# SEMESTER 5

## ELECTRONICS & COMMUNICATION ENGINEERING

## SEMESTER S5

# ELECTROMAGNETICS

| Course Code | PCECT501 | CIE Marks | 40 |
|---|---|---|---|
| Teaching Hours/Week (L: T:P: R) | 3:1:0:0 | ESE Marks | 60 |
| Credits | 4 | Exam Hours | 2Hrs. 30 Min. |
| Prerequisites (if any) | Physics for Electrical sciences (GBPHT121) | Course Type | Theory |

**Course Objectives:**

1. To impart knowledge on the basic concepts of electric and magnetic fields and its applications.

## SYLLABUS

| Module No. | Syllabus Description | Contact Hours |
|---|---|---|
| 1 | Review of coordinate system-Rectangular, cylindrical and spherical coordinate systems. Review of vector calculus- curl, divergence gradient. Review of Coulomb's law, Gauss's law and Ampere's current law. Derivation of capacitance and inductance of two wire transmission line and coaxial cable. Magnetic scalar and vector potential. Poisson and Laplace equations, Determination of voltage and electric field using Laplace and Poisson's equation. | 12 |
| 2 | Maxwell's equation from fundamental laws. Boundary condition of electric field and magnetic field from Maxwell's equations. Solution to wave equation Propagation of plane EM wave in perfect dielectric, lossy medium, good conductor, skin depth. Polarization of waves. | 10 |
| 3 | Reflection and refraction of plane electromagnetic waves at boundaries for normal & oblique incidence (parallel and perpendicular polarization), Snell's law of refraction, Brewster angle. Power density of EM wave, Poynting | 10 |

| | | |
|---|---|---|
| | vector theorem. | |
| **4** | Transmission line as circuit elements (L and C). Transmission line equations and characteristic impedance. Reflection coefficient and VSWR. Derivation of input impedance of transmission line. Calculation of line impedance and VSWR using smith chart. The hollow rectangular waveguide –TE and TM wave-dominant mode, group velocity and phase velocity –derivation and simple problems only. | **12** |

## Course Assessment Method
## (CIE: 40 marks, ESE: 60 marks)

**Continuous Internal Evaluation Marks (CIE):**

| Attendance | Assignment/ Microproject | Internal Examination-1 (Written) | Internal Examination- 2 (Written ) | Total |
|---|---|---|---|---|
| **5** | **15** | **10** | **10** | **40** |

**End Semester Examination Marks (ESE)**

*In Part A, all questions need to be answered and in Part B, each student can choose any one full question out of two questions*

| Part A | Part B | Total |
|---|---|---|
| ● 2 Questions from each module.<br>● Total of 8 Questions, each carrying 3 marks<br>**(8x3 =24 marks)** | ● Each question carries 9 marks.<br>● Two questions will be given from each module, out of which 1 question should be answered.<br>● Each question can have a maximum of 3 sub divisions.<br>**(4x9 = 36 marks)** | **60** |

## Course Outcomes (COs)

At the end of the course students should be able to:

| Course Outcome | | Bloom's Knowledge Level (KL) |
|---|---|---|
| **CO1** | Summarize the basic mathematical concepts related to electromagnetic vector fields. | **K2** |
| **CO2** | Apply Maxwell's equations in different forms to diverse electromagnetic problems. | **K3** |
| **CO3** | Analyze reflection, refraction and power density of electromagnetic waves. | **K3** |
| **CO4** | Analyse the propagation of EM waves in transmission lines and wave guides. | **K3** |

Note*: K1- Remember, K2- Understand, K3- Apply, K4- Analyse, K5- Evaluate, K6- Create*

**CO-PO Mapping Table:**

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

| Text Books | | | | |
|---|---|---|---|---|
| **Sl. No** | **Title of the Book** | **Name of the Author/s** | **Name of the Publisher** | **Edition and Year** |
| **1** | Elements of Electromagnetics | Matthew N. O. Sadiku | Oxford University Press | 7th edition, 2018 |
| **2** | Engineering Electromagnetics | William Hayt and John Buck | McGraw-Hill Higher Education | 9th edition, 2019 |
| **3** | Electromagnetic Waves and Transmission Lines | Y Mallikarjuna Reddy | The Orient Blackswan | 1st edition 2015 |

| Reference Books | | | | |
|---|---|---|---|---|
| **Sl. No** | **Title of the Book** | **Name of the Author/s** | **Name of the Publisher** | **Edition and Year** |
| 1 | Schaum's Outline of Elctromagnetics | Mahmood Nahvi; Joseph Edminister | McGraw-Hill | 5th edition, 2019 |
| 2 | Engineering Electromagnetics Essentials | B N Basu | The Orient Blackswan | 1st edition 2015 |

| Video Links (NPTEL, SWAYAM…) | |
|---|---|
| **Module No.** | **Link ID** |
| **1** | https://onlinecourses.nptel.ac.in/noc21_ee83/preview |
| **2** | https://onlinecourses.nptel.ac.in/noc21_ee83/preview |
| **3** | https://nptel.ac.in/courses/115101005 |
| **4** | https://archive.nptel.ac.in/courses/117/101/117101056/# |

## SEMESTER S5

# ANALOG AND DIGITAL COMMUNICATION

| Course Code | PCECT502 | CIE Marks | 40 |
|---|---|---|---|
| Teaching Hours/Week (L: T:P: R) | 3-1-0-0 | ESE Marks | 60 |
| Credits | 4 | Exam Hours | 2Hrs. 30 Min. |
| Prerequisites (if any) | PCECT402 Signals and Systems<br>GBMAT401 Probability, Random Process and Numerical Methods | Course Type | Theory |

**Course Objectives:**

1. To analyse different analog and digital communication systems

## SYLLABUS

| Module No. | Syllabus Description | Contact Hours |
|---|---|---|
| 1 | Block diagram of a communication system. Need for modulation. Amplitude modulation, Equation and spectrum of AM signal, DSB-SC, SSB -pilot carrier and Vestigial sideband systems.<br>Angle modulation: Narrow and wide band FM and their spectra, relationship between FM and PM, Carson's rule, pre-emphasis and de-emphasis filtering. Comparison of AM and FM, Block diagram of FM receiver.<br>Superheterodyne receivers- Characteristics of receivers –image frequency.<br>Noise: external, internal, White noise. | 12 |
| 2 | Sampling and Quantization, SQNR for uniform quantization, Companding Pulse code modulation, Transmitter and receiver. DPCM transmitter and receiver. Delta modulation, Slope overload, Line codes. | 10 |
| 3 | Baseband data transmission of digital data through AWGN channel, Mathematical model of ISI, Nyquist criterion for zero ISI, Signal modelling for ISI, Raised cosine spectrum, Equalization,Zero forcing Equaliser.<br>Geometric representation of Signals-Gram-Schmitt procedure, Signal space. Vector model of AWGN channel.<br>Matched filter and correlation receivers, MAP receiver, Maximum likelihood | 12 |

| | | |
|---|---|---|
| | receiver. | |
| **4** | Digital band pass modulation schemes-BPSK system and signal constellation. BPSK transmitter and receiver. QPSK system and Signal constellations. BER analysis of BPSK and QPSK in erfc. Plots of BER Vs SNR. QPSK transmitter and receiver. Quadrature amplitude modulation and signal constellation. | **10** |

**Course Assessment Method**

**(CIE: 40 marks, ESE: 60 marks)**

**Continuous Internal Evaluation Marks (CIE):**

| Attendance | Assignment/ Microproject | Internal Examination-1 (Written) | Internal Examination- 2 (Written) | Total |
|---|---|---|---|---|
| **5** | **15** | **10** | **10** | **40** |

**End Semester Examination Marks (ESE)**

*In Part A, all questions need to be answered and in Part B, each student can choose any one full question out of two questions*

| Part A | Part B | Total |
|---|---|---|
| • 2 Questions from each module.<br>• Total of 8 Questions, each carrying 3 marks<br><br>**(8x3 =24 marks)** | • Each question carries 9 marks.<br>• Two questions will be given from each module, out of which 1 question should be answered.<br>• Each question can have a maximum of 3 sub divisions.<br>**(4x9 = 36 marks)** | **60** |

## Course Outcomes (COs)

At the end of the course students should be able to:

| Course Outcome | | Bloom's Knowledge Level (KL) |
|---|---|---|
| CO1 | Illustrate the principles of analog communication systems | **K2** |
| CO2 | Explain the basic concepts of digital communication | **K2** |
| CO3 | Analyse the baseband transmission of digital data through AWGN channel | **K3** |
| CO4 | Apply various digital modulation techniques in the design of digital communication systems | **K3** |

Note*: K1- Remember, K2- Understand, K3- Apply, K4- Analyse, K5- Evaluate, K6- Create*

**CO-PO Mapping Table:**

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

| **Text Books** | | | | |
|---|---|---|---|---|
| **Sl. No** | **Title of the Book** | **Name of the Author/s** | **Name of the Publisher** | **Edition and Year** |
| **1** | Communication Systems | Simon Haykin and Michael Moher | Wiley | 5th Edition, 2020 |
| **2** | Modern Digital and Analog Communication Systems | B.P. Lathi and Zhi Ding | Oxford University Press | 5th Edition, 2018 |
| **3** | Introduction to Analog and Digital Communication, An Indian adaptation | Simon Haykin and Michael Moher | Wiley | 2nd Edition, 2022 |

| Reference Books | | | | |
|---|---|---|---|---|
| **Sl. No** | **Title of the Book** | **Name of the Author/s** | **Name of the Publisher** | **Edition and Year** |
| **1** | Principles of Communication Systems | Herbert Taub and Donald L. Schilling | McGraw-Hill Education | 4th Edition, 2013 |
| **2** | Digital Communications | John G. Proakis and Masoud Salehi | McGraw-Hill Education | 6th Edition, 2020 |
| **3** | Communication Systems Engineering | John G. Proakis and Masoud Salehi | Pearson | 2nd Edition, 2001 |
| **4** | Digital Communications Systems, An Indian Adaptation | Simon Haykin | John Wiley& Sons | 4th Edition, 2021 |
| **5** | Electronic communication systems | George Kennedy | McGraw Hill | 6th Edition, 2017 |
| **6** | Introduction to Digital Communications | Wayne Stark | Cambridge University Press | 1st edition 2023 |

| Video Links (NPTEL, SWAYAM…) | |
|---|---|
| **Module No.** | **Link ID** |
| **1** | https://youtu.be/hTAlcrqjNps?si=okoRHdUegx9pbOz3 |
| **2** | https://youtu.be/s_vmLqT_6NQ?si=MF2OW6AaICiYKTfj |

## SEMESTER S5

# CONTROL SYSTEMS

| Course Code | PCECT503 | CIE Marks | 40 |
|---|---|---|---|
| Teaching Hours/Week (L: T:P: R) | 3-0-0-0 | ESE Marks | 60 |
| Credits | 3 | Exam Hours | 2Hr. 30 Min. |
| Prerequisites (if any) | GBMAT301 Mathematics for Electrical Science -3 | Course Type | Theory |

**Course Objectives:**

1. To study the elements of control system, modelling and perform stability analysis of systems.
2. To design control systems with compensating techniques.
3. To understand the state variable analysis method.

