# THE NATIONAL INSTITUTE OF ENGINEERING

Manandavadi Road, Mysuru


## DEPARTMENT OF
## ELECTRONICS AND COMMUNICATION ENGINEERING

## Curriculum Structure and Syllabus

## 2025-2026

## 2023 Admitted Batch

**The National Institute of Engineering**

**Department: Electronics and Communication Engineering**

**Scheme of Teaching & Examination - 2022** **Effective from the Academic Year 2025-26**

**B.E. 2023 Admitted Batch** **Semester: V**

| Sl. No | Type of Course | Course Code | Course Title | Teaching Department (TD) | Question Paper Setting Board (PSB) | Teaching Hrs / Week | | | | Duration in Hours | Examination | | Total Marks | Credits |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | L | T | P | S | | CIE Marks | SEE Marks | | |
| 1 | HSMS | BEC501 | Engineering Management and Entrepreneurship | EC | EC | 3 | 0 | 0 | | 3 | 50 | 50 | 100 | 3 |
| 2 | IPCC | BEC502 | Integrated Professional Core Courses (IPCC): **Control Systems** | | EC | 3 | 2 | 0 | | 3 | 50 | 50 | 100 | 4 |
| 3 | PCC | BEC503 | Professional Core Course (PCC) **Communication Systems** | | EC | 3 | 0 | 0 | | 3 | 50 | 50 | 100 | 3 |
| 4 | PCC | BEC504 | Professional Core Course (PCC) **Digital Signal Processing** | | EC | 3 | 0 | 2 | | 3 | 50 | 50 | 100 | 4 |
| 5 | PCCL | BECL505 | Professional Core Course Laboratory (PCCL): **Communication Systems Lab** | | EC | 0 | 0 | 2 | | 3 | 50 | 50 | 100 | 1 |
| 6 | PEC | BEC515X | Professional Elective Course (Industry suggested course) | | EC | 2 | 0 | 2 | | 3 | 50 | 50 | 100 | 3 |
| 7 | PROJ | BEC586 | Minor Project | | | 0 | 0 | 2 | | - | 50 | - | 50 | 1 |
| 8 | AEC | BRMEC557 | Research Methodology and IPR | Any Department | EC | 2 | 0 | 0 | | 2 | 50 | 50 | 100 | 2 |
| 9 | MC | BESK508 | Environmental Studies | TD: Civil/ Chemistry | Civil | 1 | 0 | 0 | | - | 50 | - | 50 | 1 |

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 10 | MC | BNSK559 | National Service Scheme (NSS) | NSS Coordinator | 0 | 0 | 2 | | _ | 100 | _ | 100 | 0 |
| | | | Physical Education (PE) (Sports & Athletics) | PED | | | | | | | | | |
| | | | Yoga | Yoga Teacher | | | | | | | | | |
| | | | | | | | | | **Total** | **550** | **350** | **900** | **22** |

| Professional Elective Course (Industry suggested course) | |
|---|---|
| BEC515A | Embedded Systems for Automotive |
| BEC515B | Unified Verification Methodology |
| BEC515C | Operating System |

**The National Institute of Engineering**

**Department: Electronics and Communication Engineering**

**Scheme of Teaching & Examination - 2022** **Effective from the Academic Year 2025-26**

**B.E. 2023 Admitted Batch** **Semester: VI**

| Sl. No | Type of Course | Course Code | Course Title | Teaching Department (TD) | Question Paper Setting Board (PSB) | Teaching Hrs / Week | | | | Examination | | | | Credits |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | L | T | P | S | Duration in Hours | CIE Marks | SEE Marks | Total Marks | |
| 1 | IPCC | BEC601 | Integrated Professional Core Courses (IPCC): **Computer Networks** | Department name - EC | EC | 3 | 0 | 2 | | 3 | 50 | 50 | 100 | 4 |
| 2 | PCC | BEC602 | Professional Core Course (PCC): **Embedded System and Architecture** | EC | EC | 3 | 0 | 2 | | 3 | 50 | 50 | 100 | 4 |
| 3 | PEC | BEC613X | Professional Elective Course - Group II | EC | EC | 3 | 0 | 0 | | 3 | 50 | 50 | 100 | 3 |
| 4 | OEC | BEC654X | Open Elective Course - Group II | EC | EC | 3 | 0 | 0 | | 3 | 50 | 50 | 100 | 3 |
| 5 | PCC | BEC605 | Professional Core Course (PCC): **Wireless Communication** | EC | EC | 3 | 0 | 0 | | 3 | 50 | 50 | 100 | 3 |
| 6 | PCC | BEC606 | Professional Core Course (PCC): **Principles of Digital VLSI** | EC | EC | 3 | 0 | 0 | | 3 | 50 | 50 | 100 | 3 |
| 7 | PCCL | BECL607 | Professional Core Course laboratory: **VLSI Lab** | EC | EC | 0 | 0 | 2 | | - | 50 | 50 | 100 | 1 |
| 8 | AEC/SDC | BEC657L | Ability Enhancement Course – **Python for ML Application or E-waste management** / Skill Development Course V / **PCB Design and Fabrication** | EC | EC | If the course is a Theory<br>1 0 0 1<br>OR<br>If the course is a Laboratory<br>0 0 2 2 | | | | | 50 | - | 50 | 1 |

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 9 | MC | BNSK658 | National Service Scheme (NSS) | NSS Coordinator | 0 | 0 | 2 | | - | 100 | - | 100 | 0 |
| | | BPEK658 | Physical Education (PE) (Sports & Athletics) | PED | | | | | _ | 100 | _ | 100 | 0 |
| | | BYOK658 | Yoga | Yoga Teacher | | | | | | | | | |
| | | BIKS609 | Indian Knowledge System | Humanities | | | | | | | | | |
| | | | | | | | | | **Total** | **500** | **400** | **900** | **22** |

| **Professional Elective Course - Group II** | | | **Open Elective Course - Group II** | |
|---|---|---|---|---|
| BEC613A | ASIC Design | | BEC654A | Internet of Things and Applications |
| BEC613B | Signal Processing and Machine Learning | | BEC654B | Vehicular Electronics |
| BEC613C | Optical Fibre Communication | | BEC654C | Multicore systems and programming |
| BEC613D | Industrial Internet of Things | | BEC654D | Introduction to VLSI |
| BEC613E | Object Oriented Programming | | BEC654E | Introduction to Radar systems for Autonomous driving |
| BEC613F | Transmission Lines and Radiating Systems | | | |

**The National Institute of Engineering**

**Department: Electronics and Communication Engineering**

**Scheme of Teaching & Examination - 2022** **Effective from the Academic Year 2025-26**

**B.E. 2023 Admitted Batch** **Semester: VII**

| Sl. No | Type of the Course | Course Code | Course Title | Teaching Department (TD) | Question Paper Setting Board (PSB) | Teaching Hrs / Week | | | | Examination | | | | Credits |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | L | T | P | S | Duration in Hours | CIE Marks | SEE Marks | Total marks | |
| 1 | IPCC | BEC701 | Integrated Professional Core Course: **Real Time Operating Systems** | EC | EC | 3 | 0 | 2 | | 3 | 50 | 100 | 100 | 4 |
| 2 | PCC | BEC702 | Professional Core Course: **Information Theory and Coding** | EC | EC | 3 | 2 | 0 | | 3 | 50 | 100 | 100 | 4 |
| 3 | PEC | BEC713X | Professional Elective Course - Group III | EC | EC | 3 | 0 | 0 | | 3 | 50 | 100 | 100 | 3 |
| 4 | OEC | BEC754X | Open Elective Course - Group III | EC | EC | 3 | 0 | 0 | | 3 | 50 | 100 | 100 | 3 |
| 5 | PROJ | BEC785 | Major Project | EC | EC | 3 | 0 | 0 | | 3 | 100 | 100 | 200 | 6 |
| | | | | | | | | | | **Total** | **300** | **300** | **600** | **20** |

| **Professional Elective Course - Group III** | | | |
|---|---|---|---|
| BEC713A | Static Timing Analysis | BEC713H | Vehicular Electronics |
| BEC713B | Mixed Signal Circuit Design | BEC713I | Radar and Lidar Systems for Autonomous Driving |
| BEC713C | Deep Learning Techniques | BEC713J | Digital Image Processing |
| BEC713D | Estimation Theory | BEC713K | Wireless Ad Hoc network |
| BEC713E | Low Power VLSI Design | BEC713M | Information and Network Security |
| BEC713F | Semiconductor IC technology | BEC713N | Data Science and Management |
| BEC713G | 5G Wireless Systems and Industry Applications | BEC713P | Integrated Sensing and Communications |
| **Open Elective Course - Group III** | | | |
| BEC754A | Introduction to Quantum Computing | BEC754C | Mobile Communication |
| BEC754B | Next-Gen Wireless: 5G Systems and Cross-Industry Use Cases | BEC754D | Neuromorphic Engineering |

| **The National Institute of Engineering**<br>**Department: Electronics and Communication Engineering** | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Scheme of Teaching & Examination - 2022** | | | | | | | | | | | **Effective from the Academic Year 2025-26** | | | |
| **B.E. 2023 Admitted Batch** | | | | | | | | | | | | | | **Semester: VIII** |
| **Sl. No** | **Type of the Course** | **Course Code** | **Course Title** | **Teaching Department (TD)** | **Question Paper Setting Board (PSB)** | **Teaching Hrs / Week** | | | | **Examination** | | | | **Credits** |
| | | | | | | **L** | **T** | **P** | **S** | **Duration in Hours** | **CIE Marks** | **SEE Marks** | **Total marks** | |
| 1 | PEC | BEC801X | Professional Elective - Group IV (Online Course) | EC | EC | - | - | - | | - | - | 50 | 100 | 3 |
| 2 | OEC | BEC802X | Open Elective - Group IV (Online Course) | EC | EC | - | - | - | | - | - | 50 | 100 | 3 |
| 3 | INT | BEC803 | Internship (Industry/ Research) (14-16 weeks) | EC | EC | 0 | 0 | 20 | | 3 | 100 | 100 | 200 | 10 |
| | | | | | | | | | | **Total** | **100** | **200** | **400** | **16** |

| **Professional Elective Course - Group IV (Online Courses – NPTEL / Coursera)** | | **Open Elective Course - Group IV (Online Courses – NPTEL / Coursera)** | |
|---|---|---|---|
| BEC801A | Fibre Optic Communication Technology | BEC802A | Understanding Incubation and Entrepreneurship |
| BEC801B | Microelectronics: Devices to Circuits | BEC802B | Data Analytics with Python |
| BEC801C | Semiconductor device modelling and Simulation | BEC802C | Economics of Banking and Finance Markets |
| BEC801D | Photonic integrated circuit | BEC802D | Patent Law for Engineers and Scientists |
| BEC801E | Computer Vision and Image Processing Fundamentals and Applications | BEC802E | E-Business |

**Course Code: BEC501** **Course: Engineering Management and Entrepreneurship**

**Credits: 3** **L:T:P – 3:0:0**

**CIE: 50% Marks** **SEE: 50% Marks**

**SEE Hours: 3 Hrs** **Max. Marks: 100**

| | |
|---|---|
| Prerequisites if any | |
| Learning objectives | Students will be able to learn.<br>• Functions of management, ownership types and organizations.<br>• Analyse the Human Resource and Behavioural management of an organisation.<br>• Managing projects in an organization and marketing of products. |

**Course Outcomes:**

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

| COs | Course Outcomes | Bloom's level |
|---|---|---|
| CO1 | Understand the basic concepts of management, planning, organizing and staffing and evaluate the human behaviour concepts and HRM. | L2 |
| CO2 | Apply the project management tools to manage projects | L3 |
| CO3 | Understand the development of management thought and Concept of Entrepreneurs. | L2 |
| CO4 | Acquire the knowledge of product development life cycle and marketing of products and ownership types. | L2 |

**Mapping with POs and PSOs:**

| COs | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | | PSO1 | PSO2 | PSO3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | 3 | 3 | 2 | | | | 3 | | | 2 | | 2 | | 2 | 3 | |
| CO2 | 3 | 3 | 2 | | | | 3 | | | 2 | | 2 | | 2 | 3 | |
| CO3 | 3 | 3 | 2 | | | | 3 | | | 2 | | 2 | | 2 | 3 | |
| CO4 | 3 | 3 | 2 | | | | 3 | | | 2 | | 2 | | 2 | 3 | |

3 – Strong 2 – Medium 1 – Low

**Course Structure**

| Module – 1 | | No. of Lecture Hours |
|---|---|---|
| 1.1 | Introduction: Meaning, nature and characteristics of Management, Scope, and functional areas of management - Management as a science, art or profession | 2 |
| 1.2 | Management & Administration - Roles of Management, Levels of Management, Taylors Scientific Management, Functions of management. | 3 |
| 1.3 | Nature, importance, and purpose of planning process - Objectives - Types of plans (Meaning only) - Decision making - Importance of planning - steps in planning & planning premises - Hierarchy of plans. | 3 |
| Module – 2 | | |
| 2.1 | Organizational Structure and Ownership Types: Organization definition, different types of organizations – Functional, Divisional, Matrix etc. | 2 |
| 2.2 | Staffing-Need and Importance, Recruitment and Selection Process. | 2 |
| 2.3 | Controlling: Meaning and nature of directing - Leadership styles, Motivation Theories. | 4 |
| Module – 3 | | |
| 3.1 | Preparation of Project: Meaning of Project; Project Identification; Project Selection; Project Report. | 2 |
| 3.2 | Need and Significance of Report; Contents; formulation; Network Analysis; Errors of Project Report; Project Appraisal. | 2 |
| 3.3 | Project Management: Types of project management, Tools used in Project management, Network diagrams, Critical Path method, Quality concepts and 7 Q C Tools, PERT, TQM. | 4 |
| Module – 4 | | |
| 4.1 | Entrepreneur: Meaning of Entrepreneur; Evolution of the Concept, Functions of an Entrepreneur | 2 |

| | | |
|---|---|---|
| 4.2 | Types of Entrepreneurs, Entrepreneur - an emerging Class. Concept of Entrepreneurship-Evolution of Entrepreneurship, Development of Entrepreneurship | 3 |
| 4.3 | Stages in entrepreneurial process; Role of entrepreneurs in Economic Development; Entrepreneurship in India; Entrepreneurship – its Barriers. | 3 |
| Module – 5 | | |
| 5.1 | Product Development and Marketing: Product Development Life Cycle, Innovation -Managing and protecting. | 2 |
| 5.2 | Product positioning, Marketing – Selling vs Marketing, 4 Ps of marketing, | 2 |
| 5.3 | Ownership types – Proprietorship, Partnership, LLP, Pvt Ltd, Public Ltd, Section 8 company etc. Societies, Non-profit Organizations, Trusts. | 4 |
| **Total No. of Lecture Hours** | | **40** |

**Textbooks:**

1. Management and Entrepreneurship by K R Phaneesh, 6th Edition, Sudha Publication,2013.
2. Principles of Management by P.C Tripathi, P.N Reddy, McGraw Hill Education, 6th Edition, 2017. ISBN13:978-93-5260-535-4.
3. Management and Entrepreneurship by Ramesh Burbure, Rohan publishers, 2009.

