### M. Tech. (Electronics and Telecommunication) Curriculum Structure

**Specialization: Signal Processing**  
*(w.e.f. 2019-20)*

#### List of Abbreviations

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Title</th>
<th>No of courses</th>
<th>Credits</th>
<th>% of Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>PSMC</td>
<td>Program Specific Mathematics Course</td>
<td>1</td>
<td>4</td>
<td>5.88%</td>
</tr>
<tr>
<td>PSBC</td>
<td>Program Specific Bridge Course</td>
<td>1</td>
<td>3</td>
<td>4.41%</td>
</tr>
<tr>
<td>DEC</td>
<td>Department Elective Course</td>
<td>3</td>
<td>9</td>
<td>13.24%</td>
</tr>
<tr>
<td>MLC</td>
<td>Mandatory Learning Course</td>
<td>2</td>
<td>0</td>
<td>0%</td>
</tr>
<tr>
<td>PCC</td>
<td>Program Core Course</td>
<td>5</td>
<td>15</td>
<td>22.06%</td>
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<tr>
<td>LC</td>
<td>Laboratory Course</td>
<td>7</td>
<td>9</td>
<td>13.24%</td>
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<tr>
<td>IOC</td>
<td>Interdisciplinary Open Course</td>
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<td>3</td>
<td>4.41%</td>
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<tr>
<td>LLC</td>
<td>Liberal Learning Course</td>
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<tr>
<td>SLC</td>
<td>Self Learning Course</td>
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<td>SBC</td>
<td>Skill Based Course</td>
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<td><strong>Total</strong></td>
<td></td>
<td><strong>25</strong></td>
<td><strong>68</strong></td>
<td><strong>100%</strong></td>
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### Semester I

<table>
<thead>
<tr>
<th>Sr. No.</th>
<th>Course Type</th>
<th>Course Code</th>
<th>Course Name</th>
<th>Teaching Scheme</th>
<th>Credits</th>
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<tbody>
<tr>
<td>1</td>
<td>PSMC</td>
<td>ETC-19005</td>
<td>Linear Algebra and Probability Theory</td>
<td>3</td>
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<tr>
<td>2</td>
<td>PSBC</td>
<td>ESP-19001</td>
<td>DSP Algorithms</td>
<td>3</td>
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<tr>
<td>3</td>
<td>PCC</td>
<td>ESP-19002</td>
<td>Digital Audio Processing</td>
<td>3</td>
<td>--</td>
</tr>
<tr>
<td>4</td>
<td>PCC</td>
<td>ESP-19003</td>
<td>Digital Image and Video Processing</td>
<td>3</td>
<td>--</td>
</tr>
</tbody>
</table>
| 5       | DEC         | ESP(DE)-19001, ESP(DE)-19002, ETC(DE)-19011 | Department Elective I –
  a) Biomedical Signal Processing
  b) Voice and Data Networks
  c) Modeling, Simulation and Optimization | 3 | -- | -- | 3 |
| 6       | MLC         | ML-19011    | Research Methodology and Intellectual Property Rights | 2 | -- | -- | -- |
| 7       | MLC         | ML-19012    | Effective Technical Communication | 1 | -- | -- | -- |
| 8       | LC          | ESP-19004   | Digital Audio Processing Lab | -- | 2 | 1 |
| 9       | LC          | ESP-19005   | Digital Image and Video Processing Lab | -- | 1 | 2 | 2 |
| 10      | LC          | ESP-19006   | Signal Processing Lab | -- | 1 | 2 | 2 |
| 11      | LC          | ESP-19007   | Seminar | -- | -- | 2 | 1 |
|         |             |             | **Total hrs and Credits** | **18** | **3** | **8** | **22** |

### Semester II

<table>
<thead>
<tr>
<th>Sr. No.</th>
<th>Course Type</th>
<th>Course Code</th>
<th>Course Name</th>
<th>Teaching Scheme</th>
<th>Credits</th>
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<tbody>
<tr>
<td>1</td>
<td>IOC</td>
<td>ETC-19006</td>
<td>Interdisciplinary Open Course</td>
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<tr>
<td>2</td>
<td>PCC</td>
<td>ESP-19009</td>
<td>Machine Learning</td>
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<tr>
<td>3</td>
<td>PCC</td>
<td>ESP-19010</td>
<td>Adaptive Signal Processing</td>
<td>3</td>
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</table>
| 4       | DEC         | ESP(DE)-19004, ESP(DE)-19005, ESP(DE)-19006 | Department Elective –II
  a) Remote Sensing and Multispectral Signal Analysis
  b) Artificial Intelligence
  c) Signal processing for Communication Systems | 3 | -- | -- | 3 |
| 5       | DEC         | ETC(DE)-19010, ESP(DE)-19007 | Department Elective –III
  a) Joint Time Frequency | 3 | -- | -- | 3 |
Interdisciplinary Open Course on “Broadband Communication” is offered to students of other departments.

**Semester-III**

<table>
<thead>
<tr>
<th>Sr. No.</th>
<th>Course Type</th>
<th>Course Code</th>
<th>Course Name</th>
<th>Teaching Scheme</th>
<th>Credits</th>
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<tr>
<td>1.</td>
<td>SBC</td>
<td>ESP-20001</td>
<td>Dissertation Phase – I</td>
<td>--</td>
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<tr>
<td>2.</td>
<td>SLC</td>
<td>ESP-20002</td>
<td>Massive Open Online Course –I</td>
<td>3</td>
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</table>

**Total hrs and Credits**

|         | 3 | 18 | 12 |

**Semester-IV**

<table>
<thead>
<tr>
<th>Sr. No.</th>
<th>Course Type</th>
<th>Course Code</th>
<th>Course Name</th>
<th>Teaching Scheme</th>
<th>Credits</th>
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<td></td>
<td></td>
<td></td>
<td>L</td>
<td>T</td>
</tr>
<tr>
<td>1.</td>
<td>SBC</td>
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<td>Dissertation Phase – II</td>
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<tr>
<td>2.</td>
<td>SLC</td>
<td>ESP-20004</td>
<td>Massive Open Online Course –II</td>
<td>3</td>
<td>--</td>
</tr>
</tbody>
</table>

**Total hrs and Credits**

|         | 3 | 18 | 12 |

**Semester I**
### Course Outcomes:
At the end of the course, students will demonstrate the ability to:

1. Solve linear system of equations having numbers of unknowns equal to, less or more than number of equations.
2. Factorize matrix into components such as LU, QR, SVD.
3. Characterize random variables and its functions with probability distributions and cumulative distributions.
4. Specify and apply standard distributions to various applications in engineering.

