Bharatiya Vidya Bhavan's
**Sardar Patel Institute of Technology**
(Empowered Autonomous Institute Affiliated to University of Mumbai)
Bhavan's Campus, Munshi Nagar, Andheri (West), Mumbai-400058-India
**B. Tech. EXTC**

# B. Tech. (Electronics and Telecommunication Engineering)

# Syllabus
# (Semester VII-VIII)

## 2023 ITERATION: ELECTRONICS AND TELECOMMUNICATION ENGG.

**Nomenclature of the Courses**

| Abbreviation | Course Category |
|---|---|
| BSESC | Basic Science & Engineering Science Courses |
| BSESEC | Basic Science & Engineering Science Elective Courses |
| SEC | Skill Enhancement Course |
| AEC | Ability Enhancement Course |
| HSSMC | Humanities and Social Science in Management Courses |
| CC | Cocurricular Courses |
| IKS | Indian Knowledge System |
| UHV | Universal Human Values |
| PCC | Program Core Courses |
| PEC | Program Elective Courses |
| OEC | Open Elective Courses |
| ELC | Experiential Learning Courses |
| MDM | Multidisciplinary Minor |
| CP | Community Project |
| HC | Honor Courses |
| DMC | Double Minor Course |

**Abbreviations**

| | | | |
|---|---|---|---|
| L | Lecture Hour | O | Other Work (Self Study) |
| T | Tutorial Hour | E | Total Engagement in Hours |
| P | Laboratory Hour | C | Credit Assigned |

| SEM VII | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Sr. No** | **Course Category** | **Abbreviation** | **Course Code** | **Course Name** | **L** | **T** | **P** | **O** | **E** | **C** |
| 1 | Multidisciplinary Minor | MDM | MDEC4X | MDM-IV | To be defined others | | | | | 4 |
| 2 | Program Elective Courses | PEC | EC3X3 | PE-III | 2 | 0 | 2 | 4 | 8 | 3 |
| 3 | Program Elective Courses | PEC | EC3X4 | PE-IV | 2 | 0 | 2 | 4 | 8 | 3 |
| 4 | Open Elective | OE | OE1 | OE-I | 2 | 0 | 2 | 4 | 8 | 3 |
| 5 | Experiential Learning | ELC | PR3-II | Main Project Stage II | 0 | 0 | 8 | 4 | 12 | 4 |
| | | | | **Total** | **6** | **0** | **11** | **16** | **33+** | **17** |

- **Research internship of minimum 1 month for the "Honors by Research" for 3 credits HR41 (Not for DSY)**
- **For Enrollment to Honors by research, Minimum CGPA must be 8.25**

| SEM VIII | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Sr. No** | **Course Category** | **Abbreviation** | **Course Code** | **Course Name** | **L** | **T** | **P** | **O** | **E** | **C** |
| 1 | Open Elective | OE | OE2 | OE-II** | 2 | 0 | 2 | 4 | 8 | 3 |
| 2 | Experiential Learning | ELC | INTR/ INTI/PR3-III | Research/ Industry Internship/Main Project Stage III/ *** | 0 | 0 | 24 | 12 | 36 | 11 |
| | | | | **Total** | **2** | **0** | **25** | **16** | **43** | **14** |

*** To be completed from MOOCs*

**** Students neither taking research or industry internship nor willing to extend their project work can earn additional 11 credits from Swayam Platform or NPTEL or registering courses from any peer institution of higher learning., besides open elective/program elective courses offered by the institute.*

## PROGRAM ELECTIVE COURSES

| Sem- VII | | | |
|---|---|---|---|
| **Course Category** | **Abbreviation** | **PE-III(Sem VII)** | **PE-IV(Sem VII)** |
| **Program Elective Courses (Communication)** | PEC | **EC413:** Microwave Communication | **EC414:** Space Communication on Technologies |
| | | **EC433:** IoT Protocols | **EC434:** IoT Applications and Analytics |
| **Program Elective Courses ( Embedded Systems & IoT)** | PEC | **EC443:** Speech and Audio Processing | **EC444:** DSP based System Design |
| **Program Elective Courses (Signal Processing)** | PEC | **EC453:** Analog CMOS VLSI Design | **EC454:** ASIC Verification |
| **Program Elective Courses (VLSI )** | PEC | **EC433:** IoT Protocols | **EC434:** IoT Applications and Analytics |

# Semester-VII

| Course (Category) Code | Course Name | Teaching Scheme (Hrs./week) | | | | | Credits Assigned | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | L | T | P | O | E | L | T | P | Total |
| PE-III | Microwave Communication | 2 | 0 | 2 | 6 | 11 | 2 | 0 | 1 | 3 |
| | | Examination Scheme | | | | | | | | |
| EC413 | | Component | ISE | | MSE | | ESE | | | Total |
| | | Theory | 20 | | 20 | | 100 | | | 140 |
| | | Laboratory | 80 | | | | 20 | | | 100 |

| Pre-requisite Course Codes, if any. | EC201 & EC306 |
|---|---|
| **Course Objective:** The objective of the course is to provide a fundamental understanding of Microwave Communication | |
| **Course Outcomes (CO):** ***At the End of the course students will be able to*** | |
| EC413.1 | Apply EM Wave theory to understand nature of Microwave Signal and their corresponding guiding structures. |
| EC413.2 | Identify Passive Waveguide Components, Sources and Detectors |
| EC413.3 | Analyze Passive Waveguide Components, Sources and Detectors |
| EC413.4 | Evaluate amplifier design parameters on the basis of application/requirement. |
| EC413.5 | On the basis of application compute filter design parameter with justification. |
| EC413.6 | Design Microwave System components |

**CO-PO Correlation Matrix (3-Strong, 2-Moderate, 1-Weak Correlation)**

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| EC413.1 | 3 | 3 | 3 | 1 | 3 | | | | | 3 | | |
| EC413.2 | 2 | 2 | 2 | 2 | 3 | | | | | 3 | | |
| EC413.3 | 2 | 2 | 2 | 2 | 3 | | | | | 3 | | |
| EC413.4 | 2 | 2 | 2 | 2 | 3 | | | | | 3 | | |
| EC413.5 | 2 | 2 | 2 | 2 | 3 | | | | | 3 | | |
| EC413.6 | 3 | 3 | 3 | | 3 | | | | | 3 | | |

**CO-PEO/PSO Correlation Matrix (3-Strong, 2-Moderate, 1-Weak Correlation)**

| | PEO1 | PEO2 | PEO3 | PEO4 | PSO1 | PSO2 | PSO3 |
|---|---|---|---|---|---|---|---|
| EC413.1 | | 2 | | | | - | |
| EC413.2 | | 2 | | | | - | |
| EC413.3 | | 2 | | | | 2 | |
| EC413.4 | | 2 | | | | 2 | |
| EC413.5 | | 2 | | | | 2 | |
| EC413.6 | | 1 | | | | | |

**BLOOM'S Levels Targeted (Pl. Tick appropriate)**

| Remember√ | Understand√ | Apply√ | Analyze√ | Evaluate | Create |
|---|---|---|---|---|---|
| | | | | | |

**Theory Component**

| Module No. | Unit No. | Topics | Ref. | Hrs. |
|---|---|---|---|---|
| 1 | | **Introduction to Microwave Engineering** | 1 | 10 |
| | 1.1 | Lumped and Distributed Elements, Frequency Bands, Characteristics, Application, Advantages and disadvantages | | |
| | 1.2 | Rectangular and circular waveguides: TE, TM modes, dominant mode | | |
| | 1.3 | Microwave Components: Resonators, reentrant cavities, scattering parameters, tees, hybrid ring, directional couplers, phase shifters,terminations, attenuators, ferrite devices such as isolators, gyrators, and circulators. | | |
| 2 | | **Microwave Tubes and semiconductor devices** | 1 | 10 |
| | 2.1 | Two Cavity Klystron and Reflex Klystron, Helix Travelling Wave Tube, Cross Field Amplifier, Cylindrical Magnetron. | | |
| | 2.2 | PIN Diode, Varactor Diode, Schottky Diode, Gunn Diode, Tunnel Diode, IMPATT Diodes. | | |
| 3 | | **Microwave Amplifiers and Filters** | 1 | 08 |
| | 3.1 | Two port power gain and stability | | |
| | 3.2 | Microwave Low pass Filter design | | |
| 4 | Self-Study | **Microwave Frequency Applications:** Radars, Biomedical Devices, Drying materials, Microwave Tomography, Satellite Communication | | 06 |
| | | | **Total** | **28** |

**Laboratory Component, if any. (Minimum 10 Laboratory experiments using both hardware and software are expected)**

| Sr. No. | Title of the Experiment |
|---|---|
| 1 | Model and simulate rectangular waveguide in CAD to study EM wave propagation within it. |
| 2 | Model and simulate circular waveguide in CAD to study EM wave propagation within it. |
| 3 | Design of Waveguide H-plane TEE using CAD |
| 4 | Design of Directional Coupler Using CAD |

| | |
|---|---|
| **5** | Design of Low pass Filter using CAD |
| **6** | Implementation of a technical paper using CAD |
| **7** | Microwave bench setup (CO1) A) Introduction to the lab B) Identification of waveguide and its components. How to determine the parameters for each component by looking at the data sheet. C) Klystron setup and characterization plotting Vr vs Vo D) Frequency and wavelength measurement of the signal generated by klystron |
| **8** | Determination of parameters of passive components using Bench and VNA. Analysis of comparative study to be submitted. |
| **9** | Determine the frequency and wavelength in a rectangular waveguide using direct and indirect measurement. |
| **10** | Design of Planar Hybrid Ring using CAD |

**Text Books:**

| Sr. No. | Title | Authors | Edition | Publisher | Year |
|---|---|---|---|---|---|
| **1** | Microwave Engineering | David M Pozar | 4th Edition | John Wiley & Sons | **2012** |
| **2** | Microwave Devices and Circuits | Samuel Y Liao | 3rd Edition | Pearson Education | |

| Course (Category) Code | Course Name | Teaching Scheme (Hrs/week) | | | | | Credits Assigned | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | L | T | P | O | E | L | T | P | Total |
| PC | Remote Sensing and GIS | 2 | 0 | 2 | 5 | 8 | 2 | 0 | 1 | 3 |
| | | Examination Scheme | | | | | | | | |
| | | Component | ISE (%) | | MSE (%) | | ESE (%) | | | Total |
| EC423 | | Theory | 20 | | 20 | | 60 | | | 100 |
| | | Laboratory | 80 | | -- | | 20 | | | 100 |

| | |
|---|---|
| **Pre-requisite Course Codes, if any.** | Electromagnetic Wave Engineering, Digital Signal Processing |
| **Course Objective:** To equip students with the fundamental principles, analytical techniques, and application skills of Remote Sensing and GIS for effective interpretation, processing, and utilization of geospatial data in engineering and other inter-disciplinary domains. | |
| **Course Outcomes (CO):** ***At the end of the course students will be able to*** | |
| EC423.1 | *Explain* the principles of electromagnetic radiation, sensor characteristics, and microwave/SAR fundamentals to understand how remote sensing systems acquire Earth observations. |
| EC423.2 | *Apply* digital image processing techniques—pre-processing, enhancement, filtering, classification, and interpretation—to extract meaningful information from optical, thermal, and radar images. |
| EC423.3 | *Use* GIS concepts, spatial data models, map projections, and spatial analysis tools (overlay, network, and surface analysis) to manage and analyze geospatial information. |
| EC423.4 | *Analyze* real-world applications of RS–GIS, including resource mapping, environmental monitoring, disaster management, telecommunication planning, GNSS/NavIC positioning, UAV data acquisition, and IoT-based geospatial solutions. |

**CO-PO Correlation Matrix (3-Strong, 2-Moderate, 1-Weak Correlation)**

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| EC423.1 | 3 | 2 | - | - | 2 | - | - | - | - | - | - | 1 |
| EC423.2 | 2 | 3 | 2 | 2 | 3 | - | - | - | - | 1 | - | 1 |
| EC423.3 | 2 | 2 | 2 | - | 3 | 1 | 2 | - | - | 1 | - | 1 |
| EC423.4 | 1 | 2 | 3 | 2 | 3 | 2 | 3 | - | 1 | 2 | - | 2 |

**CO-PEO/PSO Correlation Matrix (3-Strong, 2-Moderate, 1-Weak Correlation)**

| | PEO1 | PEO2 | PEO3 | PSO1 | PSO2 | PSO3 |
|---|---|---|---|---|---|---|
| EC423.1 | 3 | - | 2 | 1 | 3 | **1** |
| EC423.2 | 3 | 1 | 2 | 1 | 3 | **1** |
| EC423.3 | 3 | 1 | 2 | 1 | 2 | **2** |
| EC423.4 | 3 | 3 | 2 | 2 | 2 | **3** |