**Online resource link**

1. https://nptel.ac.in/courses/110107094
2. https://nptel.ac.in/courses/110106141
3. https://nptel.ac.in/courses/122106031

Reference Books:

1. Essentials of Management: An International, Innovation and Leadership perspective by Harold Koontz, Heinz Weihrich McGraw Hill Education, 10th Edition 2016. ISBN-978-93-392-2286-4.
2. Management and Entrepreneurship by NVR Naidu, T Krishna Rao

**Code: BEC502** **Subject: Control Systems**

**Credits: 4** **L: T: P: 3:2:0**

**SEE: 50 Marks** **CIE: 50 Marks**

**SEE Hours: 3 hrs** **Max. Marks: 100**

| | |
|---|---|
| Prerequisites if any | Signals & Systems, Engineering Mathematics |
| Learning objectives | Students will be able to learn:<br>• Different mathematical models of feedback control systems.<br>• To build different types of control systems using block diagram and mathematical forms.<br>• To understand the performance characteristics and analysis of control systems in time and frequency domain. |

**Course Outcomes:**

*On the successful completion of the course, the student will be able to*

| CO's | Course Outcomes | Bloom's level |
|---|---|---|
| CO1 | Understand & explain the mathematical modelling of the physical systems | Understand |
| CO2 | Analyse performance parameters & properties of the control systems in time and frequency domain. | Apply |
| CO3 | Design control systems in time and frequency domain using appropriate mathematical concepts | Analyse |
| CO4 | Analyse the control systems using state space model | Analyse |

**Mapping with POs and PSOs**:

| COs | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | | PSO1 | PSO2 | PSO3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | 3 | 3 | 2 | | | | | | | | | 1 | | 3 | | 2 |
| CO2 | 3 | 3 | 2 | | 2 | | | | | | | 1 | | 3 | 2 | 1 |
| CO3 | 3 | 3 | 2 | | 2 | | | | | | | 1 | | 3 | 2 | 1 |
| CO4 | 3 | 3 | 2 | | | | | | | | | 1 | | 3 | | 2 |

Mapping Strength: Strong– 3 Medium – 2 Low – 1

**Course Structure**

| Module – 1 | | No. of Lecture Hours | No. of Tutorial Hours |
|---|---|---|---|
| 1.1 | Introduction: Terminology & basic structure of control systems and essence of feedback control systems | 1 | 5 |
| 1.2 | Transfer function and state space models of electrical systems | 1 | |
| 1.3 | Block diagram representation of feedback control system and its reduction techniques, Signal Flow Graphs, and Mason's gain rule. | 6 | |
| Module – 2 | | | |
| 2.1 | Time domain analysis of feedback control systems: Response of standard first- and second-order control systems. | 3 | 5 |
| 2.2 | Derivations of time-domain performance specifications of second-order systems, steady-state error constants, and analysis | 3 | |
| 2.3 | Concept of stability, stability analysis using the Routh-Hurwitz method. | 2 | |
| Module – 3 | | | |
| 3.1 | Root locus technique: Root locus concepts, guidelines for sketching root loci. | 3 | 6 |
| 3.2 | Design of PI, PD, and PID Controllers. | 3 | |

| | | | |
|---|---|---|---|
| Module – 4 | | | |
| 4.1 | Frequency domain Analysis: Specifications in Frequency-Domain, Bode plots and Stability Margins. | 5 | 5 |
| 4.2 | Introduction to Phase lead and lag compensators. | 2 | |
| 4.3 | Design of Phase Lead Compensator using Bode plot. | 3 | |
| Module – 5 | | | |
| 5.1 | Control system analysis using state space: State space variables, state space representation, solutions of state equations, state transition matrix. | 2 | 5 |
| 5.2 | Concepts of controllability and observability | 2 | |
| 5.3 | Pole placement by state feedback, observer systems | 3 | |
| **Total No. of Lecture Hours** | | **40** | **-** |
| **Total No. of Tutorial Hours** | | | **26** |

**Textbooks:**

1. **M Gopal,** "Control Systems- Principles and Design," TMH, Second Edition,2006.
2. **J.Nagarath and M.Gopal**, " Control Systems Engineering," New Age International (P) Limited, Publishers, Fifth edition-2005, ISBN: 81-224-2008-7.
3. **G.F. Franklin., G.D. Powell., A.E. Naeini,** "Feedback Control of Dynamic Systems," Pearson Education 5th Edition, 2002.

**Reference Books:**

1. **K. Ogata,** "Discrete-Time Control Systems," 2nd Edition. PHI, 2002.
2. **Norman S. Nise,** "Control Systems Engineering," 6th Edition.
3. **M. Gopal,** "Modern Control Systems Theory," Wiley Eastern, 1984**.**

**Online Resources:**

- https://www.digimat.in/nptel/courses/video/108102043/L13.html
- https://www.youtube.com/channel/UCq0imsn84ShAe9PBOFnoIrg
- https://nptel.ac.in/courses/107106081

**Course Code: BEC503** **Course: Communication Systems**

**Credits: 3** **L:T:P – 3:0:0**

**CIE: 50% Marks** **SEE: 50% Marks**

**SEE Hours: 3 Hrs** **Max. Marks: 50**

| | |
|---|---|
| Prerequisites | • Knowledge of signal processing, including time and frequency domain analysis,<br>• Basic concepts of probability and statistical analysis.<br>• 3. Proficiency in calculus, linear algebra, and differential equations. |
| Learning objectives | • To gain knowledge on theoretical aspects of analog modulation, Digital modulation, comprehensive understanding of communication through AWGN channel and capacity of wireless channels. |

**Course Outcomes:**

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

| COs | Course Outcomes | Bloom's level |
|---|---|---|
| CO1 | Discuss and Analyse the theoretical aspects of analog modulation, gain practical experience and problem-solving skills. | L3 |
| CO2 | Develop a thorough understanding of digital modulation techniques. | L3 |
| CO3 | Develop a comprehensive understanding of communication through AWGN channels. | L3 |
| CO4 | Develop a comprehensive understanding of the capacity of wireless channels. | L3 |

**Mapping with POs and PSOs**:

| COs | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | | PSO1 | PSO2 | PSO3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | 3 | 2 | - | - | 2 | | | | 1 | 1 | | | | | | 2 |
| CO2 | 3 | 2 | 2 | 1 | - | | | | 1 | 1 | | | | | | 1 |
| CO3 | 3 | 3 | 2 | 2 | 2 | | | | | 1 | | | | | | 1 |
| CO4 | 3 | 3 | 3 | 3 | 2 | | | | | 1 | | | | | | 2 |

3 – Strong 2 – Medium 1 – Low

## Course Structure

| | **Module – 1 : Analog Modulation** | **No. of Lecture Hours** |
|---|---|---|
| 1.1 | Introduction to modulation, Need for modulation in communication systems | 1 |
| 1.2 | Amplitude Modulation (AM) and Envelop Detection | 1 |
| 1.3 | DSB-SC Modulation, Coherent Detection, | 1 |
| 1.4 | SSB-SC Modulation | 1 |
| 1.5 | Nonlinear Modulations, Bandwidth of Angle Modulated Waves, | 1 |
| 1.6 | Generating of FM Waves by direct methods | 1 |
| 1.7 | Demodulation of frequency modulation | 1 |
| 1.8 | Phase-locked loop | 1 |
| **Module-2: Sampling and Analog to Digital Conversion** | | |
| 2.1 | Sampling and Analog to Digital Conversion Low Pass Sampling Theorem (Impulse, Pulse and Flat top), | 2 |
| 2.2 | Bandpass and equivalent low pass signal representation, | 2 |
| 2.3 | Quadrature Sampling of bandpass signals, Bandpass Sampling Theorem statement with Applications | 2 |
| 2.4 | ISI, Nyquist Criteria, Bandlimited channel with controlled ISI | 2 |

| | | |
|---|---|---|
| **Module – 3 : Introduction To Digital Modulation Techniques** | | |
| 3.1 | Baseband Pulse Transmission (Line Codes) (RZ and NRZ) Unipolar, Polar, Bipolar, Manchester signaling, | 1 |
| 3.2 | Geometric Representation of Signals in terms of a low pass basis set, | 1 |
| 3.3 | Gram Schmidt procedure, conversion statement to bandpass basis set. | 1 |
| 3.4 | Geometric representation of signals: Baseband modulated signals with examples Bandpass band limited signals - BPSK, QPSK, M-PSK, M-QAM. | 4 |
| 3.5 | Transmitter Architectures and PSD, Power limited – FSK, DPSK, MSK and applications. | 1 |
| **Module – 4 : Communication through AWGN Channels** | | |
| 4.1 | Detection: Centre point sampling, Matched Filter, and Correlation Receiver. Estimation Basics - MAP and MLI Estimation of Binary signals with AWGN, | 3 |
| 4.2 | Probability of error for binary signaling, Probability of error for binary baseband pulses (Line codes). | 2 |
| 4.3 | Coherent demodulation scheme – BPSK, QPSK, BFSK Receiver Architecture, Probability of symbol error. | 3 |
| **Module – 5 : Multicarrier and spread spectrum technology** | | |
| 5.1 | Multicarrier Signaling: Single carrier vs Multicarrier, Multicarrier Concepts | 2 |
| 5.2 | Types of Multicarrier in AWGN channel, OFDM | 2 |
| 5.3 | Introduction to Spread Spectrum , Advantages of Spread Spectrum, Pseudo noise sequences, Direct sequence spread spectrum with coherent binary PSK. | 2 |
| 5.4 | Frequency hopped spread spectrum applications. | 2 |
| *Total No. of Lecture Hours* | | **40** |

**Suggested Learning Resources:**

**Text Books:**

1. Modern Digital and Analog communication Systems, B.P.Lathi and Zhi Ding, 4th Edition, 2010 , Oxford University Press, ISBN: 9780198073802.

2. Digital Communications, John G. Proakis and Maoud Salehi 5th Edition, 2014, MacGraw Hill Education(India) Private Limited.
3. Analog & Digital Communication Systems, Simon Haykin, 1st Edition, 2014, John Wiley & sons, , ISBN 978-0-471-64735-5.
4. Principles of Communication Systems, Taub and Schilling, 4th Edition, 2020, MacGraw Hill Education(India) Private Limited.

**Reference Books:**

1. Communication Systems, Simon Haykin , 4th Edition, 2004, John Wiley, India Pvt. Ltd, ISBN 04711786913. Online resource link, if any.

**Course Code: BEC504** **Course: Digital Signal Processing**

**Credits: 4** **L:T:P – 3:0:2**

**CIE: 50% Marks** **SEE: 50% Marks**

**SEE Hours: 3 Hrs** **Max. Marks: 100**

| | |
|---|---|
| Prerequisites | Signals and Systems |
| Learning objectives | • Understanding various transforms<br>• Analyze DFT in linear filtering methods<br>• Designing of IIR and FIR<br>• Study of DSP architecture |

**Course Outcomes:**

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

| COs | Course Outcomes | Bloom's level |
|---|---|---|
| CO1 | Analyze signals using various Transforms. | L1 |
| CO2 | Apply an efficient DFT in linear filtering methods. | L2 |
| CO3 | Able to Design IIR and FIR filters relative to specific performance parameters. | L3 |
| CO4 | To understand architecture for DSP applications- TMS32067x processor | L3 |

**Mapping with POs and PSOs:**

| COs | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 | PSO3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | 3 | 3 | 3 | 3 | 3 | | | | 3 | | | | 3 | 3 | 2 |
| CO2 | 3 | 3 | 3 | 3 | 3 | | | | 3 | | | | 3 | 3 | 2 |
| CO3 | 3 | 3 | 3 | 3 | 3 | | | | 3 | | | | 3 | 3 | 2 |
| CO4 | 3 | 3 | 3 | 3 | 3 | | | | 3 | | | | 3 | 3 | 2 |

3 – Strong 2 – Medium 1 – Low

**Course Structure**

| Module 1: Discrete Fourier Transform (DFT) & Properties of DFT: | | No. of Lecture Hours |
|---|---|---|
| 1.1 | Frequency domain sampling and reconstruction of discrete-time signals | 1 |
| 1.2 | Discrete Fourier Transform (DFT), | 1 |
| 1.3 | DFT as a linear transformation | 1 |
| 1.4 | Relationship of the DFT to other transforms. | 1 |
| 1.5 | Properties of the DFT: linearity, | 1 |
| 1.6 | Periodicity, multiplication of two DFTs, | 1 |
| 1.7 | Circular convolution, and symmetry properties, | 1 |
| 1.8 | Frequency analysis of signals using the DFT. | 1 |
| Module 2: Fast Fourier Transform Algorithms: | | |
| 2.1 | Direct Computation of the DFT, | 1 |
| 2.2 | Efficient Computation of the DFT, | 1 |
| 2.3 | Radix-2 FFT algorithms- decimation-in-time FFT algorithm, | 2 |
| 2.4 | Decimation-in-frequency FFT algorithm, | 1 |
| 2.5 | IDFT- decimation-in-time, | 1 |
| 2.6 | Decimation-in-frequency, | 1 |
| 2.7 | Goertzel algorithm | 1 |
| Module 3: Design and Realization of FIR Filters: | | |
| 3.1 | Properties of FIR digital filters, | 1 |
| 3.2 | Different types of windows - Rectangular, | 1 |
| 3.3 | Hanning window, | 1 |
| 3.4 | Design of FIR filters using above windows. | 2 |
| 3.5 | Realization of FIR filter structures- Direct form structure | 2 |
| 3.6 | Linear phase and cascade FIR structure. | 1 |
| Module 4: Design and Realization of IIR Filters: | | |
| 4.1 | Frequency transformations in the analog domain, | 1 |

| | | |
|---|---|---|
| 4.2 | Characteristics of commonly used analog filters, | 1 |
| 4.3 | IIR filter design by impulse invariance method, | 1 |
| 4.4 | Bilinear transformation, | 1 |
| 4.5 | Application of above technique to the design of Butterworth & Chebyshev filters. | 2 |
| 4.6 | Direct forms (I & II), cascade and parallel realizations, | 2 |
| Module 5: Digital Signal Processors: | | |
| 5.1 | Architectural features of a Digital Signal Processor, | 2 |
| 5.2 | Fixed point and floating-point processors | 2 |
| 5.3 | Different generations of DSPs, | 2 |
| 5.4 | TMS 320C67X processors. (Text2) | 2 |
| **Total No. of Lecture Hours** | | **40** |

**Suggested Learning Resources:**

**Textbooks:**

1. Proakis and Manolakis, "Digital Signal Processing – Principles algorithm and application", Pearson Education 4th Edition, 2007.
2. Monson H Hayes, "Digital signal processing", Tata McGraw-Hill, New Delhi, 3rd edition, 2008.

**Reference Books:**

1. Oppenheim And Schaffer, "Discrete Time Signal Processing", PHI,2014.
2. Sanjit K. Mitra, "Digital Signal Processing", TMH, 2004.
3. Vinay K. Ingle and John G. Proakis, "Digital Signal Processing Using MATLAB: A Problem Solving Companion".

## LIST OF EXPERIMENTS USING MATLAB / SCILAB / OCTAVE / WAB

1. Verification of sampling theorem.
2. Impulse response of a given system
3. Linear convolution of two given sequences.
4. Circular convolution of two given sequences
5. Solving a given difference equation.
6. Computation of N point DFT of a given sequence and to plot magnitude and phase spectrum.
7. Design and implementation of FIR filter to meet given specifications.
8. Design and implementation of IIR filter to meet given specifications.

## II LIST OF EXPERIMENTS USING DSP PROCESSOR

1. Linear convolution of two given sequences.
2. Circular convolution of two given sequences.
3. Computation of N- Point DFT of a given sequence
4. Realization of an FIR filter (any type) to meet given specifications. The input can be a signal from function generator.
5. Realization of an IIR filter (any type) to meet given specifications. The input can be a signal from function generator.

**Textbook:**

1. Vinay K Ingle, John G Proakis, Digital Signal Processing using MATLAB, Fourth Edition, Cengage India Private Limited, 2017.

**Course Code: BECL505** **Course: Communication Systems Lab**

**Credits: 1** **L:T:P – 0:0:2**

**CIE: 50% Marks** **SEE: 50% Marks**

**SEE Hours: 2 Hrs** **Max. Marks: 50**

| | |
|---|---|
| Prerequisites if any | |
| Learning objectives | To simulate various modulation techniques. |

**Course Outcomes:**

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

| COs | Course Outcomes | Bloom's level |
|---|---|---|
| CO1 | Demonstrate proficiency in using hardware (using discrete components) and Software Defined Radio (SDR) platforms for communication signal processing. | L4 |
| CO2 | Implement and analyse analog modulation and demodulation techniques such as AM and FM. | L4 |
| CO3 | Design and simulate digital modulation schemes like BPSK and QPSK, and evaluate their performance under noise. | L3 |
| CO4 | Analyse bit error rate (BER), eye diagrams, and signal integrity for digital modulation techniques. Integrate complete digital communication systems using SDR for real-time wireless transmission and reception. | L4 |

**Mapping with POs and PSOs:**

| COs | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | | PSO1 | PSO2 | PSO3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CO1** | **3** | **2** | **-** | **-** | **2** | | | | **1** | **1** | | | | | | **2** |
| **CO2** | **3** | **2** | **2** | **1** | **-** | | | | **1** | **1** | | | | | | **1** |
| **CO3** | **3** | **3** | **2** | **2** | **2** | | | | | **1** | | | | | | **1** |
| **CO4** | **3** | **3** | **3** | **3** | **2** | | | | | **1** | | | | | | **2** |

**3 – Strong 2 – Medium 1 – Low**

**Tools and Platforms:**

**Hardware:** Adlam Pluto SDR, RTL-SDR, DSO, Spectrum Analyser

**Software:** MATLAB + Communications Toolbox, GNU Radio, Simulink (optional), Python (for SDR interfacing) (optional)

**Course Content:**

- Introduction to the usage of software-defined radios and MATLAB
- Analog modulation and demodulation (Using discrete components)
- Digital modulation and demodulation – BPSK and QPSK only

**List of Experiments**

1. Introduction to MATLAB and SDR Hardware
   - Objective: Familiarize students with MATLAB and SDR interface (e.g., USRP, RTL-SDR)
   - Tasks:
     - Installing and configuring MATLAB Communications Toolbox
     - Basic signal generation and visualization
     - Interfacing SDR with MATLAB (e.g., receiving FM radio)

2. Amplitude Modulation (AM) and Demodulation (Using Discrete Components only modulation)
   - Objective: Study the principles of AM and demodulate an AM signal
   - Tasks:
     - Generate AM signal using MATLAB
     - Transmit AM using SDR (Adlam Pluto), receive and demodulate
     - Measure the modulation index and spectral content

3. Frequency Modulation (FM) and Demodulation (Using Discrete Components only modulation)
   - Objective: Implement and analyse FM transmission and reception
   - Tasks:
     - Generate FM signal in MATLAB

- Observe frequency deviation and bandwidth
- Receive and demodulate FM using SDR

