CURRICULUM AND SYLLABUS OF

M.TECH. DEGREE PROGRAMME IN

POWER ELECTRONICS

DEPARTMENT OF ELECTRICAL ENGINEERING

NATIONAL INSTITUTE OF TECHNOLOGY
CALICUT
Vision of the Department of Electrical Engineering

To be nationally and internationally recognized in providing electrical engineering education and training candidates to become well-qualified engineers who are capable of making valuable contributions to their profession and carrying out higher studies successfully.

Mission of the Department in pursuance of its vision

To offer high quality programs in the field of electrical engineering, to train students to be successful both in professional career as well as higher studies and to promote excellence in teaching, research, collaborative activities and contributions to the society.
### Department of Electrical Engineering

**The Program Educational Objectives (PEOs) of M.Tech. in Power Electronics**

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Program Educational Objectives</th>
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</thead>
<tbody>
<tr>
<td>PEO 1</td>
<td>To equip the engineering graduates with adequate knowledge and skills in the areas of Power Electronics so as to excel in advanced level jobs in modern industry and/or teaching and/or higher education and/or research.</td>
</tr>
<tr>
<td>PEO 2</td>
<td>To transform engineering graduates to expert engineers so that they could comprehend, analyse, design and create novel products and solutions to problems in the areas of Power Electronics that are technically sound, economically feasible and socially acceptable.</td>
</tr>
<tr>
<td>PEO 3</td>
<td>To train engineering graduates to exhibit professionalism, keep up ethics in their profession and relate engineering issues to address the technical and social challenges.</td>
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<tr>
<td>PEO 4</td>
<td>To improve the communication skills, willingness to work in groups and to develop multidisciplinary approach in problem solving</td>
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</table>
Department of Electrical Engineering

The Program Outcomes (POs) of M.Tech. in Power Electronics

At the end of the Program the students will be able to:

<table>
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<tr>
<th>Sl. No.</th>
<th>Program Outcome</th>
<th>Graduate Attribute</th>
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<tbody>
<tr>
<td>PO 1</td>
<td>Achieve the ability to analyse and model the problems in the field of power electronics and solve such problems using the classsy knowledge in the advanced and latest topics in power electronics.</td>
<td>Scholarship of Knowledge</td>
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<td>PO 2</td>
<td>Acquire necessary skills to critically model, analyse and solve all the engineering problems in the field of power electronics.</td>
<td>Critical Thinking</td>
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<td>PO 3</td>
<td>Could analyse all the engineering problems in the area of power electronics through mathematical modeling as well as other possible methods so that a realistic, optimal, feasible and apposite engineering solution could be provided for them.</td>
<td>Problem Solving</td>
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<td>PO 4</td>
<td>Acquiring the awareness regarding the most recent advancements as well as current topics of research in the field of power electronics, and critically analyse the problems of this field to provide preeminent engineering solutions for all such problems through methodical research.</td>
<td>Research Skill</td>
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<tr>
<td>PO 5</td>
<td>Acquire the essential skills to learn and exploit the modern tools and technologies for solving the real life problems in the field of power electronics.</td>
<td>Usage of modern technology</td>
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<tr>
<td>PO 6</td>
<td>Capability to work with a team of engineers/researchers to take up and solve new challenges of multidisciplinary nature in the field of power electronics.</td>
<td>Collaborative and Multidisciplinary work</td>
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<tr>
<td>PO 7</td>
<td>Ability to take up the research and development projects in the area of power electronics, which involves administrative and financial challenges including total project management and time-bound completion of them.</td>
<td>Project Management and Finance</td>
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<td>PO 8</td>
<td>Acquire the enhanced communication skills of oral, writing as well as drawing natures, so that the ideas could be disseminated flawlessly and precisely.</td>
<td>Communication</td>
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<tr>
<td>PO 9</td>
<td>Develop the attitude to sustain the lifelong learning process by the way of participating in various professional activities and utilise the skills and knowledge so acquired to solve the problems in the field of power electronics.</td>
<td>Life-long Learning</td>
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<td>PO 10</td>
<td>Best utilise the acquired knowledge to solve the real life problems associated with the common man of the society in the most ethical manner, so that the standard of life will be enhanced.</td>
<td>Ethical Practices and Social Responsibility</td>
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<td>PO 11</td>
<td>Attain the ability to understand and learn the novel ideas through the self learning process and to utilise such knowledge in solving the problems in the area of power electronics.</td>
<td>Independent and Reflective Learning</td>
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Department of Electrical Engineering

Curriculum for M. Tech. in Power Electronics

**Semester 1**

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<tr>
<th>Course Code</th>
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BRIEF SYLLABUS

MA6003: Mathematical Methods for Power Engineering
REQUIRED COURSE

Pre-requisite: Nil
Total hours: 42 Hrs.