### Syllabus Contents:

#### Linear Algebra
Vectors and Linear Combinations, Dot Products
Solving Linear Equations: Elimination, Elimination Matrices, Inverse Matrices, LU Factorization
Vector Spaces and Subspaces: Solving $A\cdot x = 0$, Nullspace of $A$, Rank, Row Reduced Form, Complete solution of $A\cdot x = b$, Independence, Basis and Dimension, Dimensions of Four subspaces
Orthogonality: Orthogonality of Four Subspaces, Projections, Least Squares Approximations, Orthogonal bases, Gram-Schmidt – QR Factorization
Eigenvalues and Eigenvectors: Diagonalizing a Matrix, Symmetric Matrices, Positive Definite Matrices, Singular Value Decomposition

#### Probability and Statistics
Definitions, conditional probability, Bayes Theorem and independence.
Random Variables: Discrete, continuous and mixed random variables, probability mass, probability density and cumulative distribution functions, mathematical expectation, moments, moment generating function, Chebyshev inequality.
Special Distributions: Discrete uniform, Binomial, Geometric, Poisson, Exponential, Gamma, Normal distributions.
Pseudo random sequence generation with given distribution, Functions of a Random Variable
Joint Distributions: Joint, marginal and conditional distributions, product moments, correlation, independence of random variables, bi-variate normal distribution.
Stochastic Processes: Definition and classification of stochastic processes, Poisson process

### References:

(PSBC)[ESP-19001]- DSP Algorithms

<table>
<thead>
<tr>
<th>Teaching Scheme</th>
<th>Examination Scheme</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lectures: 3 hrs/week</td>
<td>T1, T2 – 20 marks each</td>
</tr>
<tr>
<td></td>
<td>End-Semester Exam - 60</td>
</tr>
</tbody>
</table>

Course Outcomes:

At the end of the course, students will demonstrate the ability to:
1. Interpret, represent and process discrete/digital signals and systems
2. Understand frequency domain analysis of discrete time signals.
3. Design & analyze DSP systems like FIR and IIR Filter, etc.

Syllabus Contents:
Introduction to DSP: Overview: Signals, systems and signal processing, classification of signals, elements of digital signal processing system, concept of frequency in continuous and discrete time signals, Periodic Sampling, Frequency domain representation of sampling, Reconstructions of band limited signals from its samples, Hilbert algorithm
Detailed Designing and analysis of FIR Filters, IIR Filters, Interpolation and Decimation Filters, An FFT Algorithm for DFT Computation, Overflow and Scaling

References:
### (PCC )[ ESP-19002]- Digital Audio Processing

<table>
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<tbody>
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<td>Lectures: 3 hrs/week</td>
<td>T1, T2 – 20 marks each</td>
</tr>
<tr>
<td></td>
<td>End-Semester Exam - 60</td>
</tr>
</tbody>
</table>

**Course Outcomes:**
At the end of the course, students will demonstrate the ability to:
1. Understand different characteristics of Audio signals
2. Analyze different speech analysis and synthesis systems.
3. Design models and algorithms for audio and speech processing applications.

**Syllabus Contents:**
- Audio Signal Characteristics, Production model, Hearing and Auditory model, Acoustic characteristic of speech, Speech production models, Linear Separable equivalent circuit model, Vocal Tract and Vocal Cord Model
- Audio signal acquisition, Representation and Modelling, Enhancement of audio signals: Spectral Subtraction, Weiner based filtering, Neural nets
- Psychoacoustics, Multi-microphone audio processing: Room acoustics, Array beamforming. Acoustic sound source localization and tracking
- Applications: Principles of Automatic Speech Recognition (ASR), Theory and implementation of Hidden Markov Model (HMM) for ASR, Speaker Recognition, Evolution of Speech APIs, Natural Language Processing, Sound source separation models.

**References:**

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### (PCC )[ ESP-19003] Digital Image and Video Processing

<table>
<thead>
<tr>
<th>Teaching Scheme</th>
<th>Teaching Scheme</th>
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</thead>
<tbody>
<tr>
<td>Lectures: 3 hrs/week</td>
<td>Lectures: 3 hrs/week</td>
</tr>
</tbody>
</table>

**Course Outcomes:**
At the end of this course, students will demonstrate the ability to
1. Understand and apply knowledge of various transforms and probability theory in image processing
2. Understand digital image processing fundamentals like enhancement, encoding, feature extraction, and segmentation.
3. Learn the concepts of motion in video processing
4. Analyze, apply and critically evaluate various image and video processing algorithms appropriate for practical applications

Syllabus Contents:

**Introduction to image processing**: Applications and fields of image processing, Fundamental steps in Digital image processing, Elements of visual perception, Image sensing and acquisition, Basic Concepts in Sampling and Quantization, representing digital images.

**Image Enhancement**: Some basic gray level transformations, Histogram Processing, Sharpening Spatial filters, Image Enhancement in the spatial and Frequency domain, Pseudocolouring

**Segmentation**: Some Basic Relationships between pixels, point, Edge based segmentation, Boundary detection, extraction and representation, Threshold based segmentation, Region based segmentation, Texture based segmentation.
Morphological operations, Use of motion in segmentation.