**BLOOM'S Levels Targeted (Pl. Tick appropriate)**

| Remember✓ | Understand✓ | Apply✓ | Analyze✓ | Evaluate | Create |
|---|---|---|---|---|---|

**Theory Component**

| Module No. | Unit No. | Topics | Ref. | Hrs. |
|---|---|---|---|---|
| 1 | Title | **Module1: Fundamentals of Remote Sensing** | 1, 2 | 04 |
| | 1.1 | Introduction to remote sensing; Electromagnetic Spectrum and Radiation Principles; Interaction of EM Radiation with Atmosphere and Earth Surface. | | |
| | 1.2 | Remote Sensing Platforms and Scanners; Remote sensing Sensors and Their Characteristics. | | |
| | 1.3 | Introduction to Microwave Remote Sensing & SAR Fundamentals. | | |
| 2 | Title | **Module 2: Digital Image Processing & Interpretation** | 1, 2, 4, 6 | 08 |
| | 2.1 | Visual Image Interpretation; Importance of digital image processing & Software Tools; Image Pre-processing & Radiometric / Geometric Corrections; Image Enhancement Techniques; Spatial and Frequency Domain Processing; Image Classification Methods. | | |
| | 2.2 | Image Interpretation and Analysis; Hyperspectral Remote Sensing; Thermal & Radar Image Interpretation. | | |
| 3 | Title | **Module 3: Geographic Information Systems** | 1, 2, 5 | 08 |
| | 3.1 | Definition & components of GIS; GIS-Integration of Spatial and Attribute Information; Spatial Data models: Raster & Vector; Map projections & coordinate systems. | | |
| | 3.2 | Spatial analysis: Overlay Operations, network analysis, Surface Analysis; Concept of Map, coordinate system and Projection. | | |
| 4 | Title | **Module 4: Applications of Remote Sensing & GIS** | 1, 2, 3 | 08 |
| | 4.1 | 4.1: Resource Mapping; Biodiversity Measurement & Monitoring; Disaster Management; geology; environment; Telecomm network planning; Microwave Remote Sensing and Radar Applications; GNSS-NavIC & Positioning Applications; UAV Remote Sensing; IoT& Remote Sensing Integration.<br>Applications of GIS and remote sensing in survey, mapping, natural resources management, land use and transportation planning, water resources engineering, geology and environment. | | |
| | 4.2 | 4.2: Practical on / Hands on training: map making using GPS; Georeferencing Maps etc. | | |
| 5 | Self Study | Case Studies Relevant to Electronics & Telecommunication; IoT, Wireless Sensor Networks & Remote Sensing Integration; UAV (Drone) Remote Sensing for Telecom Applications; | | |
| | | | **Total** | **28** |

**Laboratory Component, if any. (Minimum 10 Laboratory experiments are expected)**

| Sr. No. | Title of the Experiment |
|---|---|
| 1 | Study of Electromagnetic Spectrum and Spectral Signatures of Earth Features using open spectral libraries (vegetation, soil, water, built-up areas) using Python/QGIS. |
| 2 | Downloading and visual interpretation of satellite images (Landsat/Sentinel) to identify landforms, vegetation, water bodies, and urban features using QGIS/Google Earth. |
| 3 | Image preprocessing techniques – radiometric correction, atmospheric correction, and geometric correction of satellite images using SNAP/QGIS. |
| 4 | Image enhancement techniques – contrast stretching, histogram equalization, spatial filtering, and frequency domain filtering using MATLAB/Python. |
| 5 | Computation of vegetation and water indices (NDVI, NDWI, NDBI) and interpretation for resource mapping applications using QGIS/Python. |
| 6 | Supervised and unsupervised image classification of multispectral satellite data and accuracy assessment using QGIS/Google Earth Engine/Python. |
| 7 | Processing and interpretation of Sentinel-1 SAR data including calibration, speckle filtering, and terrain correction using ESA SNAP. |
| 8 | Creation of GIS database using raster and vector data, map projection transformation, and spatial data integration using QGIS. |
| 9 | GIS-based spatial analysis – overlay analysis, buffer analysis, network analysis, and surface analysis using DEM data in QGIS. |
| 10 | GPS data collection, map making, and georeferencing of scanned maps for applications in surveying, disaster management, and telecommunication planning using QGIS. |

**Text Books**

| Sr. No. | Title | Edition | Authors | Publisher | Year |
|---|---|---|---|---|---|
| 1 | Remote Sensing and GIS | | Bhatta, B | Oxford University Press | 2008 |
| 2 | RS, GIS and GPS: Basics and Applications | | https://uou.ac.in/sites/default/files/slm/ENSE-656.pdf | Uttarakhand Open University, Department of Forestry and Environmental Science School of Earth and Environmental Science | |

**Reference Books**

| Sr. No. | Title | Edition | Authors | Publisher | Year |
|---|---|---|---|---|---|
| 4 | Introductory Digital Image Processing: A Remote Sensing Perspective | | Jensen, J. R. | Pearson Prentice-Hall | 2005 |

| | | | | | |
|---|---|---|---|---|---|
| 5 | Geographic Information Systems: an Introduction | | Benhardsen, T | John Wiley & Sons, New York | 2002 |
| 6 | Remote Sensing and Image Interpretation | | Thomas. M. Lillesand and Ralph. W. Kiefer, C. | John Wiley and Sons, In | |

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**Reference Links (used while preparing syllabus)**
**NIT Agartala (Remote Sensing and Navigational systems)**
https://www.nita.ac.in/Department/Electronics%20and%20Communication%20Engineering/Syllabus_Communication_SignalProcessing_Aug24.pdf

**NIT Tiruchirapalli (GEOGRAPHICAL INFORMATION SYSTEMS AND REMOTE SENSING) for Civil Dept.**
https://www.nitt.edu/home/academics/departments/civil/programmes/btech/curriculum/electives/6/352/

**Remote Sensing Essentials**
**By Prof. Arun K. Saraf | IIT Roorkee**
**https://nptel.ac.in/courses/105107201**

**IITB, Dept. of Earth Sciences; Remote Sensing, GIS and GPS**
https://www.geos.iitb.ac.in/index.php/gs-677-remote-sensing-gis-and-gps/

Bharatiya Vidya Bhavan's

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## B. Tech. EXTC

### IOT Network Layer Protocols

Academic Year 2024–25

## 1. Course Overview

| Course (Category) Code | Course Name | Teaching Scheme (Hrs/week) | | | Credits Assigned | | | |
|---|---|---|---|---|---|---|---|---|
| | | L | T | P | L | T | P | Total |
| PE | IOT Network Layer Protocols | 2 | -- | 3 | 2 | -- | 1.5 | 3.5 |

**Examination Scheme**

| Component | ISE | MSE | ESE | Total |
|---|---|---|---|---|
| **Theory** | **20** | **20** | **60** | **100** |
| **Laboratory** | **80** | **--** | **20** | **100** |

**Pre-requisite Courses:**

- Computer Architecture and Organization
- Computer Communication and Networks
- Embedded Systems

## 2. Course Objective

To provide students a comprehensive understanding of communication protocols used in the Internet of Things (IoT) ecosystem. Students will learn about various protocols, their features, advantages, and limitations, along with hands-on experience in implementing and optimizing communication for IoT devices — including simulation and hardware implementation on the SBC.

## 3. Course Outcomes (CO)

After successful completion of the course, the student will be able to:

| CO | Course Outcome |
|---|---|
| **CO1** | Understand the fundamentals of IoT communication and network layer protocols. |
| **CO2** | Compare and contrast different IoT communication and network layer protocols. |
| **CO3** | Implement and configure communication layer protocols for IoT devices using simulation and hardware platforms (SBC). |
| **CO4** | Analyze and optimize data and network layer protocols for efficiency and security. |
| **CO5** | Simulate and evaluate IoT network topologies, routing and encapsulation protocols using Simulator and SBC. |

## 4. Theory Component

| Module | Unit | Topics | Ref. | Hrs |
|---|---|---|---|---|
| 1 | **Title** | **Introduction to IoT Communication** | | **06** |
| | **1.1** | Overview of IoT architecture<br>Importance of communication protocols in IoT<br>Types of IoT communication (Device-to-Device, Device-to-Cloud, etc.) | 1,2,4 | 02 |
| | **1.2** | Wired Communication Protocols<br>Ethernet: Basics, protocols, and standards<br>Power-line Communication (PLC)<br>Industrial Ethernet protocols (MODBUS TCP/IP, EtherNet/IP) | 1,2,4 | 02 |
| | **1.3** | Wireless Communication Protocols<br>Wi-Fi: Standards, security, and IoT applications<br>Bluetooth and Bluetooth Low Energy (BLE)<br>Zigbee and Z-Wave protocols<br>LoRaWAN | 1,2,4 | 02 |
| 2 | **Title** | **IoT Data Link Layer Protocols [MODIFIED]** | | **11** |
| | **2.1** | **Overview: IoT Communication Criteria**<br>Range, Frequency Bands, Power Consumption, Topology<br>Constrained Devices and Constrained-Node Networks<br>Data Rate and Throughput, Latency and Determinism<br>Overhead and Payload considerations<br>LoRaWAN: Standardization and Alliances, Physical Layer, MAC Layer, Topology, Security<br>Competitive Technologies: LoRaWAN vs NB-IoT vs Other LTE Variations (comparison table) | 3,4 | 03 |
| | **2.2** | **PHY/MAC Layer: 3GPP MTC — Overview, key features, communication scenarios**<br>LTE-eMTC: Uplink and Downlink layer architecture<br>IEEE 802.11: Architecture, BSS/ESS, MAC protocol, CSMA/CA, Frame format<br>IEEE 802.15 Family: 802.15.1, 802.15.4, 802.15.6, 802.15.7<br>BLE (IEEE 802.15.1): Protocol stack, power class classification, connection modes<br>IEEE 802.15.4: PHY options (DSSS, OQPSK, BPSK, ASK), MAC frame structure, addressing | 3,4 | 04 |
| | **2.3** | **Data Link Protocols — Deep Dive:**<br>WirelessHART: Architecture, TDMA MAC, protocol stack, security (AES-128), channel hopping | 3,4 | 04 |

| | | | | |
|---|---|---|---|---|
| | | Z-Wave: Architecture, sub-GHz PHY (FSK/GFSK), MAC (CSMA-CA), mesh topology, S2 security<br>DASH7: Communication models (Pull/Push), device classes (Blinker/Endpoint/Sub-controller/Gateway), MAC filtering<br>Zigbee Smart Energy: Topology (star/mesh/tree), coordinator/router/end-device roles, energy features, CSMA/CA<br>Protocol Comparison: WirelessHART vs Z-Wave vs Zigbee vs BLE vs DASH7 (frequency, range, data rate, power) | | |
| 3 | **Title** | **IoT Network Layer Protocols [MODIFIED]** | | **11** |
| | **3.1** | **Network Layer Routing Protocols:**<br>IPv4: Header format, fields and functions (TTL, fragmentation, checksum), addressing<br>IPv6: Header format and functions, advantages over IPv4, address types (unicast, multicast, anycast)<br>Dynamic IP and DHCP: Operation, DORA process, lease management<br>ICMP: Message types, error reporting, ping and traceroute<br>RPL (Routing Protocol for Low-Power and Lossy Networks): DODAG structure, objective functions (OF0, MRHOF)<br>CORPL: Opportunistic routing extension of RPL for IoT<br>CARP: Channel-Aware Routing Protocol for underwater/low-power IoT networks | 4 | 05 |
| | **3.2** | **Network Layer Encapsulation Protocols:**<br>6LoWPAN: IPv6 over Low-Power Wireless PAN — header compression, fragmentation and reassembly, mesh addressing<br>6TiSCH: IPv6 over Time-Slotted Channel Hopping (IEEE 802.15.4e) — schedule management, minimal configuration<br>6Lo: Framework for IPv6 over constrained node networks (IEEE 802.15.4, BLE, NFC, DECT-ULE, ITU-T G.9959)<br>IPv6 over G.9959 (Z-Wave): Encapsulation of IPv6 packets over Z-Wave sub-GHz networks<br>IPv6 over BLE: IPv6 header compression and adaptation for Bluetooth Low Energy links<br>RPL Routing Attributes: Rank calculation, DAG information objects (DIO/DAO/DIS), upward/downward routing, security modes | 4 | 06 |
| | **3.3** | Self Study Topics (Edge Computing and Fog Networking):<br>Edge Computing: Concepts, latency reduction, processing at network edge<br>Fog Networking: Architecture, IoT device provisioning and management<br>IoT Interoperability and Standards: oneM2M, OCF, LwM2M<br>IoT Security at Network Layer: TLS/DTLS, OSCORE | 4,5 | 03* |
| | | | **Total (* excluding self-study topics)** | **28** |

## 5. Laboratory Component

New experiments (Experiments 8–13) in **green** focus on Simulation and SBC hardware platform.