Vector spaces, Linear transformations, Matrix representation of linear transformation, Eigen values and
Eigen vectors of linear operator. Linear Programming Problems, Simplex Method, Duality, Non Linear
Programming problems, Unconstrained Problems ,Search methods, Constrained Problems , Lagrange
method ,Kuhn-Tucker conditions. Random Variables, Distributions, Independent Random Variables,
Marginal and Conditional distributions, Elements of stochastic processes.

EE6301: Power Electronic Circuits
REQUIRED COURSE

Pre-requisite: Nil
Total hours: 42 Hrs.

D.C.chopper circuits, Line Frequency Diode Rectifiers Three Phase half wave rectifier with resistive load
Three phase full wave rectifier . Line Frequency Phase-Controlled Rectifiers and Inverters .Single Phase
Input Line Current Harmonics and Power Factor- Inverter Mode of Operation - Three Phase . Half Wave
Controlled rectifier with RL Load . Half Controlled Bridge with RL Load . Fully Controlled Bridge with
RL Load . Input Side Current Harmonics and Power Factor - Dual Converters Switch-Mode dc-ac
Three Phase SPWM Inverters Output Filters . DC Side Current Converters for Static Compensation .
Standard Modulation Strategies Multi-Level Inverters Space Vector Modulation Current Regulated
Inverter

EE6303: Dynamics of Electrical Machines
REQUIRED COURSE
EE6302: Advanced Power Electronic Circuits
REQUIRED COURSE

Pre-requisite: Nil
Total hours: 42 Hrs.


EE6304: Advanced Digital Signal Processing
REQUIRED COURSE

Pre-requisite: Nil
Total hours: 42 Hrs.

Discrete time signals, systems and their representations - Discrete Fourier series- Discrete Fourier transform- Z- transform- Computation of DFT Digital filter design and realization structures Basic IIR and FIR filter realization structures- Signal flow graph representations Quantization process and errors- Coefficient quantisation effects in IIR and FIR filters- A/D conversion noise- Arithmetic round-off errors-

EE6306: Power Electronic Drives  
**REQUIRED COURSE**

**Pre-requisite:** Nil  
**Total hours:** 42 Hrs

Introduction to Motor Drives - Stability criteria D.C Motor Drives - System model motor rating - Chopper fed and 1-phase converter fed drives Induction Motor Drives - Speed control by varying stator frequency and voltage - Variable frequency PWM-VSI drives - Variable frequency square wave VSI drives - Variable frequency CSI drives - Speed control by static slip power recovery. - Vector control of 3 phase squirrelcage motors - Synchronous Motor Drives - Load commutated inverter drives. PMSM Drives, Switched reluctance Drive.

EE6308: FACTS and Custom Power  
**REQUIRED COURSE**

**Pre-requisite:** Nil  
**Total hours:** 42 Hrs


EE6321: Power Semiconductor Devices and Modeling  
**ELECTIVE COURSE**

**Pre-requisite:** Nil  
**Total hours:** 42 Hrs

Power Diodes, Thyristors, Triacs, Gate Turnoff Thyristor (GTO). V-I Characteristics. Turn on Process

**EE6322: Static Var Controllers & Harmonic Filtering**

**ELECTIVE COURSE**

**Pre-requisite:** Nil

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**Total hours:** 42 Hrs


**EE6323: Digital Simulation of Power Electronic Systems**

**ELECTIVE COURSE**

**Pre-requisite:** Nil

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**Total hours:** 42 Hrs

Examples of Power Electronic systems.-MicroSimPSpice A/D - MATLAB SIMULINK in Power system. Design Creation and Simulation with SaberDesigner - Analysing waveforms with SaberScope