**Image Compression**: Data redundancies Variable-length coding, Quantizers, Predictive coding, Transform coding, Image compression standards.

**Stereoscopic vision**: Depth perception from stereo

**Video processing**: Basics of video processing, Motion analysis, video compression, video compression standards,
Case studies: Watermarking, Biometrics, Document analysis, Moving object detection

References:


(DEC) [ESP(DE)-19001] Department Elective I –

a) Biomedical Signal Processing

<table>
<thead>
<tr>
<th>Teaching Scheme</th>
<th>Examination Scheme</th>
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</thead>
<tbody>
<tr>
<td>Lectures: 3 hrs/week</td>
<td>T1, T2 – 20 marks each</td>
</tr>
<tr>
<td></td>
<td>End-Semester Exam - 60</td>
</tr>
</tbody>
</table>

Course Outcomes:
At the end of the course, students will demonstrate the ability to:

1. Understand different types of biomedical signal.
2. Identify and analyze different biomedical signals.
3. Apply biomedical signal processing concepts to relevant domain.

**Syllabus Contents:**

Acquisition, Generation of Bio-signals, Origin of bio-signals, Types of bio-signals, Study of diagnostically significant bio-signal parameters Electrodes for bio-physiological sensing and conditioning, Electrode-electrolyte interface, polarization, electrode skin interface and motion artefact, biomaterial used for electrode,

Types of electrodes (body surface, internal, array of electrodes, microelectrodes), Practical aspects of using electrodes, Acquisition of bio-signals (signal conditioning) and Signal conversion (ADC’s DAC’s) Processing, Digital filtering,

Biomedical signal processing by Fourier analysis, Biomedical signal processing by wavelet (time-frequency) analysis, Analysis (Computation of signal parameters that are diagnostically significant), Classification of signals and noise, Spectral analysis of deterministic, stationary random signals and non-stationary signals

Coherent treatment of various biomedical signal processing methods and applications.

Principle component analysis, Correlation and regression, Analysis of chaotic signals Application areas of Bio-Signals analysis

**References:**

2. Biomedical Signal Processing and Signal Modeling by Eugene N Bruce, John Wiley & Son’s publication
4. Biomedical signal processing by D C Reddy, McGraw Hill
5. Practical Biomedical Signal Analysis using MATLAB (Series in Medical Physics and Biomedical Engineering) 2011 by Katarzyn J. Blinowska (Author), JaroslawZygierewicz CRC Press; 1 edition

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**Teaching Scheme**
Lectures: 3 hrs/week

**Examination Scheme**
T1, T2 – 20 marks each
End-Semester Exam - 60

**Course Outcomes:**
At the end of the course, students will demonstrate the ability to:

1. Understand switching and routing protocols used in data communication system.
2. Analyze network design issues and learned queuing models of networks.
3. Acquire the knowledge about next generation network architecture.

**Syllabus Contents:**

**Network Design Issues**: Network Performance Issues, Network Terminology, centralized and distributed approaches for networks design, Issues in design of voice and data networks. Layered and Layer less Communication, Cross layer design of Networks

**Switching in Networks**: Voice Networks (wired and wireless) and Switching, Circuit Switching and Packet Switching, Statistical Multiplexing,

**Data Link in Networks and their Design**: Link layer design, Link adaptation, Link Layer Protocols, Retransmission Mechanisms (ARQ), Hybrid ARQ (HARQ), Go Back N, Selective Repeat protocols and their analysis.

**Queuing Models of Networks**: Traffic Models, Little's Theorem, Markov chains, M/M/1 and other Markov systems.

**Multiple Access Protocols**: Aloha System, Carrier Sensing, Examples of Local area networks, Internetworking, Bridging, Global Internet


**References**:

1. Data Networks by D. Bertsekas and R. Gallager, Prentice Hall
4. Communications Network: A First Course by Walrand, Mcgraw Hill
6. Telecommunication Network Design Algorithms by Aaron Kershenbaum, Mcgraw Hill

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**Teaching Scheme**

| Lectures: 3 hrs/week |

**Examination Scheme**

| T1, T2 – 20 marks each |
| End-Semester Exam - 60 |

**Course Outcomes**
At the end of the course, students will demonstrate the ability to:

1. Understand the steps of modeling and experimenting simulation.
2. Apply statistical knowledge and modeling techniques to construct simulation models
3. Interpret and analyze simulation results
4. Identify, understand, formulate, and solve optimization problems
5. Understand the concepts of stochastic optimization algorithms

**Syllabus Contents:**

**Introduction to Computer Simulation:** Principle of Computer Modeling and Simulation - Monte Carlo Simulation - Nature of Computer Modeling and Simulation, types of simulation, Simulation as a decision making tool.


Continuous and Discrete event modeling and simulation: Representing complex behavior through computer program framework using core concepts of entities, events, resources, queues and time. Introduction to Simulation Languages: Development of simulation models using simulation languages like GPSS – SIMSCRIPT. Agent based modeling methodologies.


**References:**

### Teaching Scheme
Lectures: 2 hrs/week

### Examination Scheme
T1, T2 – 20 marks each
End-Semester Exam - 60

#### Course Outcomes:
At the end of the course, students will demonstrate the ability to:
1. Understand research problem formulation.
2. Analyze research related information
3. Follow research ethics

#### Syllabus Contents:
- Meaning of research problem, Sources of research problem, Criteria Characteristics of a good research problem, Errors in selecting a research problem, Scope and objectives of research problem.
- Approaches of investigation of solutions for research problem, data collection, analysis, interpretation, Necessary instrumentations
- Effective literature studies approaches, analysis
- Plagiarism, Research ethics,
- Effective technical writing, how to write report, Paper
- Developing a Research Proposal, Format of research proposal, a presentation and assessment by a review committee