| Sr. No. | Title | Details |
|---|---|---|
| 1 | **Setting up a Basic MQTT Communication Network** | **Objective:** To understand the basics of MQTT protocol and set up a communication network for IoT devices.<br>**Equipment:** MQTT broker (e.g., Mosquitto), IoT devices (e.g., Raspberry Pi, ESP8266/ESP32), MQTT client software (e.g., MQTT.fx, Eclipse Paho).<br>**Experiment Steps:**<br>✓ Install and configure MQTT broker on a server or local machine.<br>✓ Set up IoT devices as MQTT clients and connect them to the broker.<br>✓ Publish and subscribe to MQTT topics to exchange messages between devices. |
| 2 | **Configuring Ethernet-Based Communication for IoT Devices** | **Objective:** To learn about Ethernet protocols and configure wired communication for IoT devices.<br>**Equipment:** Ethernet switch, Ethernet cables, IoT devices with Ethernet ports (e.g., SBC with Ethernet adapter).<br>**Experiment Steps:**<br>● Connect IoT devices to an Ethernet switch using Ethernet cables.<br>● Configure IP addresses, subnet masks, and default gateways for devices.<br>● Test communication between IoT devices using TCP/IP protocols. |
| 3 | **Implementing Bluetooth Low Energy (BLE) Communication** | **Objective:** To implement BLE communication for IoT sensors and devices.<br>**Equipment:** BLE-enabled devices (e.g., SBC with BLE module, BLE sensors), BLE development tools (e.g., BlueZ library for Linux).<br>**Experiment Steps:**<br>● Set up BLE peripherals and central devices.<br>● Develop BLE applications for data transmission between devices.<br>● Analyze BLE communication characteristics such as range, data rate, and power consumption. |
| 4 | **Connecting IoT Devices Using Cellular Communication** | **Objective:** To establish cellular communication for IoT devices using GSM, GPRS, or LTE-M/NB-IoT standards.<br>**Equipment:** IoT devices with cellular modules (e.g., SIM800/SIM900 modules), SIM cards, cellular network access.<br>**Experiment Steps:**<br>✓ Configure IoT devices with cellular network settings and APNs.<br>✓ Test data transmission over cellular networks using AT commands or APIs.<br>✓ Evaluate cellular communication performance and reliability for IoT applications. |
| 5 | **Comparing and Analyzing IoT Messaging Protocols** | **Objective:** To compare and analyze the performance of different IoT messaging protocols such as MQTT, CoAP, and AMQP.<br>**Equipment:** IoT devices with support for multiple messaging protocols, MQTT broker, CoAP server, AMQP server. |

| | | |
|---|---|---|
| | | **Experiment Steps:**<br>1. Implement message exchange using MQTT, CoAP, and AMQP protocols.<br>2. Measure message latency, throughput, and overhead for each protocol.<br>3. Analyze protocol characteristics and suitability for different IoT scenarios. |
| **6** | **Optimizing IoT Communication Protocols** | **Objective:** To optimize IoT communication protocols for resource-constrained devices.<br>**Equipment:** IoT devices with limited memory and processing capabilities.<br>**Experiment Steps:**<br>● Implement protocol optimization techniques such as message compression, caching, and payload reduction.<br>● Measure the impact of optimizations on device performance, power consumption, and network utilization.<br>● Evaluate trade-offs between optimization techniques and protocol functionality. |
| **7** | **IoT Communication Protocol Implementation** | **Objective:** To design and implement a communication protocol for a specific IoT application.<br>**Equipment:** IoT devices relevant to the chosen application, communication protocol libraries or frameworks.<br>**Experiment Steps:**<br>● Define the communication requirements and constraints for the IoT application.<br>● Design a custom communication protocol or adapt existing protocols to meet the requirements.<br>● Implement the protocol on IoT devices and test its functionality, efficiency, and security.<br>● Present the project findings, including protocol design rationale, implementation details, and performance evaluation. |
| **8** | **Simulating IoT Network Topologies (Star, Mesh, Tree) [NEW]** | **Objective:** To simulate and compare IoT network topologies using Simulator and analyze performance metrics such as throughput, delay and packet delivery ratio.<br>**Equipment:** Linux workstation with NS3 (v3.38+) installed, Python 3.x, gnuplot for visualization.<br>**Experiment Steps:**<br>● Install NS3 on the Linux workstation: ./ns3 configure --enable-examples --enable-tests && ./ns3 build<br>● Write NS3 C++ simulation scripts for star, mesh, and tree topologies using WiFi and LR-WPAN (802.15.4) modules.<br>● Configure node counts (10, 20, 50 nodes), data rates, and packet sizes representative of IoT traffic.<br>● Enable FlowMonitor and NetAnim tracing to capture packet delivery ratio (PDR), end-to-end delay, and throughput.<br>● Run simulations for each topology (./ns3 run <script>) and collect output statistics.<br>● Plot and compare PDR vs. node density and delay vs. data rate for all three topologies using gnuplot or matplotlib.<br>● Document findings: identify which topology suits constrained IoT scenarios and justify with simulation data. |

| | | |
|---|---|---|
| **9** | **Simulating 6LoWPAN and RPL Routing for Low-Power IoT [NEW]** | **Objective:** To simulate 6LoWPAN header compression and RPL (Routing Protocol for Low-Power and Lossy Networks) using Simulator and measure routing efficiency.<br>**Equipment:** Linux workstation with NS3 (v3.38+) and sixlowpan, lr-wpan, rpl modules; Wireshark for packet capture analysis.<br>**Experiment Steps:**<br>1) Configure a LR-WPAN (IEEE 802.15.4) network in NS3 with 6LoWPAN adaptation layer enabled.<br>2) Enable the RPL module; set objective function to MRHOF and configure DODAG root node.<br>3) Deploy a 20-node network with varied link quality to simulate lossy network conditions.<br>4) Enable PCAP tracing and inspect compressed IPv6 headers vs. full IPv6 headers in Wireshark.<br>5) Measure and compare: (a) packet overhead with and without 6LoWPAN compression, (b) route convergence time with RPL, (c) energy consumption estimate using NS3 EnergyModel.<br>6) Vary network density (10 to 40 nodes) and plot RPL rank distribution and overhead per node.<br>7) Write a report comparing RPL's DODAG formation time with and without DIO suppression mechanisms. |
| **10** | **LoRaWAN Network Simulation — Coverage and Capacity Analysis [NEW]** | **Objective:** To simulate a LoRaWAN network using NS3-LoRaWAN module and evaluate coverage, spreading factor selection, and gateway capacity.<br>**Equipment:** Linux workstation with NS3 and lorawan module (SIGFOX/LoRa NS3 contrib); Python 3.x, matplotlib.<br>**Experiment Steps:**<br>● Install the NS3 LoRaWAN contrib module: git clone into contrib/ and build with ./ns3 build.<br>● Create a simulation with 1 gateway and 100 end-devices distributed in a 5 km radius circle.<br>● Assign spreading factors (SF7–SF12) automatically based on device-to-gateway distance using NS3 ADR.<br>● Simulate uplink traffic at different packet rates (0.1, 1, 10 packets/hour/device) and record network-level throughput and collision rate.<br>● Enable per-device energy consumption tracking using LoraEnergyModel and compare battery life estimates across SFs.<br>● Scale gateway count (1, 2, 4 gateways) and measure the impact on PDR and air-time utilization.<br>● Generate coverage maps using the simulation output and discuss LoRaWAN duty-cycle constraints (1% regional limit). |
| **11** | **SBC: Setting Up as IoT Edge Node with Linux and MQTT [NEW]** | **Objective:** To configure the SBC as a fully functional IoT edge gateway running Linux (Ubuntu 22.04), collecting sensor data and publishing via MQTT.<br>**Equipment:** SBC, microSD card (16GB+), USB-UART adapter, DHT22 temperature/humidity sensor, jumper wires, host PC.<br>**Experiment Steps:**<br>● Flash Ubuntu 22.04 (MATE or Server) image onto the microSD using Etcher or dd. |

| | | |
|---|---|---|
| | | • Boot SBC, configure hostname, static IP, SSH access, and update packages (apt update && apt upgrade).<br>• Connect DHT22 sensor to SBC GPIO: VCC to 3.3V, DATA to GPIO pin 6, GND to GND.<br>• Install Python 3, Adafruit-DHT library, and Paho MQTT client: pip3 install Adafruit_DHT paho-mqtt<br>• Write a Python script to read DHT22 sensor data every 5 seconds and publish temperature/humidity to MQTT broker topics.<br>• Install Mosquitto MQTT broker on SBC and verify local publish/subscribe: mosquitto_pub / mosquitto_sub<br>• Set up a remote MQTT subscriber on a PC and validate end-to-end sensor data flow; log data to a CSV file. |
| **12** | **SBC: Implementing BLE Central/Peripheral Communication [NEW]** | **Objective:** To use the SBC as a BLE central device to scan, connect to, and read data from a BLE peripheral (ESP32 or BLE sensor).<br>**Equipment:** SBC with USB BLE dongle (CSR4.0+), ESP32 dev board as BLE peripheral, Arduino IDE, BlueZ stack.<br>**Experiment Steps:**<br>• Install BlueZ BLE stack on SBC: sudo apt install bluez python3-bluez bluez-tools<br>• Flash ESP32 with a BLE GATT server sketch (Arduino IDE) exposing a custom service with temperature characteristic.<br>• Scan for BLE devices from SBC: bluetoothctl scan on — confirm ESP32 appears with its MAC address.<br>• Use Python gatttool or bleak library to connect to ESP32 and read the temperature characteristic UUID.<br>• Write a continuous polling script that reads BLE characteristic every 2 seconds and logs timestamp + temperature.<br>• Measure BLE connection parameters: RSSI, latency, and data throughput at varying distances (1m, 5m, 10m).<br>• Implement BLE connection retry on disconnect and evaluate robustness; publish final data to a local dashboard (Node-RED). |
| **13** | **SBC + Simulator: Hybrid IoT Protocol Performance Comparison [NEW]** | **Objective:** To benchmark real-world IoT protocol performance on SBC hardware against simulation results, validating the simulation model accuracy.<br>**Equipment:** SBC , NS3 workstation, Wi-Fi router, ESP32 nodes, network analyzer (Wireshark), iperf3.<br>**Experiment Steps:**<br>1. Set up a real Wi-Fi network with Odroid C5 as server and 2 ESP32 nodes as clients; measure UDP throughput using iperf3.<br>2. Replicate the same network topology in NS3 (WiFi module, same number of nodes, same data rate) and simulate UDP throughput.<br>3. Compare real vs. simulated throughput, latency, and packet loss — calculate simulation accuracy percentage.<br>4. Repeat the comparison for BLE topology: measure real BLE PDR on Odroid C5; simulate equivalent BLE/802.15.1 in NS3.<br>5. Introduce interference in the real network (microwave or co-channel WiFi) and measure throughput degradation; model interference in NS3 using YansErrorModel. |

| | | |
|---|---|---|
| | | 6. Tabulate results: real-world vs. NS3 simulation for WiFi and BLE across throughput, delay, PDR, and energy metrics.<br>7. Present a critical analysis of NS3 model fidelity and suggest parameter tuning to improve simulation accuracy. |

## 6. Self Study Topics

- Edge Computing and Fog Networking — architecture, use-cases, latency benefits
- IoT Device Provisioning and Management — LwM2M, TR-069, OMA-DM
- IoT Interoperability and Standards — oneM2M, OCF, W3C WoT
- IoT Security at Network Layer — DTLS, OSCORE, certificate management

## 7. Reference Books

| Sr. | Title | Author | Publisher | Year |
|---|---|---|---|---|
| 1 | IoT Fundamentals: Networking Technologies, Protocols, and Use Cases for the Internet of Things | David Hanes, Gonzalo Salgueiro, Patrick Grossetete, Robert Barton, Jerome Henry | CISCO Press | 2017 |
| 2 | Internet of Things: Architectures, Protocols and Standards | Simone Cirani, Gianluigi Ferrari, Marco Picone, Luca Veltri | WILEY | 2019 |
| 3 | From Machine-to-Machine to the Internet of Things: Introduction to a New Age of Intelligence | Jan Holler, Vlasios Tsiatsis, Catherine Mulligan, Stefan Avesand, Stamatis Karnouskos, David Boyle | Elsevier AP | 2014 |
| 4 | The Internet of Things: Key Applications and Protocols | Hersent, Olivier, David Boswarthick, and Omar Elloumi | Wiley | 2011 |
| 5 | NS-3 Network Simulator: A Comprehensive Guide | Thomas R. Henderson et al. | NS-3 Project / Online | 2023 |

## 8. Online References

- https://www.nabto.com/guide-iot-protocols-standards/
- https://azure.microsoft.com/en-in/solutions/iot/iot-technology-protocols
- https://www.datamation.com/applications/iot-protocols-and-standards/
- https://onlinecourses.nptel.ac.in/noc22_cs53/preview
- https://archive.nptel.ac.in/courses/108/108/108108098/
- **https://www.nsnam.org/documentation/ (NS3 official documentation)**
- **https://wiki.odroid.com/odroid-c5/odroid-c5 (Odroid C5 Wiki)**
- **https://lora-alliance.org/resource_hub/ (LoRa Alliance Resources)**

| Course (Category) Code | Course Name | Teaching Scheme (Hrs/week) | | | | | Credits Assigned | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | L | T | P | O | E | L | T | P | Total |
| PEC | Speech and Audio Processing | 2 | 0 | 1 | 5 | 10 | 2 | 0 | 1 | 3 |
| | | Examination Scheme | | | | | | | | |
| | | Component | ISE (%) | | MSE (%) | | ESE (%) | | | Total |
| EC342 | | Theory | 20 | | 20 | | 60 | | | 100 |
| | | Laboratory | 80 | | -- | | 20 | | | 100 |

| Pre-requisite Course Codes, if any | Digital Signal Processing |
|---|---|

**Course Objective:** To help students understand how speech is produced and perceived, and to enable them to analyze speech signals using time and frequency domain methods. The course also aims to introduce speech processing models such as linear prediction, and to develop skills in building and evaluating systems for speech modeling and synthesis.