4. Study of Sampling Theorem and Reconstruction of Signals
   - Objective: Understand sampling and Nyquist criteria
   - Tasks: To verify the **Sampling Theorem** using MATLAB and/or hardware tools, and to demonstrate **aliasing effects** and signal **reconstruction** from samples.
5. Digital Baseband Signal Generation
   - Objective: Generate digital binary signals for BPSK and QPSK
   - Tasks:
     - Create binary data stream using random bit generators
     - Use MATLAB to simulate NRZ, RZ formats
6. BPSK Modulation and Demodulation
   - Objective: Implement Binary Phase Shift Keying
   - Tasks:
     - Simulate BPSK modulation and demodulation in MATLAB
     - Analyze the constellation diagram and BER
     - Transmit/Receive BPSK using SDR in loopback or over-the-air
7. QPSK Modulation and Demodulation
   - Objective: Implement Quadrature PSK and analyze performance
   - Tasks:
     - Use MATLAB to simulate QPSK with Gray coding
     - Plot constellation diagram and calculate BER vs SNR
     - Perform SDR-based QPSK transmission and reception
8. Noise and BER Analysis of Digital Modulation Schemes
   - Objective: Analyze how noise affects digital communication
   - Tasks:
     - Add AWGN to BPSK and QPSK signals in MATLAB
     - Compute BER for varying Eb/N0 values
     - Compare theoretical and simulated results
9. Eye Diagram and Signal Integrity in Digital Communication
   - Objective: Analyze timing jitter and inter-symbol interference
   - Tasks:
     - Plot eye diagram for received signals (BPSK/QPSK)
     - Identify factors degrading signal quality

10. SDR-Based Real-Time Communication Link

- Objective: Demonstrate a basic digital communication system
- Tasks:
    - Implement a complete transmitter-receiver chain (modulation, transmission, reception, demodulation)
    - Use GNU Radio or MATLAB with SDRs
    - Transmit simple text/image wirelessly using QPSK

Optional (if time/resources permit):

- Experiment on Channel Effects: Introduce Rayleigh fading and Doppler shift in MATLAB
- Comparative study of modulation schemes: Evaluate bandwidth efficiency and power efficiency

**Course Code:** BEC515A **Course: Embedded Systems for Automotive**

**Credits:** 3 **L:T:P – 3**:0:0

**CIE:** 50% Marks **SEE:** 50% Marks

**SEE Hours: 3**Hrs **Max. Marks:** 50

| Prerequisites if any | |
|---|---|
| Learning objectives | 1. **Understanding Automotive Embedded Systems**: Gain a comprehensive understanding of the architecture and components of embedded systems used in automotive applications.<br>2. **System Design and Architecture**: Learn about the design principles and architectural considerations for developing reliable and efficient automotive embedded systems.<br>3. **Software Development and Testing**: Acquire knowledge about the software development lifecycle, including design, coding, testing, and debugging of embedded software for automotive systems.<br>4. **Real-Time Systems**: Understand the requirements and challenges of real-time systems in automotive applications, including scheduling, task management, and timing constraints.<br>5. **Communication Protocols**: Familiarize yourself with various communication protocols used in automotive embedded systems, such as CAN, LIN, and Ethernet. |

**Course Outcomes:**

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

| COs | Course Outcomes | Bloom's level |
|---|---|---|
| CO1 | Learn about safety standards and reliability measures, including ISO 26262 for functional safety, and strategies for ensuring the robustness of automotive embedded systems. | L1 |
| CO2 | Explore the interaction between hardware and software in automotive embedded systems and the principles of co-design to optimize performance and resource utilization. | L1 |
| CO3 | Gain insights into the security challenges and solutions for protecting automotive embedded systems from various threats. | L2 |
| CO4 | Stay informed about the latest trends and advancements in automotive embedded systems, including the integration of advanced driver-assistance systems (ADAS) and autonomous driving technologies. | L3 |

**Mapping with POs and PSOs**:

| COs | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | PO 8 | PO 9 | PO 10 | PO 11 | PO 12 | | PSO 1 | PSO 2 | PSO 3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | **3** | **3** | **3** | **3** | **2** | | | | | | | | | **3** | **2** | **1** |
| CO2 | **3** | **3** | **3** | **3** | **2** | | | | | | | | | **3** | **2** | **1** |
| CO3 | **3** | **3** | **3** | **3** | **2** | | | | | | | | | **3** | **2** | **1** |
| CO4 | **3** | **3** | **3** | **3** | **2** | | | | | | | | | **3** | **2** | **1** |

3 – Strong 2 – Medium 1 – Low

**Course Structure**

| | **Module – 1 :Automotive Architectures** | **No. of Lecture Hours** |
|---|---|---|
| 1.1 | Vehicle Functional Domains and Their Requirements | 2 |
| 1.2 | Application of the AUTOSAR Standard | 2 |
| 1.3 | AUTOSAR in Practice | 2 |
| 1.4 | Intelligent Vehicle Technologies | 2 |
| | **Module – 2 : Embedded Communications** | |
| 2.1 | A Review of Embedded Automotive Protocols | 2 |
| 2.2 | FlexRay Protocol | 2 |
| 2.3 | Dependable Automotive CAN Networks | 2 |
| 2.4 | FTT-CAN | 2 |
| | **Module – 3 :Embedded Software and Development Processes** | |
| 3.1 | Product Lines in Automotive Electronics | 2 |
| 3.2 | Reuse of Software in Automotive Electronics | 2 |
| 3.3 | Automotive Architecture Description Languages | 2 |
| 3.4 | Model-Based Development of Automotive Embedded Systems | 2 |
| | **Module – 4 : Verification, Testing** | |
| 4.1 | Testing Automotive Control Software | 2 |
| 4.2 | Control Software | 2 |
| 4.3 | Testing of FlexRay-Based Applications | 2 |
| 4.4 | Monitoring of FlexRay-Based Applications | 2 |
| | **Module – 5 : TimingAnalysis** | |
| 5.1 | Timing Analysis of CAN-Based Automotive Communication | 2 |
| 5.2 | Scheduling Messages with Offsets | 2 |
| 5.3 | Controller Area Network with Performance boost | 2 |
| 5.4 | Formal Methods in the Automotive Domain | 2 |
| | *Total No. of Lecture Hours* | **40** |

## Suggested Learning Resources:

**Text Books:**

1. Automotive Embedded Systems Handbook, Edited by Nicolas Navet and Françoise Simonot-Lion, CRC Press
2. Integration Technologies for Industrial Automated SystemsEdited by Richard Zurawski, , CRC Press

3. Electronic Design Automation for Integrated Circuits Handbook, Edited by Luciano Lavagno, Grant Martin, and Lou Scheffer, , CRC Press

**Reference Books:**

1. Embedded System Design: A unified Hardware / Software Introduction" – Frank Vahid and Tony Givargis, Wiley India Publishers.
2. A Practical Introduction to Hardware/Software Co-Design"- Patrick R. Schaumont, Springer Publishers
3. Embedded Systems Handbook, Edited by Richard Zurawski, , CRC Press
4. Industrial Communication Technology Handbook, Edited by Richard Zurawski, , CRC Press

**Course Code:** BEC515B **Course: Unified Verification Methodology**

**Credits:** 3 **L:T:P – 3**:0:0

**CIE:** 50% Marks **SEE:** 50% Marks

**SEE Hours: 3**Hrs **Max. Marks:** 50

| | |
|---|---|
| Prerequisites if any | |
| Learning objectives | Learning VLSI verification using UVM techniques. |

**Course Outcomes:**

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

| COs | Course Outcomes | Bloom's level |
|---|---|---|
| CO1 | Understanding the writing testbench for UVM techniques | L1 |
| CO2 | Analysing the config of UVM and TLM implementation | L3 |
| CO3 | Understanding the RAL and UVM advanced concepts | L2 |

**Mapping with POs and PSOs**:

| COs | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | PO 8 | PO 9 | PO 10 | PO 11 | PO 12 | | PSO 1 | PSO 2 | PSO 3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | **3** | **3** | **3** | **3** | **2** | | | | | | | **2** | | **3** | **2** | **1** |
| CO2 | **3** | **3** | **3** | **3** | **2** | | | | | | | **2** | | **3** | **2** | **1** |
| CO3 | **3** | **3** | **3** | **3** | **2** | | | | | | | **2** | | **3** | **2** | **1** |
| CO4 | **3** | **3** | **3** | **3** | **2** | | | | | | | **2** | | **3** | **2** | **1** |

3 – Strong 2 – Medium 1 – Low

## Course Structure

| | | No. of Lecture Hours |
|---|---|---|
| | **Module – 1 : Introduction to UVM** | |
| 1.1 | Limitation of SV Test bench, Evolution of UVM, | 2 |
| 1.2 | Features of UVM,UVM Class Hierarchy, UVM Phases, Factory Registration, TLM, RAL | 2 |
| 1.3 | **UVM Phases**: Motivation for Phases in UVM, UVM Phases Categorization | 2 |
| 1.4 | Built Time Phases, Run Time Phases, Clean Up Phases, Reporting mechanism | 2 |
| | **Module – 2 : UVM- Transaction Level Modeling (TLM)** | |
| 2.1 | Introduction to TLM, Ports, exports, implementation, Analysis ports, TLM FIFO, Hierarchical Connections | 2 |
| 2.2 | Example of TLM Connections, TLM Implementation Ports Declaration Macros | 2 |
| 2.3 | **UVM- Factory Registration and Methods:** Introduction to Factory, Factory Registration, UVM Field Macros | 2 |
| 2.4 | UVM Field Macros, Create Methods, Factory Over ride | 2 |
| | **Module – 3 : UVM- Construction of Universal Verification Components** | |
| 3.1 | Virtual Interface, | 2 |
| 3.2 | UVM Config & Resource Database | 2 |
| 3.3 | Database Construction of UVC, Generating Sequences, | 2 |
| 3.4 | Sequence Drive Communication | 2 |
| | **Module – 4 : UVM- Register Abstraction Layer (RAL)** | |
| 4.1 | Introduction to RAL, Register Model Building Block Classes | 2 |
| 4.2 | Register Model in UVM Environment | 2 |
| 4.3 | Access API | 2 |
| 4.4 | Front door and Backdoor Access | 2 |
| | **Module – 5 : UVM- Advanced Concepts** | |
| 5.1 | Virtual Sequence and Virtual Sequencer | 2 |
| 5.2 | UVM Callbacks, UVM Event | 2 |
| 5.3 | Commonly used Command line Switches | 2 |
| 5.4 | Lab 1, Lab2 | 2 |
| *Total No. of Lecture Hours* | | **40** |

**Suggested Learning Resources:**

**Text Books:**

4. A Practical Guide to Adopting the Universal Verification Methodology (UVM), Sharon Rosenberg, Kathleen Meade, Second Edition Paperback – Import, 29 January 2013
5. The UVM Primer: A Step-by-Step Introduction to the Universal Verification Methodology, Ray Salemi, Paperback – 23 October 2013
6. Getting Started with UVM: A Beginner's Guide, Vanessa R Cooper Paperback – 22 May 2013

**Course Code: BEC515C** **Course: Operating Systems**

**Credits: 3** **L:T:P: 2-0-2**

**CIE: 25** **SEE: 50%**

**SEE Hours: 3** **Max. Marks: 100**

| | |
|---|---|
| Prerequisites if any | |
| Learning objectives | • Understand the architecture and core concepts of the QNX RTOS.<br>• Learn to develop and debug applications using the QNX Momentics IDE.<br>• Gain knowledge of process and thread management, including synchronization techniques.<br>• Explore inter-process communication (IPC) methods and their applications in QNX.<br>• Understand hardware programming concepts, including interrupting handling and memory access.<br>• Learn to build and configure QNX boot/OS images for embedded systems. |

**Course Outcomes:**

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

| COs | Course Outcomes | Bloom's level |
|---|---|---|
| CO1 | Describe the QNX OS architecture and its microkernel-based design. | L2 |
| CO2 | Develop and debug QNX-based applications using appropriate tools. | L3 |
| CO3 | Apply process/thread management and synchronization techniques in QNX. | L3 |
| CO4 | Implement inter-process communication methods for real-time systems. | L4 |
| CO5 | Develop strong knowledge on the POSIX standards that help in System Application Development. | L2 |

**Mapping with POs and PSOs**:

| COs | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | | PSO1 | PSO2 | PSO3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | 3 | 2 | 1 | | | | | | | | | | | 2 | | |
| CO2 | 2 | | 3 | | 2 | | | | | 1 | | 1 | | 2 | 2 | |
| CO3 | 3 | 2 | 3 | 2 | 2 | | | | | | | 1 | | 3 | 2 | 1 |
| CO4 | 3 | 2 | 3 | 2 | | | | | | 1 | | 2 | | 3 | 2 | 2 |
| CO5 | 2 | 2 | 2 | | | | | | | | | | | 2 | | |

3 – Strong 2 – Medium 1 – Low

## Course Structure

| | **Module – 1** | No. of Lecture Hours |
|---|---|---|
| 1.1 | Introduction to QNX OS Architecture: microkernel, process manager | 2 |
| 1.2 | Introduction to inter-process communication IPC and synchronization. | 2 |
| 1.3 | Interrupt handling, scheduling | 2 |
| | **Module – 2** | |
| 2.1 | Process manager, resource manager | 2 |
| 2.2 | Boot sequence, security, OS services | 1 |
| 2.3 | Process and threads management: creation, termination and cleanup | 2 |
| | **Module – 3** | |
| 3.1 | Synchronization techniques: mutexes and condition variables | 2 |
| 3.2 | Overview of IPC methods in QNX: message passing | 2 |
| 3.3 | Pulses, shared memory, and event delivery | 1 |
| | **Module – 4** | |
| 4.1 | Introduction to hardware programming: Hardware IO | 2 |
| 4.2 | Handling interrupts | 2 |
| 4.3 | Introduction to timing architecture: Getting and setting the system clock | 1 |
| | **Module – 5** | |
| 5.1 | Introduction to timers, high resolution timers | 2 |
| 5.2 | Design considerations, kernel timeouts | 2 |

| | | |
|---|---|---|
| 5.3 | Build a QNX neutrino boot/OS image | 1 |
| **Total No. of Lecture Hours** | | **26** |

**Suggested Learning Resources:**

**Text Books:**

1. QNX Neutrino RTOS User's Guide, QNX Software Systems.
2. Programming for Embedded Systems, Michael Barr, O'Reilly Media.
3. Hands-on RTOS with Microcontrollers, Brian Amos, Packt Publishing, 2020.
4. Operating System Concepts, Abraham Silberschatz, et al., 9th Edition, Wiley, 2018.

**Online Resources:**

- https://blackberry.qnx.com/en/products/qnx-everywhere
- https://gitlab.com/qnx
- https://www.reddit.com/r/QNX/
- https://stackoverflow.com/questions/tagged/qnx
- https://www.youtube.com/qnxcam
- https://gitlab.com/qnx/projects
- https://github.com/qnx-ports

**Lab Experiments – 15 Hours**

1. QNX configuration and application development using QNX Momentics IDE
2. Process and thread creation, management, and synchronization: Hands-on exercises: process/thread creation and synchronization.
3. Implementation of IPC methods: message passing and shared memory.
4. Hands-on exercises: message passing and shared memory.
5. Hands-on exercises: interrupt handling and timing mechanisms.
6. Building and deploying QNX boot/OS images.
7. Mini capstone project: Design and implement a QNX-based embedded system.

**Course: Research Methodology & IPR** **Course Code: BRMEC557**

**Credits: 2** **L: T: P: 2:0:0**

**CIE: 50 Marks** **SEE: 50 Marks**

**SEE Hours:2 hrs** **Max. Marks:50**

| | |
|---|---|
| Prerequisites if any | NIL |
| Learning Objectives | Describe research, process of research and different types of research.<br>1. Explain guidelines for data collection and data analysis.<br>2. Develop an understanding of different sampling techniques.<br>3. Select and define a research problem.<br>4. Prepare a research report. |

**Course Outcomes:**

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

| COs | Course Outcomes | Bloom's level |
|---|---|---|
| CO1 | Define Research and the process involved in it. | Understand |
| CO2 | Develop an understanding of different sampling techniques and hypothesis testing. | Understand |
| CO3 | Describe various data collection and data analysis methods | Apply |

**Mapping with POs and PSOs**:

| CO's | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 | PSO3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | 3 | 3 | 1 | 2 | 2 | | | | | | | | | | |
| CO2 | 3 | 3 | 1 | 2 | 2 | | | | | | | | | | |
| CO3 | 3 | 3 | 1 | 2 | 2 | | | | | | | | | | |

**Mapping Strength: Strong– 3 Medium – 2 Low – 1**

**Course Structure**

| Sl. No | Module | No. of Lecture Hours |
|---|---|---|
| | **Module – 1:** | |
| 1.1 | **Basics:** Meaning, Objectives of research, Motivation in research, Types ofresearch, Significance of research, Criteria of good research. | 3 |
| 1.2 | **Research Process**: Formulating the research problem, Literature survey, Development Of working hypotheses, Preparing the research design, determining sample design, Collecting the data, Execution of the project, Analysis of data, Hypothesis-testing, Generalizations and interpretation, | 5 |
| | **Module – 2:** | |
| 2.1 | **Research Hypothesis**: Meaning, Characteristics of hypothesis, Types of hypothesis, level of significance, Type I & Type II errors, One tailed & two tailed tests, Procedure for hypothesis testing, | 5 |
| 2.2 | Need for Sampling, Fundamental Definitions, Probability & Non- probability Sampling Designs, | 4 |
| | **Module – 3:** | |
| 3.1 | Types & Sources of data, collection of data, measurement & scaling techniques, Techniques of data analysis | 5 |
| 3.2 | Writing Thesis, writing article for journal and conference publication, IEEE and Harvard style of referencing, Effective Presentation. | 4 |
| | ***Total No. of Lecture Hours*** | **26** |

**Text Books:**

1.C R Kotari, "Research Methodology", New Age International, 2nd revised edition, 2014.