#### References:
2. Wayne Goddard and Stuart Melville, “Research Methodology: An Introduction”

### Effective Technical Communication Skills

#### Teaching Scheme
Lectures: 1 hr/week

#### Examination Scheme

### Course Outcomes:
At the end of the course, students will demonstrate the ability to:
1. Produce effective dialogue for business related situations
2. Use listening, speaking, reading and writing skills for communication purposes and attempt tasks by using functional grammar and vocabulary effectively
3. Analyze critically different concepts / principles of communication skills
4. Demonstrate productive skills and have a knack for structured conversations
5. Appreciate, analyze, evaluate business reports and research papers
### Syllabus Contents:

**Fundamentals of Communication**  
7 Cs of communication, common errors in English, enriching vocabulary, styles and registers

**Aural-Oral Communication**  
The art of listening, stress and intonation, group discussion, oral presentation skills

**Reading and Writing**  
Types of reading, effective writing, business correspondence, interpretation of technical reports and research papers

### References:

### (LC) [ESP-19004]- Digital Audio Processing Lab

<table>
<thead>
<tr>
<th>Teaching Scheme</th>
<th>Examination Scheme</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lectures: 2 hrs/week</td>
<td>Term work/Practical: 100 marks</td>
</tr>
</tbody>
</table>

#### Course Outcomes:
At the end of the lab course, the students will demonstrate the ability to:
1. Analyze audio signal characteristics using softwares.
2. Process audio signals and implement various speech analysis techniques in MATLAB.
3. Implement any audio processing application in MATLAB.

#### Lab Assignments:

1. Audio signal analysis and introduction to various parameters of audio signal using PRAAT, Audacity.
2. Writing MATLAB code or function for:
   - Finding energy of an audio frame
   - Detection and removal of silence region in audio
   - Plotting spectrogram for given audio signal
3. Extraction of Mel Frequency Cepstral Coefficients (MFCCs) from an audio signal in MATLAB.
4. Extraction of Linear Predictive Coding (LPC) coefficients from an audio signal in MATLAB.
5. Calculation of minimum edit distance between two strings using Dynamic Programming algorithm in MATLAB.
6. Designing a codebook as stated in VQ method using K-means clustering algorithm in MATLAB.
7. Evaluation of probabilities using HMM and Viterbi algorithm for a given sequence in MATLAB.
8. Estimation of DOA.
9. Source separation using ICA.

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### (LC) [ESP-19005] Digital Image and Video Processing Lab

<table>
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<th>Teaching Scheme</th>
<th>Examination Scheme</th>
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</thead>
<tbody>
<tr>
<td>Lab: 2 hrs/week</td>
<td>Term work/Practical: 100 marks</td>
</tr>
</tbody>
</table>

#### Course Outcomes:
At the end of the lab course, the students will demonstrate the ability to:
1. Implement various image processing and image enhancement techniques in MATLAB and identify their application areas.
2. Execute various image segmentation techniques.
3. Implement image and video compression techniques.

#### Lab Assignments:

1. Obtaining row profile of a given row of an image in MATLAB
2. Plotting histogram of an image in MATLAB
3. Adjusting the brightness of an image using a constant value in MATLAB
4. Calculating mean and variance of an image in MATLAB
5. Histogram Equalization of an image in MATLAB
6. Spatial Filtering: Applying low pass, high pass and median filters on an image in MATLAB
7. Pseudo Coloring an image using sinusoidal transforms in MATLAB
8. Detection of edges of an image using Canny Edge Detection algorithm in MATLAB
9. Image Thresholding using OTSU Thresholding algorithm in MATLAB.
10. Region-based Image Segmentation using region growing in MATLAB.
11. Apply Discrete Cosine Transform (DCT) on an image in MATLAB.
12. Motion Estimation for video sequence using full search algorithm.

<table>
<thead>
<tr>
<th><strong>Teaching Scheme</strong></th>
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</thead>
<tbody>
<tr>
<td>Lab: 3 hrs/week</td>
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</table>

<table>
<thead>
<tr>
<th><strong>Examination Scheme</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Term work/Practical 100 marks</td>
</tr>
</tbody>
</table>

**Course Outcomes:**
At the end of laboratory course students will demonstrate the ability to
1. Simulate and analyze digital signal processing systems in MATLAB
2. Generate and Analyze analog and digital signals with the help Labview.

**Lab Assignments:**

**Experimentation using Matlab**
- To find the FFT/IDFT of given signal.
- Design and Implementation of FIR Filter
- Design and Implementation of IIR Filter
- Implementation of Interpolation /Decimation Process
- FFT and its Applications

**Experimentation using Labview**
- Acquisition of signal in lab view
- Generating signal with Lab view
- To find the FFT/IDFT of given signal
- Spectral analysis, STFT
- Design and Implementation of FIR Filter
- Design and Implementation of IIR Filter
<table>
<thead>
<tr>
<th>Teaching Scheme</th>
<th>Examination Scheme</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lab: 2 hrs/week</td>
<td></td>
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</table>

**Guidelines:**

- Each student is expected to give a seminar on a topic of current relevance in Signal Processing area.
- Students have to refer published papers from standard journals.
- The seminar report must not be the reproduction of the original papers but it can be used as reference.
Semester II

(IOC)[ ETC-19006]- Interdisciplinary Open Course
Broadband Communication

<table>
<thead>
<tr>
<th>Teaching Scheme</th>
<th>Examination Scheme</th>
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</thead>
<tbody>
<tr>
<td>Lectures: 3 hrs/week</td>
<td>T1, T2 – 20 marks each</td>
</tr>
<tr>
<td></td>
<td>End-Semester Exam - 60</td>
</tr>
</tbody>
</table>

Course Outcomes:
At the end of this course, students will demonstrate the ability to
1. Distinguish Cellular Communication Systems from 2G to 5G
2. Compare Optical Fiber Communication and Wireless Communication on the basis of Bandwidth, Cost, Security, and Durability requirements.
3. Understand the operating principles of Wi-Fi and Wi-MAX systems, fixed wireless systems and Quality of services in broadband.
4. Evaluate the parameters related to orbital motion and link budget for the satellite.