**Course Outcomes (CO):** ***At the end of the course students will be able to***

| | |
|---|---|
| **EC342.1** | Understand the Mechanisms of Speech Production |
| **EC342.2** | Analyze Human Auditory Perception in Speech Processing |
| **EC342.3** | Apply Time and Frequency Domain Techniques for Speech Analysis |
| **EC342.4** | Explore Linear Predictive Analysis and Speech Processing Models |
| **EC342.5** | Develop and Evaluate Speech Modeling and Synthesis Techniques |

**CO-PO Correlation Matrix (3-Strong, 2-Moderate, 1-Weak Correlation)**

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **EC342.1** | 2 | | | | | | | | | | | |
| **EC342.2** | | 2 | | | | | | | | | | |
| **EC342.3** | | | 2 | | | | | | | | | |
| **EC342.4** | | | | | 2 | | | | | | | |
| **EC342.5** | | | | 2 | | | | | | | | |

**CO-PEO/PSO Correlation Matrix (3-Strong, 2-Moderate, 1-Weak Correlation)**

| | PEO1 | PEO2 | PEO3 | PSO1 | PSO2 |
|---|---|---|---|---|---|
| **EC342.1** | 2 | 2 | | 2 | |
| **EC342.2** | 2 | 2 | | 2 | |
| **EC342.3** | 2 | 2 | | | 2 |
| **EC342.4** | | | 2 | | |
| **EC342.5** | | | 2 | | |

**BLOOM'S Levels Targeted (Pl. Tick appropriate)**

| Remember | Understand✓ | Apply✓ | Analyze✓ | Evaluate | Create |
|---|---|---|---|---|---|

**Theory Component**

| Module No. | Unit No. | Topics | Ref. | Hrs. |
|---|---|---|---|---|
| 1 | Title | **Mechanics of speech** | 1,2 | 6 |
| | 1.1 | Speech production: Mechanism of speech production, Acoustic phonetics – Digital models for speech signals -Sampling speech signals, basics of quantization, delta modulation, and Differential PCM | | |
| | 1.2 | Signal Processing Models of Audio Perception: Basic anatomy of hearing System. Auditory Filter Banks, Psycho-acoustic analysis: Critical Band Structure, Absolute Threshold of Hearing, Simultaneous Masking, Temporal Masking, Quantization Noise Shaping, MPEG psycho-acoustic model. | | |
| 2 | Title | **Time domain methods for speech processing** | 1,2 | 6 |
| | 2.1 | Time domain parameters of Speech signal – Methods for extracting the parameters Energy, Average Magnitude, zero crossing Rate – Silence Discrimination using ZCR and energy | | |
| | 2.2 | Short Time Auto Correlation Function – Pitch period estimation using Auto Correlation Function. | | |
| 3 | Title | **Frequency domain method for speech processing** | 1,2 | 6 |
| | 3.1 | Short Time Fourier analysis: Fourier transform and linear filtering interpretations. | | |
| | 3.2 | Sampling rates - Spectrographic displays - Pitch and formant extraction - Analysis by Synthesis - Analysis synthesis systems: Phase vocoder, Channel Vocoder. | | |
| | 3.3 | Homomorphic speech analysis: Cepstral analysis of Speech, Formant and Pitch Estimation, Homomorphic Vocoders, Speech coding, speech enhancement. | | |
| 4 | Title | **Linear predictive analysis, synthesis of speech** | 1,2, 3 | 4 |
| | 4.1 | Basic Principles of linear predictive analysis – Auto correlation method – Covariance metho | | |
| | 4.2 | Solution of LPC equations – Cholesky method – Durbin's Recursive algorithm. | | |
| | 4.3 | Application of LPC parameters – Pitch detection using LPC parameters – Formant analysis – VELP – CELP, Speech synthesis: basics of articulatory, source-filter, and concatenative synthesis – VOIP. | | |

| | | | | |
|---|---|---|---|---|
| **5** | **Title** | **Speech modeling and synthesis** | **1,2, 3** | **6** |
| | **5.1** | Speech Modeling: Hidden Markov Models: Markov Processes, HMMs – Evaluation, Optimal State Sequence – Viterbi Search, Baum-Welch Parameter Re-estimation | | |
| | **5.2** | Speech Synthesis: Text-to-Speech Synthesis: Concatenative and waveform synthesis methods, subword units for TTS, intelligibility and naturalness – role of prosody | | |
| **6** | **Self Study** | Audio compression methods, Audio quality analysis, Spatial Audio Perception and rendering, Speaker identification and verification | | |
| | | | **Total** | **28** |

**Laboratory Component, if any. (Minimum 10 Laboratory experiments are expected)**

| Sr. No. | Title of the Experiment |
|---|---|
| **1** | Applying and Analyzing Speech Production Techniques |
| **2** | Analysis of speech signal with Formant Frequency Estimation |
| **3** | Practical Analysis of Speech Signals and Short-Time Spectrum |
| **4** | Spectrographic and Pitch Detection Analysis for Speech Processing |
| **5** | Emotion Recognition from Speech and extract features related to prosody, pitch, and energy to identify emotions in speech recordings |
| **6** | Implement MFCC extraction to capture spectral features important for speech recognition tasks. |
| **7** | Analysis of Speech using Cepstral and Linear Prediction methods |
| **8** | Implement Speech-to-Text Conversion and Advanced Analysis Techniques |
| **9** | Hands-On Speech Analysis and Signal Processing Techniques |
| **10** | Mini-Project: Speech Signal Analysis and Text Conversion |

**Text Books**

| Sr. No. | Title | Edition | Authors | Publisher | Year |
|---|---|---|---|---|---|
| **1** | Speech Communications: Human & Machine | Second | Douglas O'Shaughnessy | IEEE Press, Hardcover 2/e, ISBN: 0780334493. | 1999 |
| **2** | Discrete-Time Speech Signal Processing | First | Thomas F, Quatieri, | Prentice Hall /Pearson Education | 2004 |

**Reference Books**

| Sr. No. | Title | Edition | Authors | Publisher | Year |
|---|---|---|---|---|---|
| **1** | Speech and Audio Signal Processing | Second | Ben Gold and Nelson Morgan | John Wiley and Sons Inc., Singapore | 2011 |
| **2.** | Digital Processing of Speech Signals | First | L.R.Rabiner and R.W.Schaffer | Prentice Hall | 1979 |
| **3.** | Discrete-Time Speech Signal Processing: Principles and Practice | First | Thomas F. Quatieri | Pearson | 2002 |

| Course (Category) Code | Course Name | Teaching Scheme (Hrs/week) | | | | | Credits Assigned | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | L | T | P | O | E | L | T | P | Total |
| PE | Analog CMOS VLSI Design | 2 | 0 | 1 | 4 | 7 | 2 | 0 | 1 | 3 |
| EC453 | | Examination Scheme | | | | | | | | |
| | | Component | ISE (%) | | MSE (%) | | ESE (%) | | | Total |
| | | Theory | 20 | | 20 | | 60 | | | 100 |
| | | Laboratory | 80 | | -- | | 20 | | | 100 |

| | |
|---|---|
| **Pre-requisite Course Codes, if any.** | EC101: Digital Systems and Microprocessors<br>EC102: Basic Electrical Engineering<br>AS101: Engineering Physics<br>EC202: Electronic Devices & Circuits<br>EC207: Mixed Signal Integrated Circuits<br>EC304: Digital CMOS VLSI Design |

**Course Objective:** This primary goal of this course is to impart knowledge related to basic building blocks of CMOS analog circuits. This course will make students aware of technological challenges offered by scaled technologies coupled with multiple trade-offs in analog design. This course is expected to build analytical skills related to CMOS analog design among the students. Knowledge of fundamentals of MOSFET and Digital CMOS Digital VLSI design is a must to understand this course in a better manner.

**Course Outcomes (CO):** ***At the end of the course students will be able to***

| | |
|---|---|
| EC453.1 | Recognize trade-offs involved in analog VLSI Circuits |
| EC453.2 | Analyze current mirrors and bandgap references |
| EC453.3 | Analyze single stage amplifier using small signal model as well as large signal methodology |
| EC453.4 | Analyze MOSFET based differential and operational amplifier |

**CO-PO Correlation Matrix (3-Strong, 2-Moderate, 1-Weak Correlation)**

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| EC453.1 | 3 | | | | | | | | | | | |
| EC453.2 | | 3 | 3 | 2 | 3 | | | | | | | |
| EC453.3 | | 3 | 3 | 2 | 3 | | | | | | | |
| EC453.4 | | 3 | 3 | 2 | 3 | | | | | | | |

**CO-PEO/PSO Correlation Matrix (3-Strong, 2-Moderate, 1-Weak Correlation)**

| | PEO1 | PEO2 | PEO3 | PEO4 | PSO1 | PSO2 |
|---|---|---|---|---|---|---|
| EC453.1 | 2 | | 2 | | 1 | |
| EC453.2 | 2 | | 2 | | 1 | |
| EC453.3 | 2 | | 2 | | 1 | |
| EC453.4 | 2 | | 2 | | 1 | |

**BLOOM'S Levels Targeted (Pl. Tick appropriate)**

| Remember✓ | Understand✓ | Apply✓ | Analyze✓ | Evaluate✓ | Create |
|---|---|---|---|---|---|
| | | | | | |

**Theory Component**

| Module No. | Unit No. | Topics | Ref. | Hrs. |
|---|---|---|---|---|
| 1 | Title | **CMOS analog building blocks** | 1 | 04 |
| | 1.1 | Necessity of CMOS analog design | | |
| | 1.2 | MOS Models: Structure of MOSFET, Review of characteristics of MOS device, Second order effects, MOS small signal model, MOS spice models | | |
| 2 | Title | **Current Mirrors and Bandgap References** | 1 | 04 |
| | 2.1 | Passive and Active Current Mirrors: Basic current mirrors, Cascode current mirrors and Active current mirrors | | |
| | 2.2 | **Band Gap References:** General Considerations | | |
| 3 | Title | **Single Stage Amplifiers** | 1 | 06 |
| | 3.1 | Basic concepts, Common source stage: resistive load, diode-connected load, current-source load, triode load and source degeneration | | |
| | 3.2 | Source follower, Common gate stage, Cascode stage | | |
| 4 | Title | **Differential Amplifiers** | 1 | 04 |
| | 4.1 | Single ended and differential operation, Basic differential pair, Common-mode response, Differential pair with MOS loads and Gilbert cell | | |
| 5 | Title | **MOS Operational Amplifiers** | 1,2,3 | 08 |
| | 5.1 | **Op-amp:** General Considerations, performance parameters, One-stage op-amps | | |
| | 5.2 | Two-stage op-amps, Gain Boosting, Common- mode feedback, Input range limitations, Slew Rate, Power supply rejection | | |
| 4 | Self-Study | **Band Gap References Techniques:** Supply- independent biasing, Temperature independent references, PTAT ,**Compensation of MOS Operational Amplifiers:** General Considerations, Multipole systems, Phase margin, Frequency compensation, compensation of two stage op-amps | 1,2,, 3 | 04* |
| | | | **Total** | **28** |