## SYLLABUS

| Module No. | Syllabus Description | Contact Hours |
|---|---|---|
| 1 | **Introduction:** Basic Components of Control Systems, Open-Loop and Closed-Loop Control Systems with examples.<br>**Mathematical modelling of control systems**: Electrical Systems and Mechanical translational systems.<br>**Transfer Function:** Block diagram reduction techniques, Signal flow graph, Mason's gain formula. | 8 |
| 2 | **Time Domain Analysis of Control Systems:** Standard Test signals, Time response of first order systems (unit impulse, step and ramp inputs) and second order systems (step input only). Time response of undamped, under damped, critically damped second order system to unit step signal, Time domain specifications for a second order underdamped system, Steady state error and static error coefficients. | 8 |
| 3 | **Stability of linear control systems**: Concept of BIBO stability, absolute stability, Routh Hurwitz Criterion.<br>**Root Locus Techniques**: Introduction, properties and its construction. | 12 |

| | | |
|---|---|---|
| | **Frequency domain analysis**: Frequency domain specifications<br>**Relative stability**: gain margin and phase margin. Stability analysis using Bode plot and Nyquist stability criterion.<br>**P, PI & PID controllers**: Introduction.<br>**Design of Compensators**: Need for compensators, lag and lead compensators using Bode plots(only design steps) | |
| **4** | **State Variable Analysis of Linear Systems:**<br>State variables, state equations, state variable representation of electrical systems. Transfer function from State equation, Solutions of the state equations, state transition matrix, Controllability and observability - Kalman's Test. | **8** |

## Course Assessment Method

## (CIE: 40 marks, ESE: 60 marks)

### Continuous Internal Evaluation Marks (CIE):

| Attendance | Assignment/ Microproject | Internal Examination-1 (Written) | Internal Examination-2 (Written) | Total |
|---|---|---|---|---|
| **5** | **15** | **10** | **10** | **40** |

### End Semester Examination Marks (ESE)

*In Part A, all questions need to be answered and in Part B, each student can choose any one full question out of two questions*

| Part A | Part B | Total |
|---|---|---|
| • 2 Questions from each module.<br>• Total of 8 Questions, each carrying 3 marks<br>**(8x3 =24marks)** | • Each question carries 9 marks.<br>• Two questions will be given from each module, out of which 1 question should be answered.<br>• Each question can have a maximum of 3 sub divisions.<br>**(4x9 = 36 marks)** | **60** |

## Course Outcomes (COs)

At the end of the course students should be able to:

| Course Outcome | | Bloom's Knowledge Level (KL) |
|---|---|---|
| **CO1** | Analyze the systems using transfer function approach | **K3** |
| **CO2** | Perform time domain analysis and steady state analysis of systems | **K2** |
| **CO3** | Determine the absolute stability and relative stability of a system using Routh Hurwitz Criterion and root locus | **K3** |
| **CO4** | Apply frequency domain techniques to assess the system stability and to design different compensation techniques | **K3** |
| **CO5** | Analyse system Controllability and Observability using state space representation | **K3** |

Note*: K1- Remember, K2- Understand, K3- Apply, K4- Analyse, K5- Evaluate, K6- Create*

**CO-PO Mapping Table:**

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

| Text Books | | | | |
|---|---|---|---|---|
| **Sl. No** | **Title of the Book** | **Name of the Author/s** | **Name of the Publisher** | **Edition and Year** |
| **1** | Control Systems Engineering | I.J. Nagarath, M. Gopal | New Age International Publishers | 7th Edition 2022 |
| **2** | Automatic Control Systems | Benjamin C. Kuo, Farid Golnaraghi, | Wiley | 10th Edition 2017 |
| **3** | Modern Control Engineering | Katsuhiko Ogata | Pearson | Fifth Edition 2015 |

| Reference Books | | | | |
|---|---|---|---|---|
| **Sl. No** | **Title of the Book** | **Name of the Author/s** | **Name of the Publisher** | **Edition and Year** |
| **1** | Feedback and Control Systems | Joseph DiStefano, Allen R. Stubberud, and Ivan J. Williams | McGraw Hill | Third Edition 2013 |
| **2** | Control systems | Ashok Kumar | Tata McGraw-Hill | Second Edition 2010 |
| **3** | Control Systems: Principles and Design | M Gopal | McGraw Hill Education | Fourth Edition 2012 |
| **4** | Nise's Control Systems Engineering | Norman S. Nise | Wiley India | 8th Edition 2017 |

| Video Links (NPTEL, SWAYAM…) | |
|---|---|
| **Module No.** | **Link ID** |
| **1** | https://youtu.be/Cl23xQrvFhk?feature=shared<br>https://youtu.be/fsxSst10_cE?feature=shared |
| **2** | https://youtu.be/cLyT6OWcmyU?feature=shared |
| **3** | https://youtu.be/CZL7_Z0i1KQ?feature=shared |
| **4** | https://youtu.be/CrXOMBlYFp0?feature=shared |

## SEMESTER S5

## DIGITAL SIGNAL PROCESSING

| Course Code | PBECT504 | CIE Marks | 60 |
|---|---|---|---|
| Teaching Hours/Week (L: T:P: R) | 3:0:0:1 | ESE Marks | 40 |
| Credits | 4 | Exam Hours | 2 Hrs. 30 Min. |
| Prerequisites (if any) | Signals & Systems PCECT402 | Course Type | Theory |

**Course Objectives:**

1. To describe signals mathematically and understand how to perform mathematical operations on signals
2. To gain knowledge of Digital filters

## SYLLABUS

| Module No. | Syllabus Description | Contact Hours |
|---|---|---|
| 1 | Review of sampling, Z-Transform and DTFT<br>The Discrete Fourier Transform: DFT as a linear transformation (Matrix Relation), IDFT, Properties of DFT and examples (proof not necessary).<br>Circular convolution, linear convolution using circular convolution, Filtering of long data sequences, overlap save and overlap add methods.<br>Frequency Analysis of Signals using the DFT (concept only required) | 9 |
| 2 | Design of FIR Filters - Symmetric and Anti-symmetric FIR Filters, Design of linear phase FIR filters using Window methods, (rectangular, Hamming and Hanning). Design of IIR Digital Filters from Analog Filters (Butterworth), IIR Filter Design by Impulse Invariance, and Bilinear Transformation, Frequency Transformations in the Analog Domain. | 9 |
| 3 | Structures for the realization of Discrete-Time Systems - Block diagram and signal flow graph representations of filters.<br>FIR Filter Structures: Linear structures, Direct Form.<br>IIR Filter Structures: Direct Form, Transposed Form, Cascade Form and Parallel Form.<br>Multi-rate Digital Signal Processing: | 9 |

| | | |
|---|---|---|
| | Decimation and Interpolation (Time domain and Frequency Domain Interpretation ), Anti- aliasing and anti-imaging filter. | |
| **4** | Efficient Computation of DFT: Fast Fourier Transform and computational advantage over DFT, Radix-2 Decimation in Time FFT Algorithm.<br>Computer architecture for signal processing: Harvard Architecture, pipelining, MAC, Introduction to TMS320C67xx digital signal processor, Functional Block Diagram.<br>Finite word length effects in DSP systems: Introduction, fixed-point and floating-point DSP arithmetic, ADC quantization noise. | **9** |

**Suggestion on Project Topics**

**Projects can include but not limited to, analysing various signals/finding their transforms and designing filters for extracting different frequency components. Projects can be simulated or implemented in hardware.**

## Course Assessment Method

## (CIE: 60 marks, ESE: 40 marks)

**Continuous Internal Evaluation Marks (CIE):**

| Attendance | Project | Internal Ex-1 | Internal Ex-2 | Total |
|---|---|---|---|---|
| **5** | **30** | **12.5** | **12.5** | **60** |

**End Semester Examination Marks (ESE)**

*In Part A, all questions need to be answered and in Part B, each student can choose any one full question out of two questions*

| Part A | Part B | Total |
|---|---|---|
| • 2 Questions from each module.<br>• Total of 8 Questions, each carrying 2 marks<br>**(8x2 =16 marks)** | • 2 questions will be given from each module, out of which 1 question should be answered. Each question can have a maximum of 2 sub divisions. Each question carries 6 marks.<br>**(4x6 = 24 marks)** | **40** |

## Course Outcomes (COs)

At the end of the course students should be able to:

| Course Outcome | | Bloom's Knowledge Level (KL) |
|---|---|---|
| **CO1** | Illustrate fundamental properties and relations relevant to DFT and solve basic problems involving DFT-based filtering methods. | **K2** |
| **CO2** | Design linear phase FIR filters and IIR filters of different specifications. | **K3** |
| **CO3** | Realise the various FIR and IIR filter structures for a given system function. | **K3** |
| **CO4** | Compute DFT efficiently using FFT method and to explain the architecture of a DSP processor. | **K2** |

Note*: K1- Remember, K2- Understand, K3- Apply, K4- Analyse, K5- Evaluate, K6- Create*

**CO-PO Mapping Table:**

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

| Text Books | | | | |
|---|---|---|---|---|
| **Sl. No** | **Title of the Book** | **Name of the Author/s** | **Name of the Publisher** | **Edition and Year** |
| **1** | Digital Signal Processing using Matlab | Vinay K. Ingle, John G. Proakis | Cengage Learning | 3rd Ed., 2011 |
| **2** | Think DSP: Digital Signal Processing using Python | Allen B. Downey | Green Tea Press | 2nd Ed., 2012 |
| **3** | Discrete-Time Signal Processing | Alan V Oppenheim, Ronald W. Schafer | Pearson Education | 3rd Ed., 2014 |

| Reference Books | | | | |
|---|---|---|---|---|
| **Sl. No** | **Title of the Book** | **Name of the Author/s** | **Name of the Publisher** | **Edition and Year** |
| **1** | Digital Signal Processing | Shaila D. Apte | Wiley | 2nd Ed, 2019 |
| **2** | Digital Signal Processing: A Computer based Approach | Mitra S. K. | McGraw Hill | 4th Ed., 2014 |
| **3** | Digital Signal Processing: A Practical Approach | Ifeachor E. C., Jervis B. W. | Pearson Education | 2nd Ed., 2009 |
| **4** | Digital Signal Processing | Salivahanan S. | McGraw Hill | 4th Ed., 2019 |

| Video Links (NPTEL, SWAYAM…) | |
|---|---|
| **Module No.** | **Link ID** |
| **1** | https://nptel.ac.in/courses/117102060<br>https://nptel.ac.in/courses/108105055 |
| **2** | same as above |
| **3** | same as above |
| **4** | same as above |