2.Deepak Chawla, NeenaSandhi, "Research Methodology Concepts & Cases", Vikas Publications, 2nd edition, 2011.

**Reference Books:**

1.Garg B L, Karadia, R Agarwal and Agarwal, "An introduction to research methodology", RBSA Publishers, 2002.

2.Sinha S C and Dhiman A K, "Research Methodology", ESS Publications, 2002

**Course Code: BEC601** **Course: Computer Networks**

**Credits: 4** **L:T:P – 3:0:2**

**CIE: 50% Marks** **SEE: 50% Marks**

**SEE Hours: 3 Hrs** **Max. Marks: 100**

| | |
|---|---|
| Prerequisites if any | Nil |
| Learning objectives | Students will be able to learn.<br>• Develop awareness towards basic internetworking principles.<br>• Explain protocols operating at different layers of computer networks.<br>• Analyze various aspects involved in multiple access, addressing, network and congestion control. |

**Course Outcomes:**

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

| COs | Course Outcomes | Bloom's level |
|---|---|---|
| CO1 | Understanding the OSI and TCP/IP Protocol Stack, and analysing the Transmission Delays, the correlation between Data Transmission delay and Propagation Delay. | L2 |
| CO2 | Design different Networks, Class addresses, subnet and subnet masking | L3 |
| CO3 | Analysing the protocols and algorithms to illustrate the basic principles on which they are designed at different layers of the protocol stack. | L4 |
| CO4 | Analyze switching, different routing protocols and performance of various scheduling algorithm | L4 |
| CO5 | Implement communication protocols using TCP/UDP in network applications. | L3 |

**Mapping with POs and PSOs:**

| COs | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | | PSO1 | PSO2 | PSO3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | 3 | 3 | 2 | | 3 | | | | | | | 2 | | 3 | 3 | |
| CO2 | 3 | 3 | 2 | | 3 | | | | | | | 2 | | 3 | 3 | |
| CO3 | 3 | 3 | 2 | | 3 | | | | | | | 2 | | 3 | 3 | |
| CO4 | 3 | 3 | 2 | | 3 | | | | | | | 2 | | 3 | 3 | |

3 – Strong 2 – Medium 1 – Low

**Course Structure**

| Module – 1 | | No. of Lecture Hours |
|---|---|---|
| 1.1 | Introduction: Data communication: Components, Data representation, Data flow, Networks: Network criteria, Physical Structures, Network types: LAN, WAN, Switching Packet Switching: Datagram Approach, Virtual Circuit Approach. | 2 |
| 1.2 | Network Models and Physical Layer:<br>Layers in OSI Model, TCP/IP protocol suite, Addressing, Data Rate Limits. | 3 |
| 1.3 | Performance Parameters, Bandwidth, Latency, Problem solving. | 3 |
| Module – 2 | | |
| 2.1 | Introduction: Nodes and Links, Services, Two Categories of link,<br>Sublayers, Link Layer addressing: Types of addresses, ARP | 2 |
| 2.2 | Framing, Flow and Error Control, Protocols, Noiseless and Noisy Channels, Random Access, Controlled Access. | 2 |
| 2.3 | Wired LANs: Ethernet, Wireless LANs (IEEE 802.11), VLANs. | 4 |
| Module – 3 | | |
| 3.1 | Network Layer: Introduction, Network Layer services: Packetizing, | 3 |

| | | |
|---|---|---|
| | Routing and Forwarding, IPV4 Addresses: Address Space, Classful Addressing, Classless Addressing, DHCP. | |
| 3.2 | IPv4 and IPv6 Addresses, Structure, Address Space, Transition from IPV4 to IPV6. | 2 |
| 3.3 | Unicast routing: Inter and intra-domain routing, RIP, OSPF, BGP. | 3 |
| Module – 4 | | |
| 4.1 | Introduction: Transport Layer Services, Connectionless and Connection oriented Protocols, Transport Layer Protocols: Simple protocol, Stop and wait protocol, Go-Back N Protocol, Selective repeat protocol, Piggybacking | 2 |
| 4.2 | User Datagram Protocol: User Datagram, UDP Services, UDP Applications, Transmission Control L1, L2, L3 Protocol: TCP Services, TCP Features, Segment, Connection, State Transition diagram, | 3 |
| 4.3 | Windows in TCP, Error control, TCP congestion control: Slow start, Fast retransmit and Fast recovery, Congestion avoidance mechanisms. | 3 |
| Module – 5 | | |
| 5.1 | Application Layer: Application- layer paradigms, Client/Server Programming Concept. | 3 |
| 5.2 | Standard Client – Server Protocols: Hyper Text Transfer Protocol, FTP: Two connections, Control Connection, Data Connection, SMTP. | 3 |
| 5.3 | DNS: Name space, DNS in internet, Resolution, DNS Messages, Registrars, DDNS, security of DNS. | 2 |
| Total No. of Lecture Hours | | 40 |

Suggested Learning Resources:

**Textbooks:**

1. "Data Communication and Networking" Behrouz A Forouzan, 5th Edition, McGraw Hill, 2013, ISBN: 1-25-906475-3.
2. "Computer Networks – A System Approach" Larry. Peterson and Bruce S. Davie, Morgan Kaufmann Publications, 5thEdition.

| List of Experiments | |
|---|---|
| 1. Introduction to Packet Sniffing and Wireshark.<br>2. Study of Network Administration and Configuration commands | 1 |
| 3. Study of IP, ARP, UDP, TCP and DNS using Wireshark | 1 |
| 4. Simulate a four-node point-to-point network and analyse the network by changing the bandwidth and latency using NS2. | 1 |
| 5. Simulate and analyse the routing protocols and deduce the relevant inference from the observations using NS2. | 1 |
| 6. Simulate a 6 node Ethernet LAN network using NS2. | 1 |
| 7. Simulation of STOP and WAIT Protocol. | 1 |
| 8. NETSIM experiment 1 | 1 |
| 9. NETSIM experiment 2 | 1 |
| 10. Introduction to Cisco packet tracer | 1 |
| 11. Network design using Cisco packet tracer | 1 |
| **Total No. of Practical Hours** | **15** |

**Online resource link**

1. https://www.e-booksdirectory.com/details.php?ebook=10361
2. https://www.e-booksdirectory.com/details.php?ebook=7190
3. http://nptel.ac.in/video.php?subjectId=106105081
4. http://freevideolectures.com/Course/2278/Data-Communication
5. https://cosmolearning.org/courses/computer-networks-524/video-lectures/
6. https://www.eecis.udel.edu/~bohacek/videoLectures/ComputerNetworking/ComputerNetworking_v2.html

**Reference Books:**

1. "Computer Communication Networks", Andrew S Tannenbaum, Prentice Hall of India Pvt. Ltd., 4th Edition.
2. "Computer Networks", James F. Kurose, Keith W. Ross, 2nd Edition, 2003, Pearson Education.

**Course Code: BEC602** **Course: Embedded System and Architecture**

**Credits: 4** **L:T:P:3:0:2**

**SEE: 50% Marks** **CIE:50% Marks**

**SEE Hours: 3 hrs** **Max.Marks:100**

| | |
|---|---|
| Prerequisites if any | Digital electronics, Microprocessors/microcontrollers |
| Learning objectives | • Apply logic design conventions to construct and analyse simple data paths and control schemes.<br>• Evaluate cache performance and implement cache controllers using finite-state machines.<br>• Utilize embedded hardware building blocks for processor selection, memory allocation, and interfacing.<br>• Implement and troubleshoot device drivers for parallel and serial communication devices in embedded systems. |

**Course Outcomes:**

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

| COs | Course Outcomes | Bloom's level |
|---|---|---|
| CO1 | Understand the principles of logic design conventions, Datapath building, pipelining, and hazards in computer architecture. | L2 |
| CO2 | Analyze memory hierarchy including memory technologies, cache performance, and parallelism in memory systems. | L3 |
| CO3 | Apply knowledge of embedded hardware building blocks, memory selection, interfacing processors, and system performance in embedded systems. | L3 |
| CO4 | Demonstrate proficiency in embedded software tools and techniques including assemblers, boot loaders, system design, and debugging. | L3 |

**Mapping with POs and PSOs:**

| COs | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | | PSO1 | PSO2 | PSO3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | | 3 | 2 | 2 | | | | | | | | | | 2 | 2 | 2 |
| CO2 | | 3 | 2 | 2 | | | | | | | | | | 2 | 2 | 2 |
| CO3 | | 3 | 2 | 2 | | 1 | | | | | | | | 2 | 2 | 2 |
| CO4 | | 3 | 2 | 2 | | 1 | | | | | | | | 2 | 2 | 2 |

3 – Strong 2 – Medium 1 – Low

**Course Structure**

| Module – 1: Processor | | No. of Lecture Hours |
|---|---|---|
| 1.1 | Introduction, Logic Design Conventions. | 2 |
| 1.2 | Building a Datapath, A Simple Implementation Scheme. | 2 |
| 1.3 | An Overview of Pipelining, Pipelined Datapath and Control. | 2 |
| 1.4 | Hazards, Parallelism via Instructions. | 2 |
| Module – 2: Register Transfer And Micro-Operations | | |
| 2.1 | Register Transfer Language, Register Transfer, Bus and Memory Transfers, | 2 |
| 2.2 | Arithmetic Micro-Operations, Logic Micro-Operations, Shift Micro-Operations, Arithmetic logic shift unit. | 2 |
| 2.3 | MICRO-PROGRAMMED CONTROL: Control Memory, Address Sequencing, | 2 |
| 2.4 | Micro-Program example, Design of Control Unit. | 2 |
| Module – 3: Memory Hierarchy | | |

| | | |
|---|---|---|
| 3.1 | Introduction, Memory Technologies, The Basics of Caches, Measuring and Improving Cache Performance | 2 |
| 3.2 | Dependable Memory Hierarchy, A Common Framework for Memory Hierarchy, Using a Finite-State Machine to Control a Simple Cache | 2 |
| 3.3 | Parallelism and Memory Hierarchies: Cache Coherence, Parallelism and Memory Hierarchy: Redundant Arrays of Inexpensive Disks | 2 |
| 3.4 | Advanced Material: Implementing Cache Controllers | 2 |
| Module – 4: Embedded Hardware | | |
| 4.1 | Embedded hardware building blocks, Structural units in a processor, Processor selection for an embedded system. | 2 |
| 4.2 | Memory selection of an embedded system, Allocation of memory, DMA, Interfacing processor. | 2 |
| 4.3 | Memories, and I/O devices, Timers and counting devices. | 2 |
| 4.4 | Serial and parallel communication devices, processor performance. | 2 |
| Module – 5: Device Drivers | | |
| 5.1 | Introduction, parallel port device drivers, serial port device drivers, internal programmable timing devices. | 2 |
| 5.2 | Interrupt servicing, Context switching deadline and latency. | 2 |
| 5.3 | Examples-Initializing an Ethernet Driver. | 2 |
| 5.4 | Initializing an USB Driver. | 2 |
| **Total No. of Lecture Hours** | | 40 |

**List of Experiments**

To implement the below experiments, use any embedded architecture tools like Mucos / Gem 5 / Vx works / oc MPI / MIPS Simulator/ etc.

1. Design, implement and test: The Seven Segment Display and A simple Arithmetic Logic Unit (ALU)
2. Design, implement and test: Register File, Read only Memories – ROMs, Random Access Memories – RAMs
3. Design implement and test: Associative / Direct Mapped Cache memory design
4. Study, design, implement and test: Single-Cycle MIPS CPU
5. Study, design, implement and test: Instruction Fetch Unit for the 16-bit Single-Cycle MIPS CPU
6. Study, design, implement and test: MIPS 16 CPU, pipeline version
7. Study, design, implement and test: Serial Communication

**Suggested Learning Resources**:

**Textbooks:**

1. David A. Patterson and John L. Hennessey, Computer Organization and Design: The Hardware/Software Interface , 5th ed., Morgan Kaufmann, 2014.
2. Tammy Noergaard, "Embedded Systems Architecture: A Comprehensive Guide for Engineers and Programmers", Elsevier, 2005.
3. Gene Sally, "Professional Linux Embedded System", Academic Press 2010.

**Reference Books:**

1. Frank Vahid, Tony D. Givargis, "Embedded system Design: A Unified Hardware/Software Introduction", John Wily & Sons Inc.2002.
2. Peter Marwedel, "Embedded System Design", Science Publishers, 2007.
3. Arnold S Burger, "Embedded System Design", 2002.
4. Rajkamal, "Embedded systems", McGraw Hill, 4th Edition, 2020

**Code: BEC613A** **Course: ASIC Design**

**Credits: 3** **L: T: P: 3:0:0**

**SEE: 50% Marks** **CIE:50% Marks**

**SEE Hours: 3 hrs** **Max.Marks:100**

| | |
|---|---|
| Prerequisites if any | Digital Electronics and Circuit Theory |
| Learning objectives | Students will be able to learn<br>• ASIC Design Flow.<br>• Analyse the design of FPGAs and ASICs<br>• Analyse data path elements for ASIC cell libraries |

**Course Outcomes:**

On the successful completion of the course, the student will be able to

| **COs** | **Course Outcomes** | **Bloom's level** |
|---|---|---|
| CO1 | Understand the concepts of ASIC design methodology, data path elements, logical effort and FPGA architectures. | L2 |
| CO2 | Analyse the design of FPGAs and ASICs suitable for specific tasks, perform design entry and explain the physical design flow. | L4 |
| CO3 | Analyse data path elements for ASIC cell libraries and compute optimum path delay. | L4 |

**Mapping with POs and PSOs:**

| COs | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 | PSO3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | 3 | 3 | 2 | - | 2 | | | | 1 | | | 1 | 3 | 2 | 2 |
| CO2 | 3 | 2 | 3 | - | 2 | | | | 1 | | | 1 | 3 | 2 | 2 |
| CO3 | 3 | 2 | 3 | - | 3 | | | | 1 | | | 1 | 3 | 2 | 2 |

Strong– 3 Medium – 2 Low – 1

**Course Structure**

| Module – 1- Introduction to ASICs | | No. of Lecture Hours |
|---|---|---|
| 1.1 | Full custom, Semi-custom and Programmable ASICs, | 1 |
| 1.2 | ASIC Design flow, ASIC cell libraries, CMOS Logic, Address | 3 |
| 1.3 | Carry Skip, Carry saves, Carry selects, Conditional sum, Multiplier (Booth) | 2 |
| 1.4 | Datapath Operators, I/O cells, Cell Compilers. | 2 |
| Module-2- ASIC Library Design | | |
| 2.1 | Logical effort: Predicting Delay, Logical area and logical efficiency paths, Multi stage cells | 2 |
| 2.2 | Optimum delay and number of stages, library cell design. Programmable ASIC Logic Cells: MUX as Boolean function generators, | 3 |
| 2.3 | Schematic entry: Hierarchical design, The cell library, Names, Schematic Icons & Symbols, Nets, Schematic Entry for ASICs, Connections vectored instances & buses, Edit in place, attributes, Net list screener. ASIC Construction: Physical Design, CAD Tools System partitioning, Estimating ASIC size. | 3 |
| Module-3- Low-level design entry | | |
| 3.1 | Partitioning: Goals and objectives, Constructive Partitioning, Iterative Partitioning Improvement, KL, FM and Look Ahead algorithms. | 4 |
| 3.2 | Goals and objectives, Measurement of delay in Floor planning, Floor planning tools, Channel definition, I/O and Power planning and Clock planning. | 4 |
| Module 4: Placement and CTS | | |
| 4.1 | Placement: Goals and Objectives, Min-cut Placement algorithm, Iterative Placement Improvement, Time driven placement methods, Physical Design Flow, Clock tree synthesis – CTS, Clock tree Optimization -CTO | 5 |

| | | |
|---|---|---|
| 4.2 | Global Routing: Goals and objectives, Global Routing Methods, Global routing between blocks, Back-annotation. | 3 |
| Module 5: Routing and Timing Closure | | |
| 5.1 | Detailed Routing: Goals and objectives, Measurement of Channel Density, Left-Edge Algorithm, Area-Routing Algorithms, Multilevel routing, Special Routing, Circuit extraction and DRC. | 4 |
| 5.2 | Timing Closure: Timing Analysis and Performance Constraints, Timing-Driven Placement, Timing-Driven Routing, Physical Synthesis, Performance-Driven Design Flow | 4 |
| **Total No. of Theory** | | **40** |

Text books:

1. Application -Specific Integrated Circuits Michael John Sebastian Smith Addison Wesley Professional 2005
2. VLSI Design: A Practical Guide for FPGA and ASIC Implementations Vikram Arkalgud Chandrasetty, Springer, ISBN: 978-1-4614-1119-2. 2011
3. An ASIC Low Power Primer Rakesh Chadha, Bhasker J Springer, ISBN: 978-14614-4270-7
4. VLSI Physical Design:From Graph Partitioning to Timing Closure, Andrew B. Kahng, Jens Lienig, Igor L. Markov, Jin Hu, Springer, ISBN 978-90-481-95909,2011