Syllabus Contents:
Mobile Communication: Introduction, Concepts of coverage area and dead zones, Cellular system design, Frequency reuse, Co channel and adjacent channel interference, Interference reduction techniques, Fixed and Dynamic Channel Assignment Strategies, concepts of cell splitting, Handoff Process, Factors affecting Handoff Process, Handoff Strategies, Microcell Zone concept, GSM architecture, Call Flows in GSM, Multiple access techniques.

Satellite Communication: Introduction, Kepler laws, apogee and perigee heights, Orbital equations, LEO, MEO, GEO satellites, Orbit perturbations, Satellite Sub-Systems, Solar eclipse on satellite, Sun transit outage phenomena, Doppler frequency shift, Satellite Link Budget- Flux density, EIPR and received signal power equations, Calculation of system noise temperature for satellite receiver, noise power calculation, C/N ratio calculations in clear air and rainy conditions.

Fixed Wireless Systems: Microwave links, Private unlicensed links (Spread spectrum), MMDS (Multi-channel Multi-point Distribution Service), LMDS (Local Multipoint Distribution Service).

Wi-Fi and Wi-MAX Technologies: Introduction to Wi-Fi and Wi-MAX, Principles and parameters for Wireless LAN (IEEE 802.11 standards), Operating principles for Wi-MAX (IEEE 802.16 standard), Comparison of Wi-Fi and Wi-MAX.

Optical Fiber Communication: Principles of optical fiber communication, advantages and disadvantages of optical fiber communication, Optical Spectral bands, Basic optical laws and definitions, Single-mode fiber, Graded-index fiber, Signal Degradation in optical fiber: Attenuation, Dispersion.

Quality-of-Service (QoS) in Broadband: QoS issues in broadband communication, A case study of broadband service regulations for maintaining QoS by telecom regulatory bodies such as TRAI.

References:


<table>
<thead>
<tr>
<th>Course Code: (PCC ) [ESP-19009]</th>
<th>Machine Learning</th>
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<tr>
<td></td>
<td>End-Semester Exam - 60</td>
</tr>
</tbody>
</table>

**Course Outcomes:**

At the end of the course, students will demonstrate the ability to:

1. Design and implement machine learning solutions to a) Classification b) Regression c) Clustering problems
2. Evaluate and interpret the results of the machine learning algorithms
3. Build rapid prototypes and for actual deployment.

**Syllabus Contents:**

- Review of Probability Theory and Linear algebra
- Regression: Linear Regression, Multivariate Regression, Subset Selection, Shrinkage Methods, Principal Component Regression, Logistic Regression, Partial Least Squares
- Classification: Linear Classification, LDA
- Introduction to Perceptron and SVM Neural Networks: Introduction, Early Models, Perceptron Learning, Back-propagation, Initialization of neural network, Training and Validation, Parameter Estimation
- Decision Trees - Stopping Criterion and Pruning, Loss function, Categorical Attributes, Multiway Splits, Missing values, Instability, Regression Trees. Bootstrapping and Cross Validation, Class Evaluation, Measures, ROC curve, MDL, Ensemble methods, Committee Machines and Stacking. Gradient Boosting, Random Forests, Multi-class Classification, Naïve Bayes, Bayesian Networks, Undirected Graphical Models, HMM, Variable elimination, Belief Propagation, Partitional clustering, Hierarchical Clustering, Birch Algorithm, CURE Algorithm, Density- Based Clustering, Gaussian Mixture Models, Expectation Maximization, Learning Theory, Re-enforcement Learning
- Convolutional Neural Networks - CNN Operations, CNN architectures, Training, Transfer Learning.
- Recurrent Neural Networks - RNN, LSTM, GRU, Applications.
- Introduction to Deep learning

**References:**

**Teaching Scheme**

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<tr>
<th>Lectures: 3 hrs/week</th>
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<tbody>
<tr>
<td>T1, T2 – 20 marks each</td>
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<tr>
<td>End-Semester Exam - 60</td>
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**Course Outcomes:** At the end of the course, students will demonstrate the ability to:

1. Evaluate the performance of various methods for designing adaptive filters through estimation of different parameters of stationary random process.
2. Ability to experiment and identify merits and demerits of various adaptive algorithms.
3. Design and implement filtering solutions for various applications.

**Syllabus Contents:**

**Introduction to Adaptive Filters.**
1. Adaptive filter structures, issues and examples.
2. Applications of adaptive filters.

a. Channel equalization, active noise control.
   b. Echo cancellation, beamforming

**Discrete time stochastic processes.**
1. Re-visiting probability and random variables.
2. Discrete time random processes.
3. Power spectral density - properties.
4. Autocorrelation and covariance structures of discrete time random processes.
5. Eigen-analysis of autocorrelation matrices.

**Wiener filter, search methods and the LMS algorithm.**
1. Wiener FIR filter (real case).
2. Steepest descent search and the LMS algorithm.
3. Extension of optimal filtering to complex valued input.
The Complex LMS algorithm.

**Convergence and Stability Analyses.**
1. Convergence analysis of the LMS algorithm.
2. Learning curve and mean square error behaviour.
3. Weight error correlation matrix.
4. Dynamics of the steady state mean square error (mse).
   Misadjustment and stability of excess mse.

**Variants of the LMS Algorithm.**
1. The sign-LMS and the normalized LMS algorithm.
2. Block LMS.
4. Overlap and save method, circular correlation.
   FFT based implementation of the block LMS Algorithm.

**Vector space framework for optimal filtering.**
1. Axioms of a vector space, examples, subspace.
2. Linear independence, basis, dimension, direct sum of subspaces.
3. Linear transformation, examples.
4. Range space and null space, rank and nullity of a linear operator.
5. Inner product space, orthogonality, Gram-Schmidt orthogonalization.
6. Orthogonal projection, orthogonal decomposition of subspaces.