## PBL Course Elements

| L: Lecture (3 Hrs.) | R: Project (1 Hr.), 2 Faculty Members | | |
|---|---|---|---|
| | **Tutorial** | **Practical** | **Presentation** |
| Lecture delivery | Project identification | Simulation/ Laboratory Work/ Workshops | Presentation (Progress and Final Presentations) |
| Group discussion | Project Analysis | Data Collection | Evaluation |
| Question answer Sessions/ Brainstorming Sessions | Analytical thinking and self-learning | Testing | Project Milestone Reviews, Feedback, Project reformation (If required) |
| Guest Speakers (Industry Experts) | Case Study/ Field Survey Report | Prototyping | Poster Presentation/ Video Presentation: Students present their results in a 2 to 5 minutes video |

## Assessment and Evaluation for Project Activity

| Sl. No | Evaluation for | Allotted Marks |
|---|---|---|
| 1 | Project Planning and Proposal | 5 |
| 2 | Contribution in Progress Presentations and Question Answer Sessions | 4 |
| 3 | Involvement in the project work and Team Work | 3 |
| 4 | Execution and Implementation | 10 |
| 5 | Final Presentations | 5 |
| 6 | Project Quality, Innovation and Creativity | 3 |
| **Total** | | **30** |

1. **Project Planning and Proposal (5 Marks)**

    - Clarity and feasibility of the project plan
    - Research and background understanding
    - Defined objectives and methodology

2. **Contribution in Progress Presentation and Question Answer Sessions (4 Marks)**

    - Individual contribution to the presentation
    - Effectiveness in answering questions and handling feedback

3. **Involvement in the Project Work and Team Work (3 Marks)**

    - Active participation and individual contribution
    - Teamwork and collaboration

4. **Execution and Implementation (10 Marks)**

    - Adherence to the project timeline and milestones
    - Application of theoretical knowledge and problem-solving
    - Final Result

5. **Final Presentation (5 Marks)**

    - Quality and clarity of the overall presentation
    - Individual contribution to the presentation
    - Effectiveness in answering questions

6. **Project Quality, Innovation, and Creativity (3 Marks)**

    - Overall quality and technical excellence of the project
    - Innovation and originality in the project
    - Creativity in solutions and approaches

## SEMESTER S5

## BIOMEDICAL ENGINEERING

| Course Code | PEECT521 | CIE Marks | 40 |
|---|---|---|---|
| Teaching Hours/Week (L: T:P: R) | 3-0-0-0 | ESE Marks | 60 |
| Credits | 3 | Exam Hours | 2 Hrs. 30 min. |
| Prerequisites (if any) | None | Course Type | Theory |

**Course Objectives:**

1. This course will introduce the various aspects of biomedical engineering and its applications described using engineering principles
2. The student will be able to understand the techniques and uses of modern diagnostic and therapeutic equipment.

## SYLLABUS

| Module No. | Syllabus Description | Contact Hours |
|---|---|---|
| 1 | Introduction to bio-medical engineering,<br>Sources of bio-electric potential: Resting and action potential, propagation of action potentials. Various bioelectric potentials (ECG, EEG, EMG, ERG, EOG, EGG concept only.)<br>Electrode theory: Nernst equation, Electrode skin interface<br>Bio-potential electrodes: Microelectrodes, skin surface electrodes, needle electrodes<br>Bio-potential amplifiers: instrumentation amplifiers, carrier amplifiers, isolation amplifiers, chopper amplifiers | 9 |
| 2 | Heart and cardiovascular system: electro conduction system of the heart, ECG lead configurations, Einthoven triangle, Electrocardiography, ECG machine - block diagram, ECG recording system.<br>The human nervous system: Neurons, action potential of brain, brain waves, placement of electrodes, EEG recording, evoked potential, | 9 |

| | | |
|---|---|---|
| | Electrical activity of muscles: EMG signal acquisition and analysis. Myoelectric control system. Electrical stimulation of the muscle and nerve, Applications of EMG | |
| **3** | Instruments for clinical laboratory: Oxymeters, blood cell counter, flame photometer, Spectrophotometer<br>Therapeutic Equipments: Principles, block schematic diagram, working and applications of pacemakers, cardiac defibrillators, heart–lung machine, dialyzers, surgical diathermy equipment, ventilators<br>Biomedical Telemetry system: Components of biotelemetry system, application of telemetry in medicine, single channel telemetry system for ECG. | **9** |
| **4** | Medical Imaging systems (Basic Principle only): X-ray imaging - X-ray machine, applications of X-rays in medicine.<br>Computed Tomograpy: Principle, image reconstruction, scanning system and applications<br>Ultrasonic imaging systems: Basic pulse echo system, Different types of Ultrasonics systems:, A-Scan, B-Scan, M-Scan, applications, real-time ultrasonic imaging systems and probes.<br>Magnetic Resonance Imaging – Basic NMR components, Biological effects and advantages of NMR imaging | **9** |

**Course Assessment Method**

**(CIE: 40 marks , ESE: 60 marks)**

**Continuous Internal Evaluation Marks (CIE):**

| Attendance | Assignment/ Microproject | Internal Examination-1 (Written) | Internal Examination- 2 (Written ) | Total |
|---|---|---|---|---|
| **5** | **15** | **10** | **10** | **40** |

**End Semester Examination Marks (ESE)**

*In Part A, all questions need to be answered and in Part B, each student can choose any one full question out of two questions*

| Part A | Part B | Total |
|---|---|---|
| • 2 Questions from each module.<br>• Total of 8 Questions, each carrying 3 marks<br><br>**(8x3 =24marks)** | • Each question carries 9 marks.<br>• Two questions will be given from each module, out of which 1 question should be answered.<br>• Each question can have a maximum of 3 sub divisions.<br>**(4x9 = 36 marks)** | **60** |

## Course Outcomes (COs)

At the end of the course students should be able to:

| Course Outcome | | Bloom's Knowledge Level (K) |
|---|---|---|
| **CO1** | Outline the basic bioelectric potentials and their implications in diagnostics | **K2** |
| **CO2** | Summarize the principles used for diagnosis of abnormalities in the cardiovascular system | **K2** |
| **CO3** | Identify the techniques used for diagnosis and therapy in the neuromuscular and myoelectric systems. | **K2** |
| **CO4** | Illustrate the principle and working of different types of bio medical equipment/devices | **K2** |
| **CO5** | State various diagnostic medical imaging techniques. | **K2** |

Note*: K1- Remember, K2- Understand, K3- Apply, K4- Analyse, K5- Evaluate, K6- Create*

**CO-PO Mapping Table:**

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

| **Text Books** | | | | |
|---|---|---|---|---|
| **Sl. No** | **Title of the Book** | **Name of the Author/s** | **Name of the Publisher** | **Edition and Year** |
| **1** | Handbook of Biomedical Instrumentation | R. S. Khandpur | Tata Mc Graw Hill | Third edition |
| **2** | Biomedical Instrumentation and Measurement | Leslie Cromwell, Fred J. Weibell, Erich A. Pfeiffer, | PHI | 2nd Edition, 2004 |

| **Reference Books** | | | | |
|---|---|---|---|---|
| **Sl. No** | **Title of the Book** | **Name of the Author/s** | **Name of the Publisher** | **Edition and Year** |
| **1** | Medical Instrumentation application and design | John G Webster | John Wiley | 5th edition 2020 |
| **2** | Introduction to Biomedical Equipment Technology | J. J. Carr | Pearson Education | 4th edition 2020 |
| **3** | Principle of Biomedical Instrumentation and Measurement | Richard Aston | Merrill Education/Prentice Hall | 1st edition 2007 |
| **4** | Introduction to Biomedical Instrumentation | Barbara Christe | Cambridge University Press, | 2nd edition 2017 |

| Video Links (NPTEL, SWAYAM…) | |
|---|---|
| **Module No.** | **Link ID** |
| **1** | https://www.youtube.com/watch?v=_fD9gOqiBVE |
| **2** | http://www.digimat.in/nptel/courses/video/127106134/L16.html |

## SEMESTER S5

# DATA STRUCTURES

| Course Code | PEECT522 | CIE Marks | 40 |
|---|---|---|---|
| Teaching Hours/Week (L: T:P: R) | 3:0:0:0 | ESE Marks | 60 |
| Credits | 3 | Exam Hours | 2 Hr. 30 Min. |
| Prerequisites (if any) | None/ (Course code) | Course Type | Theory |

**Course Objectives:**

1. To familiarise with different data structures and the techniques involved.

## SYLLABUS

| Module No. | Syllabus Description | Contact Hours |
|---|---|---|
| 1 | Basic Concepts of Data Structures: Algorithms, Performance Analysis, Space Complexity, Time Complexity, Asymptotic Notations<br>Arrays: Linear Search and Binary Search, Stacks, Queues-Circular Queues, Priority Queues, Double Ended Queues, Evaluation of Expressions | 9 |
| 2 | Linked List: Self-Referential Structures, Dynamic Memory Allocation, Singly Linked List- Operations on Linked List. Doubly Linked List, Circular Linked List, Stacks and Queues using Linked List, Polynomial representation using Linked List | 9 |
| 3 | Trees and Graphs: Trees, Binary Trees-Tree Operations, Binary Tree Representation, Tree Traversals, Binary Search<br>Trees- Binary Search Tree Operations<br>Graphs, Representation of Graphs, Depth First Search and Breadth First Search on Graphs, Applications of Graphs | 9 |
| 4 | Sorting and Hashing: Sorting Techniques – Selection Sort, Insertion Sort, Quick Sort, Merge Sort and Heap Sort<br>Hashing- Hashing Techniques, Collision Resolution, Overflow handling, Hashing functions – Mid square, Division, Folding, Digit Analysis | 9 |

**Course Assessment Method**

**(CIE: 40 marks, ESE: 60 marks)**

**Continuous Internal Evaluation Marks (CIE):**

| Attendance | Assignment/ Microproject | Internal Examination-1 (Written) | Internal Examination- 2 (Written ) | Total |
|---|---|---|---|---|
| 5 | 15 | 10 | 10 | 40 |