**Course Code: BEC613B** **Course: Signal Processing and Machine Learning**

**Credits: 3** **L: T: P: 3:0:0**

**SEE: 50% Marks** **CIE:50% Marks**

**SEE Hours: 3 hrs** **Max.Marks:100**

| | |
|---|---|
| Prerequisites if any | NIL |
| Learning objectives | Students will be able to learn:<br>• Adaptive filter and wavelets for signal processing.<br>• Estimate and analyse signal characteristics.<br>• ML Algorithms used in signal processing applications. |

**Course Outcomes:**

On the successful completion of the course, the student will be able to

| CO's | Course Outcomes | Bloom's level |
|---|---|---|
| CO1 | Understand the concepts of adaptive filter and Multi rate signals. | L2 |
| CO2 | Estimate spectral characteristics of signals. | L4 |
| CO3 | Analyse signals using Wavelets and multiresolution methods. | L4 |
| CO4 | Apply ML algorithm for signal processing applications. | L3 |

**Mapping with POs and PSOs:**

| COs | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 | PSO3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | 3 | 2 | | | 1 | | | | | | | 1 | 3 | 2 | 1 |
| CO2 | 3 | 2 | | | 1 | | | | | | | 1 | 3 | 2 | 1 |
| CO3 | 2 | 3 | | | 1 | | | | | | | 1 | 2 | 3 | 1 |
| CO4 | 2 | 2 | | | 1 | | | | | | | 1 | 2 | 2 | 1 |

Mapping Strength: Strong– 3 Medium – 2 Low – 1

**Course Structure**

| Module – 1 | | No. of Lecture Hours |
|---|---|---|
| 1.1 | Multi Rate Signal Processing - Review of sampling, Nyquist rate, aliasing, reconstruction, anti-aliasing filters. | 3 |
| 1.2 | Decimation and interpolation, Sampling rate conversion and implementation. | 3 |
| 1.3 | Digital filter banks, Sampling rate conversion for multistage and bandpass signals. | 2 |
| Module – 2 | | |
| 2.1 | Adaptive Filters - Adaptive filter applications – System identification channel equalization. | 3 |
| 2.2 | Echo cancellation, Adaptive line enhancer. | 2 |
| 2.3 | Adaptive noise cancellation, LPC of speech signals, LMS and RLS algorithms. | 3 |
| Module – 3 | | |
| 3.1 | Power Spectral Estimation – Estimation of power spectra, non- parametric estimation – Barlet, Welch methods, characteristics of nonparametric power spectrum estimators. | 3 |
| 3.2 | parametric power spectrum estimation – Auto correlation model parameters. | 3 |
| 3.3 | Yule-walker method, unconstrained least squares, AR model parameters. | 2 |
| Module – 4 | | |
| 4.1 | Wavelets - Continuous time wavelets, CWT as operator | 3 |
| 4.2 | Inverse CWT, DWT and vector subspaces | 2 |
| 4.3 | MRA, Formal definition, scaling functions and subspaces Wavelet basis for MRA | 3 |
| Module – 5 | | |
| 5.1 | Machine Learning for Signal Processing – Supervised learning, Classification models to predict class models. | 4 |
| 5.2 | Regression models. | 2 |
| 5.3 | classifying iris species. | 2 |
| **Total No. of Lecture Hours** | | **40** |

**Suggested Learning Resources:**

1. https://www.deeplearningbook.org/
2. NPTEL Courses: https://www.youtube.com/watch?v=HVGW85eGPQQ&list=PLyqSpQzTE6M_h5UgZWpybzBVDGmHGhQQb.
3. https://www.microsoft.com/en-us/research/people/cmbishop/prml-book/
4. https://www.sp4comm.org/

**Textbooks**

1. Digital Signal Processing, by Tarun Kumar Rawat, Oxford university press, New Delhi, 2015.
2. Fundamentals of Wavelets theory algorithms and applications, by Jaideva C Goswami and Andres K Chan, Wiley India 2006.
3. Pattern Recognition and Machine Learning, by Christopher M Bishop, Springer, 2011.

**Course Code: BEC613C** **Course: Optical Fiber Communication**

**Credits: 3** **L: T: P: 3:0:0**

**SEE: 50% Marks** **CIE:50% Marks**

**SEE Hours: 3 hrs** **Max.Marks:100**

| | |
|---|---|
| Prerequisites if any | Electromagnetic Theory |
| Learning objectives | • Understand Basic Blocks of Optical Fiber Communication System<br>• Analyze Different types of Errors and losses<br>• Analyze Different types of optical sources and Optical Detectors<br>• Understand and Design optical communication receivers<br>• Analyze optical fiber networks |

**Course Outcomes:**

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

| **COs** | **Course Outcomes** | **Bloom's level** |
|---|---|---|
| CO1 | Identify the basic elements of optical fiber transmission link, fiber modes configurations and structures. | L1 |
| CO2 | Analyse the different kinds of losses, signal distortion in optical waveguides and their signal degradation factors and the various optical source materials, LED structures, Laser diodes. Principles of Photo diodes. | L3 |
| CO3 | Apply the fiber optical receiver's concepts in communication, basics of optical amplifiers, receiver operation and configuration. | L3 |
| CO4 | Analyse the fiber optical networks like SONET/SDH and Operational principles of WDM. | L3 |

**Mapping with POs and PSOs:**

| COs | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | | PSO1 | PSO2 | PSO3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | 3 | 2 | 1 | | | | | | | | | 1 | | 3 | 1 | 2 |
| CO2 | 3 | 2 | 1 | | | | | | | | | 1 | | 3 | 1 | 2 |
| CO3 | 3 | 2 | 1 | | | | | | | | | 1 | | 3 | 1 | 2 |
| CO4 | 3 | 2 | 1 | | | | | | | | | 1 | | 3 | 1 | 2 |

3 – Strong 2 – Medium 1 – Low

**Course Structure**

| Module – 1: Overview of optical fiber communication | | No. of Lecture Hours |
|---|---|---|
| 1.1 | Key elements of optical fiber systems, Advantages and Disadvantages of optical fiber Communication, | 1 |
| 1.2 | Basic optical laws and definitions | 2 |
| 1.3 | optical fiber modes and configuration | 2 |
| 1.4 | Mode theory of circular waveguides: Overview, summery of key modal concepts | 1 |
| 1.5 | single mode fibers, graded index fibers, | 2 |
| 1.6 | fiber materials. | 1 |
| Module – 2: Signal Degradation in Optical Fibers | | |
| 2.1 | Attenuation | 1 |
| 2.2 | signal losses in optical waveguides: Absorption | 1 |
| 2.3 | Scattering losses | 1 |
| 2.4 | Bending losses | 2 |
| 2.5 | Signal distortion in Fibers | 2 |
| Module – 3: Optical Sources and Detectors | | |
| 3.1 | Introduction to semiconductor materials, | 1 |
| 3.2 | LEDs and Types | 1 |

| | | |
|---|---|---|
| 3.3 | LASER diodes: LASER diodes | 1 |
| 3.4 | LASER Modes and threshold conditions | 1 |
| 3.5 | Single mode Lasers | 1 |
| 3.6 | Principles of Photo diodes | 3 |
| Module – 4: Optical Receiver and Digital Transmission System | | |
| 4.1 | Fundamental receiver operation: Digital signal transmission | 2 |
| 4.2 | Error sources | 1 |
| 4.3 | Receiver configurations | 3 |
| 4.4 | Overview of analog links | 1 |
| Module – 5: Optical Amplifiers and Optical Networks | | |
| 5.1 | Basic applications and types of optical amplifiers | 2 |
| 5.2 | semiconductor optical amplifiers | 2 |
| 5.3 | Erbium doped fiber amplifiers | 2 |
| 5.4 | SONET / SDH | 3 |
| 5.5 | Operational principles of WDM | 2 |
| **Total No. of Lecture Hours** | | 40 |

**Suggested Learning Resources:**

**Textbooks:**

1. Gerd Keiser, "Optical Fiber Communication", MGH, 4th Ed., 2011.

**Reference Books:**

1. John M. Senior, "Optical Fiber Communications", Pearson Education. 3rd Impression, 2007.

**Suggested Learning Resources:**

1. https://www.youtube.com/playlist?list=PLbMVogVj5nJQxs7jmzJkGENCYYLWnP_F
2. https://www.youtube.com/watch?v=ap00IUJm7k&list=PLFW6lRTa1g83Yaqm M9r2MAAiJVY93bOP7

**Course Code: BEC613D** **Course: Industrial Internet of Things**

**Credits: 3** **L: T: P: 3:0:0**

**SEE: 50% Marks** **CIE:50% Marks**

**SEE Hours: 3 hrs** **Max.Marks:100**

| | |
|---|---|
| Prerequisites if any | |
| Learning objectives | • Gain an understanding of the various industrial revolutions and the role of IoT and IIoT in modern industry.<br>• Develop the ability to implement IIoT systems using sensors, actuators, microcontrollers, embedded PCs, and relevant network technologies and protocols.<br>• Acquire skills in monitoring and controlling IIoT data through edge system programming, cloud computing, and data analytics while ensuring cybersecurity.<br>• Become familiar with cyber-physical systems and advanced technologies such as AI, big data, augmented reality, and virtual reality in the context of Industry 4.0. |

**Course Outcomes:**

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

| COs | Course Outcomes | Bloom's level |
|---|---|---|
| CO1 | Understand the role and impact of IoT and IIoT in Industry 4.0, including smart factories and reference architecture. | L2 |
| CO2 | Learn about IIoT implementation systems, encompassing sensors, actuators, microcontrollers, embedded PCs, network technologies, and protocols. | L2 |
| CO3 | Develop skills in IIoT data monitoring and control, including edge systems programming, cloud computing, data analytics, predictive maintenance, and cybersecurity. | L3 |
| CO4 | Explore cyber-physical systems, focusing on next-generation sensors, collaborative platforms, augmented reality, virtual reality, AI, big data, and advanced analytics. | L3 |

**Mapping with POs and PSOs:**

| COs | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | | PSO1 | PSO2 | PSO3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | | 3 | 2 | | 2 | 1 | 1 | | | | | 1 | | | | |
| CO2 | | 3 | 2 | | 2 | 1 | 1 | | | | | 1 | | | | |
| CO3 | | 3 | 2 | | 2 | 1 | 1 | | | | | 1 | | | | |
| CO4 | | 3 | 2 | | 2 | 1 | 1 | | | | | 1 | | | | |

3 – Strong 2 – Medium 1 – Low

**Course Structure**

| Module – 1: Introduction to Industrial IoT (IIoT) Systems: | | No. of Lecture Hours |
|---|---|---|
| 1.1 | The Various Industrial Revolutions, Role of Internet of Things (IoT) | 2 |
| 1.2 | & Industrial Internet of Things (IIoT) in Industry, Industry 4.0 revolutions, | 2 |
| 1.3 | Support System for Industry 4.0, Smart Factories. | 2 |
| 1.4 | IIoT Reference Architecture | 2 |
| Module – 2: Implementation systems for IIoT | | |
| 2.1 | Sensors and Actuators for Industrial Processes, Sensor networks, Process automation and Data Acquisitions on IoT Platform, | 2 |
| 2.2 | Microcontrollers and Embedded PC roles in IIoT | 2 |
| 2.3 | Designing Industrial Internet Systems, Examining the Access Network Technology and Protocols, Examining the Middleware Transport Protocols | 2 |
| 2.4 | IIoT WAN Technologies and Protocols | 2 |
| Module – 3 : IIoT Data Monitoring & Control | | |
| 3.1 | IoT Gate way, IoT Edge Systems and It's Programming, | 2 |
| 3.2 | Cloud computing, Real Time Dashboard for Data Monitoring, | 2 |
| 3.3 | Data Analytics and Predictive Maintenance with IIoT technology. | 2 |
| 3.4 | Cybersecurity in Industry 4.0 | 2 |

| | | |
|---|---|---|
| Module – 4: Cyber Physical Systems | | |
| 4.1 | Industry 4.0: Cyber Physical Systems and Next Generation Sensors, | 2 |
| 4.2 | Collaborative Platform and Product Lifecycle Management, | 2 |
| 4.3 | Augmented Reality and Virtual Reality, | 2 |
| 4.4 | Artificial Intelligence, Big Data and Advanced Analysis | 2 |
| Module – 5: Applications | | |
| 5.1 | Healthcare, Power Plants, | 2 |
| 5.2 | Inventory Management & Quality Control, | 2 |
| 5.3 | Plant Safety and Security (Including AR and VR safety applications), | 2 |
| 5.4 | Facility Management. | 2 |
| **Total No. of Lecture Hours** | | **40** |

**Suggested Learning Resources:**

**Textbooks:**

1. Industry 4.0: The Industrial Internet of Things Alasdair Gilchrist Publications: Apress.
2. Industrial Internet of Things: Cyber manufacturing Systems, Sabina Jeschke, Christian Brecher, Houbing Song, Danda B. Rawat Editors, Springer.
3. The Concept Industry 4.0 An Empirical Analysis of Technologies and Applications in Production Logistics Authors: Bartodziej, Christoph Jan Springer: Publication in the field of economic science.
4. Embedded System: Architecture, Programming and Design by Rajkamal, TMH3.
5. Dr. Ovidiu Vermesan, Dr. Peter Friess, “Internet of Things: Converging Technologies for Smart Environments and Integrated Ecosystems”, River Publishers

**Online resources**: https://www.youtube.com/watch?v=BRTxpGUmn_Q

Course Code: BEC613E Course: Object Oriented Programming

Credits: 3 L: T: P: 3:0:0

SEE: 50% Marks CIE:50% Marks

SEE Hours: 3 hrs Max.Marks:100

| | |
|---|---|
| Prerequisites if any | C Programming or Some Programming Concepts |
| Learning objectives | Students will be able to learn<br>1. To Provide the knowledge of fundamental principles of Object Oriented Programming<br>2. To introduce the concepts of any language as a class object, inheritance, overloading, Data structures. |

**Course Outcomes:**

On the successful completion of the course, the student will be able to

| **COs** | **Course Outcomes** | **Bloom's level** |
|---|---|---|
| CO1 | Explain principles of Object-Oriented Programming using class and objects | L2 |
| CO2 | Implementation of Inheritance and Polymorphism | L3 |
| CO3 | Identify the importance of Abstract classes and methods and implementation of Exceptions | L3 |
| CO4 | Design Implementation of Data Structures such as Stack, Queues and Linked Lists | L3 |
| CO5 | Design and analyse Searches and Trees | L3 |

**Mapping with POs and PSOs:**

| **COs** | **PO1** | **PO2** | **PO3** | **PO4** | **PO5** | **PO6** | **PO7** | **PO8** | **PO9** | **PO10** | **PO11** | **PO12** | | **PSO1** | **PSO2** | **PSO3** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CO1** | 3 | | 2 | 1 | 2 | | | | 1 | 1 | 1 | 2 | | | 3 | |
| **CO2** | 3 | | 3 | 1 | 2 | | | | 1 | 1 | 1 | 2 | | | 3 | |
| **CO3** | 3 | | 2 | 1 | 3 | | | | 1 | 1 | 1 | 2 | | | 3 | |
| **CO4** | 3 | | 2 | 1 | 3 | | | | 1 | 1 | 1 | 2 | | | 3 | |
| **CO5** | 3 | | 2 | 1 | 3 | | | | 1 | 1 | 1 | 2 | | | 3 | |

Mapping Strength: Strong– 3 Medium – 2 Low – 1

**Course Structure**

| Module – 1 Introduction to OPS | | No. of Lecture Hours |
|---|---|---|
| 1.1 | Introduction to procedure oriented | 1 |
| 1.2 | Object Oriented programming, | 1 |
| 1.3 | Types of Variable, Namespaces, | 2 |
| 1.4 | Types of Methods – Instance methods, Class methods, Static methods | 2 |
| 1.5 | Passing Members of one class to Another Class | 2 |
| Module – 2 Inheritance and Polymorphism | | |
| 2.1 | Constructors in Inheritance, Static and Dynamic memory allocation - > Deep copy and shallow constructor, Destructors (Specific to C++) | 1 |
| 2.2 | Overriding Super Class Constructors and Methods | 1 |
| 2.3 | Types of Inheritance – Single and Multiple Inheritance, Diamond Problem | 2 |
| 2.4 | Method Overloading and Overriding | 2 |
| Module – 3 ADT and Exceptions | | |
| 3.1 | Abstract Methods and Class | 1 |
| 3.2 | Interfaces, Comparison between Abstract and Interfaces | 1 |
| 3.3 | Exceptions: Why exceptions | 2 |
| 3.4 | Exception handling, Types of Exceptions | 2 |
| 3.5 | Except Block, Assert and User-Defined Exceptions | 2 |
| Module – 4 Data Structures | | |
| 4.1 | Stack, Implementation | 2 |
| 4.2 | Queues – Implementation | 2 |
| 4.3 | Linked List – Single and Double, Circular | 2 |
| 4.4 | Deques and its Implementation | 2 |
| Module – 5 Searches and Trees | | |

| | | |
|---|---|---|
| 5.1 | Binary Search Tree – Traversal Order (In order, Post order and Preorder implementation) | 1 |
| 5.2 | Introduction to Graphs, DFS and BFS | 2 |
| 5.3 | Linear – Binary Search Tree, AVL Tree | 2 |
| 5.4 | Sorting Algorithm – Merge Sort | 2 |
| 5.5 | Quick Sort and Comparison | 1 |
| **Total No. of Lecture Hours** | | **40** |

Text Books:

1. Herbert Schmidt, "The Complete Reference C++", Tata McGraw-Hill., 4th Edition.
2. A.M. Tenenbaum, Data Structures Using C, Pearson Education. 3. Y. Langsam, M. Augenstein and A.M. Tenenbaum, "Data Structures using C and C++",Prentice Hall India.