**The lattice filter and estimator.**
1. Forward and backward linear prediction, signal subspace decomposition using forward and backward predictions.
2. Order updating the prediction errors and prediction error variances, basic lattice section.
3. Reflection coefficients, properties, updating predictor coefficients.
4. Lattice filter as a joint process estimator.
5. AR modeling and lattice filters.

Gradient adaptive lattice.

**RLS lattice filter.**
2. Vector space framework for LS estimation.
3. Time and order updating of an orthogonal projection operator.
4. Order updating prediction errors and prediction error power.
   Time updating PARCOR coefficients.

**References:**
Lectures: 3 hrs/week

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**Course Outcomes:**
At the end of the course, students will demonstrate the ability to:
1. Identify and formalize architectural level characterization of P-DSP hardware
2. Ability to design, programming, and testing code for DSP applications using Code Composer Studio environment in simulation mode and using starter kits
3. Deployment of DSP hardware for Control, Audio and Video Signal processing applications

**Syllabus Contents:**
Programmable DSP Hardware: Processing Architectures (von Neumann, Harvard), DSP core algorithms (FIR, IIR, Convolution, Correlation, FFT), IEEE standard for Fixed and Floating Point Computations, Special Architectures Modules used in Digital Signal Processors (like MAC unit, Barrel shifters), On-Chip peripherals, DSP benchmarking.


VLIW Architecture: Current DSP Architectures, GPUs as an alternative to DSP Processors, TMS320C6X Family, Addressing Modes,Replacement of MAC unit by ILP, Detailed study of ISA, Assembly Language Programming, Code Composer Studio, Mixed C and Assembly Language programming, on-chip peripherals, Simple applications developments as an embedded environment.

Multi-core DSPs: Introduction to Multi-core computing and applicability for DSP hardware, Concept of threads, introduction to P-thread, mutex and similar concepts, heterogeneous and homogenous multi-core systems, Shared Memory parallel programming – OpenMP approach of parallel programming, PRAGMA directives, OpenMP Constructs for work sharing like for loop, sections, TI TMS320C6678 (Eight Core subsystem).

FPGA based DSP Systems: Limitations of P-DSPs, Requirements of Signal processing for Cognitive Radio (SDR), FPGA based signal processing design- case study of a complete design of DSP processor, High Performance Computing using P-DSP: Preliminaries of HPC, MPI, OpenMP, multicore DSP as HPC infrastructure.

**References:**
1. Digital Signal Processors Architecture, Programming and Applications by B. Venkatramani, M. Bhaskar
2. Introduction to Parallel Processing by M. Sasikumar, D. Shikhare, Ravi Prakash, PHI
3. Algorithms and Parallel Computing by Fayez Gebali, Wiley
4. Parallel Programming in OpenMP by Rohit Chandra, L. Dagun, Memon- Morgan Kaufman
5. Multicore Embedded systems- GeorgiousKormarakos, CRC Press
7. Algorithmic Collections for Digital Signal Processing Applications- E.S. Gopi
### (DEC) Departmental Elective -II

#### a) [ ESP(DE)-19004]- Remote Sensing and Multispectral Analysis

<table>
<thead>
<tr>
<th>Teaching Scheme</th>
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#### Course Outcomes:
Upon completion of the course, the student will be able to
1. Understand the basic principles of remote sensing
2. Apply various corrections required in processing remote sensed images
3. Analyse remote sensing images to solve problems in different areas like LULC, change detection, image fusion
4. Apply acquired knowledge and critical thinking skills to solve a real-world problem with appropriate remote sensing data and processing methods

#### Concepts and Foundations of Remote Sensing
Introduction, energy sources and radiation principles, energy interactions in the atmosphere, energy interactions with earth surface features, an ideal remote sensing system, characteristics of real remote sensing systems, energy sources and electromagnetic spectrum, different resolutions for remote sensing images, successful application of remote sensing.

Correcting and Registering images
Sources of distortions and correction in remote sensing images, georeferencing.

#### Visual Image Interpretation
Fundamentals of visual image interpretation, basic visual image interpretation equipment, land use/land cover mapping, geologic and soil mapping, agricultural applications, forestry applications, rangeland applications, water resource applications, urban and regional planning applications, wetland mapping, wildlife ecology applications, archaeological applications, environmental assessment, natural disaster assessment, principles of landform identification and evaluation.

#### Different Types of Remote Sensors
Across-track scanning, along-track scanning, operating principles of across-track multispectral scanners, example along-track multispectral scanner and data, across-track thermal scanning, thermal radiation principles, interpreting thermal scanner imagery, geometric characteristics of across-track scanner imagery, geometric characteristics of along-track scanner imagery, radiometric calibration of thermal scanners, temperature mapping with thermal scanner data, FLIR systems, hyperspectral sensing, microwave remote sensing – synthetic aperture radar, radar image characteristics, radar image interpretation, examples of multispectral, panchromatic and SAR sensors.

#### Digital Image Processing of Remote Sensing Images
Image file formats (BSQ, BIP, BIL), image rectification and restoration, image enhancement, multi-image manipulation, image fusion – PCA and wavelet-based techniques, image classification, post-classification smoothing, classification accuracy assessment, data
merging and GIS integration, hyperspectral image analysis, biophysical modelling, scale effects, image transmission and compression.

References:

References:

6. Time Series Analysis Paper by Elizabeth Bradley and Videos by Bradley

(DEC) Departmental Elective -II

c)  [ESP(DE)-19006] Signal Processing for Communication

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Interpolation and Sampling, A/D and D/A Conversions.
Multirate Signal Processing: Downsampling, Upsampling, Oversampling.

References

(DEC III)- Department Elective III

a)  [ETC(DE)-19010] Joint Time Frequency Analysis
Teaching Scheme
Lectures: 3 hrs/week

Examination Scheme
T1, T2 – 20 marks each
End-Semester Exam - 60

Course Outcomes:
At the end of the course, students will demonstrate the ability to:
1. Understand the limitations of Fourier Transform and the significance of Wavelets Time-Frequency.
3. Understand applications of Time-Frequency and Multi-Resolution Analysis techniques.