**End Semester Examination Marks (ESE)**

*In Part A, all questions need to be answered and in Part B, each student can choose any one full question out of two questions*

| Part A | Part B | Total |
|---|---|---|
| • 2 Questions from each module.<br>• Total of 8 Questions, each carrying 3 marks<br>**(8x3 =24marks)** | • Each question carries 9 marks.<br>• Two questions will be given from each module, out of which 1 question should be answered.<br>• Each question can have a maximum of 3 sub divisions.<br>**(4x9 = 36 marks)** | 60 |

**Course Outcomes (COs)**

At the end of the course students should be able to:

| Course Outcome | | Bloom's Knowledge Level (KL) |
|---|---|---|
| CO1 | Compare performance of algorithms using asymptotic notations | K2 |
| CO2 | Solve real world problems efficiently using appropriate data structures like arrays, linked list, stacks and queues. | K3 |
| CO3 | Make use of nonlinear data structures like trees and graphs to design algorithms for various applications. | K3 |
| CO4 | Apply and compare various techniques for searching and sorting. | K3 |
| CO5 | Apply appropriate hash function to store and access a given dataset | K3 |

Note*: K1- Remember, K2- Understand, K3- Apply, K4- Analyse, K5- Evaluate, K6- Create*

## CO-PO Mapping Table (Mapping od Course Outcomes to Program Outcomes)

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

Note: *1: Slight (Low), 2: Moderate (Medium), 3: Substantial (High), -: No Correlation*

| **Text Books** | | | | |
|---|---|---|---|---|
| **Sl. No** | **Title of the Book** | **Name of the Author/s** | **Name of the Publisher** | **Edition and Year** |
| 1 | Fundamentals of Data Structures in C | Ellis Horowitz, Sartaj Sahni and Susan Anderson-Freed | Universities Press | 2/e, 2008 |
| 2 | Classic Data Structures | Samanta D | Prentice Hall India | 2/e, 2009 |

| **Reference Books** | | | | |
|---|---|---|---|---|
| **Sl. No** | **Title of the Book** | **Name of the Author/s** | **Name of the Publisher** | **Edition and Year** |
| 1 | Data Structures: A Pseudocode Approach with C | Richard F. Gilberg, Behrouz A. Forouzan | Cengage Learning | 2/e, 2005 |
| 2 | Data Structures and Algorithms | Aho A. V., J. E. Hopcroft and J. D. Ullman | Pearson Publication | 1/e. 1983 |
| 3 | Introduction to Data Structures with Applications | Tremblay J. P. and P. G. Sorenson | Tata McGraw Hill | 2/e, 1995 |
| 4 | Advanced Data Structures | Peter Brass | Cambridge University Press | 2/e, 2018 |
| 5 | Theory and Problems of Data Structures | Lipschuts S. | Schaum's Series | 2/e, 2016 |

| Video Links (NPTEL, SWAYAM…) | |
|---|---|
| **Module No.** | **Link ID** |
| **1** | https://nptel.ac.in/courses/106102064<br>https://youtu.be/zWg7U0OEAoE<br>https://youtu.be/g1USSZVWDsY<br>https://youtu.be/PGWZUgzDMYI |
| **2** | https://nptel.ac.in/courses/106102064<br>https://youtu.be/PGWZUgzDMYI |
| **3** | https://nptel.ac.in/courses/106102064<br>https://youtu.be/tORLeHHtazM<br>https://youtu.be/eWeqqVpgNPg<br>https://youtu.be/9zpSs845wf8 |
| **4** | https://youtu.be/KW0UvOW0XIo<br>https://youtu.be/gtWw_8VvHjk |

## SEMESTER S5

## SENSORS AND ACTUATORS

| Course Code | PEECT 523 | CIE Marks | 40 |
|---|---|---|---|
| Teaching Hours/Week (L: T:P: R) | 3:0:0:0 | ESE Marks | 60 |
| Credits | 3 | Exam Hours | 2 Hrs. 30 min. |
| Prerequisites (if any) | None | Course Type | Theory |

**Course Objectives:**

1. The course on Sensors and Actuators typically aims to provide students with comprehensive knowledge in the principles, design, and application of various sensors and actuators used in real-world applications

## SYLLABUS

| Module No. | Syllabus Description | Contact Hours |
|---|---|---|
| 1 | **Introduction to Sensors and actuators**: Block diagram of a closed loop control System, Sensors and Transducers, Sensors Classification, Sensor Characteristics - Transfer Function, Calibration, Span (Full Scale Input), Full-Scale Output, Accuracy, Precision, Hysteresis, Nonlinearity, Saturation, Repeatability, Dead Band, Sensitivity, Resolution. | 9 |
| 2 | Position and Displacement Sensors - Potentiometric Sensors, Capacitive Sensors, LVDT, Hall Effect Sensors<br>Pressure Sensors -Mercury Pressure Sensor, Bellows, Membranes, and Thin plates, Piezoresistive Sensors, Capacitive Sensors.<br>Force, Strain, and Tactile Sensors - Strain Gauges, Tactile Sensors - Switch Sensors, Piezoelectric Sensors, Piezoresistive Sensors, Capacitive Touch Sensors, Acoustic Touch Sensors, Optical Touch Sensors, Piezoelectric Force Sensors. | 9 |
| 3 | Flow Sensors - Ultrasonic Flow Sensors, Electromagnetic Flow Sensors.<br>Temperature Sensors - Resistance Temperature Detectors, Thermistors, Thermocouple. | 9 |

| | | |
|---|---|---|
| | Proximity Sensors - PIR sensors. Ultrasonic proximity sensors.<br>Smart Sensors - Block Diagram, Difference between Normal Sensor & Smart Sensor, Advantages, Disadvantages and Applications. | |
| **4** | **Actuators**: - Definition- classification-Electric, Hydraulic, Pneumatic actuators.<br>Hydraulic System - Physical Components and typical circuit. Hydraulic actuators - Linear actuators, Rotary actuators - Gear motor, vane motor.<br>Pneumatic System - Components and typical circuit. Pneumatic Actuators - Bellows actuator, Flapper-nozzle, Diaphragm actuators for industrial control valves.<br>Electric actuators- Solenoids, Stepper motors, DC motors, DC servo motors.<br>Electro-Pneumatic actuator; rotary output actuators, Linear output actuators. | **9** |

## Course Assessment Method
## (CIE: 40 marks, ESE: 60 marks)

**Continuous Internal Evaluation Marks (CIE):**

| Attendance | Assignment/ Microproject | Internal Examination-1 (Written) | Internal Examination- 2 (Written ) | Total |
|---|---|---|---|---|
| **5** | **15** | **10** | **10** | **40** |

**End Semester Examination Marks (ESE)**

*In Part A, all questions need to be answered and in Part B, each student can choose any one full question out of two questions*

| Part A | Part B | Total |
|---|---|---|
| • 2 Questions from each module.<br>• Total of 8 Questions, each carrying 3 marks<br>**(8x3 =24 marks)** | • Each question carries 9 marks.<br>• Two questions will be given from each module, out of which 1 question should be answered.<br>• Each question can have a maximum of 3 sub divisions.<br>**(4x9 = 36 marks)** | **60** |

## Course Outcomes (COs)

At the end of the course students should be able to:

| Course Outcome | | Bloom's Knowledge Level (KL) |
|---|---|---|
| CO1 | Describe Sensor Fundamentals | **K2** |
| CO2 | Explain the basic principles and concepts of commonly used different types of sensors, including their purpose, how they work, and the various types of sensors available. | **K2** |
| CO3 | Illustrate the working principles of smart sensors | **K2** |
| CO4 | Explain the working principle of different types of actuators. | **K2** |

Note*: K1- Remember, K2- Understand, K3- Apply, K4- Analyse, K5- Evaluate, K6- Create*

**CO-PO Mapping Table:**

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

| **Text Books** | | | | |
|---|---|---|---|---|
| **Sl. No** | **Title of the Book** | **Name of the Author/s** | **Name of the Publisher** | **Edition and Year** |
| **1** | Handbook of Modern Sensors | Jacob Fraden | Springer | Fourth Edition, 2010 |
| **2** | Hydraulics and Pneumatics | Andrew Parr | Elsevier Science | Second edition, 1999 |
| **3** | Process Control | K. Krishnaswamy | New Age International | Second edition, 2009 |

| Reference Books | | | | |
|---|---|---|---|---|
| **Sl. No** | **Title of the Book** | **Name of the Author/s** | **Name of the Publisher** | **Edition and Year** |
| **1** | Sensors and Actuators in Mechatronics, Design and Applications | Andrzej M. Pawlak | Taylor & Francis Group | 1/e, 2016 |
| **2** | Mechatronic systems, Sensors and Actuators Fundamentals and Modelling | Robert H. Bishop | Taylor & Francis Group | 3/e, 2022 |
| **3** | Process Control Instrumentation Technology | Curtis D. Johnson | Pearson/Prentice Hall | 8/e, 2019 |
| **4** | Sensors and Transducers | D. Patranabis | PHI Learning | 4/e, 2021 |

| Video Links (NPTEL, SWAYAM…) | |
|---|---|
| **Module No.** | **Link ID** |
| **1** | https://onlinecourses.nptel.ac.in/noc21_ee32/preview |
| **2** | https://onlinecourses.nptel.ac.in/noc21_ee32/preview |
| **3** | https://onlinecourses.nptel.ac.in/noc21_ee32/preview |
| **4** | https://onlinecourses.nptel.ac.in/noc21_ee32/preview |

## SEMESTER S5

## ARM ARCHITECTURE AND PROGRAMMING

| Course Code | PEECT524 | CIE Marks | 40 |
|---|---|---|---|
| Teaching Hours/Week (L: T:P: R) | 3:0:0:0 | ESE Marks | 60 |
| Credits | 3 | Exam Hours | 2 Hrs. 30 Min. |
| Prerequisites (if any) | Programming in C | Course Type | Theory |