**EE6324: Advanced Control of PWM Inverter Fed induction Motors**

**ELECTIVE COURSE**

**Pre-requisite:** Nil

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**Total hours: 42 Hrs**


**EE6325: Switched Mode and Resonant Converters**

**ELECTIVE COURSE**

**Pre-requisite:** Nil

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**Total hours: 42 Hrs**


**EE6327: Linear and Digital Electronics**

**ELECTIVE COURSE**

**Pre-requisite:** Nil

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Total hours: 42 Hrs

BJT and MOSFET Differential amplifiers and their analysis, Properties of ideal Opamps, Dominant polecompensation – internal and external compensation. The IOA model of an Opamp, analysis and design of standard linear applications of Opamps Sinusoidal oscillators using Opamps Active filtering – Butterworthlow pass filter functions — Sallen and Key second order LP section Butterworth high pass filters — multiple feedback single OPAMP LPF, HPF and BPF – State variable active filter, Regenerative Comparators, Monostable and Astable using Opamps, PLL and applications.

Time division multipliers - Analog switches - sample and hold amplifier – D/A conversion - successive approximation ADC - Basic digital circuits: Arithmetic Circuits, multiplexers and demultiplexers, decoders and encoders. Combinational circuit design using Multiplexer, ROM, PAL, PLA.

Design and analysis of sequential circuits: Analysis and design of Synchronous sequential Finite State Machine – Counters-Ripple Counters – Ring Counters – Shift registers counter design. Asynchronous sequential logic: Analysis and Design

EE6102: Optimal and Adaptive Control
ELECTIVE COURSE

Pre-requisite: Nil

Total hours: 42 Hrs.

Optimal control problem — fundamental concepts and theorems of calculus of variations – Euler - Language equation and extremal of functionals - the variational approach to solving optimal control problems - Hamiltonian and different boundary conditions for optimal control problem – linear regulator problem - Pontryagin’s minimum principle - dynamic programming - principle of optimality and its application to optimal control problem - Hamilton-Jacobi-Bellman equation - model reference adaptive systems (MRAS) - design hypothesis - introduction to design method based on the use of Liapunov function – design and simulation of variable structure adaptive model following control

EE6121: Data Acquisition & Signal Conditioning
ELECTIVE COURSE

Pre-requisite: Nil

Total hours: 42 Hrs.

Conversion(DAC)- Data transmission systems- Modulation techniques and systems-Telemetry systems-
Study of a representative DAS Board-Interfacing issues with DAS Boards- Software Drivers, Virtual
Instruments, Modular Programming Techniques-Bus standard for communication between instruments -
Software Design Strategies for DAS.

EE6122: Biomedical Instrumentation
ELECTIVE COURSE

Pre-requisite: Nil

Total hours: 42 Hrs.

Fundamental of Biomedical Instrumentation – origin of bio potentials – biomedical transducers – bio
signals ,ECG,EMG,EEG etc – measurement of cardiac output, blood flow, blood pressure etc –
oximetersmeasurements on pulmonary system – blood gas analyzers – audiometers – patient safety –
lasers in medicine – X-ray applications – ultrasound in medicine – pacemakers – defibrillators –
electrotherapy –hemodialysis – ventilators –radiotherapy

EE6125: Digital Control Systems
ELECTIVE COURSE

Pre-requisite: Nil

Total hours: 42 Hrs

Data conversion and quantisation- z transform and inverse z transform - Difference equation - Solution
by recursion and z-transform- Discretisation Methods- z transform analysis of closed loop and open loop
systems- Modified z- transfer function- Multirate z-transform- Stability of linear digital control systems-
Steady state error analysis- Root loci - Frequency domain analysis- Digital controller design using
bilineartransformation- Root locus based design- Digital PID controllers- Dead beat control design- Case
studyexamples using MATLAB- State variable models- Controllability and Observability - Response
between sampling instants using state variable approach-Pole placement using state feedback – Servo
Design- Statefeedback with Integral Control-Deadbeat Control by state feedback and deadbeat observers-
Dynamicoutput feedback- Effects of finite wordlength on controllability and closed loop pole placement-
Case studyexamples using MATLAB.

EE6129: Artificial Neural Networks and Fuzzy Systems
ELECTIVE COURSE
Pre-requisite: Nil

Total hours: 42 Hrs.