**Laboratory Component, if any. (Minimum 10 Laboratory experiments are expected)**

| Sr. No. | Title of the Experiment |
|---|---|
| Experiments based on circuit simulation tool like LTSPICE | |
| 1 | **MOSFET I-V Characteristics Measurement** – Simulate and analyze transfer and output characteristics, studying second-order effects like channel length modulation, body effect, and subthreshold conduction. |
| 2 | **Current Mirror Analysis –** Simulate basic, cascode, and Wilson current mirrors, measuring current replication accuracy and output resistance. |
| 3 | **Bandgap Reference Design –** Design and simulate a PTAT current source, verifying supply-independent biasing and temperature stability. |
| 4 | **Single-Stage CMOS Amplifier Design –** Simulate common-source, common-gate, and source follower amplifiers, analyzing gain, bandwidth, and distortion. |
| 5 | **Two-Stage CMOS Op-Amp Simulation –** Design and analyze a two-stage operational amplifier, studying DC gain, phase margin, and frequency response. |
| Experiments based on schematic and layout design tools like Cadence, Synopsys as per the design flow mentioned below for the DC, AC and Transient Analysis of the analog CMOS circuit designed using specifications given<br>a. Draw the Layout and verify the DRC, ERC<br>b. Check for LVS<br>c. Extract RC and back annotate the same and verify the design | |
| 6 | **MOSFET Layout and Parasitic Extraction –** Design and optimize the layout of an nMOS and pMOS transistor, extracting parasitic and analyzing their impact on performance. |
| 7 | **Current Mirror Layout and Matching Analysis** – Implement the layout of a basic and cascode current mirror, analyzing the impact of device mismatch on current accuracy. |
| 8 | **Bandgap Reference Layout with Temperature Analysis** – Implement the layout of a bandgap reference circuit, verifying temperature stability through post-layout simulations. |
| 9 | **Differential Pair Layout Design –** Create a matched differential pair layout, ensuring proper common-mode rejection and symmetry in layout design. |
| 10 | **Operational Amplifier Layout and Performance Validation –** Design and verify the layout of a two-stage CMOS op-amp, considering layout-dependent effects like latch-up and metal routing. |

**Text Books**

| Sr. No. | Title | Edition | Authors | Publisher | Year |
|---|---|---|---|---|---|
| 1 | Design of Analog CMOS Integrated Circuits | First | B Razavi | Tata McGraw Hill | 2017 |
| 2 | CMOS Circuit Design, Layout, and Simulation | Student Edition | R. Jacaob Baker, Harry W. Li, David E. Boyce | Wiley | 2009 |
| 3 | CMOS Analog Circuit Design | First | Douglas Holberg and Phillip E. Allen | Oxford University Press, USA | 2011 |

**Reference Books**

| Sr. No. | Title | Edition | Authors | Publisher | Year |
|---|---|---|---|---|---|
| 1 | CMOS Circuit Design-Layout, and Simulation | Third | Jacob Baker | Wiley–Blackwell | 2010 |
| 2 | Microelectronic Circuits-Theory & Applications | Sixth | A.S. Sedra and K.C. Smith, Adapted by A.N. Chandorkar | Oxford | 2013 |
| 3 | Operation and Modeling of the MOS Transistor | Second | Yannis Tsividis | Oxford University Press, USA | 2003 |
| 4 | Analysis and design of Analog Integrated circuits | Third | Paul R. Gray and R.G.Meyer | John Wiley and Sons, USA | |

Online Resources:

1. CMOS Analog VLSI Design,
   Prof. A.N. Chandorkar, IIT Bombay
   Link: - https://archive.nptel.ac.in/courses/117/101/117101105/

| Course (Category) Code | Course Name | Teaching Scheme (Hrs/week) | | | | | Credits Assigned | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | L | T | P | O | E | L | T | P | Total |
| PE-IV | Space Communication Technologies | 2 | - | 2 | 2 | 6 | 2 | - | 1 | 3 |
| | | Examination Scheme | | | | | | | | |
| | | Component | ISE | | MSE | | ESE | | Total | |
| EC-414 | | Theory | 20 | | 20 | | 60 | | 100 | |
| | | Laboratory | 80 | | -- | | 20 | | 100 | |

| Pre-requisite Course Codes, if any. | Electromagnetics, FOA |
|---|---|
| **Course Objective:** The objective of the course is to provide foundational and advanced understanding of satellite communication principles, orbital mechanics, link design, Earth station technologies, and modern satellite systems such as LEO constellations, | |
| **Course Outcomes (CO):** ***At the end of the course students will be able to*** | |
| EC414.1 | Explain satellite orbits, orbital elements, and geometry of GSO links. |
| EC414.2 | Describe satellite subsystems and Earth station configurations. |
| EC414.3 | Analyze satellite link budgets and predict system performance. |
| EC414.4 | Evaluate atmospheric and space impairments and propose fade mitigation. |
| EC414.5 | Apply multiple access and modulation techniques in satellite systems. |

### CO-PO Correlation Matrix (3-Strong, 2-Moderate, 1-Weak Correlation)

| CO / PO | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| EC414.1 | 3 | 1 | – | 2 | – | – | – | – | 1 | – | – | 1 |
| EC414.2 | 2 | 1 | – | 2 | – | – | – | – | 1 | – | – | 1 |
| EC414.3 | 3 | 2 | 1 | 3 | – | – | – | – | 1 | – | – | 1 |
| EC414.4 | 2 | 1 | 1 | 3 | – | – | – | – | – | – | – | 1 |
| EC414.5 | 2 | 1 | 1 | 3 | 2 | – | – | – | 1 | – | – | 1 |

### CO-PEO/PSO Correlation Matrix (3-Strong, 2-Moderate, 1-Weak Correlation)

| CO | PEO1 | PEO2 | PEO3 | PEO4 | PSO1 | PSO2 | PSO3 |
|---|---|---|---|---|---|---|---|
| EC414.1 | 2 | 1 | – | – | 2 | – | – |
| EC414.2 | 2 | 1 | – | – | 2 | – | – |
| EC414.3 | 3 | 2 | 1 | – | 3 | 2 | – |
| EC414.4 | 2 | 1 | 1 | – | 3 | 2 | – |
| EC414.5 | 3 | 2 | 1 | – | 3 | 2 | 1 |

**BLOOM'S Levels Targeted (Pl. Tick appropriate)**

| Remember | Understand | ✓ Apply | ✓ Analyze | ✓ Evaluate | Create |
|---|---|---|---|---|---|

| Module No. | Unit No. | Topics | Ref. | Hrs. |
|---|---|---|---|---|
| 1 | Title | **Satellite Orbits** | 2 | 06 |
| | 1.1 | Introduction, basic definitions, Kepler's laws, orbital parameters, orbits in common use: Geostationary Orbit (GEO), Low Earth Orbit (LEO), Medium Earth Orbit (MEO), Highly Elliptical Orbit (HEO), and Polar Orbit. | | |
| | 1.2 | Geometry of GSO links: range to satellite, elevation angle to satellite, azimuth angle to satellite, sample calculations. | | |
| 2 | Title | **Satellite Subsystems & Earth Segment** | 1,2 | 06 |
| | 2.1 | Satellite bus: physical structure, power subsystem, attitude control, orbital control, thermal control, tracking, telemetry, command, and monitoring (TT&C). | | |
| | 2.2 | Satellite payload: transponder and antennas. | | |
| | 2.3 | Frequency Conversion, HPA, LNA | | |
| 3 | Title | **Satellite Link and Performance** | 1,2 | 06 |
| | 3.1 | Effective isotropic radiated power (EIRP), power flux density, antenna gain, free-space path loss, basic link equation for received power. | | |
| | 3.2 | System noise: noise figure, noise temperature, system noise temperature, figure of merit (G/T). | | |
| | 3.3 | Link performance parameters: carrier-to-noise ratio (C/N), carrier-to-noise density ratio ($C/N_0$), energy-per-bit to noise density ratio ($E_\beta/N_0$). | | |
| 4 | Title | **Space Transmission Impairments** | 1,2 | 06 |
| | 4.1 | Radio wave frequency and space communication; radio wave propagation mechanisms; propagation above and below about 3 GHz: ionospheric scintillation | | |
| | 4.2 | Rain attenuation, gaseous attenuation, cloud and fog attenuation, depolarization, tropospheric scintillation. | | |
| 5 | Title | **Satellite Multiple Access** | 1,2 | 04 |
| | 5.1 | FDMA, TDMA, CDMA, OFDMA | | |
| | 5.2 | Applications of satellite multiple access techniques in satellite communication networks. | | |
| 6 | Self-Study* | High Throughput Satellites (HTS), LEO mega-constellations, (Starlink, OneWeb), Mobile Satellite Services: Iridium, Inmarsat, Navigation satellites: GPS, GLONASS, NavIC. | 1,2 | |
| | | | **Total (*Not included)** | **28** |

**Laboratory**:

| Sr. No. | Title of the Experiment |
|---|---|
| ● | Familiarization with Scientech 2272A kit and signal chain. |
| ● | AM & FM modulation and demodulation. |
| ● | ASK/FSK modulation and BER analysis. |
| ● | BPSK/QPSK modulation and constellation analysis using MATLAB. |
| ● | Orbit simulation (LEO/GEO) using MATLAB. |
| ● | Look angle computation and coverage plotting. |
| ● | Link budget calculation (FSPL, EIRP, G/T). |
| ● | Transponder operation & frequency translation. |
| ● | Noise figure measurement, SNR analysis, MATLAB comparison |
| ● | End-to-end satellite communication link simulation project |

**Text Book:**

| Sr. No. | Title | Edition | Authors | Publisher | Year |
|---|---|---|---|---|---|
| 1 | Satellite Communications Systems Engineering Atmospheric Effects, Satellite Link Design and System Performance | 1st | Louis J. Ippolito, Jr | Wiley | 2008 |
| 2 | Satellite Communications | 4th | Dennis Roddy | McGraw-Hill | 2006 |

**Reference Books:**

| Sr. No. | Title | Edition | Authors | Publisher | Year |
|---|---|---|---|---|---|
| 1 | Satellite Communication Systems Design Principles | 2nd | M. Richharia | Macmillan Press Ltd. | 2003 |
| 2 | Satellite Communication | 4th | Gerard Maral and Michel Bosquet | Wiley | 2001 |

| Course (Category) Code | Course Name | Teaching Scheme (Hrs/week) | | | | | Credits Assigned | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | L | T | P | O | E | L | T | P | Total |
| PE- IV | Telecom Network Operations and Management | 2 | 0 | 2 | 2 | 6 | 2 | 0 | 1 | 3 |
| | | Examination Scheme | | | | | | | | |
| | | Component | ISE (%) | | MSE (%) | | ESE(%) | | | Total |
| EC424 | | Theory | 20 | | 20 | | 60 | | | 100 |
| | | Laboratory | 80 | | -- | | 20 | | | 100 |

| | |
|---|---|
| **Pre-requisite Course Codes, if any.** | EC307: Computer Communication Network, Mobile and wireless communication. |
| **Course Objective:** To develop understanding the concept of Telecommunication network management, architecture and protocol. Appreciate the need for interoperable network management. This course offers students a hands-on experience managing network hardware and essential network services such as ARP, FTP, Telnet, HTTP, SSH, and SNMP through the use of scripting and python programming. | |
| **Course Outcomes (CO):** ***At the end of the course students will be able to*** | |
| EC424.1 | Identify network requirements and apply the concept of structured wiring, structured Network Design and select the best solutions to meet the needs of a business. |
| EC424.2 | Analyze the network management standards and protocols to support FCAPS Model of Network Management. |
| EC424.3 | Identify the functions of the Network Manager and show how management information is stored & accessed within a managed object. |
| EC424.4 | Apply troubleshooting and network management principles to implement server–agent architectures. |

**CO-PO Correlation Matrix (3-Strong, 2-Moderate, 1-Weak Correlation)**

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| EC424.1 | | | 2 | 2 | | | | | | | |
| EC424.2 | | | 2 | 2 | | | | | | | |
| EC424.3 | | | | | 3 | | | | | | |
| EC424.4 | | | | | 3 | | 2 | 2 | 2 | | |

**CO-PEO/PSO Correlation Matrix (3-Strong, 2-Moderate, 1-Weak Correlation**

| | PEO1 | PEO2 | PEO3 | PSO1 | PSO2 | PSO3 |
|---|---|---|---|---|---|---|
| EC424.1 | | | 2 | | | |
| EC424.2 | | 2 | | | | |
| EC424.3 | | | 2 | | | |
| EC424.4 | | 2 | | 3 | 2 | |

**BLOOM'S Levels Targeted (Pl. Tick appropriate)**

| Remember | Understand | • Apply | ✓ Analyze | • Evaluate | • Create |
|---|---|---|---|---|---|