**Course Objectives:**

1. To introduce ARM Cortex M programming in assembly and C
2. To lay the foundation for practical embedded system design

## SYLLABUS

| Module No. | Syllabus Description | Contact Hours |
|---|---|---|
| 1 | Embedded C: Fixed-width integer data types in C99, boolean type, mixing types, manipulating bits in memory and IO ports, accessing memory mapped IO using pointers, structures, packed structures, bit fields, casting address of an object, unions.<br>[1] Ch. 4<br>Review of computer organization: Memory, CPU, IO, Introduction to Arm cortex M architecture: Internal organization-general purpose and special registers, instruction pipelining, memory model, bit banding, Arm assembly language instruction format and operands<br>[1] Ch. 5 | 9 |
| 2 | Arm assembly language programming: Loading constants into registers, loading memory data into registers, storing data from registers to memory, converting C assignment statements to assembly, memory address calculations, Memory addressing examples: translating C pointer expressions to assembly, translating C subscript expressions to assembly, translating structure references to assembly, Stack instructions, data processing instructions: updating flags in APSR, arithmetic instructions, bit | 9 |

| | | |
|---|---|---|
| | manipulation instructions, shift instructions, bit field manipulation instructions<br>[1] Ch. 6 | |
| **3** | Control structures in assembly language: instruction sequencing, conditional branch instructions, translating if-then and if-then-else statements to assembly, compound conditionals, implementing loops, speeding up array access, Implementing functions: function call and return, register usage, parameter passing, return values, temporary variables, preserving registers<br>[1] Ch. 7. | **9** |
| **4** | IO programming in assembly: Interrupts and exceptions, thread and handler modes, entering the exception handler, returning from exception handler, latency reduction techniques, priorities and nested exceptions, synchronization, transfer rate and latency, buffers and queues, double buffering, polled waiting loops, interrupt driven IO, DMA<br>[1] Ch. 8.<br>System initialization: Memory layout, cpu and vector table, C run-time environment, System Timer<br>[1] Ch. 13 | **9** |

**Course Assessment Method**

**(CIE: 40 marks, ESE: 60 marks)**

**Continuous Internal Evaluation Marks (CIE):**

| Attendance | Assignment/ Microproject | Internal Examination-1 (Written) | Internal Examination- 2 (Written ) | Total |
|---|---|---|---|---|
| **5** | **15** | **10** | **10** | **40** |

**End Semester Examination Marks (ESE)**

*In Part A, all questions need to be answered and in Part B, each student can choose any one full question out of two questions*

| Part A | Part B | Total |
|---|---|---|
| • 2 Questions from each module.<br>• Total of 8 Questions, each carrying 3 marks<br><br>**(8x3 =24 marks)** | • Each question carries 9 marks.<br>• Two questions will be given from each module, out of which 1 question should be answered.<br>• Each question can have a maximum of 3 sub divisions.<br>**(4x9 = 36 marks)** | **60** |

## Course Outcomes (COs)

At the end of the course students should be able to:

| Course Outcome | | Bloom's Knowledge Level (KL) |
|---|---|---|
| **CO1** | Use the features of C that are frequently used in embedded systems | **K3** |
| **CO2** | Explain a programmer's view of processor architecture | **K2** |
| **CO3** | Choose between programming at the level of assembly or C as appropriate | **K3** |

Note*: K1- Remember, K2- Understand, K3- Apply, K4- Analyse, K5- Evaluate, K6- Create*

## CO-PO Mapping Table (Mapping of Course Outcomes to Program Outcomes)

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

Note: *1: Slight (Low), 2: Moderate (Medium), 3: Substantial (High), -: No Correlation*

| Text Books | | | | |
|---|---|---|---|---|
| **Sl. No** | **Title of the Book** | **Name of the Author/s** | **Name of the Publisher** | **Edition and Year** |
| 1 | Fundamentals of Embedded Software with the ARM Cortex M3 | Daniel W Lewis | Pearson | 2e, 2015 |

| Reference Books | | | | |
|---|---|---|---|---|
| **Sl. No** | **Title of the Book** | **Name of the Author/s** | **Name of the Publisher** | **Edition and Year** |
| 1 | The Definitive Guide to ARM Cortex-M3 and Cortex-M4 Processors | Joseph Yiu | Elsevier | 3e, 2014 |
| 2 | Embedded systems with ARM Cortex M Microcontrollers in Assembly and C | Yifeng Zhu | E-man Press | 3e, 2018 |

| Video Links (NPTEL, SWAYAM…) | |
|---|---|
| **Module No.** | **Link ID** |
| **1** | https://archive.nptel.ac.in/courses/117/106/117106111/ |
| **2** | https://archive.nptel.ac.in/courses/106/105/106105193/ |
| **3** | https://onlinecourses.nptel.ac.in/noc22_cs93/preview |

## SEMESTER S5

# HIGH SPEED DIGITAL DESIGN

| Course Code | PEECT526 | CIE Marks | 40 |
|---|---|---|---|
| Teaching Hours/Week (L: T:P: R) | 3:0:0:0 | ESE Marks | 60 |
| Credits | 3 | Exam Hours | 2 Hrs. 30 Min. |
| Prerequisites (if any) | BASIC ELECTRONICS | Course Type | Theory |

**Course Objectives:**

1. To understand the fundamentals of the effects of passive circuit elements on signal propagation in high speed digital circuits
2. To understand the high speed properties of logic gates and the measurement techniques at high frequencies
3. To analyse the effects of wiring, source, and load on the signal propagation from one end of a circuit to the other end
4. To design the power supply and clock distribution circuits for high speed devices,

## SYLLABUS

| Module No. | Syllabus Description | Contact Hours |
|---|---|---|
| 1 | **High Speed Digital Design:** Fundamentals: Frequency and time, Time and distance, Lumped versus distributed systems, four kinds of reactance-ordinary capacitance and inductance, mutual capacitance and inductance, Relation of mutual capacitance and mutual inductance to cross talk. | 9 |
| 2 | **High Speed properties of Logic gates**: Power, Quiescent vs active dissipation, Active power driving a capacitive load, Active power due to overlapping bias currents, Input power, Speed, Packaging (Power dissipation analysis of only CMOS logic gates are required)<br>**Measurement Techniques:** Rise time and bandwidth of oscilloscope probes, self inductance of probe ground loop, spurious signal pick up from probe ground loops, special probing fixtures, Avoiding pickup from probe shield currents, slowing down of a system clock, observing metastable states. | 9 |

| | | |
|---|---|---|
| **3** | **Transmission Lines:** Problems of point to point wiring, signal distortion, EMI, cross talk. Infinite Uniform transmission line; ideal distortion less lossless transmission line, RC transmission line, Skin effect, Proximity effect, Dielectric loss. Effects of source and load impedance. Termination: End terminator, Source terminators, middle terminators, AC biasing for end terminators, Resistor selection, Cross talk in terminators. | **9** |
| **4** | **Power system:** Stable voltage reference, Uniform voltage distribution, distribution problems, choosing a bypass capacitor.<br>**Clock Distribution**: Timing margin, Clock skew, Using low impedance drivers, using low impedance distribution lines, delay adjustments, Differential distribution, Clock signal duty cycle, Decoupling clock receivers from the clock bus. Clock Oscillators, Canned clock oscillator, Clock Jitter. | **9** |

## Course Assessment Method
## (CIE: 40 marks, ESE: 60 marks)

### Continuous Internal Evaluation Marks (CIE):

| Attendance | Assignment/ Microproject | Internal Examination-1 (Written) | Internal Examination- 2 (Written ) | Total |
|---|---|---|---|---|
| **5** | **15** | **10** | **10** | **40** |

### End Semester Examination Marks (ESE)

*In Part A, all questions need to be answered and in Part B, each student can choose any one full question out of two questions*

| Part A | Part B | Total |
|---|---|---|
| • 2 Questions from each module.<br>• Total of 8 Questions, each carrying 3 marks<br>**(8x3 =24 marks)** | • Each question carries 9 marks.<br>• Two questions will be given from each module, out of which 1 question should be answered.<br>• Each question can have a maximum of 3 sub divisions.<br>**(4x9 = 36 marks)** | **60** |

## Course Outcomes (COs)

At the end of the course students should be able to:

| Course Outcome | | Bloom's Knowledge Level (KL) |
|---|---|---|
| **CO1** | Illustrate the fundamentals of the effects of passive circuit elements on signal propagation in high speed digital circuits | **K2** |
| **CO2** | Describe the high speed properties of logic gates and the measurement techniques at high frequencies | **K2** |
| **CO3** | Analyze the effects of wiring, source, and load on the signal propagation from one end of a circuit to the other end | **K3** |
| **CO4** | Design the power supply and clock distribution circuits for high speed devices | **K3** |

Note*: K1- Remember, K2- Understand, K3- Apply, K4- Analyse, K5- Evaluate, K6- Create*

## CO-PO Mapping Table (Mapping of Course Outcomes to Program Outcomes)

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

Note: *1: Slight (Low), 2: Moderate (Medium), 3: Substantial (High), -: No Correlation*

| Text Books | | | | |
|---|---|---|---|---|
| **Sl. No** | **Title of the Book** | **Name of the Author/s** | **Name of the Publisher** | **Edition and Year** |
| 1 | High Speed Digital Design: A Handbook of Black Magic | Howard Johnson & Martin Graham | Prentice Hall PTR, | Second Edition, 2008 |
| 2 | Noise Reduction Techniques in Electronic Systems | Henry W. Ott | John Wiley & Sons | Second Edition, 1988 |

| Reference Books | | | | |
|---|---|---|---|---|
| **Sl. No** | **Title of the Book** | **Name of the Author/s** | **Name of the Publisher** | **Edition and Year** |
| 1 | High-Speed Digital System Design—A Handbook of Interconnect Theory and Design Practices | Stephen H. Hall<br>Garrett W. Hall<br>James A. McCall | John Wiley & Sons | First Edition, 2000 |
| 2 | Digital Systems Engineering | William S. Dally & John W. Poulton | Cambridge University Press, | First Edition, 1998 |
| 3 | High Speed Digital Circuits | Masakazu Shoji | Addison Wesley Publishing Company | First Edition, 1996 |
| 4 | Digital Integrated Circuits: A Design perspective, | Jan M, Rabaey | Pearson | Second Edition, 2003 |

| Video Links (NPTEL, SWAYAM…) | |
|---|---|
| **Module No.** | **Link ID** |
| **1** | https://nptel.ac.in/courses/108105375 |
| **2** | https://nptel.ac.in/courses/108105375 |
| **3** | https://nptel.ac.in/courses/108105375, https://nptel.ac.in/courses/108106069 |
| **4** | https://nptel.ac.in/courses/108105375 |

## SEMESTER S5

# ESTIMATION AND DETECTION

| | | | |
|---|---|---|---|
| **Course Code** | **PEECT527** | **CIE Marks** | 40 |
| **Teaching Hours/Week (L: T:P: R)** | 3:0:0:0 | **ESE Marks** | 60 |
| **Credits** | 3 | **Exam Hours** | 2 Hrs. 30 Min. |
| **Prerequisites (if any)** | None/ (Course code) | **Course Type** | Theory |