EE6204: Digital Protection of Power Systems
ELECTIVE COURSE

Pre-requisite: Nil

Total hours: 42 Hrs.


EE6222: Power Quality
ELECTIVE COURSE

Pre-requisite: Nil

Total hours: 42 Hrs.

Power quality measures and standards-IEEE guides, standards and recommended practices, Harmonics--important harmonic introducing devices -effect of power system harmonics on power system equipment and loads. - Modeling of networks and components under non-sinusoidal conditions, power quality problems created by drives - Power factor improvement- Passive Compensation - Active Power Factor Correction - Single Phase APFC, Three Phase APFC and Control Techniques, static var compensators- SVCand STATCOM - Active Harmonic Filtering- Dynamic Voltage Restorers for sag, swell and flicker problems. - Grounding and wiring-introduction

EE6401: Energy Auditing & Management
ELECTIVE COURSE

Pre-requisite: Nil
Total hours: 42 Hrs

Energy auditing: Types and objectives-audit instruments, Energy efficient /high efficient Motors-Case study; Load Matching and selection of motors, Reactive Power management-Capacitor Sizing-Degree of Compensation-Capacitor losses-Location-Placement-Maintenance, case study, Cogeneration-Types and Schemes-Optimal operation of cogeneration plants-case study, Energy conservation in Lighting Schemes, VFD, Energy conservation measures in Gysers, Transformer, Feeder, Pumps and Fans

**EE6402: Process Control & Automation**

ELECTIVE COURSE

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Pre-requisite: Nil

Total hours: 42 Hrs

Process Modeling, Transfer function-State space models-Time series models, Feedback &Feedforward Control, PID design and tuning, Cascade control- Selective control loops-Ratio control-Control, State feedback control- LQR problem- Pole placement, Process Interactions-Singular value analysis-tuning of multi loop PID control systems-decoupling control, Real-time optimization, Model predictive control-Batch Process control-Plant-wide control & monitoring, Introduction to Fuzzy Logic in Process Control, Introduction to OPC, Comparison of performance different types of control with examples on software packages

**EE6403: Computer Controlled Systems**

ELECTIVE COURSE

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Pre-requisite: Nil

Total hours: 42 Hrs

Multivariable control, Singular values- Stability norms, Robustness- Robust stability- H2 / H∞ Theory, Interaction and decoupling- Relative gain analysis, Decoupling control, Programmable logic controllers, SCADA, DCS, Real time systems, Supervisory control- direct digital control- Distributed control- PC based automation.

**EE6404: Industrial Load Modeling& Control**

ELECTIVE COURSE

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Pre-requisite: Nil

Total hours: 42 Hrs
Load Management, Load Modeling; Electricity pricing, Direct load control- Interruptible load control, Load scheduling- Continuous and Batch processes, Computer methods of optimization, -Reactive power control in industries- Cooling and heating load profiling, Energy Storage devices and limitations, Captive power units- Operating strategies- Power Pooling, Integrated Load management for Industries; Software packages-Case study.

**EE6406: Industrial Instrumentation**
ELECTIVE COURSE

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Total hours: 42 Hrs

Industrial measurement systems, sensors and transducers for different industrial variables, Amplifiers – Filters – A/D converters for industrial measurements systems, Calibration and response of industrial instrumentation, Generalized performance characteristics – static response characterization – dynamic response characterization, Response to different forcing functions such as step, sinusoidal etc. to zero, first,second third and higher orders of systems, Regulators and power supplies for industrial instrumentation, Servo drives, stepper motor drives types and characteristics, hybrid and permanent magnet motors. Advanced modeling tools and their characteristics for automated control instrumentation application

**EE6421: Advanced Microcontroller Based Systems**
ELECTIVE COURSE

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Total hours: 42 Hrs


**EE6422: Engineering Optimization**
ELECTIVE COURSE

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Total hours: 42 Hrs
Concepts of optimization, Classical Optimization Techniques, Linear programming, dual simplex method, Minimum cost flow problem, Network problems-transportation, assignment & allocation, Nonlinear programming, Unconstrained optimization, Constrained optimization, Dynamic programming, Genetic algorithms, optimization using software packages