**Theory Component**

| Module No. | Unit No. | Topics | Ref. | Hrs. |
|---|---|---|---|---|
| 1 | Title | **Introduction to Enterprise and telecommunication Network Design** | 1,3,4, 5,7 | 06 |
| | 1.1 | Overview of medium enterprise network design, including LAN design principles, multi-tier LAN models, and foundation services emphasizing scalability and uptime. WAN design considerations supporting business and network-based economic needs. Challenges faced by IT managers in planning, deploying, and maintaining enterprise networks. Network management architecture and perspectives, covering goals, functions, and organizational structures for effective network operations. | | |
| | 1.2 | Transmission & Backhaul Evolution: Overview of transport media including copper, microwave, and fiber-optic technologies used in telecom networks. IP/MPLS transport architectures for scalable, converged, and QoS-enabled service provider networks. X-haul concepts covering fronthaul, midhaul, and backhaul requirements in modern 4G/5G systems. Integration and design considerations for building high-performance, low-latency transport networks. | | |
| 2 | Title | **OSI Network Management and Encoding** | 1,2,3 | 04 |
| | 2.1 | Network management standards, Network management models, Organization model, Information model, Communication model and functional model, Abstract syntax notation ,encoding structure, macros, BER, DER encoding rules, BER/DER conversion examples, ASN.1 programming basics, functional model CMIP/CMISE,MPLS, SDH/SONET, DWDM, Routing: OSPF, BGP | | |
| 3 | Title | **Internet Management (SNMP) and TMN** | 1,2,3 | 06 |
| | 3.1 | SNMP-organizational model-System overview. Information model, communication model, functional model, SNMP proxy server, Management information, Protocol SNMPv1,v2 and V3, Remote monitoring. RMON, Limitations of SNMP, Beyond SNMP, NETCONF/YANG | | |

| | | | | |
|---|---|---|---|---|
| | **3.2** | Need for TMN, Conceptual TNM model, TMN Network Management Architecture, TMN management services architecture and TMN implementation. | | |
| **4** | **Title** | **Telecommunication Network Design** | 4,5,7 | **07** |
| | **4.1** | Radio network planning: link budget, coverage & capacity design, spectrum planning, MIMO/beamforming, small-cell densification; transport network design using copper, microwave, fiber, and X-haul (fronthaul, midhaul, backhaul); IP/MPLS-based core and backhaul design; QoS, latency, and reliability requirements. | | |
| | **4.2** | Telecom Network Management Architecture & OAM<br>TMN and FCAPS functions; SNMP, NETCONF/YANG, telemetry; OSS/BSS concepts; SON (Self-Organizing Networks); performance monitoring KPIs (RSRP, RSRQ, SINR, throughput for 4G/5G); alarm/event management; fault isolation and troubleshooting techniques. | | |
| **5** | **Title** | **Network Management Tools and Applications** | 1,2,5 | **05** |
| | **5.1** | System Utilities for network management, Network statistics and measurements, NMS Design, NMS components, NMS Server Architecture, Network Management Systems and FCAPS, Automatic Fault Management and Event correlation Techniques, Security Management | | |
| **6** | **Self Study** | **Broadband Network Management:** ATM Network Management and Wireless Network Management. | | **04** |
| | | | **Total** | **28** |

**Laboratory Component**

| Sr. No. | Title of the Experiment |
|---|---|
| **1** | Network Monitoring tools: a) Status b) Route c) Traffic Tools d) Audit |
| **2** | Monitoring and management network using SNMP: a) Basic SNMP b) Advanced SNMP v3 Authentication/Encryption and ACL c) SNMP Trap Daemon Implementation |
| **3** | Configuration SNMP Protocol on Cisco Router using Packet Tracer |
| **4** | Configuration manageable Switch: L2/L3 Switch |
| **5** | LAN Troubleshooting using tcpdump and Wireshark |

| | |
|---|---|
| **6** | Monitoring of services and Servers using a) Observium/ Cacti b)Nagios/Icinga |
| **7** | Performance Monitoring of LTE/5G KPIs in NS-3 (RSRP, SINR, Throughput) |
| **8** | Fault Detection & SON-based Auto-Recovery Using NS-3 LTE/NR |
| **9** | Python scripts for Network Monitoring |
| **10** | Network Management using Python |

**Reference Books**

| Sr. No. | Title | Edition | Authors | Publisher | Year |
|---|---|---|---|---|---|
| 1 | Network Management Principles and Practice | -- | Mani Subramaniam | Addison Wisely, New York | 2000 |
| 2 | Designing and Supporting Computer Networks, CCNA Discovery Learning Guide | -- | Kenneth Stewart, Aubrey Adams, Allan Reid, Jim Lorenz | Cisco Press | --- |
| 3 | Network Management: Concepts and Practice, A Hands-On Approach | -- | J. Richard Burke | Pearson Publications. | -- |
| 4 | Next Generation Telecommunications Networks, Services, and Management | 1st | Thomas Plevyak | John Wiley & Sons Ltd | 2010 |
| 5 | Telecommunication Switching, Traffic and Networks | 1st | J. E. Flood | Pearson Education India | 2016 |
| 6 | Python for Software Design | -- | Allen B. Downey | Cambridge University Press ISBN-13: 978-0521725965 | 2009 |
| 7 | Communication Networks: Fundamental Concepts and Key Architectures | 2nd | Leon-Garcia & Widjaja | McGraw-Hill Education 978-0070595019 | 2004 |

| Course (Category) Code | Course Name | Teaching Scheme (Hrs/week) | | | | | Credits Assigned | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | L | T | P | O | E | L | T | P | Total |
| PE-IV EC444 | IoT Applications and Analytics | 2 | -- | 2 | 2 | 6 | 2 | -- | 1 | 3 |
| | | Examination Scheme | | | | | | | | |
| | | Component | ISE (%) | | MSE (%) | | ESE (%) | | | Total |
| | | Theory | 20 | | 20 | | 60 | | | 100 |
| | | Laboratory | 80 | | -- | | 20 | | | 100 |

| | |
|---|---|
| **Pre-requisite Course Codes, if any.** | Computer Architecture and Organization<br>Computer Communication and Networks<br>Embedded Systems, IoT Protocols |

**Course Objective:** To provide students a comprehensive understanding of IoT system design and data analytics, enabling them to learn how data is collected, processed, and analyzed in IoT applications, along with insights into real-world use cases, decision-making, and associated security challenges.

**Course Outcomes (CO):** After successful completion of the course, student will be able to

| | |
|---|---|
| EC444.1 | Explain IoT system architectures and design considerations for real-world applications. |
| EC444.2 | Analyze IoT data flow, communication models, and data engineering pipelines. |
| EC444.3 | Evaluate data storage and management techniques for handling large-scale IoT data. |
| EC444.4 | Apply data analytics techniques to IoT data for extracting insights and identifying patterns. |
| EC444.5 | Interpret IoT applications and assess visualization, decision-making, and security challenges. |

**CO-PO Correlation Matrix (3-Strong, 2-Moderate, 1-Weak Correlation)**

| CO \ PO | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| EC444.1 | 3 | 2 | 3 | - | 2 | - | - | - | - | - | - | - |
| EC444.2 | 2 | 3 | 2 | 2 | 3 | - | - | - | - | - | - | - |
| EC444.3 | 2 | 2 | - | 2 | 3 | - | - | - | - | - | - | - |
| EC444.4 | 3 | 3 | - | 3 | 3 | - | - | - | - | - | - | 1 |
| EC444.5 | 2 | 2 | 2 | - | 2 | 2 | 1 | 2 | 1 | 2 | - | 2 |

**CO-PEO/PSO Correlation Matrix (3-Strong, 2-Moderate, 1-Weak Correlation)**

| CO | PEO1 | PEO2 | PEO3 | PEO4 | PSO1 | PSO2 |
|---|---|---|---|---|---|---|
| EC444.1 | 2 | 2 | | | 3 | |
| EC444.2 | 2 | 2 | 2 | | 3 | |
| EC444.3 | 2 | 2 | 2 | | 3 | |
| EC444.4 | 2 | 2 | 2 | | 3 | 1 |
| EC444.5 | 2 | 2 | 2 | 2 | 2 | 2 |

**Theory Component**

| Module No. | Unit No. | Topics | Ref. | Hrs |
|---|---|---|---|---|
| 1 | Title | **IoT System Design & Architecture** | | 05 |
| | 1.1 | **IoT System Architecture:** End-to-end architecture (device–gateway–cloud), functional roles and system workflow | 1,2 | |
| | 1.2 | **Design Considerations:** Scalability, latency, reliability, energy efficiency, deployment constraints | 1,3 | |
| | 1.3 | **Distributed Models:** Edge, fog and cloud computing roles in IoT systems | 2,3 | |
| 2 | Title | **IoT Data Communication & Pipeline** | | 06 |
| | 2.1 | **IoT Data Flow and Communication Models:** End-to-end data flow in IoT systems, communication patterns such as request–response, publish–subscribe, and push–pull (overview only) | 1,2 | |
| | 2.2 | **IoT Data Pipeline and Ingestion:** Data acquisition, ingestion techniques, message handling, buffering, filtering, and aggregation in IoT systems | 4 | |
| | 2.3 | **Data Processing Concepts:** Streaming vs batch processing, introduction to real-time data processing, characteristics of time-series data in IoT | 4,5 | |
| 3 | Title | **IoT Data Storage & Management** | | 05 |
| | 3.1 | **Data Characteristics & Requirements:** Nature of IoT data, need for scalable storage systems | 2,4 | |
| | 3.2 | **Database Models:** Relational vs NoSQL databases and their suitability for IoT | 4 | |
| | 3.3 | **Cloud Data Management:** Cloud storage concepts, data lifecycle and retention strategies | 2 | |

| | | | | |
|---|---|---|---|---|
| **4** | **Title** | **Data Analytics for IoT Systems** | | **07** |
| | **4.1** | **Data Preparation:** Data cleaning, transformation and normalization for IoT datasets | 4 | |
| | **4.2** | **Time-Series Analysis:** Trend analysis, variation patterns and basic forecasting concepts. | 5 | |
| | **4.3** | **Insight Generation:** Anomaly detection, pattern recognition and predictive analytics concepts | 4,5 | |
| **5** | **Title** | **IoT Applications, Visualization & Security** | | **05** |
| | **5.1** | **Application Domains:** Smart healthcare, agriculture, industrial IoT and smart cities | 1,2 | |
| | **5.2** | **Visualization & Interpretation:** Graphical representation, dashboards and decision-making from IoT data | 4 | |
| | **5.3** | **Security & Challenges:** Data security, privacy, scalability and interoperability challenges | 1,2 | |
| **6** | **Title** | **Case Studies in IoT Applications (Self-Learning)** | | |
| | **6.1** | **Smart Healthcare Systems:** Remote patient monitoring, wearable devices, real-time health data analysis and alert generation | 1,2 | |
| | **6.2** | **Industrial IoT (Predictive Maintenance):** Machine monitoring, sensor-based fault detection, data-driven maintenance strategies | 2,5 | |
| | **6.3** | **Smart Agriculture / Smart Cities:** Precision farming using sensor data, smart irrigation, traffic monitoring, and urban management systems | 1,4 | |
| | | | **Total** | **28** |

**Laboratory Component: Faculty can take any 10 experiment from suggested list**

| Sr. No. | Title of the Experiment |
|---|---|
| 1 | **Data Smoothing using Moving Average**<br>**Problem Statement:** Develop an IoT-based system using an IoT board to acquire sensor data and apply a moving average technique to reduce noise in the readings, and evaluate how smoothing improves data quality for further analysis. |
| 2 | **Weighted Sensor Fusion**<br>**Problem Statement:** Design and implement an IoT system using an IoT board that combines readings from multiple sensors using weighted fusion to produce a more reliable and meaningful output parameter. |
| 3 | **Event-Driven Data Transmission**<br>**Problem Statement:** Implement an IoT system using an IoT board that transmits sensor data only when significant changes occur, thereby reducing redundant communication and optimizing the data pipeline. |

| | |
|---|---|
| 4 | **Data Aggregation and Optimization**<br>**Problem Statement:** Develop an IoT application using an IoT board that aggregates sensor data by computing statistical measures such as minimum, maximum, and average values before transmission to improve efficiency. |
| **5** | **Time-Window Based Data Processing**<br>**Problem Statement:** Design an IoT system using an IoT board that processes sensor data over fixed time windows to analyze variations and prepare structured data for analytical use. |
| **6** | **Trend Detection in IoT Data**<br>**Problem Statement:** Implement an IoT application using an IoT board that detects trends such as increasing or decreasing patterns in sensor data based on sequential observations**.** |
| **7** | **Dynamic Threshold-Based Decision System**<br>**Problem Statement:** Develop an IoT system using an IoT board that dynamically adjusts threshold values based on historical or averaged data and triggers actions accordingly. |
| **8** | **Rule-Based Decision Engine**<br>**Problem Statement:** Design an IoT application using an IoT board that applies multiple conditional rules on sensor inputs to perform intelligent decision-making and control output devices. |
| **9** | **Anomaly Detection using Statistical Methods**<br>**Problem Statement:** Implement an IoT system using an IoT board that identifies abnormal sensor readings by comparing current values with statistical measures such as mean or deviation and generates alerts. |
| **10** | **Lightweight Encryption for Secure Data Transmission**<br>**Problem Statement:** Develop an IoT-based system using an IoT board that encrypts sensor data using a lightweight encryption technique before transmission and decrypts it at the receiving end to ensure secure communication. |
| **11** | **Data Compression for Efficient IoT Transmission**<br>**Problem Statement:** Design an IoT system using an IoT board that reduces the volume of transmitted data by implementing simple compression or data reduction techniques such as transmitting only significant values or summarized data. |
| **12** | **Adaptive Sampling Rate System**<br>**Problem Statement:** Implement an IoT application using an IoT board that dynamically adjusts the data sampling rate based on the rate of change in sensor readings to optimize performance and efficiency. |
| **13** | **Fault-Tolerant Data Handling System**<br>**Problem Statement:** Design an IoT system using an IoT board that handles missing or inconsistent sensor data by applying basic recovery or estimation techniques to maintain data reliability. |
| **14** | **Energy-Efficient IoT Operation**<br>**Problem Statement:** Develop an IoT-based system using an IoT board that optimizes power consumption by controlling sensing frequency, transmission intervals, or device operation modes. |

| | |
|---|---|
| 15 | **Secure Access Control for IoT Devices**<br>**Problem Statement:** Implement an IoT system using an IoT board that restricts access to data or device functionality using authentication mechanisms such as password or key-based validation. |