**Course Objectives:**

1. This course aims to impart the fundamentals of statistical signal processing theory in engineering applications.

## SYLLABUS

| Module No. | Syllabus Description | Contact Hours |
|---|---|---|
| **1** | **Statistical Estimation Theory I**<br>Fundamentals of estimation theory, the mathematical estimation problem, Minimum variance unbiased estimation, basics of Cramer-Rao Lower Bound, linear models, best linear unbiased estimation, application examples. | **9** |
| **2** | **Statistical Estimation Theory II**<br>Maximum likelihood estimation, least squares, Bayesian philosophy, minimum mean square error estimation, application examples. | **9** |
| **3** | **Statistical Detection Theory I**<br>Fundamentals of detection theory, the mathematical detection problem, Hypothesis testing, classical approach, Neyman-Pearson theorem, likelihood ratio test, receiver operating characteristics, Bayesian approach, minimum probability of error, Bayes risk, multiple hypothesis testing. | **10** |
| **4** | **Statistical Detection Theory II**<br>Detection of deterministic signals, matched filters, detection of random signals, estimator-correlator, linear model, application examples. | **8** |

**Course Assessment Method**

**(CIE: 40 marks , ESE: 60 marks)**

**Continuous Internal Evaluation Marks (CIE):**

| Attendance | Assignment/ Microproject | Internal Examination-1 (Written) | Internal Examination- 2 (Written ) | Total |
|---|---|---|---|---|
| 5 | 15 | 10 | 10 | 40 |

**End Semester Examination Marks (ESE)**

*In Part A, all questions need to be answered and in Part B, each student can choose any one full question out of two questions*

| Part A | Part B | Total |
|---|---|---|
| • 2 Questions from each module.<br>• Total of 8 Questions, each carrying 3 marks<br>**(8x3 =24marks)** | • Each question carries 9 marks.<br>• Two questions will be given from each module, out of which 1 question should be answered.<br>• Each question can have a maximum of 3 sub divisions.<br>**(4x9 = 36 marks)** | **60** |

**Course Outcomes (COs)**

At the end of the course students should be able to:

| Course Outcome | | Bloom's Knowledge Level (KL) |
|---|---|---|
| **CO1** | Summarize the fundamentals of statistical estimation principles used in various engineering problems. | **K2** |
| **CO2** | Apply different types of estimation algorithms in engineering applications. | **K3** |
| **CO3** | Illustrate the fundamentals of statistical detection principles used in various engineering problems. | **K2** |
| **CO4** | Apply various types of statistical decision rules in engineering applications. | **K3** |

Note*: K1- Remember, K2- Understand, K3- Apply, K4- Analyse, K5- Evaluate, K6- Create*

**CO-PO Mapping Table:**

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

| Text Books | | | | |
|---|---|---|---|---|
| **Sl. No** | **Title of the Book** | **Name of the Author/s** | **Name of the Publisher** | **Edition and Year** |
| **1** | "Fundamentals of Statistical Signal Processing" Vol I: Estimation Theory, | S.M. Kay, | Pearson, | 3/e, 2010. |
| **2** | "Fundamentals of Statistical Signal Processing" Vol II: Detection Theory, | S.M. Kay, | Pearson, | 3/e, 2010. |

| Reference Books | | | | |
|---|---|---|---|---|
| **Sl. No** | **Title of the Book** | **Name of the Author/s** | **Name of the Publisher** | **Edition and Year** |
| **1** | Detection, Estimation, and Modulation Theory, Vol. I, | H. L. Van Trees | John Wiley & Sons | 2/e, 2001 |
| **2** | Statistical Digital Signal Processing and Modelling | Monson H. Hayes | John Wiley & Sons | 2/e, 2018 |

| Video Links (NPTEL, SWAYAM…) | |
|---|---|
| **Module No.** | **Link ID** |
| **1** | https://nptel.ac.in/courses/117103018 |
| **2** | https://nptel.ac.in/courses/117103018 |
| **3** | https://nptel.ac.in/courses/117103018 |
| **4** | https://nptel.ac.in/courses/117103018 |

## SEMESTER S5

# ARM ARCHITECTURE, PROGRAMMING AND INTERFACING

| Course Code | PEECT525 | CIE Marks | 40 |
|---|---|---|---|
| Teaching Hours/Week (L: T:P: R) | 3:0:0:0 | ESE Marks | 60 |
| Credits | 5/3 | Exam Hours | 2 Hrs.30 Min. |
| Prerequisites (if any) | None | Course Type | Theory |

**Course Objectives:**

1. To introduce ARM Cortex M programming in assembly and C
2. To lay the foundation for practical embedded system design

## SYLLABUS

| Module No. | Syllabus Description | Contact Hours |
|---|---|---|
| 1 | Embedded C: Fixed-width integer data types in C99, boolean type, mixing types, manipulating bits in memory and IO ports, accessing memory mapped IO using pointers, structures, packed structures, bit fields, casting address of an object, unions.<br>[1] Ch. 4<br>Review of computer organization: Memory, CPU, IO, Introduction to Arm cortex M architecture: Internal organization-general purpose and special registers, instruction pipelining, memory model, bit banding, Arm assembly language instruction format and operands<br>[1] Ch. 5 | 9 |
| 2 | Arm assembly language programming: Loading constants into registers, loading memory data into registers, storing data from registers to memory, converting C assignment statements to assembly, memory address calculations, Memory addressing examples: translating C pointer expressions to assembly, translating C subscript expressions to assembly, translating structure references to assembly, Stack instructions, data processing | 9 |

| | | |
|---|---|---|
| | instructions: updating flags in APSR, arithmetic instructions, bit manipulation instructions, shift instructions, bit field manipulation instructions<br>[1] Ch. 6 | |
| **3** | Control structures in assembly language: instruction sequencing, conditional branch instructions, translating if-then and if-then-else statements to assembly, compound conditionals, implementing loops, speeding up array access, Implementing functions: function call and return, register usage, parameter passing, return values, temporary variables, preserving registers<br>[1] Ch. 7. | **9** |
| **4** | IO programming in assembly: Interrupts and exceptions, thread and handler modes, entering the exception handler, returning from exception handler, latency reduction techniques, priorities and nested exceptions, synchronization, transfer rate and latency, buffers and queues, double buffering, polled waiting loops, interrupt driven IO, DMA<br>[1] Ch. 8.<br>System initialization: Memory layout, cpu and vector table, C run-time environment, System Timer<br>[1] Ch. 13 | **9** |

**Course Assessment Method**

**(CIE: 40 marks, ESE: 60 marks)**

**Continuous Internal Evaluation Marks (CIE):**

| Attendance | Internal Ex | Evaluate | Analyse | Total |
|---|---|---|---|---|
| **5** | **15** | **10** | **10** | **40** |

**Criteria for Evaluation (Evaluate and Analyse): 20 marks**

Interfacing experiments on Arm Microcontroller boards TM4C123G/ STM32 Nucleo

GPIO – push button, LED, keypad scan ([2] Ch. 14)

Toggling LED using timers ([2] Ch. 15)

Stepper motor control ([2] Ch. 16)

LCD interfacing ([2] Ch. 17)

ADC and DAC with DMA ([2] Ch. 19, 20, 21)

Serial Communication ([2] Ch. 22)

Course Project involving the design and implementation of an embedded system for a chosen application

Project phases: Proposal, Implementation, Testing, Final Report, Presentations and Viva Voce

**End Semester Examination Marks (ESE):**

*In Part A, all questions need to be answered and in Part B, each student can choose any one full question out of two questions*

| Part A | Part B | Total |
|---|---|---|
| • 2 Questions from each module.<br>• Total of 8 Questions, each carrying 3 marks<br>**(8x3 =24marks)** | 2 questions will be given from each module, out of which 1 question should be answered. Each question can have a maximum of 3 sub divisions. Each question carries 9 marks.<br>**(4x9 = 36 marks)** | **60** |

## Course Outcomes (COs)

At the end of the course students should be able to:

| Course Outcome | | Bloom's Knowledge Level (KL) |
|---|---|---|
| **CO1** | Use the features of C that are frequently used in embedded systems | **K3** |
| **CO2** | Explain a programmer's view of processor architecture | **K2** |
| **CO3** | Choose between programming at the level of assembly or C as appropriate | **K3** |
| **CO4** | Analyze the interfacing of peripherals | **K4** |

Note*: K1- Remember, K2- Understand, K3- Apply, K4- Analyse, K5- Evaluate, K6- Create*

## CO-PO Mapping Table (Mapping of Course Outcomes to Program Outcomes)

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

Note: *1: Slight (Low), 2: Moderate (Medium), 3: Substantial (High), -: No Correlation*

| **Text Books** | | | | |
|---|---|---|---|---|
| **Sl. No** | **Title of the Book** | **Name of the Author/s** | **Name of the Publisher** | **Edition and Year** |
| 1 | Fundamentals of Embedded Software with the ARM Cortex M3 | Daniel W Lewis | Pearson | 2e, 2015 |
| 2 | Embedded systems with ARM Cortex M Microcontrollers in Assembly and C | Yifeng Zhu | E-man Press | 3e, 2018 |

| **Reference Books** | | | | |
|---|---|---|---|---|
| **Sl. No** | **Title of the Book** | **Name of the Author/s** | **Name of the Publisher** | **Edition and Year** |
| 1 | The Definitive Guide to ARM Cortex-M3 and Cortex-M4 Processors | Joseph Yiu | Elsevier | 3e, 2014 |

| Video Links (NPTEL, SWAYAM…) | |
|---|---|
| **Module No.** | **Link ID** |
| **1** | Modern Embedded Systems Programming Course Quantum Leaps, LLC https://youtube.com/playlist?list=PLPW8O6W-1chwyTzI3BHwBLbGQoPFxPAPM&si=vmU66G3vMmQihUPk |
| **2** | Modern Embedded Systems Programming Course Quantum Leaps, LLC https://youtube.com/playlist?list=PLPW8O6W-1chwyTzI3BHwBLbGQoPFxPAPM&si=vmU66G3vMmQihUPk |
| **3** | Modern Embedded Systems Programming Course Quantum Leaps, LLC https://youtube.com/playlist?list=PLPW8O6W-1chwyTzI3BHwBLbGQoPFxPAPM&si=vmU66G3vMmQihUPk |
| **4** | Modern Embedded Systems Programming Course Quantum Leaps, LLC https://youtube.com/playlist?list=PLPW8O6W-1chwyTzI3BHwBLbGQoPFxPAPM&si=vmU66G3vMmQihUPk |