Suggested Learning Resources:

1.https://www.youtube.com/watch?v=1VKZhiuMeM&list=PLI4OVrCFuY56E57FdYzFNSWcEDS-ZKK26&index=34

Reference Books:

1. Stanley B. Lippmann, Josee Lajore, Sartaj Sahni, "Data Structures using C++", Tata McGraw Hill.
2. "C++Primer", Addison Wesley, 4th Edition, 2005.
3. Owen L. Astrachan, "Programming with C++ - A Computer Science Tapestry", Tata McGraw-Hill., Special Indian Edition 2007.
4. E. Horowitz, and Sartaj Sahni, "Fundamentals of Data Structures", Galgoti Publications.

**Course Code: BEC613F** **Course: Transmission Lines and Radiating Systems**

**Credits: 3** **L:T:P:S – 3-0-0-0**

**CIE: 50% Marks** **SEE: 50% Marks**

**SEE Hours: 3 Hrs** **Max. Marks: 100**

| | |
|---|---|
| Prerequisites if any | Engineering Electromagnetics |
| Learning objectives | • To understand the EM wave characteristics along transmission lines<br>• To study and learn the EM wave characteristics on TL lines and to learn impedance matching.<br>• To study and learn guiding structures (waveguides) and their characteristics for high frequency applications.<br>• To understand and learn about radiating systems and their parameters. |

**Course Outcomes:**

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

| COs | Course Outcomes | Bloom's level |
|---|---|---|
| CO1 | Understand the EM propagation on Transmission lines | L1 |
| CO2 | Analyze impedance matching problems in transmission lines. | L3 |
| CO3 | Understand the working principles of waveguides. | L1 |
| CO4 | Understand analyse radiation mechanism of radiating systems. | L3 |

**Mapping with POs and PSOs:**

| COs | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | | PSO1 | PSO2 | PSO3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | 3 | 2 | 2 | | | | | | | | | 2 | | 3 | | 2 |
| CO2 | 3 | 2 | 2 | | | | | | | | | 2 | | 3 | | 2 |
| CO3 | 3 | 2 | 2 | | | | | | | | | 2 | | 3 | | 2 |
| CO4 | 3 | 2 | 2 | | | | | | | | | 2 | | 3 | | 2 |

3 – Strong 2 – Medium 1 – Low

**Course Structure**

| Module – 1: Transmission Lines: Finite and Infinite | | No. of Lecture Hours |
|---|---|---|
| 1.1 | Introduction | 1 |
| 1.2 | Transverse EM wave along parallel-plate Transmission lines—lossy parallel-plate transmission lines | 2 |
| 1.3 | General transmission line equations, Wave characteristics on an infinite TL, TL parameters | 3 |
| 1.4 | Wave characteristics on finite TL, TL as circuit element, Lines with resistive termination | 2 |
| Module – 2 : Transmission Lines: The Smith chart and Stub Matching | | |
| 2.1 | The Smith Chart---Introduction, Derivations. | 2 |
| 2.2 | Smith chart calculations for lossy line | 2 |
| 2.3 | TL impedance matching, Impedance by quarter wave transformer | 2 |
| 2.4 | Single stub matching, | 2 |
| Module – 3: Wave Guiding Structures | | |
| 3.1 | Introduction | 1 |
| 3.2 | General wave behaviours along uniform guiding structures—TE waves and TM waves, properties | 3 |
| 3.3 | Parallel plate waveguide----TE waves, TM waves, Properties, Attenuation | 4 |
| 3.4 | Rectangular waveguide—TE Waves, TM waves, Properties, Attenuation | 3 |
| Module – 4: Antennas | | |
| 4.1 | Introduction | 1 |
| 4.2 | Radiation Mechanism---Single wire, Two-wires, Dipole | 2 |
| 4.3 | Fundamental Parameters of Antennas---Radiation Pattern, Radiation Power Density, Radiation Intensity, Beam Width, Directivity, Efficiency, Gain, Radiation Efficiency | 2 |
| Module – 5 : Types of Antennas | | |

| | | |
|---|---|---|
| 5.1 | Types of antenna---Wire Antennas, Aperture Antennas, Microstrip Antennas, Array Antennas, Reflector Antennas, Lens Antenna, Dipole Antenna | 2 |
| 5.2 | Antenna array---Introduction, Two-element array, N-Element Linear Array, Planar array, Circular array, Three-dimensional characteristics | 2 |
| 5.3 | Antenna Design Procedure and Simulation | 4 |
| **Total No. of Lecture Hours** | | **40** |

**Suggested Learning Resources:**

**Text Books:**

1. David K. Cheng, "Field and Wave Electromagnetics", Pearson Education, Second Edition, 2002.
2. Constantine A. Balanis, "Antenna Theory: Analysis and Design",4th Edition, 2016.

**Reference Books:**

1. Clayton R. Paul, Keith W. Whites, Syed A. Nasar, "Introduction to Electromagnetic Fields", Tata McGraw-Hill Education Private Limited, Third Edition (Fifth Reprint), 2009.
2. David M Pozar, "Microwave Engineering", John Wiley,3rd Edition, 2005.

**Course Code: BEC654A** **Course: Internet of Things & its Applications**

**Credits: 3** **L: T: P: 3:0:0**

**SEE: 50% Marks** **CIE:50% Marks**

**SEE Hours: 3 hrs** **Max.Marks:100**

| | |
|---|---|
| Pre requisites if any | NIL |
| Learning Objectives | Students will be able to learn:<br>• Principles and components of the IoT ecosystem, including sensors, actuators, connectivity, data collection, and analysis.<br>• Identify and analyse various contexts where IoT can be implemented, such as smart homes, healthcare systems, industrial automation, or environmental monitoring.<br>• Apply suitable machine learning techniques/algorithms for data collected through the Internet of things. |

**Course Outcomes:**

On the successful completion of the course, the student will be able to

| CO's | Course Outcomes | Bloom's level |
|---|---|---|
| CO1 | Understand building blocks of the Internet of Things, challenges. | L2 |
| CO2 | Identify various protocols for communication with different sensors and actuators. | L3 |
| CO3 | Use and validate data analytics and security for IoT using tools. | L3 |
| CO4 | Apply data science and machine learning algorithm in IoT. | L3 |

**Mapping with POs and PSOs:**

| COs | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | 3 | 3 | 2 | | | | | | | | | 1 |
| CO2 | 3 | 2 | 3 | | | | | | | | | 1 |
| CO3 | 3 | 2 | 3 | | 3 | | 2 | | | | | 1 |
| CO4 | 3 | 3 | 2 | | 3 | | 2 | | | | | 1 |

Mapping Strength: Strong– 3 Medium – 2 Low – 1

Course Structure

| Module – 1 | | No. of Lecture Hours |
|---|---|---|
| 1.1 | What is IoT, Genesis of IoT, IoT and Digitization, IoT Impact, Convergence of IT and IoT, IoT Challenges, | 2 |
| 1.2 | IoT Network Architecture and Design, Drivers Behind New Network Architectures, Comparing IoT Architectures. | 2 |
| 1.3 | A Simplified IoT Architecture, The Core IoT Functional Stack. | 3 |
| Module-2 | | |
| 2.1 | Smart Objects: The "Things" in IoT, Smart Objects, Sensor Netwo Connecting Smart Objects, Communications Criteria | 3 |
| 2.2 | The need for Optimization, Optimizing IP for IoT. Application Protocol for IoT: The Transport Layer, IoT Application Transport Methods, SCADA | 2 |
| 2.3 | IoT Application Layer Protocols, CoAP, Message Queuing Telemetry Transport (MQTT) | 3 |
| Module-3 Data and Analytics | | |
| 3.1 | Data and Analytics for IoT, An Introduction to Data Analytics for IoT: Structured Versus Unstructured Data, Data in Motion Versus Data at Rest, | 2 |
| 3.2 | IoT Data Analytics Overview, IoT Data Analytics Challenges. | 2 |
| 3.3 | Data Analytics for IoT: Introduction, Apache Hadoop, Using Hadoop Map Reduce for Batch Data Analysis, Apache Oozie, Apache Spark, Apache Storm, Using Apache Storm for Real- time Data Analysis. | 4 |
| Module 4: Floor planning and placement | | |
| 4.1 | Industrial Internet of Things, Industry 4.0, IoT Architecture, Basic Technologies, Applications and Challenges, Security and Safety, Generic Application Security | 4 |

| | | |
|---|---|---|
| 4.2 | Application Process Security and Safety, Reliable-and-Secure- by-Design IoT Applications, Run-Time Monitoring, The ARMET Approach, Privacy and Dependability | 4 |
| Module – 5 | | |
| 5.1 | Machine Learning Overview, Supervised Learning, Unsupervised Learning, Neural Networks. | 4 |
| 5.2 | Regression and classification algorithms | 4 |
| **Total No. of Theory Hours** | | **40** |

**Textbooks**

1. "Building the Internet of Things with IPv6 and MIPv6: The Evolving World of M2M Communications", Daniel Minoli, Wiley, 2013.
2. "Internet of Things: A Hands on Approach" Arshdeep Bahga, Vijay Madisetti", Universities Press, 2015.
3. "Internet-of-Things (IoT) Systems Architectures, Algorithms, Methodologies" Dimitrios Serpanos, Marilyn Wolf , Springer International Publishing 2018.
4. Christopher M. Bishop, "Pattern Recognition and Machine Learning", Springer, 2006.

**Reference Books:**

1. "The Internet of Things", Michael Miller, First edition, Pearson, 2015.
2. "Designing Connected Products", Claire Rowland, Elizabeth Goodman et.al, First edition, O'Reilly, 2015.
3. Vijay Madisetti and ArshdeepBahga, "Internet of Things (A Hands-on-Approach)", 1st Edition, VPT, 2014. (ISBN: 978-8173719547)

**Course Code: BEC654B** **Course: Vehicular Electronics**

**Credits: 3** **L: T: P: 3:0:0**

**SEE: 50% Marks** **CIE:50% Marks**

**SEE Hours: 3 hrs** **Max.Marks:100**

| | |
|---|---|
| Prerequisites if any | Basic Circuit theory and mechanical dynamics |
| Learning objectives | Students will be able to learn:<br>• Electronics Automotive systems.<br>• Electronics Hybrid vehicles. |

**Course Outcomes:**

On the successful completion of the course, the student will be able to

| CO's | Course Outcomes | Bloom's level |
|---|---|---|
| CO1 | Understand constraints and opportunities of sensors and actuators used in the modern vehicle design. | L2 |
| CO2 | Use basic measurement tools to determine the real-time performance of vehicles and Automotive Instrumentation, Safety factors and diagnostics of Automobile systems. | L2 |
| CO3 | Analyse the implementation of the interconnected wireless embedded sensor networks and the Electronic Control Systems | L2 |

**Mapping with Pos and PSOs:**

| COs | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | 3 | 3 | 2 | | | | | | 1 | | | 1 |
| CO2 | 3 | 2 | 3 | | | | | | 1 | | | 1 |
| CO3 | 3 | 2 | 3 | | | | | | 1 | | | 1 |

Mapping Strength: Strong– 3 Medium – 2 Low – 1

**Course Structure**

| Module – 1-Introduction | | No. of Lecture Hours |
|---|---|---|
| | | |
| 1.1 | Automotive fundamentals overview: four stroke cycle, engine control | 2 |
| 1.2 | Ignition system, spark plug, sparks pulse generation, ignition timing | 3 |
| 1.3 | Drive train, transmission, brakes, steering system, Power Brakes, AntiLock Brake System (ABS), Electronic Steering Control, Power Steering, Traction Control, Electronically controlled suspension, starting system. | 3 |
| Module-2- Sensors | | |
| 2.1 | Oxygen (O2/EGO) Sensors, Throttle Position Sensor (TPS), Engin Crankshaft Angular Position (CKP) Sensor, magnetic reluctance, position sen speed sensor, ignition timing sensor, hall effect position sensor | 3 |
| 2.2 | Shielded field sensor, optical crankshaft position, sensor, Manifold Absolute Pressure (MAP) Sensor - strain gauge and capacitor capsule, Engine Coolant Temperature (ECT) sensor, Intake Air Temperature (IAT) sensor, knock sensor, airflow rate sensor, Operating Principles of Fuel Cells, Electrode Potential and Current–Voltage Curve. | 3 |
| 2.3 | Actuators: Automotive Engine Control Actuators, Fuel Injection, Exhaust Gas Recirculation Actuator, Variable Valve Timing, Electric Motor Actuators, fuel metering actuator, Ignition actuator, catalytic converter. | 2 |
| Module-3-Electronic Engine Control and Automotive Networking | | |
| 3.1 | Electronic Engine Control: Engine parameters, variables, engine performance terms, electronic fuel control system, electronic ignition control, idle speed control, air/fuel systems fuel handling, air intake system, Protection, Remote Keyless Entry, | 4 |

| | | |
|---|---|---|
| 3.2 | Automotive communication/networking: Automotive networking, cross system function, Requirements for bus systems, Classification of bus systems, Applications in the vehicle, Coupling of networks, Examples of networked vehicles. Bus systems: CAN, LIN. | 4 |
| | Module 4: Diagnostics and Battery systems | |
| 4.1 | On and Off board diagnostics: Electronic Control System Diagnostics, Service Bay Diagnostic Tool, Onboard Diagnostics, Model-Based Sensor Failure Detection, Expert Systems in Automotive Diagnosis, Occupant Protection Systems. | 4 |
| 4.2 | Battery Systems: Energy Storages: Batteries in Electric and Hybrid Vehicles, Battery Basics, Battery Parameters, Electrochemical Cell Fundamentals, Battery Modelling, Electrochemical Batteries, Ultra capacitors, Battery Pack Management. | 4 |
| | Module 5: Electric and Hybrid Vehicles | |
| 5.1 | Electric Vehicles: Configurations of Electric Vehicles, Performance of Electric Vehicles, Tractive Effort in Normal Driving. | 3 |
| 5.2 | Hybrid Electric Vehicles: Concept of Hybrid Electric Drive Trains, Architectures of Hybrid Electric Drive Trains. | 3 |
| 5.3 | Fuel Cell Vehicles: Fuel and Oxidant Consumption, Fuel Cell System Characteristics, Fuel Cell Technologies, Fuel Supply, Non Hydrogen Fuel Cells. | 2 |
| **Total No. of Lecture Hours** | | **40** |

**Text Books:**

1. William B. Ribbens, "Understanding Automotive Electronics," 6th Edition, SAMS / Elsevier Publisher, 2010.
2. Robert Bosch GMBH, "Automotive Electrics Automotive Electronics Systems and Components," 5th Edition, John Wiley& Sons Ltd., 2007.
3. Mehrdad Ehsani, Yimin Gao, Sebastien E. Gay, Ali Emadi, "Modern Electric, Hybrid Electric, and Fuel Cell Vehicles- Fundamentals, Theory, and Design," CRC Press, 2004.
4. Iqbal Husain, "Electric and Hybrid Vehicles Design Fundamentals," 2nd edition, CRC press.