**Reference Books**

| Sr. No. | Title | Edition | Author(s) | Publisher | Year |
|---|---|---|---|---|---|
| 1 | Internet of Things: A Hands-on Approach | First | Arshdeep Bahga, Vijay Madisetti | Universities Press | 2017 |
| 2 | Internet of Things: Principles and Paradigms | First | Rajkumar Buyya et al. | Morgan Kaufmann | 2016 |
| 3 | Architecting the Internet of Things | First | Dieter Uckelmann et al. | Springer | 2011 |
| 4 | Data Science for Business | First | Foster Provost, Tom Fawcett | O'Reilly Media | 2013 |
| 5 | Practical Time Series Analysis | First | Aileen Nielsen | O'Reilly Media | 2019 |

**MOOC/NPTEL/Online Resources:**

- ✓ NPTEL: Introduction to Internet of Things – IIT Kharagpur : https://onlinecourses.nptel.ac.in/noc22_cs53/preview
- ✓ Coursera: Introduction to the Internet of Things and Embedded Systems – UCI : https://sl1nk.com/4906uro
- ✓ edX: IoT Systems and Industrial Applications with Design Thinking https://www.edx.org/learn/iot-internet-of-things/ecole-polytechnique-federale-de-lausanne-iot-systems-and-industrial-applications-with-design-thinking

| Course (Category) Code | Course Name | Teaching Scheme (Hrs/week) | | | | | Credits Assigned | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | L | T | P | O | E | L | T | P | Total |
| EC | Digital Signal Processors System Design | 2 | 1 | 2 | 5 | 10 | 3 | 1 | 1 | 4 |
| | | Examination Scheme | | | | | | | | |
| | | Component | ISE (%) | | MSE (%) | | ESE (%) | | | Total |
| 341 | | Theory | 20 | | 20 | | 60 | | | 100 |
| | | Laboratory | 80 | | -- | | 20 | | | 100 |

| | |
|---|---|
| **Pre-requisite Course Codes, if any.** | |
| **Course Objective:** | |
| **Course Outcomes (CO):** ***At the end of the course students will be able to*** | |
| EC341.1 | Identify and evaluate design trade-offs in DSP processor architectures. |
| EC341.2 | Analyze and compare various DSP architectures with emphasis on TMS320C54XX. |
| EC341.3 | Design and implement interrupt service routines (ISRs) in DSP systems. |
| EC341.4 | Understand peripheral and memory interfacing with real-time constraints. |
| EC341.5 | Design and implement real-time signal processing applications using TMS320C54XX. |

**CO-PO Correlation Matrix (3-Strong, 2-Moderate, 1-Weak Correlation)**

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| EC341.1 | 3 | | 2 | | | | | | | | | |
| EC341.2 | 3 | 2 | | | | | | | | | | |
| EC341.3 | 2 | 3 | | | 2 | | | | | | | |
| EC341.4 | | 2 | 2 | | 3 | | | | | | | |
| EC341.5 | | | 3 | 2 | 3 | | | | | | | |

**CO-PEO/PSO Correlation Matrix (3-Strong, 2-Moderate, 1-Weak Correlation)**

| | PEO1 | PEO2 | PEO3 | PSO1 | PSO2 | PSO3 |
|---|---|---|---|---|---|---|
| EC341.1 | 3 | | | 3 | | |
| EC341.2 | 3 | | | 2 | | |
| EC341.3 | | 2 | | 2 | | |
| EC341.4 | | 2 | | | 3 | |
| EC341.5 | | 3 | | 3 | 2 | |

**BLOOM'S Levels Targeted (Pl. Tick appropriate)**

| Remember ✓ | Understand ✓ | Apply ✓ | Analyze ✓ | Evaluate ✓ | Create ✓ |
|---|---|---|---|---|---|
| | | | | | |

**Theory Component**

| Module No. | Unit No. | Topics | Ref. | Hrs. |
|---|---|---|---|---|
| 1 | Title | **Number Systems & Quantization** | 1,2 | 4 |
| | | Representation of Numbers in the digital system (Floating point, Fixed-point representation), Types of arithmetic in a digital system, Quantization effect & Errors therein, Concept of Cycle Oscillations & Scaling | | |
| 2 | Title | **DSP Processor Fundamentals** | 1,2 | 6 |
| | | Comparison with general-purpose processors, Harvard architecture, pipelining, parallelism, DMA, MAC units, specialized addressing modes, circular buffers. Introduction to DSP architecture. Peripherals available in DSP IC chips, | | |
| 3 | Title | **Architecture of TMS320C54XX DSPs** | 2 | 6 |
| | | Internal structure, CPU, memory map, peripherals (ADC, timers, serial ports), bus structure, instruction set overview. | | |
| 4 | Title | **DSP Hardware Design Concepts** | 1,2 | 4 |
| | | Real-time constraints, low-power design, memory interfacing, DMA, bootloading, power optimization techniques, fixed-point design challenges. | | |
| 5 | Title | **DSP System Integration** | 2 | 4 |
| | | Interfacing with I/O devices, memory mapped vs port mapped I/O, external peripherals, interrupts, interrupt service routines, bus contention. | | |
| 6 | Self Study | **Application Case Studies**: Real-time audio filtering, speech recognition front-end, vibration monitoring, ECG analysis—using TI DSPs. | | 4 |
| | | | **Total** | **28** |

**Laboratory Component, if any. (Minimum 10 Laboratory experiments are expected)**

| Sr. No. | Title of the Experiment |
|---|---|
| 1 | Introduction to Code Composer Studio |
| 2 | Study of TMS320C54XX DSP architecture and toolchain setup |
| 3 | Fixed-Point Arithmetic Implementation and Analysis |
| 4 | Bit-Manipulation Operations for Control Signal Design |
| 5 | Design and Comparison of Delay Loops |

| | |
|---|---|
| 6 | Assembly and C-based FIR filter implementation using C54XX |
| 7 | FFT implementation on TMS320C54XX using optimized addressing |
| 8 | Interrupt-based real-time data acquisition and processing |
| 9 | PWM generation and control using C54XX timer peripherals |
| 10 | Interfacing ADC/DAC with DSP and sampling analog signals |
| 11 | Audio input/output system: Real-time audio effect using DSP |
| 12 | Memory interfacing |
| 13 | DMA-based data transfer and performance evaluation |
| 14 | Real-time ECG signal denoising and compression on DSP |
| 15 | Custom Peripheral Integration (e.g., SPI or I2C Sensor) |

**Text Books**

| Sr. No. | Title | Edition | Authors | Publisher | Year |
|---|---|---|---|---|---|
| 1 | Digital Signal Processors | Second Edition | B. Venkataramani M. Bhaskar | Tata McGraw Hill | 2012 |
| 2 | DSP Implementation using DSP microprocessor with Examples from TMS32C54XX | First Edition | Avtar Singh, S. Srinivasan | Thomson Publication | 2004 |

**Reference Books**

| Sr. No. | Title | Edition | Authors | Publisher | Year |
|---|---|---|---|---|---|
| 1 | DSP Processor Fundamentals, Architectures & Features | First Edition | Phil Lapsley, Jeff Bier, Amit Shoham, Edward A. Lee | Wiley Publication | 1997 |
| 2. | Digital Signal Processors Architectures, Implementation and Application | First Edition | Sen M. Kuo Woon Serg Gan | Pearson | 2009 |
| 3. | Architectures for Digital Signal Processing | Second Edition | Peter Pirsch | Wiley Publication | 1998 |

**Web References:**

TI Application Notes and User Manuals for TMS320C54XX (available at: TI C54x DSP Portal).

**NPTEL Courses**

- Real-Time Digital Signal Processing by Prof. Rathma G. N. IISc Bangalore

  **https://onlinecourses.nptel.ac.in/noc22_ee99/preview**

- Mapping of Signal Processing Algorithms to Architectures By Prof.Nitin Chandrachoodan, IIT Madras
  **https://onlinecourses.nptel.ac.in/noc19_ee70/preview**

**Online Video :**

- TI Code Composer Studio Guide

  **https://software-dl.ti.com/ccs/esd/documents/users_guide/ccs_getting-started.html**

- TI DSP YouTube Playlist

  **https://www.youtube.com/watch?v=11lsNYW7zkw**

| Course (Category) Code | Course Name | Teaching Scheme (Hrs/week) | | | | | Credits Assigned | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | L | T | P | O | E | L | T | P | Total |
| PE | ASIC Verification | 2 | -- | 2 | 4 | 8 | 2 | -- | 1 | 3 |
| | | Examination Scheme | | | | | | | | |
| | | Component | ISE (%) | | MSE (%) | | ESE (%) | | | Total |
| EC454 | | Theory | 20 | | 20 | | 60 | | | 100 |
| | | Laboratory | 80 | | -- | | 20 | | | 100 |

| | |
|---|---|
| **Pre-requisite Course Codes, if any.** | Basic Electrical Engineering EC102<br>Programming Lab I CE101<br>Programming Lab II CE102<br>Hardware Description Language (HDL) Programming AS202<br>Digital CMOS VLSI Design EC351<br>Semiconductor Technology EC352<br>Analog CMOS VLSI Design EC453 |

**Course Objective:** The course aims to familiarize students and select the verification methodology like simulation-based verification, formal verification, and hardware emulation based on their strengths, weaknesses, and when to use each approach. It would lead to build proficiency in hardware description System Verilog, as well as verification languages like System Verilog Assertions (SVA) and Universal Verification Methodology (UVM). Learners will be able to develop comprehensive testbenches that thoroughly exercise the ASIC design under various conditions to identify bugs and ensure functional correctness. Proficiency in using industry-standard verification tool, formal verification tools and debugging tools.

**Course Outcomes (CO):** ***At the end of the course students will be able to***

| | |
|---|---|
| EC454.1 | Recognise trends in ASIC verification |
| EC454.2 | Apply System Verilog constructs for verification |
| EC454.3 | Create testbenches, threads and show interprocess communication |
| EC454.4 | Create test cases under constrained environment |
| EC454.5 | Validate design with System Verilog assertions and functional coverage |

**CO-PO Correlation Matrix (3-Strong, 2-Moderate, 1-Weak Correlation)**

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| EC454.1 | 1 | | | | | | | 1 | 1 | 1 | | 2 |
| EC454.2 | 3 | | 3 | 3 | 3 | | | 1 | 1 | 1 | | 1 |
| EC454.3 | 3 | | 3 | 3 | 3 | | | 1 | 1 | 1 | | 1 |
| EC454.4 | 3 | | 3 | 3 | 3 | | | 1 | 1 | 1 | | 1 |
| EC454.5 | 3 | | 3 | 3 | 3 | | | 1 | 1 | 1 | | 1 |

**CO-PEO/PSO Correlation Matrix (3-Strong, 2-Moderate, 1-Weak Correlation)**

| | PEO1 | PEO2 | PEO3 | PEO4 | PSO1 | PSO2 |
|---|---|---|---|---|---|---|
| EC454.1 | | | | | | |
| EC454.2 | | | | | | |
| EC454.3 | | | | | | |
| EC454.4 | | | | | | |
| EC454.5 | 1 | | 2 | | 1 | |

**BLOOM'S Levels Targeted (Pl. Tick appropriate)**

| Remember | Understand√ | Apply√ | Analyze√ | Evaluate√ | Create√ |
|---|---|---|---|---|---|