Syllabus Contents:

Piecewise constant approximation - the Haar wavelet, Building up the concept of dyadic Multiresolution Analysis (MRA),

Relating dyadic MRA to filter banks, review of discrete signal processing, Elements of multirate systems and two-band filter bank design for dyadic wavelets,

Families of wavelets: Orthogonal and biorthogonal wavelets, Daubechies' family of wavelets in detail, Vanishing moments and regularity, Conjugate Quadrature Filter Banks (CQF) and their design, Dyadic MRA more formally, Data compression – fingerprint compression standards, JPEG-2000 standards,


Variants of the wavelet transform and its implementational structures, The wavepacket transform, Computational efficiency in realizing filter banks - Polyphase components, The lattice structure, The lifting scheme,

An exploration of applications: Transient analysis; singularity detection; Biomedical signal processing applications; Geophysical signal analysis applications; Efficient signal design and realization: wavelet based modulation and demodulation; Applications in mathematical approximation; Applications to the solution of some differential equations; Applications in computer graphics and computer vision; Relation to the ideas of fractals and fractal phenomena.

References:
1. Wavelet Analysis: The Scalable Structure of Information by Howard L. Resnikoff, Raymond O. Wells, Springer
2. Wavelet Transforms: Introduction by Raghuveer M. Rao, Ajit S. Bopardikar
3. Insight Into Wavelets - From Theory to Practice by K. P. Soman, K. I. Ramachandran, Prentice Hall
4. An Introduction to Wavelets Through Linear Algebra by Michael W. Frazier, Springer
5. Multirate Systems and Filter Banks by P. P. Vaidyanathan, Pearson Education

(DEC III)- Department Elective III
b) [ESP(DE)-19007] Signal Acquisition Devices and Systems

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<td>Lectures: 3 hrs/week</td>
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<td>End-Semester Exam - 60</td>
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**Course Outcomes:**
At the end of the course, students will demonstrate the ability to:

1. Understands the elements of data acquisition techniques
2. Evaluate and select appropriate techniques and devices for realising a data acquisition system.
3. Design and implement a data acquisition solution for a particular application

**Syllabus Contents:**
Concepts of data acquisition systems, sample signals that measure real physical conditions and convert the resulting samples into digital, numeric values to be analyzed

Problem-solving approach to data acquisition, sensors that convert physical parameters to electrical signals, signal conditioning circuitry to convert sensor signals into a form that can be converted to digital values and analog-to-digital converters, which convert conditioned sensor signals to digital values. hands-on approach, culminating with data acquisition projects

Fundamental principles of measurement, sensors and signal conditioning. software packages related to data acquisition

**References:**
1. Data Acquisition systems from Fundamentals To Applied Design Hardcover-March
(DEC III) - Department Elective III

c) [ESP(DE)-19008] Signal Processing for Surveillance Systems

Teaching Scheme
Lectures: 3 hrs/week

Examination Scheme
T1, T2 – 20 marks each
End-Semester Exam - 60

Course Outcomes: At the end of the course, students will demonstrate the ability to:

1. Understand and analyze various computer vision techniques for object segmentation, localization, recognition and tracking
2. Apply various state-of-the-art techniques for object localization, recognition and tracking in autonomous vehicles
3. Apply and implement various recent deep learning based techniques for object localization, recognition and tracking in autonomous vehicles

Syllabus Contents:
Study of various methods for shape representation and segmentation: Deformable curves and Snakes, Fourier and Wavelet descriptors
Introduction to various object recognition methods: Hough Transform, Shape correspondence, Shape Matching, Principal Component Analysis etc.
Study of image formation models, camera model and camera calibration
Introduction to various computer vision algorithms for segmentation, recognition and tracking
State-of-the-art methods for object representation such as HoG, Texture features, Bag-of-Words, Sparse Representation, Haar like features.
Can include some state-of-the-art techniques for object localization: Various Object proposal methods
Study of state-of-the-art classifiers: KNN, SVM, Adaboost, ANN
Introduction to CNN as the recent emerging classifier for signal processing applications in Autonomous vehicles
Familiarity with recent deep learning based algorithms for object localization and recognition: RCNN, FAST RCNN, FASTER RCNN, YOLO


Advanced driver assistance systems (ADAS): ADAS domain controller, Automotive thermal camera, Camera module without processing, Conditionally automated drive controller, Drive assist ECU, Driver monitoring, Driver vital sign monitoring, Front/Rear camera, advance features.

Internet of vehicles and VANET: Types of IOV, Benefits of IOV, Difference between IOV and VANET, Connected cars IoT Transportation, Activity Monitoring.

References:
3. Pattern Recognition and Machine Learning by Christopher Bishop, McGraw-Hill
4. Digital Signal Processing for in-vehicle system and processing, Springer
5. Practical Convolutional Neural Networks by M. Sewak, Md. R. Karim and P. Pujari

(LLC)- Liberal Learning Course

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<tr>
<th>Teaching Scheme</th>
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<td>Lectures: 1 hr/week</td>
<td>Term Work - 100 Marks</td>
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Course Outcomes:

At the end of the course, students will demonstrate the ability to:

1. Exhibit self learning capabilities and its use in effective communication.
2. Inculcate impact of various areas to relate with society at large.