**Course Code: BEC654C** **Course: Multicore Systems and Programming**

**Credits: 3** **L: T: P: 3:0:0**

**SEE: 50% Marks** **CIE:50% Marks**

**SEE Hours: 3 hrs** **Max.Marks:100**

| | |
|---|---|
| Prerequisites if any | C Programming, Computer Architecture |
| Learning objectives | Students will be able to learn:<br>• Limitation of single core systems and the need for multicore<br>• To port multithreading to multicore and synchronize the operations |

**Course Outcomes:**

On the successful completion of the course, the student will be able to

| CO's | Course Outcomes | Bloom's level |
|---|---|---|
| CO1 | Identify performance related parameters in the field of Computer Architecture and need for multicore architecture | L2 |
| CO2 | Apply the concept of multithreading and OPENMP to parallelise a process. | L3 |
| CO3 | Analyse the features of different multi-core architectures and how they apply parallelism. | L4 |

**Mapping with POs and PSOs:**

| COs | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | 3 | 2 | 1 | | | | 1 | | | | | 1 |
| CO2 | 2 | 2 | 1 | | 3 | | 1 | | | | | 1 |
| CO3 | 3 | 2 | 1 | | | | 1 | | | | | 1 |

Mapping Strength: Strong– 3 Medium – 2 Low – 1

**Course Structure**

| Module – 1: Module 1: Introduction To Multi-Core Architecture: | | No. of Lecture Hours |
|---|---|---|
| 1.1 | Motivation for Concurrency In Software, Parallel Computing Platforms, Parallel Computing in Microprocessors | 2 |
| 1.2 | Differentiating Multi-Core Architectures from Hyper Threading Technology, Multi-Threading on Single-Core Versus Multi-Core Platforms, Understanding Performance, Amdahl's Law, Growing Returns: Gustafson's Law. | 2 |
| 1.3 | Defining Threads, System View of Threads, Threading Above The Operating System, Threads Inside The OS, Threads Inside The Hardware, What Happens When A Thread Is Created | 2 |
| 1.4 | Application Programming Models and Threading, Virtual Environment: VMs And Platforms, Runtime Virtualization | 2 |
| Module – 2: Concepts of Parallel Programming | | |
| 2.1 | Designing for Threads, Task Decomposition, Data Decomposition, Decomposition, Implications of Different Decompositions | 3 |
| 2.2 | Challenges, Parallel Programming Patterns, Motivating Problem: An Error Diffusion Algorithm | 3 |
| 2.3 | Alternate Approach: Parallel Error Diffusion and other alternatives | 2 |
| Module – 3: Threading and Parallel Programming Constructs | | |
| 3.1 | Synchronization, Critical Sections, Deadlock, Synchronization Primitives, Semaphores, Locks, Messages, Flow Control- Based Concepts, Fence, Barrier, Implementation-Dependent Threading Features. | 3 |
| 3.2 | Threading APIS For Microsoft Windows, Win32/MFC Thread APIS, Threading APIS For Microsoft. NET Framework | 2 |
| 3.3 | Creating Threads, Managing Threads, Thread Pools, Thread Synchronization, POSIX Threads | 2 |
| 3.4 | Signalling, Compilation and Linking | 1 |
| Module – 4: OpenMP - A Portable Solution For Threading | | |

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|---|---|---|
| 4.1 | Challenges in Threading A Loop, Loop-Carried Dependence, Data-Race Conditions, Managing Shared and Private Data, Loop Scheduling and Portioning | 2 |
| 4.2 | Effective Use of Reductions, Minimizing Threading Overhead, Work-Sharing Sections, Performance-Oriented Programming | 2 |
| 4.3 | Using Barrier and No Wait, Interleaving Single-Thread And Multi-Thread Execution, Data Copy-In and Copy-Out, Protecting Updates of Shared Variables | 2 |
| 4.4 | Intel Task Queuing Extension to OpenMP, OpenMP Library Functions, OpenMP Compilation, Debugging, Performance | 2 |
| Module -5 | | |
| 5.1 | Too Many Threads, Data Races, Deadlocks, And Live Locks, Heavily Contended Locks, Priority Inversion, Solutions For Heavily Contended Locks, Non-Blocking Algorithms, ABA Problem | 2 |
| 5.2 | Cache Line Ping-Ponging, Memory Reclamation Problem, Recommendations, Thread-Safe Functions and Libraries, Memory Issues, Bandwidth, Working in The Cache, Memory Contention, Cache-Related Issues, | 3 |
| 5.3 | False Sharing, Memory Consistency | 1 |
| 5.4 | Current IA-32 Architecture, Itanium Architecture, High-Level Languages, Avoiding Pipeline Stalls On IA-32 | 2 |
| **Total No. of Lecture Hours** | | **40** |

**Suggested Learning Resources:**

https://www.youtube.com/playlist?list=PLwdnzlV3ogoU0TR333JyxG8T3HDg52_S0h (John Jose)

**Text Books:**

1. Multicore Programming, Increased Performance through Software Multithreading, by Shameem Akhter and Jason Roberts, Intel Press, 2006
2. Computer Architecture A Quantitative Approach, by Hennessey and Patterson, 4thEdition, Elsevier, 2012
3. Advanced Computer Architecture - Parallelism, Scalability, Programmability by Kai Hwang, Naresh Jotwani, Tata McGraw Hill, 2nd Edition, 2011.

**Course Code: BEC654D** **Course: Introduction to VLSI**

**Credits: 3** **L: T: P: 3:0:0**

**SEE: 50% Marks** **CIE:50% Marks**

**SEE Hours: 3 hrs** **Max.Marks:100**

| Prerequisites if any | NIL |
|---|---|

**Course Outcomes:**

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

| COs | Course Outcomes | Bloom's level |
|---|---|---|
| CO1 | Summarize on Digital system design | L1 |
| CO2 | Understand the construction, Design, Analyse the Digital circuit through testing and verification in different phases of the design cycle | L2 |
| CO3 | Verify the design of combinational and sequential circuits using Verilog HDL | L2 |

**Mapping with POs and PSOs:**

| COs | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 | PSO3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | 3 | 2 | 1 | 1 | | | | | | | | 2 | 2 | | 2 |
| CO2 | 3 | 2 | 1 | 1 | | | | | | | | 2 | 2 | | 2 |
| CO3 | 3 | 2 | 1 | 1 | | | | | | | | 2 | 2 | | 2 |
| CO4 | 3 | 2 | 1 | 1 | | | | | | | | 2 | 2 | | 2 |

3 – Strong 2 – Medium 1 – Low

**Course Structure**

| Module – 1: Review of Digital Circuits | | No. of Lecture Hours |
|---|---|---|
| 1.1 | Digital system design options and trade-offs, Number System, Boolean Algebra, | 2 |
| 1.2 | Demorgan's Theorem, Logic Gates, SOP and POS forms, MVP techniques, | 2 |
| 1.3 | Combinational circuits: Adders, Mux & Demux, | 2 |
| 1.4 | Sequential design: Latches, Flip-Flops, Counters (Synchronous and Asynchronous), state machine design: FSM, | 2 |
| Module – 2 : Introduction | | |
| 2.1 | VLSI design Flow, Analog and Digital design flow, ASIC and FPGA design Flow and Y chart | 2 |
| 2.2 | Fabrication: Wafer Processing, oxidation, Epitaxial, deposition, Ion-implantation and Diffusion, Silicon gate process, n-well & p- well process, Twin-tube process. | 4 |
| 2.3 | Design of digital circuits using Switch & Gate logic and CMOS logic | 2 |
| Module – 3: Introduction to Verilog | | |
| 3.1 | Introduction to Verilog and Dataflow descriptions: Program structure, Logic systems | 2 |
| 3.2 | Nets, Variables and Constants, Vectors and Operators, Arrays, Logical operators, and expressions | 2 |
| 3.3 | Dataflow Design elements: Continuous assignments, delay specification | 2 |
| 3.4 | expressions, rise, fall, and turn-off delays, Structural description | 2 |
| Module – 4: Behavioural Description | | |
| 4.1 | Behavioural Design elements: Structured procedures, initial and always | 2 |
| 4.2 | blocking and non-blocking statements, | 1 |
| 4.3 | Delay control, generate statement, event control | 1 |
| 4.4 | Conditional statements, multiway branching, loops, sequential and parallel blocks, Simulation, Test benches | 2 |

| | | |
|---|---|---|
| 4.5 | ASM charts, FSM code development, | 2 |
| | Module – 5: VLSI design Verification | |
| 5.1 | Introduction to Verification and Verification Plan, Verification Tools, Stimulus and Response | 2 |
| 5.2 | Introduction to UVM: UVM Classes, UVM Factory, Sequence Item, Sequencer, Virtual Sequences, Transaction Level Modelling, UVM Reporting Methods, Development of Reusable Verification Environment | 3 |
| 5.3 | Introduction to formal methods for design verification, Introduction and Basic Operations on Temporal Logic, Syntax and Semantics of CLT, Equivalences checking, Introduction to Model Checking, Introduction to Binary Decision Diagram. | 3 |
| **Total No. of Lecture Hours** | | **40** |

Text Books:

1. Neil H E Weste and Kamran Eshraghian, "Principles of CMOS VLSI design, A system perspective," 2nd edition, Addison Wesley. (Module 2)
2. UVM reference Manual (Module 5)
3. M. Morris Mano, Michael D. Ciletti, "Digital Design with an Introduction to the Verilog HDL", 5th Edition. (Module-1)
4. Samir Palnitkar, "Verilog HDL", Published by Pearson Education 2003.(Module 3 & 4)

Suggested Learning Resources:

https://www.youtube.com/watch?v=H34hLpUU9PA

**Course Code: BEC654E**

**Course: Introduction to Radar Systems for Autonomous Driving**

**Credits: 3** **L: T: P: 3:0:0**

**SEE: 50% Marks** **CIE:50% Marks**

**SEE Hours: 3 hrs** **Max.Marks:100**

| | |
|---|---|
| Prerequisites if any | |
| Learning objectives | • Learn principles of radar systems.<br>• To use radar techniques for target detection and tracking in autonomous driving scenario.<br>• To understand real-world case studies and applications of radar and Lidar systems in autonomous cars, including adaptive cruise control (ACC), collision avoidance, pedestrian detection, and intersection management.<br>• To learn principles of LiDAR systems. |

**Course Outcomes:**

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

| COs | Course Outcomes | Bloom's level |
|---|---|---|
| CO1 | Explain working principle of radar systems | L2 |
| CO2 | Understand radar techniques for target detection and tracking in autonomous driving scenario. | L2 |
| CO3 | Understand real-world case studies and applications of radar systems in autonomous cars, including adaptive cruise control (ACC), collision avoidance, pedestrian detection and intersection management. | L2 |
| CO4 | Explain working principles of LiDAR systems | L2 |

Mapping with POs and PSOs:

| COs | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 | PSO3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | 3 | 3 | 2 | 2 | | | | | 3 | | 2 | | 3 | 2 | |
| CO2 | 3 | 3 | 2 | 2 | | | | | 3 | | 2 | | 3 | 2 | |
| CO3 | 3 | 3 | 2 | 2 | | | | | 3 | | 2 | | 3 | 2 | |
| CO4 | 3 | 3 | 2 | 2 | | | | | 3 | | 2 | | 3 | 2 | |

3 – Strong 2 – Medium 1 – Low

**Course Structure**

| Module – 1: Fundamentals of Radar Systems | | No. of Lecture Hours |
|---|---|---|
| 1.1 | Introduction, Essential Functions of Radar, Radar System Fundamentals, | 2 |
| 1.2 | Antennas for Radar Measurements, Challenges for Automotive Radar Developers (Basic level) | 2 |
| 1.3 | Mathematical model of Radar Range Equation (Basic level) | 2 |
| 1.4 | Radar Equation for Automotive Applications. (Basic level) | 2 |
| Module – 2: FMCW Radars | | |
| 2.1 | Fundamentals, Block diagram of FMCW radars, Range and Velocity measurement using FMCW radars, (Basic level) | 4 |
| 2.2 | Range resolution, velocity resolution, Application of FMCW radars for Autonomous driving, Case Study: TI FMCW Radar. (Basic level) | 4 |
| Module – 3: LiDAR for Autonomous Driving | | |
| 3.1 | Introduction to LiDAR, Types of LiDAR, Components and architecture of a typical LiDAR system, Role of LiDAR in autonomous vehicles (Basic level) | 4 |
| 3.2 | Object detection and classification using LiDAR, Range measurement using LiDAR, Current limitations and challenges in LiDAR technology | 4 |
| Module – 4: Modern Radar Sensors | | |

| | | |
|---|---|---|
| 4.1 | Modern Radar Sensors in Advanced Automotive Architectures: Motivation for Advanced Systems, The Evolving Automotive Radar Landscape, Vehicle Network and Compute Considerations, Design Considerations for Automotive Radar. (Fundamentals level) | 4 |
| 4.2 | Vehicle Network and Compute Considerations, Design Considerations for Automotive Radar. (Fundamentals) | 4 |
| | Module – 5: Automotive Radar Applications | |
| 5.1 | Introduction, Short-Range Radar (SRR, Long-Range Radar (LRR), Trends in Automotive Applications (Basics) | 4 |
| 5.2 | Future Roadmaps Automotive Applications, Future Contributions of Automotive Applications (Basics) | 4 |
| **Total No. of Lecture Hours** | | **40** |

**Suggested Learning Resources:**

**Text Books:**

1. Jonah Gamba "Radar Signal Processing for Autonomous Driving", Springer, 2020
2. Matt Markel" Radar for Fully Autonomous Driving", Artech House, 2022.

**Reference Books:**

1. Merrill I. Skolnik Handbook of Radar Systems, McGraw Hill; 3rd edition, 2008.
2. Pinliang Dong LiDAR Remote Sensing and Applications, CRC Press, 2017.

**E-Resources:**

1. https://www.coursera.org/specializations/self-driving-cars.
2. https://www.edx.org/course/self-driving-cars-with-duckietown

**Course Code: BEC605** **Course: Wireless Communication**

**Credits: 3** **L: T: P: 3:0:0**

**SEE: 50% Marks** **CIE:50% Marks**

**SEE Hours: 3 hrs** **Max.Marks:100**

| | |
|---|---|
| Prerequisites if any | Linear Algebra, Signal Processing, Communication |
| Learning objectives | Students will be able to learn:<br>• To understand the issues involved in mobile communication system design and analysis in terms of fading.<br>• To understand the concept of frequency reuse capacity and Spectrum Sharing.<br>• To know the fundamentals of MIMO and OFDM wireless channels.<br>• To Know the basics of LTE Networks |

**Course Outcomes:**

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

| COs | Course Outcomes | Bloom's level |
|---|---|---|
| CO1 | Review and classify the different generations of wireless cellular communication systems and fading concepts. | L1 |
| CO2 | Apply and study the cellular communication concepts to identify the cellular capacity. | L3 |
| CO3 | Apply and examine the multiple antennas systems using symbolic representations to further enhance wireless capacity. | L3 |
| CO4 | Research on Multicarrier modulation (OFDM) and its implementation for a better utilization of wireless system. | L4 |
| CO5 | Understand the basics of LTE Network Architecture. | L2 |

**Mapping with POs and PSOs:**

| COs | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 | PSO3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | 3 | 3 | 2 | - | 2 | | | | 1 | | 2 | 2 | 2 | 2 | 3 |
| CO2 | 3 | 2 | 3 | - | 2 | | | | 1 | | 2 | 2 | 2 | 2 | 3 |
| CO3 | 3 | 2 | 2 | - | 3 | | | | 1 | | 2 | 2 | 2 | 2 | 3 |
| CO4 | 3 | 3 | 3 | - | 2 | | | | 1 | | 2 | 2 | 2 | 2 | 3 |
| CO5 | 3 | 2 | 3 | - | 3 | | | | 1 | | 2 | 2 | 2 | 2 | 3 |

3 – Strong 2 – Medium 1 – Low

**Course Structure**

| Module – 1 | | No. of Lecture Hours |
|---|---|---|
| 1.1 | Different generations of wireless cellular networks: 1G cellular systems, 2G cellular systems, 2.5G cellular systems, 3G cellular systems, 4G cellular systems and beyond, wireless standard organizations, | 2 |
| 1.2 | Small Scale Fading: Small Scale Multipath Propagation, Impulse Response Model of a Multipath Channel, | 2 |
| 1.3 | Small Scale Multipath Measurements, Parameters of Mobile Multipath Channels, | 3 |
| 1.4 | Types of Small-Scale Fading, Rayleigh, and Rician Distributions. | 2 |
| Module – 2 | | |
| 2.1 | Mobile Communication Concepts: Introduction, Concept of cellular communications, Cell Fundamentals, Frequency Reuse concepts, Concept of cell cluster, | 2 |
| 2.2 | Cellular layout for frequency reuse, Geometry of hexagonal cell, Frequency Reuse Ratio, Co-channel, and Adjacent Channel Interference, | 2 |
| 2.3 | Various mechanisms for capacity increase, Cell Splitting, Sectoring, Microcell Zone Concept, Channel Assignment Strategies, Handoff Strategies. | 3 |
| Module – 3 | | |

| | | |
|---|---|---|
| 3.1 | Multiple Antennas: Narrowband MIMO Model, Parallel Decomposition of the MIMO Channel, | 4 |
| 3.2 | MIMO Channel Capacity, | 2 |
| 3.3 | MIMO Diversity Gain: Beamforming, Diversity-Multiplexing Trade-offs, Frequency-Selective MIMO Channels, Smart Antennas | 2 |
| Module – 4 | | |
| 4.1 | Multicarrier Modulation: Data Transmission using Multiple Carriers, Multicarrier Modulation with Overlapping Subchannels, | 3 |
| 4.2 | Mitigation of Subcarrier Fading, Discrete Implementation of Multicarrier Modulation, | 3 |
| 4.3 | Challenges in Multicarrier Systems | 2 |
| Module – 5 | | |
| 5.1 | Overview and Channel Structure of LTE: Introduction to LTE, Channel Structure of LTE, | 3 |
| 5.2 | Downlink OFDMA Radio Resource, | 3 |
| 5.3 | Uplink SC-FDMA Radio Resource. | 2 |
| **Total No. of Lecture Hours** | | **40** |

**Suggested Learning Resources:**

NPTEL :: Electronics & Communication Engineering - Wireless Communication □

SWAYAM: Introduction to Wireless and Cellular Communications - Course (nptel.ac.in) □

Virtual Labs: Fading Channels and Mobile Communications (iitkgp.ac.in)

**Textbooks:**

1. Andrea Goldsmith, “Wireless Communications,”1st edition, Cambridge University Press, 2005
2. Sanjay Sharma, “Wireless Cellular Communications,” 2nd Edition, Katson, 2007.
3. Rappaport Theodore, “Wireless Communications: Principles and Practice,” 2nd Edition, Pearson Education India, 2009.