**Theory Component**

| Module No. | Unit No. | Topics | Ref. | Hrs. |
|---|---|---|---|---|
| 1 | Title | **Basics of System Verilog** | 1 (T), 5 (R) | 2 |
| | 1.1 | **Verification Basics:** Technology challenges, Verification methodology, Testbench creation, Verification languages, Verification IP reuse, Verification approaches, Verification plans | | |
| 2 | Title | **Data types, procedural statements and testbench** | 1 (T), 1 (R), 3 (R) | 6 |
| | 2.1 | **Data Types:** Built in, Fixed size array, dynamic array, queues, associative array, linked list, array methods, choosing a storage type, creating new types with typedef, creating user-defined structures, type conversion, enumerated types, constants, strings, expression width | | |
| | 2.2 | **Procedural Statements and Routines:** Procedural statements, tasks, functions and void functions, task and function overview, routine arguments, returning from a routine, local data storage, time values | | |
| | 2.3 | **Connecting the Testbench and Design:** Separating the testbench and design, the interface construct, stimulus timing, interface driving and sampling, top-level scope, program-module, interactions | 1 (T), 1 (R), 3 (R) | |
| 3 | Title | **OOP and Randomization** | 1 (T), 1 (R), 3 (R) | 6 |
| | 3.1 | **Basic OOP:** Class, creating new objects, Object deallocation, using objects, variables, class methods, defining methods outside class, scoping rules, using one class inside another, understanding dynamic objects, copying objects, public Vs local, building a testbench | | |
| | 3.2 | **Randomization:** Randomization in system Verilog, constraint | | |

| | | | | |
|---|---|---|---|---|
| | | details, solution probabilities, controlling multiple constraint blocks, valid constraints, In-line constraints, pre-randomize and post-randomize functions, Random number functions, Constraints tips and techniques, common randomization problems, Iterative and array constraints, Atomic stimulus generation Vs scenario generation, random control, random number generators, random device configuration | | |
| **4** | **Title** | **IPC and advanced OOP** | 1 (T), 1 (R), 3 (R) | **8** |
| | **4.1** | **Threads and Interprocess Communication:** working with threads, disabling threads, interprocess communication, events, semaphores, mailboxes, building a testbench with threads and IPC | | |
| | **4.2** | **Advanced OOP and Testbench Guidelines:** Inheritance, Blueprint pattern, downcasting and virtual methods, composition, inheritance and alternatives, copying an object, abstract classes and pure virtual methods, callbacks, parameterized classes | | |
| **5** | **Title** | **Assertions and Functional Coverage** | 1 (T), 1 (R), 2 (R), 4 (R) | **6** |
| | **5.1** | **System Verilog Assertions:** Assertions in verification methodology, understanding sequences and properties, System Verilog Assertions in the Design Process, Formal Verification Using Assertions and System Verilog Assertions Guidelines | | |
| | **5.2** | **Functional Coverage:** Coverage types, strategies, examples, anatomy of a cover group, triggering a cover group, data sampling, cross coverage, generic cover groups, coverage options, analyzing coverage data, measuring coverage statistics during simulation | | |
| **6** | **Self Study** | **Advanced Interfaces:** Virtual interfaces with the ATM router, connecting to multiple design configurations, procedural code in an interface, **A complete System Verilog Testbench:** Design blocks, testbench blocks, alternate tests, **Interfacing with C:** Passing simple values, connecting to a simple C routine, connecting to C++, simple array sharing, open arrays, sharing composite types, pure and context imported methods, communicating from C to system Verilog, connecting other languages | 1 (T), 1 (R), 2 (R), 4 (R) | **4*** |
| | | | **Total (*Not included)** | **28** |

**Laboratory Component, if any. (Minimum 10 Laboratory experiments are expected)**

| Sr. No. | Title of the Experiment |
|---|---|
| 1 | Design MUX and D-FF modules with parameters to enable students to understand how different parameters influence module behavior and functionality. |

| | |
|---|---|
| 2 | Familiarization of simulation tool for verification of design using System Verilog. Simulate MUX and D-FF. |
| 3 | Complete the given task on literals and data types in System Verilog. Also write the simulation output for the given Procedural Statements |
| 4 | Write the simulation output for the given Interprocess Communication |
| 5 | Write the simulation output for the given randomization code |
| 6 | Write the simulation output for the given Interfaces, Program and Clocking Blocks |
| 7 | Write the simulation output for the given Processes |
| 8 | Write the simulation output for the given Functional Coverage |
| 9 | Write the simulation output for the given Assertions |
| 10 | Open-ended problem: Apply System Verilog concepts to any real-life application and its execution/implementation.<br>i. **Designing and Verifying Peripheral Interfaces:** Design, verify, and simulate interfaces like UART, SPI, I2C, or PCIe using SystemVerilog to ensure compatibility and reliability in ASIC designs.<br>ii. **Developing Verification IP (VIP):** Create Verification IP (VIP) for popular protocols or interfaces, such as USB, Ethernet, or HDMI, to be used in larger ASIC verification environments.<br>iii. **Verifying ASIC Components for IoT Devices:** Verify ASIC components like sensors, communication modules, or processing units for Internet of Things (IoT) devices, ensuring low power consumption, reliability, and interoperability.<br>iv. **ASIC Verification for Automotive Electronics:** Verify ASIC components used in automotive electronics, such as engine control units, safety systems, or infotainment systems, to ensure compliance with industry standards and safety requirements.<br>v. **ASIC Verification for Consumer Electronics:** Verify ASIC components for consumer electronics devices like smartphones, tablets, or gaming consoles, ensuring functionality, performance, and compatibility with diverse hardware and software environments. |

**Text Books**

| Sr. No. | Title | Edition | Authors | Publisher | Year |
|---|---|---|---|---|---|
| **1** | System Verilog for Verification: A guide to learning the testbench language features | 2nd | Chris Spear | Springer | 2010 |

**Reference Books**

| Sr. No. | Title | Edition | Authors | Publisher | Year |
|---|---|---|---|---|---|
| 1 | System Verilog for Design: A guide to using system Verilog for hardware design and modeling | 2nd | Stuart Sutherland, Simon Davidmann, and Peter Flake | Springer | 2006 |
| 2 | System Verilog Assertions Handbook | 4th | Ben Cohen, Srinivasan Venkataramanan, Ajeetha Kumari and Lisa Piper | VhdlCohen Publishing | 2015 |
| 3 | System Verilog Language Reference manual | -- | -- | -- | -- |
| 4 | System on Chip Verification Methodologies and Techniques | 1st | S Prakash Rashinkar, Peter Paterson and Leena Singh | Kluwer Academic | 2003 |

| Course (Category) Code | Course Name | Teaching Scheme (Hrs/week) | | | | | Credits Assigned | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | L | T | P | O | E | L | T | P | Total |
| ELC | Main Project Stage 2 | 0 | 0 | 8 | 4 | 12 | 0 | 0 | 4 | 4 |
| | | Examination Scheme | | | | | | | | |
| | | Component | ISE (%) | | MSE (%) | | ESE (%) | | | Total |
| PR3-II | | Theory | -- | | -- | | -- | | | -- |
| | | Laboratory | -- | | -- | | -- | | | -- |
| | | Self-Study | 80 | | -- | | 20 | | | 100 |

| | |
|---|---|
| **Pre-requisite Course Codes, if any.** | All the Courses till fourth Semester |

**Course Objective:** Main Project Stage 2 provides an opportunity to create a significant impact on the educational experience by tackling real-world problems. This phase involves using scientific methods to analyze, correct, and evaluate decisions related to a specific issue. By connecting theoretical knowledge with practical application, it encourages students to develop a scientific mindset, helping them address everyday challenges more effectively.

**Course Outcomes (CO):** ***At the end of the course students will be able to***

| | |
|---|---|
| PR3-II.1 | Identify problems based on societal/environmental issues. |
| PR3-II.2 | Apply engineering knowledge to propose innovative and sustainable solutions to practical problems in a group. |
| PR3-II.3 | Analyze the results obtained using theoretical, experimental, or simulation methods and draw appropriate conclusions. |
| PR3-II.4 | Apply self-learning skills in teamwork with following professional ethics, contributing to the development of lifelong learning habits. |
| PR3-II.5 | Document the findings and foster communication, organizational abilities, and personal growth through discussions and presentations. |
| PR3-II.6 | Apply project management principles during the project work. |

**CO-PO Correlation Matrix (3-Strong, 2-Moderate, 1-Weak Correlation)**

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| PR3-I.1 | 1 | 3 | 3 | 1 | 1 | 3 | 3 | 1 | 1 | 1 | 1 | 1 |
| PR3-I.2 | 3 | 2 | 3 | 2 | 3 | 1 | 1 | 1 | 3 | 1 | 1 | 1 |
| PR3-I.3 | 2 | 2 | 2 | 3 | 2 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| PR3-I.4 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 3 | 3 | 2 | 2 | 3 |
| PR3-I.5 | 2 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 3 | 1 | 1 |
| PR3-I.6 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 3 | 1 |
| **PR3-I** | **1.83** | **1.83** | **2** | **1.67** | **1.67** | **1.5** | **1.5** | **1.33** | **1.67** | **1.5** | **1.5** | **1.33** |

**CO-PEO/PSO Correlation Matrix (3-Strong, 2-Moderate, 1-Weak Correlation)**

| | PEO1 | PEO2 | PEO3 | PEO4 | PSO1 | PSO2 |
|---|---|---|---|---|---|---|
| PR3-I.1 | | | | | 2 | 3 |
| PR3-I.2 | | | | | 3 | 2 |
| PR3-I.3 | | | | | 3 | 2 |
| PR3-I.4 | | | | | 2 | 3 |
| PR3-I.5 | | | | | 2 | 3 |
| PR3-I.6 | | | | | 2 | 3 |
| **PR3-I** | | | | | **2.33** | **2.67** |

**Guidelines for Main Project Stage II:**

1) The main project stage 2 would be continuation of main project stage 1.
2) A log book to be prepared by each group, wherein group can record weekly work progress, mentor/co-mentor can verify and record notes/comments.
3) Faculty mentor may give inputs to students during mini project activity; however, focus shall be on self learning.
4) Students in a group shall understand problem effectively, propose multiple solution and select best possible solution in consultation with mentor/ co-mentor.
5) Students shall convert the best solution into working model using various components of their domain areas and demonstrate.
6) The solution to be validated with proper justification and report to be compiled in standard format given by department. Project report should contain project title, student details, certificate, and acknowledgements. Other sections of the report shall be introduction, necessity of project, objectives, hypothesis, plan, observations, analysis of results, conclusion, and references along with other sections related to technology. The report must be written in Latex and must include report of plagiarism check.

**Guidelines for Assessment of Main Project Stage II: (ISE: Through 2 Phases of Evaluation) and ESE**

**In Semester Evaluation:**

- The review/ progress monitoring committee shall be constituted by Head of Department.

- The progress of main project to be evaluated on continuous basis, with the help of two phase evaluation in the semester.
- In continuous assessment focus shall also be on each individual student, assessment based on individual's contribution in group activity, their understanding and response to questions.
- As the main project stage 2 would be continuation of main project stage 1, the phase 1 evaluation (during 6th week of semester) shall be done by mentor and co-mentor considering the factors like project planning, work done, ethics, presentation skills along with attendance in terms of weekly meeting with mentor/co-mentor.
- The phase 2 evaluation (during 12th week of semester) shall be done by mentor and co-mentor considering the factors like demonstration of the work undertaken, project outcome with respect to scope defined, teamwork, ethics, submission of poster and project report (with plagiarism check) in prescribed format given by department.
- The phase 2 evaluation (during 12th week of semester) shall be done by mentor and co-mentor considering the factors like demonstration of the work undertaken, project outcome with respect to scope defined, teamwork, ethics, submission of poster and project report (with plagiarism check) in prescribed format given by department.

**End Semester Evaluation:**

- The ESE shall be scheduled during the last week of semester in terms of exhibition.
- External experts from the other colleges shall be called for the evaluation.
- The exhibition will be conducted in 2 phases
- For phase 1 all groups will participate.
- For phase 2 shortlisted groups will demonstrate the project once again to higher authorities and domain experts from the college.

4. During the exhibition, the projects will be evaluated by an external examiner based on
   - Problem Definition/Idea/Originality/Novelty/Feasibility/Application in Society
   - Work Done (Survey/Design/Simulation/experimentation/Tools Usage/Budget Plan/Execution Plan)
   - Presentation (Demo/Oral/Written) and Ethics (Attitude/Deadline/Distribution of Work)
   - Outcome of project (paper/ patent/winner of competition)
   - Knowledge/Question-Answer
5. Each external examiner will evaluate 8 to 10 groups.
6. The best 2 or 3 projects shortlisted by each examiner will be eligible for phase 2 evaluation. The ranking of shortlisted projects will be given by higher authorities and domain experts from the college.
7. The prizes will be in terms of reimbursement of the hardware component expenses done for the projects as defined by the department reimbursement policy.

8. Each group must write research proposal as per prescribed TIH of Nidhi Prayas proposal format for reimbursement of the hardware component used in project.
9. The winning team of the exhibition will be eligible to take part in the AICTE Techfest and YUKTI ideation competition.
10. The paper and patent publication of the project or prize obtained after participating in project competition will have weightage in In Semester Evaluation rubric.