Syllabus Contents:

Identification of topic and resources, scope, and synthesize viewpoints for the areas such as performing arts, social sciences, business, philosophy, Agriculture sports and athletics, Fine Arts Medicine and Health Linguistics, defence studies and education

(DSP Architecture Lab)

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<tr>
<td>Lab: 3 hrs/week</td>
<td>Term work / Practical 100 marks</td>
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Course Outcomes: At the end of the lab course, the students will demonstrate the ability to:

1. Implement various digital signal processing algorithms using Code Composer Studio in simulation
mode.
2. Demonstrate various digital signal processing algorithms on DSP hardware.
3. Deploy DSP hardware using Code Composer Studio for various digital signal processing applications

### Lab Assignments:
1. Study of TMSC6713 DSK and introduction to Code Composer Studio 5.4.0.
2. Bit Reversal using TMSC6713 DSK
3. Signed Integer Division using TMSC6713 DSK
4. Signed Integer Division using TMSC6713 DSK
5. Unsigned Integer Division using TMSC6713 DSK
6. Convolution of 2 sequences using TMSC6713 DSK
7. Complex Number Multiplication using TMSC6713 DSK
8. Computation of Radix-2 and Radix-4 FFT using TMSC6713 DSK

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**Teaching Scheme**
Lectures: 2 hrs/week

**Examination Scheme**
Term work/Practical 100 marks

### Course Outcomes:
At the end of the course the student should be able to

1. Learn application of AI in practical field
2. Apply ML concepts to find solution in problem domain.

### Syllabus Contents:
- Overview of Python - Starting with Python
- Introduction to installation of Python
- Introduction to Python Editors & IDE's (Canopy, pycharm, Jupyter, Rodeo, Ipython etc.)
- Understand Jupyter notebook & Customize Settings
- Concept of Packages/Libraries - Important packages (NumPy, SciPy, scikit-learn, Pandas, Matplotlib, etc)
- Installing & loading Packages & Name Spaces
- Data Types & Data objects/structures (strings, Tuples, Lists, Dictionaries)
- List and Dictionary Comprehensions
- Variable & Value Labels - Date & Time Values
- Basic Operations - Mathematical - string - date
- Reading and writing data
- Simple plotting, Control flow & conditional statements, Debugging & Code profiling
- Algorithms for machine learning
## Teaching Scheme
Lectures: 3 hrs/week

## Examination Scheme
Term work/Practical 100 marks

## Course Outcomes:
At the end of the lab course, the students will demonstrate the ability to:

1. Devise filtering solutions for various applications and appreciate the need for adaptation in design.
2. Analyse convergence and stability issues associated with adaptive filter design

## Lab Assignments:
1. Convolution of two sequences in MATLAB.
2. Computation of Discrete Fourier Transform of a given sequence in MATLAB.
3. Implementations of Finite Impulse Response (FIR) filter in MATLAB.
4. Implementations of Infinite Impulse Response (IIR) filter in MATLAB.
5. Implementation of decimation in MATLAB.
6. Implementation of interpolation in MATLAB.
7. Implementation of adaptive filter using Least Mean Squares (LMS) algorithm in MATLAB.
8. Implementation of adaptive filter using Recursive Least Squares (RLS) algorithm in MATLAB.
9. Presentation: Any topic on recent areas of research in Multirate and Adaptive Signal processing.
Semester III and IV

(Dissertation) Dissertation Phase – I and Phase - II

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<td>Lectures: 4 hrs/week</td>
<td>Term work – 50 marks, Oral – 50</td>
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Course Outcomes:
At the end of this course, students will demonstrate the ability to
1. Ability to synthesize knowledge and skills previously gained and applied to an in-depth study and execution of new technical problem.
2. Capable to select from different methodologies, methods and forms of analysis to produce a suitable research design, and justify their design.
3. Ability to present the findings of their technical solution in a written report.
4. Presenting the work in International/ National conference or reputed journals.

Syllabus Contents:
The dissertation / project topic should be selected / chosen to ensure the satisfaction of the urgent need to establish a direct link between education, national development and productivity and thus reduce the gap between the world of work and the world of study. The dissertation should have the following
- Relevance to social needs of society
- Relevance to value addition to existing facilities in the institute
- Relevance to industry need
- Problems of national importance
- Research and development in various domain

The student should complete the following:
- Literature survey  Problem Definition
- Motivation for study and Objectives
- Preliminary design / feasibility / modular approaches
- Implementation and Verification
- Report and presentation

The dissertation stage II is based on a report prepared by the students on dissertation allotted to them. It may be based on:
- Experimental verification / Proof of concept.
- Design, fabrication, testing of Communication System.
- The viva-voce examination will be based on the above report and work.

- As per the AICTE directives, the dissertation is a yearlong activity, to be carried out and evaluated in two phases i.e. Phase – I: July to December and Phase – II: January to June.
- The dissertation may be carried out preferably in-house i.e. department“s laboratories and centers OR in industry allotted through department”s T & P coordinator.
- After multiple interactions with guide and based on comprehensive literature survey, the
student shall identify the domain and define dissertation objectives. The referred literature should preferably include IEEE/IET/IETE/Springer/Science Direct/ACM journals in the areas of Computing and Processing (Hardware and Software), Circuits-Devices and Systems, Communication-Networking and Security, Robotics and Control Systems, Signal Processing and Analysis and any other related domain. In case of Industry sponsored projects, the relevant application notes, while papers, product catalogues should be referred and reported.

- Student is expected to detail out specifications, methodology, resources required, critical issues involved in design and implementation and phase wise work distribution, and submit the proposal within a month from the date of registration.
- Phase – I deliverables: A document report comprising of summary of literature survey, detailed objectives, project specifications, paper and/or computer aided design, proof of concept/functionality, part results, A record of continuous progress.
- Phase – I evaluation: A committee comprising of guides of respective specialization shall assess the progress/performance of the student based on report, presentation and Q & A. In case of unsatisfactory performance, committee may recommend repeating the phase-I work.
- During phase – II, student is expected to exert on design, development and testing of the proposed work as per the schedule. Accomplished results/contributions/innovations should be published in terms of research papers in reputed journals and reviewed focused conferences OR IP/Patents.
- Phase – II deliverables: A dissertation report as per the specified format, developed system in the form of hardware and/or software, A record of continuous progress.
- Phase – II evaluation: Guide along with appointed external examiner shall assess the progress/performance of the student based on report, presentation and Q & A. In case of unsatisfactory performance, committee may recommend for extension or repeating the work