4. Mullet, “Introduction to Wireless Telecommunications Systems and Networks,” 6thEdition, Cengage Learning, 2010.

**Reference books:**

1. William C.Y. Lee, “Wireless & cellular Telecommunication systems,” 3rd edition, McGraw Hill, 2006
2. Arunabha Ghosh, Jan Zhang, Jefferey Andrews, Riaz Mohammed, “Fundamentals of LTE,” 1st edition, Pearson, 2010

**Course Code: BEC606** **Course: Principles of Digital VLSI**

**Credits: 3** **L:T:P – 3:0:0**

**CIE: 50% Marks** **SEE: 50% Marks**

**SEE Hours: 3 Hrs** **Max. Marks: 100**

| | |
|---|---|
| Prerequisites if any | Digital Electronics and Circuit Theory |
| Learning objectives | Students will be able to<br>• Understand IC fabrication process<br>• Understand various design aspects of CMOS inverter, CMOS logic families<br>• Design combinational & sequential circuits.<br>• Understand the basic concepts of design verification & testing |

**Course Outcomes:**

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

| COs | Course Outcomes | Bloom's level |
|---|---|---|
| CO1 | Understand the fabrication process, layout design rules, technology scaling and design aspects of a CMOS Inverter. | L2 |
| CO2 | Sketch the stick diagrams and Layout diagram. | L3 |
| CO3 | Design combinational, sequential logic circuits and realize logic functions using various logic families. | L3 |
| CO4 | Analyze verification and testing aspects of Digital Circuits | L3 |

**Mapping with POs and PSOs:**

| COs | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 | PSO3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | 3 | | | | | | | | | | | 2 | 3 | | |
| CO2 | 3 | 3 | | | | | | | | | | 2 | 3 | | |
| CO3 | 3 | 3 | 3 | | | 3 | 3 | | | | | 2 | 3 | | |
| CO4 | 3 | | | | | | | | | | | 2 | 3 | | |

3 – Strong 2 – Medium 1 – Low

**Course Structure**

| Module – 1 : Introduction & CMOS Inverter | | No. of Lecture Hours |
|---|---|---|
| 1.1 | Digital VLSI Design Flow, Y Chart | 1 |
| 1.2 | Fabrication: Wafer Processing, Oxidation, Epitaxial deposition, Ion-implantation and Diffusion, Silicon gate process, n-well & p-well process, Twin-tube process, CMOS Process Enhancements. | 1 |
| 1.3 | Static Load Inverter DC Characteristics, CMOS Inverter DC Characteristics, Switching Threshold ($V_M$), Effect of $\beta_n/\ \beta_p$ variation on Characteristics, Noise Margin ($NM_H$, $NM_L$) | 4 |
| 1.4 | Inverter Capacitances, Switching Characteristics ($t_r$, $t_f$, $t_p$), Sizing a chain of inverters, Power & Energy Consumption | 2 |
| Module – 2: Logic Families, Layout & Scaling | | |
| 2.1 | CMOS Logic, Pseudo NMOS logic, Bi-CMOS Logic, Dynamic CMOS Logic, Clocked CMOS Logic, CMOS Domino Logic, NP Domino Logic, CVSL, Pass Transistor Logic, Transmission Gate Logic, Elmore delay model, Logical effort, Transistor sizing for optimizing area, power & delay. | 4 |
| 2.2 | Stick Diagrams, λ based layout design rules, Layouts, Resistance, Capacitance & Inductance estimation, Latch up problem, Standard Cell Design. | 4 |
| 2.3 | Scaling, Scaling Models & factors, Scaling factors for device parameters, Limitations of scaling | 2 |
| Module – 3: Combinational & Sequential Logic Circuits | | |
| 3.1 | Adders (CSA, CLA, Tree Adder) | 2 |
| 3.2 | Multipliers (Baugh-Wooley, Booth & Wallace Tree) | 2 |
| 3.3 | Latches & Registers (Static & Dynamic) | 2 |
| 3.4 | Memory (ROM, SRAM, DRAM), Memory Peripheral Circuitry (Row/Column Decoders & Read/Write Circuitry) | 2 |
| Module – 4: Design Verification | | |

| | | |
|---|---|---|
| 4.1 | Introduction to Verification and Verification Plan, Verification Tools, Stimulus and Response | 2 |
| 4.2 | Introduction to UVM<br>· UVM Classes<br>· UVM Factory<br>· Sequence Item, Sequencer, Virtual Sequences<br>· Transaction Level Modelling<br>· UVM Reporting Methods<br>· Development of Reusable Verification Environment | 2 |
| 4.3 | Introduction to formal methods for design verification, Introduction and Basic Operations on Temporal Logic, Syntax and Semantics of CLT, Equivalences checking, Introduction to Model Checking, Introduction to Binary Decision Diagram. | 2 |
| Module – 5 : Testing & Testability | | |
| 5.1 | Introduction to Testing - Need for testing , Faults in digital circuits, Modelling of faults and its logics, Fault detection, Logic Simulation, ATPG | 2 |
| 5.2 | Test generation for combinational logic circuits (Only Basic), Test generation for sequential circuits (Only Basic) | 2 |
| 5.3 | Design for testability: Ad-Hoc testing, scan based test techniques, BIST, IDDQ Testing | 3 |
| 5.4 | Fault Diagnosis for Combinational Circuits | 1 |
| **Total No. of Lecture Hours** | | **40** |

Suggested Learning Resources:

**Textbooks:**

1. Neil H E Weste and Kamran Eshraghian, “Principles of CMOS VLSI design, A system perspective”, 4th edition, Addison Wesley.
2. Jan M. Rabaey, Anantha Chandrakasan, and Borivoje Nikolic, “Digital Integrated Circuits:A Design Perspective”, 2nd Edition, PHI Learning
3. Douglas A Pucknell and Kamran Eshraghian, “Basic VLSI design”, 3rd Edition, PHI Learning.

4. M. Abramovici, M.A. Breuer and A.D. Friedman, "Digital Systems and Testable Design", Jaico Publishing House.
5. 5.UVM reference Manual

Reference Books:

1. Eugene D. Fabricius, “Introduction to VLSI design”, McGraw-Hill, 1990
2. S.M. Kang and Y. Leblebici, “CMOS Digital Integrated Circuits”, McGraw-Hill.
3. M.L. Bushnell and V.D. Agrawal, "Essentials of Electronic Testing for Digital, Memory and Mixed-Signal VLSI Circuits", Kluwer Academic Publishers.

**Course Code: BECL607** **Course: VLSI Lab**

**Credits: 3** **L: T: P: 0:0:2**

**SEE: 50% Marks** **CIE:50% Marks**

**SEE Hours: 2 hrs** **Max. Marks: 50**

| | |
|---|---|
| Prerequisites if any | Digital Electronics & Circuit Theory |
| Learning objectives | Students will be able to<br>• Understand the dc and transient analysis of digital gates<br>• Understand the dc, transient and ac analysis of analog circuits<br>• Understand the layout design rule using Design Rule Check & Layout versus Schematic and the parasitic associated with layout<br>• Implement the layout of digital & analog circuits |

**Course Outcomes:**

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

| COs | Course Outcomes | Bloom's level |
|---|---|---|
| CO1 | Design & simulate various digital & analog circuits | L3 |
| CO2 | Implement the layout of various digital & analog circuits | L3 |

**Mapping with POs and PSOs:**

| COs | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | | PSO1 | PSO2 | PSO3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | 3 | 3 | 3 | 3 | 3 | | 3 | | 3 | | 3 | 2 | | 3 | 3 | 2 |
| CO2 | 3 | 3 | 3 | 3 | 3 | | 3 | | 3 | | 3 | 2 | | 3 | 3 | 2 |

3 – Strong 2 – Medium 1 – Low

**List of Experiments**

| Sl. No | Part 1 : Schematic Design & Simulation | No. of Practical Sessions |
|---|---|---|
| 1.1 | Analyze the DC characteristics, Switching Characteristics, Noise Margin and Power Consumption of CMOS Inverter by varying the transistor sizing. | 2 |
| 1.2 | Analyze the DC characteristics, Switching Characteristics and Power Consumption of NAND gate by varying the transistor sizing | 1 |
| 1.3 | Analyze the logic design using Pass transistor logic with & without logic restoration | 1 |
| 1.4 | Design an inverter chain with optimum number of stages and sizing of transistors in order to reduce the propagation delay while driving a larger capacitive load. | 1 |
| 1.5 | Analyze a CS Amplifier (DC, Transient & AC analysis). | 1 |
| 1.6 | Analyze a two stage Operational Amplifier (DC, Transient & AC analysis) | 1 |
| Part 2 : Layout Design & Post Layout Simulation | | |
| 2.1 | Implement the layout of the above circuits. Verify DRC, LVS and perform RC-parasitic extraction. Perform post layout simulation and compare it with schematic simulation. | 5 |
| 2.2 | Design Project | 2 |
| **Total No. of Practical Sessions** | | **14** |

**Course Code: BEC657L** **Course: Python for Machine Learning**

**Credits: 1** **L: T: P: 1:0:0**

**SEE:** **CIE:50 Marks**

**SEE Hours:** **Max. Marks: 50**

| | |
|---|---|
| Prerequisites if any | Python Programming Basics and Mathematics for Machine Learning |
| Learning Objectives | • Understand Core Python Concepts<br>• Handle and Manipulate Data<br>• Visualize Data |

**Course Outcomes:**

On the successful completion of the course, the student will be able to

| COs | Course Outcomes | Bloom's level |
|---|---|---|
| CO1 | Apply Python programming and data handling skills to prepare and pre-process datasets for machine learning tasks. | L3 |
| CO2 | Build and evaluate machine learning models using Scikit-learn to solve classification, regression, and clustering problems. | L3 |
| CO3 | Interpret machine learning results and communicate insights using data visualization and performance metrics. | L3 |

**Mapping with POs and PSOs:**

| COS | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 | PSO3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | 3 | 2 | | | 3 | | | | 1 | 1 | | 1 | 3 | 3 | |
| CO2 | 3 | 3 | 3 | 3 | 3 | | | | 1 | 1 | | 1 | 3 | 3 | |
| CO3 | 3 | 3 | 3 | 3 | 3 | | | | 1 | 1 | | 1 | 3 | 3 | |

Mapping Strength: Strong– 3 Medium – 2 Low – 1

**Course Structure**

| Module – 1: Data analysis and Exploration | | No. of Lecture Hours |
|---|---|---|
| 1.1 | Introduction to Data Analysis & visualization | 1 |
| 1.2 | Numpy arrays and mathematical operations | 1 |
| 1.3 | Panda utilization for analysis of data | 4 |
| 1.4 | Matplotlib visualization, Scipy operations for scientific analysis | 2 |
| Module – 2: Introduction to Machine learning | | |
| 2.1 | Introduction to machine learning | 2 |
| 2.2 | Supervised machine learning, Unsupervised machine learning | 4 |
| 2.3 | Reinforcement machine learning, Classification and Regression | 4 |
| Module – 3: Applications of machine learning | | |
| 3.1 | K-Nearest neighbor | 2 |
| 3.2 | K-Means clustering | 2 |
| 3.3 | Logistic Regression, Support Vector Machines (SVM) | 2 |
| 3.4 | Decision Tree algorithms | 2 |
| **Total No. of Lecture Hours** | | **26** |

**Text book:**

1. Python Programming- A modular Approach (with Graphics, database, Mobile and Web Applications by Sheetal Taneja and Naveen Kumar, Pearson.
2. Machine Learning an algorithmic Perspective by Stephen Marshland

**Reference Books:**

1. Beginning Programming with Python Dummies by John Paul Meuller.
2. Introduction to Machine Learning with python by Andreas C Muller, Sarah Guido.

**Course Code: BEC657L** **Course: E-waste management**

**Credits: 1** **L: T: P: 1:0:0**

**SEE:** **CIE:50 Marks**

**SEE Hours:** **Max. Marks: 50**

| | |
|---|---|
| Prerequisites if any | Basic Environmental Science Awareness, Knowledge of Electronic Devices and Materials and Awareness of E-Waste Issues. |
| Learning Objectives | • Understand the Scope and Impact of E-Waste<br>• Analyze the Composition and Lifecycle of Electronic Products<br>• Learn E-Waste Management Strategies and Technologies |

**Course Outcomes:**

On the successful completion of the course, the student will be able to

| **COs** | **Course Outcomes** | **Bloom's level** |
|---|---|---|
| CO1 | Identify and analyze various types of electronic waste and assess their environmental and health impacts. | L2 |
| CO2 | Apply appropriate methods and technologies for the collection, recycling, and safe disposal of e-waste. | L2 |
| CO3 | Interpret and evaluate national and international e-waste policies, and propose sustainable management strategies based on regulatory frameworks. | L2 |

**Mapping with POs and PSOs:**

| COS | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 | PSO3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | 3 | 2 | | | 3 | | | | 1 | 1 | | 1 | 3 | 3 | |
| CO2 | 3 | 3 | 3 | 3 | 3 | | | | 1 | 1 | | 1 | 3 | 3 | |
| CO3 | 3 | 3 | 3 | 3 | 3 | | | | 1 | 1 | | 1 | 3 | 3 | |

Mapping Strength: Strong– 3 Medium – 2 Low – 1

**Course Structure**

| Module – 1 | | No. of Lecture Hours |
|---|---|---|
| 1.1 | Introduction, Electronic waste Environment and society | 1 |
| 1.2 | Current and new electronic waste recycling techniques | 1 |
| 1.3 | Materials used in manufacturing electrical and electronic product | 4 |
| 1.4 | Dumping, burning, and landfill, recycling and recovery | 2 |
| Module – 2 | | |
| 2.1 | Integrated approach to e-waste recycling management | 2 |
| 2.2 | key learning from around the world current international flows of electronic wastes | 4 |
| 2.3 | future perspectives on electronic scrap | 4 |
| Module – 3 | | |
| 3.1 | Case Studies | 8 |
| **Total No. of Lecture Hours** | | **26** |

**Text Books:**

1. Hester, Ronald E and Roy M Harrison, Electronic waste management. V.27, Royal society of chemistry, 2009

2. Hieronymi, Klaus, Ramzu Kahhat and Eric Williams eds. E-waste management: From waste to resource. Routledge, 2012

**Course Code: BEC657L** **Course: PCB Design and Fabrication**

**Credits: 1** **L: T: P: 0:0:2**

**SEE: -** **CIE:50 Marks**

**SEE Hours: -** **Max. Marks: 50**

| | |
|---|---|
| Prerequisites if any | Knowledge of analog and digital circuits |
| Learning Objectives | • The need for PCB Design and steps involved in PCB design and fabrication process.<br>• To familiarize schematic and layout design flow using Electronic Design Automation (EDA) Tools. |

**Course Outcomes:**

On the successful completion of the course, the student will be able to

| COs | Course Outcomes | Bloom's level |
|---|---|---|
| CO1 | Understand the steps involved in schematic, layout, fabrication, and assembly process of PCB design. | L1 |
| CO2 | Design (schematic and layout) PCB for analog circuits, and digital circuits. | L4 |
| CO3 | Design (schematic and layout) and fabricate PCB for simple circuits. | L4 |

**Mapping with POs and PSOs:**

| COS | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 | PSO3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | 3 | 2 | | | 3 | | | | 1 | 1 | | 1 | 3 | 3 | |
| CO2 | 3 | 3 | 3 | 3 | 3 | | | | 1 | 1 | | 1 | 3 | 3 | |
| CO3 | 3 | 3 | 3 | 3 | 3 | | | | 1 | 1 | | 1 | 3 | 3 | |

Mapping Strength: Strong– 3 Medium – 2 Low – 1

**Course Structure**

| List of Experiments | | No. of Practical Hours |
|---|---|---|
| 1 | Introduction to PCB design steps of Schematic design, layout design, create new schematic components and component footprint. | 2 |
| 2 | Regulator circuit using 7805 | 2 |
| 3 | Full-wave Rectifier | 2 |
| 4 | Astable multivibrator using IC555 | 2 |
| 5 | Monostable multivibrator using IC555 | 2 |
| 6 | Full-Adder using half-adders. | 2 |
| 7 | Design an 8051-development board having serial communication section consisting of Max232 capacitor, DB9 connector, jumper, and LED. | 2 |
| 8 | Fabricate single-sided PCB, mount the components, and assemble in a cabinet for any one of the circuits mentioned above. - 1 | 2 |
| 9 | Fabricate single-sided PCB, mount the components, and assemble in a cabinet for any one of the circuits mentioned above. - 2 | 2 |
| 10 | Identification of various types of PCB and soldering techniques | 2 |
| **Total No. of Practical Hours** | | **20** |

Tools: OrCAD / NI Multisim / Proteus 8 / TINAPRO / KiCad

Text books:

1. Printed Circuit Board by RS Khandpur, Tata McGraw Hill Education Pvt Ltd., New Delhi
2. Electronic Product Design Volume-I by S D Mehta, S Chand Publications Online Resources
3. Open source EDA Tool KiCad Tutorial: http://kicad-pcb.org/help/tutorials/

4. PCB Fabrication user guide page: http://www.wikihow.com/Create-Printed-Circuit-Boards
5. PCB Fabrication at home(video): https://www.youtube.com/watch?v=mv7Y0A9YeUc, https://www.youtube.com/watch?v=imQTCW1yWkg