless Systems", Hüseyin Arslan, Springer, ISBN 978-1-4020-5541-6 (HB), 2007.

Course Title	Course Code	Structure (I-P-C)		
Testing and Testability		**3**	**0**	**3**

Pre-requisite, if any: Digital Logic Design

Course Outcomes: At the end of the course, the students will be able to:

CO1	Identify the significance of testable design
CO2	Understand the concept of yield and identify the parameters influencing the same
CO3	Specify fabrication defects, errors and faults.
CO4	Implement combinational and sequential circuit test generation algorithms
CO5	Identify techniques to improve fault coverage

Syllabus:

Role of testing in VLSI Design flow, Testing at different levels of abstraction, Fault error, defect, diagnosis, yield, Types of testing, Rule of Ten, Defects in VLSI chip. Modelling basic concepts, Functional modelling at logic level and register level, structure models, logic simulation, delay models.

Various types of faults, Fault equivalence and Fault dominance in combinational sequential circuits. Fault simulation applications, General fault simulation algorithms- Serial, and parallel, Deductive fault simulation algorithms. Combinational circuit test generation, Structural Vs Functional test, ATPG, Path sensitization methods.

Difference between combinational and sequential circuit testing, five and eight valued algebra, and Scan chain based testing method. D-algorithm procedure, Problems, PODEM Algorithm, Problems on PODEM Algorithm. FAN Algorithm, Problems on FAN algorithm, Comparison of D, FAN and PODEM Algorithms. Design for Testability, Ad-hoc design, Generic scan based design.

Classical scan based design, System level DFT approaches, Test pattern generation for BIST, and Circular BIST, BIST Architectures, and Testable memory design-Test algorithms-Test generation for Embedded RAMs.

Fault Diagnosis Logic Level Diagnosis - Diagnosis by UUT reduction - Fault Diagnosis for Combinational Circuits - Self-checking design - System Level Diagnosis.

Text Book(s):

1. M. Abramovici, M. Breuer, and A. Friedman, “Digital Systems Testing and Testable Design, IEEE Press, 1990
2. Stroud, “A Designer’s Guide to Built-in Self-Test”, Kluwer Academic Publishers, 2002

References & Web Resources:

1. M. Bushnell and V. Agrawal, “Essentials of Electronic Testing for Digital, Memory & Mixed-Signal VLSI Circuits”, Kluwer Academic Publishers, 2000
2. V. Agrawal and S.C. Seth, Test Generation for VLSI Chips, Computer Society Press.1989.
3. M. Abramovici, M.A. Breuer and A.D. Friedman, "Digital Systems and Testable Design", Jaico Publishing House.
4. M.L. Bushnell and V.D. Agrawal, "Essentials of Electronic Testing for Digital, Memory and Mixed-Signal VLSI Circuits", Kluwer Academic Publishers.
5. P.K. Lala, "Digital Circuit Testing and Testability", Academic Press, 2002.
6. A.L. Crouch, "Design Test for Digital IC's and Embedded Core Systems", Prentice Hall International.

Course Title	Course Code	Structure (I-P-C)		
VLSI Technology		**3**	**2**	**4**

Pre-requisite, if any: Electronic Devices

Course Outcomes: At the end of the course, the students will be able to:

CO1	Appreciate the intricacies involved in VLSI circuit fabrication.
CO2	Understand the various processes needed to fabricate the VLSI devices.
CO3	Learn fabrication steps for existing and coming generation devices.

Syllabus:

Theory

1. Introduction to VLSI Design, Bipolar Junction Transistor Fabrication, MOSFET Fabrication. (3 hours)

2. Crystal Structure of Si, Defects in Crystal, Crystal growth (3 hours)

3. Epitaxy, Vapour phase Epitaxy, Doping during Epitaxy, Molecular beam Epitaxy (3 hours)

4. Oxidation – Kinetics, Rate constants, Dopant Redistribution, Oxide Charges (3 hours)

5. Diffusion-Theory of Diffusion, Doping Profiles, Diffusion Systems Ion Implantation - Process, Annealing of Damages, Masking during Implantation (3 hours)

6. Lithography, immersion lithography, e-beam lithography (3 hours)

7. Etching-Wet Chemical Etching, Dry Etching, Plasma Etching, Si, SiO2, SiN and other materials (3 hours)

8. Deposition-Plasma Deposition, Metallization, Problems in Aluminium Metal contacts, Copper interconnects (3 hours)

9. IC BJT - LOCOS, Trench isolation, Poly-emitter-poly-base-BJT and its suitability for high-speed applications (3 hours)

10. MOSFET - Metal gate vs. Self-aligned Poly-gate, Tailoring of Device Parameters, CMOS Technology, Latch - up in CMOS, MOSFET structures with strained channels and high-k gate dielectrics, Bi-CMOS Technology, introduction to FINFETs (3 hours)

11. Small-Dimension Effects of MOSFET: Modelling for Circuits Simulation- Quantum-Mechanical Effects; Gate Current, Junction Leakage, Scaling and New Technologies, Approaches, and Properties of Good Models, Model Formulation Considerations, Parameter Extraction, Compact Models, Benchmark Tests (7 hours)

12. Small-Signal Modelling of MOSFET: Conductance Parameter Definitions and Equivalent Circuits, Conductance Parameters Due to Gate and Body Leakage, Transconductance, Source-Drain and Output Conductance, Capacitance Definitions and Equivalent Circuits, Capacitance Evaluation and Properties, y-Parameter Model, RF Models (6 hours)

Practice

1. Simulation of various properties of Si, SiO2, SiN and other materials (40 hours)

Text Book(s):

1. S. K. Ghandhi, “VLSI Fabrication Principles- Silicon and Gallium Arsenide”, Wiley Publications.

2. Y. Tsividis and C. McAndrew, “MOSFET modelling for Circuit Simulation”, Oxford University Press, 2011

References & Web Resources:

1. S. M. Sze, “VLSI Technology”, Tata McGraw Hill, 2008

2. J. Plummer, M. D. Deal, and P. B. Griffin, “Silicon VLSI Technology, Fundamentals, Practice and Modeling”, Pearson Higher Education, 2000

3. T. A. Fjeldly, T. Yetterdal, and M. Shur, “Introduction to Device Modeling and Circuit Simulation”, John Wiley, 1998.

4. Y. Taur and T. H. Ning, “Fundamentals of Modern VLSI Devices”, Cambridge University Press, 1998.