## SEMESTER S5

# DIGITAL SIGNAL PROCESSING LAB

| Course Code | PBECL507 | CIE Marks | 50 |
|---|---|---|---|
| Teaching Hours/Week (L: T:P: R) | 0:0:3:0 | ESE Marks | 50 |
| Credits | 2 | Exam Hours | 2 Hrs. 30 Min. |
| Prerequisites (if any) | Signals & Systems, DSP | Course Type | Lab |

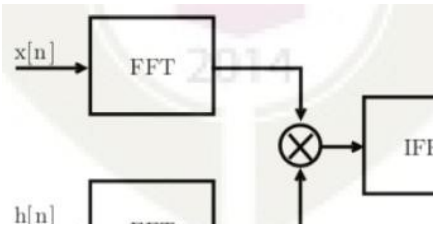
**Course Objectives:**

1. To realize the DFT, filtering techniques and familiarize DSP hardware
2. To implement Digital Filter.

**Details of Experiment**

| Expt. | Experiment |
|---|---|
| 1 | **Simulation of Signals** Simulate the following signals using Python/ Scilab/MATLAB.<br>1. Unit impulse signal 2. Unit pulse signal 3. Unit ramp signal 4. Bipolar pulse 5. Triangular signal |
| 2 | **Verification of the Properties of DFT**<br>1. Generate a DFT matrix and apply it to an example sequence.<br>2. Write a function that returns the N point DFT matrix VN for a given N.<br>3. Plot its real and imaginary parts of VN as images using matshow or imshow commands (in Python) for N = 16, N = 64 and N = 1024<br>4. Compute the DFTs of 16 point, 64 point and 1024 point random sequences using the above matrices.<br>5. Observe the time of computations for N = 2σ for different values of σ. (You may use the time module in Python).<br>6. Use some iterations to plot the times of computation against x. Plot and understand this curve. Plot the computation times for the FFT function over this curve and observe the computational advantage of FFT.<br>Circular Convolution.<br>1. Write a python function *circcon.py* that returns the circular convolution of an *N*1 point |

| | |
|---|---|
| | sequence and an $N2$ point sequence given at the input. The easiest way is to convert a linear convolution into circular convolution with $N = max(N1, N2)$.<br>Parseval's Theorem<br>Take two complex random sequences $x1[n]$ and $x2[n]$, and verify Parseval's Theorem. |
| **3** | **Familarization of DSP Hardware**<br>1. Familiarization of the code composer studio (in the case of TI hard- ware)<br>or Visual DSP (in the case of Analog Devices hardware) or any equivalent<br>cross-compiler for DSP programming.<br>2. Familiarization of the analog and digital input and output ports of the DSP board.<br>3. Generation and cross compilation and execution of the C code to connect the input digital switches to the output LEDs.<br>4. Generation and cross compilation and execution of the C code to connect the input analog port to the output. Connect a microphone, speak into it and observe the output electrical signal on a DSO and store it. |
| **4** | **Linear convolution**<br>1. Write a C function for the linear convolution of two arrays.<br>2. The arrays may be kept in different files and downloaded to the DSP hardware.<br>3. Store the result as a file and observe the output. |
| **5** | **FFT of signals**<br>1. Write a C function for N - point FFT.<br>2. Connect a precision signal generator and apply 1 $mV$ , 1 $kHz$ sinusoid at the analog port.<br>3. Apply the FFT on the input signal with appropriate window size and observe the result.<br>4. Connect microphone to the analog port and read in real time speech.<br>5. Observe and store the FFT values. |
| **6** | **IFFT with FFT**<br>1. Use the FFT function in the previous experiment to compute the IFFT of the input signal.<br>2. Apply IFFT on the stored FFT values from the previous experiments and<br>observe the reconstruction. |
| **7** | **FIR low pass filter**<br>1. Use Python/scilab to implement the FIR filter response $h[n] = \omega c\ n)/\pi$ for a filter size $N = 50$, $\omega c = 0.1\pi$ and $\omega c = 0.3\pi$.<br>2. Realize the hamming ($wH$ [$n$]) and kaiser ($wK[n]$) windows.<br>3. Compute $h[n]w[n]$ in both cases and store as file.<br>4. Observe the low pass response in the simulator.<br>5. Download the filter on to the DSP target board and test with 1 $mV$ sinusoid from a signal generator connected to the analog port. |

| | |
|---|---|
| | 6. Test the operation of the filters with speech signals. |
| **8** | **Overlap Save Block Convolution**<br>1. Use the file of filter coefficients from the previous experiment.<br>2. Realize the system shown below for the input speech signal $x[n]$.<br>  <br>3. Segment the signal values into blocks of length $N = 2000$. Pad the last block with zeros, if necessary.<br>4. Implement the *overlap save* block convolution method |
| **9** | **9. Overlap Add Block Convolution**<br>1. Use the file of filter coefficients from the previous experiment.<br>2. Realize the system shown in the previous experiment for the input speech signal $x[n]$.<br>3. Segment the signal values into blocks of length $N = 2000$. Pad the last block with zeros, if necessary.<br>4. Implement the *overlap add* block convolution method. |

## Course Assessment Method (CIE: 50 Marks, ESE 50 Marks)

## Continuous Internal Evaluation Marks (CIE):

| Attendance | Preparation/Pre-Lab Work, experiments, Viva and Timely completion of Lab Reports / Record. (Continuous Assessment) | Internal Exam | Total |
|---|---|---|---|
| **5** | **25** | **20** | **50** |

## End Semester Examination Marks (ESE):

| Procedure/ Preparatory work/Design/ Algorithm | Conduct of experiment/ Execution of work/ troubleshooting/ Programming | Result with valid inference/ Quality of Output | Viva voce | Record | Total |
|---|---|---|---|---|---|
| 10 | 15 | 10 | 10 | 5 | 50 |

**Mandatory requirements for ESE:**

- Submission of Record: Students shall be allowed for the end semester examination only upon submitting the duly certified record.
- Endorsement by External Examiner: The external examiner shall endorse the record.

## Course Outcomes (COs)

At the end of the course the student will be able to:

| Course Outcome | | Bloom's Knowledge Level (KL) |
|---|---|---|
| **CO1** | Generate basic signal waveforms | **K2** |
| **CO2** | Verify the properties of DFT | **K2** |
| **CO3** | Familiarize with DSP hardware and interface with Computer | **K2** |
| **CO4** | Implement LTI systems | **K3** |
| **CO5** | Design and Implement FIR low-pass filters | **K3** |

*K1- Remember, K2- Understand, K3- Apply, K4- Analyse, K5- Evaluate, K6- Create*

## CO-PO Mapping Table

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

*1: Slight (Low),2: Moderate (Medium),3: Substantial (High), : No Correlation*

| Text Books | | | | |
|---|---|---|---|---|
| **Sl. No** | **Title of the Book** | **Name of the Author/s** | **Name of the Publisher** | **Edition and Year** |
| **1** | Digital Signal Processing using Matlab | Vinay K. Ingle, John G. Proakis | Cengage Learning | 3rd Ed., 2011 |
| **2** | Think DSP: Digital Signal Processing using Python | Allen B. Downey | Green Tea Press | 1st Ed. 2019 |
| **3** | DSP applications using C and the TMS320C6x DSK | Chassaing, Rulph | Wiley & Sons | 2/e. 2008 |

| Reference Books | | | | |
|---|---|---|---|---|
| **Sl. No** | **Title of the Book** | **Name of the Author/s** | **Name of the Publisher** | **Edition and Year** |
| **1** | Discrete-Time Signal Processing | Alan V Oppenheim, Ronald W. Schafer | Pearson Education | 4th Ed.,2018 |

| Video Links (NPTEL, SWAYAM…) | |
|---|---|
| **Sl. No.** | **Link ID** |
| **1** | https://www.youtube.com/watch?v=6dFnpz_AEyA |
| **2** | https://onlinecourses.nptel.ac.in/noc21_ee20/preview |

## Continuous Assessment (25 Marks)

### 1. Preparation and Pre-Lab Work (7 Marks)

- Pre-Lab Assignments: Assessment of pre-lab assignments or quizzes that test understanding of the upcoming experiment.
- Understanding of Theory: Evaluation based on students' preparation and understanding of the theoretical background related to the experiments.

**2. Conduct of Experiments (7 Marks)**

- Procedure and Execution: Adherence to correct procedures, accurate execution of experiments, and following safety protocols.
- Skill Proficiency: Proficiency in handling equipment, accuracy in observations, and troubleshooting skills during the experiments.
- Teamwork: Collaboration and participation in group experiments.

**3. Lab Reports and Record Keeping (6 Marks)**

- Quality of Reports: Clarity, completeness and accuracy of lab reports. Proper documentation of experiments, data analysis and conclusions.
- Timely Submission: Adhering to deadlines for submitting lab reports/rough record and maintaining a well-organized fair record.

**4. Viva Voce (5 Marks)**

- Oral Examination: Ability to explain the experiment, results and underlying principles during a viva voce session.

*Final Marks Averaging: The final marks for preparation, conduct of experiments, viva, and record are the average of all the specified experiments in the syllabus.*

**Evaluation Pattern for End Semester Examination (50 Marks)**

**1. Procedure/Preliminary Work/Design/Algorithm (10 Marks)**

- Procedure Understanding and Description: Clarity in explaining the procedure and understanding each step involved.
- Preliminary Work and Planning: Thoroughness in planning and organizing materials/equipment.
- Algorithm Development: Correctness and efficiency of the algorithm related to the experiment.
- Creativity and logic in algorithm or experimental design.

**2. Conduct of Experiment/Execution of Work/Programming (15 Marks)**

- Setup and Execution: Proper setup and accurate execution of the experiment or programming task.

### 3. Result with Valid Inference/Quality of Output (10 Marks)

- Accuracy of Results: Precision and correctness of the obtained results.
- Analysis and Interpretation: Validity of inferences drawn from the experiment or quality of program output.

### 4. Viva Voce (10 Marks)

- Ability to explain the experiment, procedure results and answer related questions
- Proficiency in answering questions related to theoretical and practical aspects of the subject.

### 5. Record (5 Marks)

- Completeness, clarity, and accuracy of the lab record submitted

## SEMESTER S5

# COMMUNICATION LAB I

| Course Code | PCECL508 | CIE Marks | 50 |
|---|---|---|---|
| Teaching Hours/Week (L: T:P: R) | 0:0:3:0 | ESE Marks | 50 |
| Credits | 2 | Exam Hours | 2 Hrs. 30 Min. |
| Prerequisites (if any) | Analog circuits, Signals and systems, Digital Signal Processing | Course Type | Lab |

**Course Objectives:**

1. Understanding and Implementing Modulation and Detection Techniques
2. Analyzing and Evaluating Communication System Performance.

**Details of Experiment**

| Expt. No | Experiment |
|---|---|
| | **PART A: Hardware Experiments** |
| 1 | **Any one from the following Analog modulation schemes**<br>● AM modulation and detection using Transistors or ICS<br>● FM modulation and detection |
| 2 | **Hardware Experiment: Any one from the following Digital modulation & Waveform coding Schemes**<br>● Generation and Detection of PCM signals<br>● Generation and Detection of Delta modulated signals<br>● Generation and Detection of BPSK<br>● Generation and Detection of QPSK |
| | **PART B: Simulation Experiments** |
| 1. | Performance of Waveform Coding Using PCM |

| | |
|---|---|
| **2.** | Pulse Shaping and Matched Filtering |
| **3.** | Eye diagram |
| **4.** | Error Performance of BPSK |
| **5.** | Error Performance of QPSK |
| | **PART C: Software Defined Radio** |
| **1.** | Familiarization with Software Defined Radio (Hardware and Control Software) |
| **2.** | FM reception or FM transmission using SDR |

## Experiment Details

### PART A: Hardware Experiments

The students shall design and setup simple prototype circuits with the help of available ICs. They can observe waveforms produced by these circuits for standard ideal inputs

### PART B: Simulation Experiments

The students shall write scripts to simulate components of communication systems for the following experiments.

### Performance of Waveform Coding Using PCM

1. Generate a sinusoidal waveform with a DC offset so that it takes only
2. positive amplitude value.
3. Sample and quantize the signal using a uniform quantizer with number of
4. representation levels L. Vary L. Represent each value using decimal to
5. binary encoder.
6. Compute the signal-to-noise ratio in dB.
7. Plot the SNR versus number of bits per symbol. Observe that the SNR
8. increases linearly

### Pulse Shaping and Matched Filtering

1. Generate a string of message bits.
2. Use Root Raised Cosine (RRC) pulse p(t) as the shaping pulse, and generate the

3. corresponding baseband signal with a fixed bit duration Tb. You may use roll-off factor as $\alpha = 0.4$. Vary the roll off rate and study.
4. Simulate transmission of baseband signal via an AWGN channel
5. Apply matched filter with frequency response Pr(f) =P*(f) to the received signal.
6. Sample the signal at mTb and compare it against the message sequence.

### Eye diagram

1. Generate a string of message bits.
2. Use raised cosine pulse p(t) as the shaping pulse, and generate the corresponding baseband signal with a fixed bit duration Tb You may use roll-off factor as $\alpha = 0.4$
3. Use various roll off factors and plot the eye diagram in each case for the received signal. Make a comparison study among them.

### Error Performance of BPSK

1. Generate a string of message bits.
2. Encode using BPSK with energy per bit Eb and represent it using points in a signal-space.
3. Simulate transmission of the BPSK modulated signal via an AWGN channel with variance No/2.
4. Detect using an ML, decoder and plot the probability of error as a function of SNR per bit Eb/No.

### Error Performance of QPSK

1. Generate a string of message bits.
2. Encode using QPSK with energy per symbol $E_b$ and represent it using points in a signal-space.
3. Simulate transmission of the QPSK modulated signal via an AWGN channel with variance No/2 in both I-channel and Q-channel.
4. Detect using an ML decoder and plot the probability of error as a function of SNR per bit $E_b/N_0$ where $E_s=2E_b$

### PART C: Software Defined Radio

The students shall emulate communication systems with the help of software-defined-radio hardware and necessary control software. Use available blocks in GNU Radio (or similar software's like Simulink/ Lab- View) to implement all the signal processing.

**Familiarization with Software Defined Radio (Hardware and Control Software)**

1. Familiarize with an SDR hardware for reception and transmission of RF signal
2. Familiarize how it can be interfaced with computer
3. Familiarize with GNU Radio (or similar software's like Simulink/ Lab- View) that can be used to process the signals received through the SDR hardware.
4. Familiarize available blocks in GNU radio. Study how signals can be generated and spectrum (or power spectral density) of signals can be analyzed. Study how filtering can be performed.

**FM reception using SDR**

1. Receive digitized FM signal (for the clearest channel in the lab) using the SDR board.
2. Set up an LPF and FM receiver using GNU Radio.
3. Use appropriate sink in GNU Radio to display the spectrum of signal.
4. Resample the voice to make it suitable for playing on computer speaker. or playing on compute

**FM transmission using SDR**

1. Use a wave file source.
2. Set up an FM transmitter using GNU Radio.
3. Resample the voice source and transmit using the SDR.

## Course Assessment Method (CIE: 50 Marks, ESE 50 Marks)

## Continuous Internal Evaluation Marks (CIE):

| Attendance | Preparation/Pre-Lab Work, experiments, Viva and Timely completion of Lab Reports / Record. (Continuous Assessment) | Internal Exam | Total |
|---|---|---|---|
| 5 | 25 | 20 | 50 |

## End Semester Examination Marks (ESE):

| Procedure/ Preparatory work/Design/ Algorithm | Conduct of experiment/ Execution of work/ troubleshooting/ Programming | Result with valid inference/ Quality of Output | Viva voce | Record | Total |
|---|---|---|---|---|---|
| 10 | 15 | 10 | 10 | 5 | 50 |

**Mandatory requirements for ESE:**

- Submission of Record: Students shall be allowed for the end semester examination only upon submitting the duly certified record.
- Endorsement by External Examiner: The external examiner shall endorse the record.

## Course Outcomes (COs)

**At the end of the course the student will be able to:**

| Course Outcome | | Bloom's Knowledge Level (KL) |
|---|---|---|
| CO1 | Setup simple prototype circuits for waveform coding and digital modulation techniques working in a team. | K3 |
| CO2 | Simulate the error performance of a digital communication system using standard binary and M-ary modulation schemes. | K4 |
| CO3 | Develop hands-on skills to emulate a communication system with software-designed-radio working in a team. | K5 |

*K1- Remember, K2- Understand, K3- Apply, K4- Analyse, K5- Evaluate, K6- Create*

## CO-PO Mapping Table

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

*1: Slight (Low),2: Moderate (Medium),3: Substantial (High), : No Correlation*

| **Text Books** | | | | |
|---|---|---|---|---|
| **Sl. No** | **Title of the Book** | **Name of the Author/s** | **Name of the Publisher** | **Edition and Year** |
| **1** | The Hobbyist's Guide to the RTL-SDR: Really Cheap Software Defined Radio | Carl Laufer | CreateSpace Independent Publishing Platform | 2nd Edition, 2015 |
| **2** | Principles of Communication Systems Simulation with Wireless Applications | WH Tranter, KS Shanmugan, TS Rappaport, KL Kosbar | Prentice Hall | 2nd Edition, 2006 |
| **3** | Digital Modulations using Python | Mathuranathan Viswanathan, " | Independently Published | 1st Edition, 2019 |

| **Reference Books** | | | | |
|---|---|---|---|---|
| **Sl. No** | **Title of the Book** | **Name of the Author/s** | **Name of the Publisher** | **Edition and Year** |
| **1** | Communication Systems | Simon Haykin and Michael Moher | Wiley | 5th Edition, 2020 |
| **2** | Modern Digital and Analog Communication Systems | B.P. Lathi and Zhi Ding | Oxford University Press | 5th Edition, 2018 |
| **3** | Introduction to Analog and Digital Communication | Simon Haykin and Michael Moher | Wiley | 2nd Edition, 2006 |
| **4** | Electronic communication systems | George Kennedy | McGraw Hil | 6th Edition, 2017 |

| Video Links (NPTEL, SWAYAM…) | |
|---|---|
| **Sl. No.** | **Link ID** |
| **1** | Neel Pandeya, "Implementation of a Simple FM Receiver in GNU Ra- dio," https://kb.ettus.com/ |
| **2** | Michael Ossmann, "Software Defined Radio with HackRF," YouTube Tutorial, https://www.youtube.com/watch?v=BeeSN14JUYU |
| **3** | Nptel videos on Software Defined radio, https://www.youtube.com/watch?v=0KQWPFwFByU |
| **4** | Experimenting with software defined radio, https://www.youtube.com/watch?v=tx5xofG2Fxg |

## Continuous Assessment (25 Marks)

### 1. Preparation and Pre-Lab Work (7 Marks)

- Pre-Lab Assignments: Assessment of pre-lab assignments or quizzes that test understanding of the upcoming experiment.
- Understanding of Theory: Evaluation based on students' preparation and understanding of the theoretical background related to the experiments.

### 2. Conduct of Experiments (7 Marks)

- Procedure and Execution: Adherence to correct procedures, accurate execution of experiments, and following safety protocols.
- Skill Proficiency: Proficiency in handling equipment, accuracy in observations, and troubleshooting skills during the experiments.
- Teamwork: Collaboration and participation in group experiments.

### 3. Lab Reports and Record Keeping (6 Marks)

- Quality of Reports: Clarity, completeness and accuracy of lab reports. Proper documentation of experiments, data analysis and conclusions.
- Timely Submission: Adhering to deadlines for submitting lab reports/rough record and maintaining a well-organized fair record.

### 4. Viva Voce (5 Marks)

- Oral Examination: Ability to explain the experiment, results and underlying principles during a viva voce session.

*Final Marks Averaging: The final marks for preparation, conduct of experiments, viva, and record are the average of all the specified experiments in the syllabus.*

**Evaluation Pattern for End Semester Examination (50 Marks)**

### 1. Procedure/Preliminary Work/Design/Algorithm (10 Marks)

- Procedure Understanding and Description: Clarity in explaining the procedure and understanding each step involved.
- Preliminary Work and Planning: Thoroughness in planning and organizing materials/equipment.
- Algorithm Development: Correctness and efficiency of the algorithm related to the experiment.
- Creativity and logic in algorithm or experimental design.

### 2. Conduct of Experiment/Execution of Work/Programming (15 Marks)

- Setup and Execution: Proper setup and accurate execution of the experiment or programming task.

### 3. Result with Valid Inference/Quality of Output (10 Marks)

- Accuracy of Results: Precision and correctness of the obtained results.
- Analysis and Interpretation: Validity of inferences drawn from the experiment or quality of program output.

### 4. Viva Voce (10 Marks)

- Ability to explain the experiment, procedure results and answer related questions
- Proficiency in answering questions related to theoretical and practical aspects of the subject.

### 5. Record (5 Marks)

- Completeness, clarity, and accuracy of the lab record submitted