EE6424: Robotics Systems and Applications
ELECTIVE COURSE

Pre-requisite: Nil

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Total hours: 42 Hrs


EE6426: Distribution Systems Management and Automation
ELECTIVE COURSE

Pre-requisite: Nil

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Total hours: 42 Hrs


EE6428: SCADA Systems and Applications
ELECTIVE COURSE

Pre-requisite: Nil

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Total hours: 42 Hrs

Introduction to SCADA, Monitoring and supervisory functions, SCADA applications in Utility Automation, SCADA System Components, RTU, IED, PLC, Communication Network, SCADA Server, SCADA/HMI Systems, Various SCADA architectures, single unified standard architecture -IEC 61850, SCADA Communication, open standard communication protocols.
DETAILED SYLLABUS

MA6003: MATHEMATICAL METHODS FOR POWER ENGINEERING
REQUIRED COURSE

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Pre-requisite: Nil

Course outcomes:

CO1: Acquire knowledge about vector spaces, linear transformation, eigenvalues and eigenvectors of linear operators.

CO2: To learn about linear programming problems and understanding the simplex method for solving linear programming problems in various fields of science and technology.

CO3: Acquire knowledge about nonlinear programming and various techniques used for solving constrained and unconstrained nonlinear programming problems.

CO4: Understanding the concept of random variables, functions of random variable and their probability distribution.

CO5: Acquire knowledge about stochastic processes and their classification.

Total hours: 42 Hrs.

Module 1: Linear Algebra (10 hours)

Vector spaces, subspaces, Linear dependence, Basis and Dimension, Linear transformations, Kernels and Images, Matrix representation of linear transformation, Change of basis, Eigen values and Eigen vectors of linear operator

Module 2: Optimisation Methods I (11 hours)

Mathematical formulation of Linear Programming Problems, Simplex Method, Duality in Linear Programming, Dual Simplex method.

Module 3: Optimisation Methods II (10 hours)
Non Linear Programming preliminaries, Unconstrained Problems, Search methods, Fibonacci Search, Golden Section Search, Constrained Problems, Lagrange method, Kuhn-Tucker conditions

Module 4: Operations on Random Variables (11 hours)


Text Books and References:

8. Simmons D M, Non Linear Programming for Operations Research, PHI, 1975
**EE6301: POWER ELECTRONIC CIRCUITS**  
REQUIRED COURSE

Pre-requisite: Nil

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Total hours: 42 Hrs.

Course outcomes:

CO1: Acquire knowledge about analysis and design of various types of DC Chopper circuits

CO2: Acquire knowledge about harmonic analysis and filter circuit design of uncontrolled rectifiers

CO3: Acquire knowledge about various types of controlled rectifiers

CO4: Acquire knowledge about various PWM techniques of 2-level DC to AC converters

CO5: Acquire knowledge about analysis of multilevel inverters with advanced PWM techniques.

**Module 1**  
(11 hours)


**Module 2**  
(10 hours)


Module 3 (10 hours)

Module 4 (11 hours)

Textbooks and References:
1. Ned Mohan et.al “Power electronics: converters, applications, and design” John Wiley and Sons, 2006
EE6303: DYNAMICS OF ELECTRICAL MACHINES
REQUIRED COURSE

Pre-requisite: Nil

Total hours: 42 Hrs.

Course outcomes:

CO1: Formulation of electrodynamics equations of all electric machines and analyzes the performance characteristics.

CO2: Knowledge of transformations for the dynamic analysis of machines.

CO3: Knowledge of the determination of stability of the machines under small signal and transient conditions

Module 1 (12 hours)


Module 2 (11 hours)

Module 3  
(10 hours)


Module 4  
(9 hours)


Text Books and References:
EE6391: POWER ELECTRONICS LAB
LABORATORY COURSE

Pre-requisites: Nil

Course Outcomes:
CO1: To familiarize with the simulation and analytical softwares.
CO2: Analyze simulation results and do effective documentation.
CO3: Developing skills for designing, simulating and developing hardwares for power electronic circuits.
CO4: Acquire expertise in usage of modern power electronic hardware and software tools.

Total Hours: 42 Hours

List of Experiments
1. MOSFET Characteristics
2. IGBT Characteristics
3. Fullwave Uncontrolled Rectifier With C-Filter
4. Fullwave Uncontrolled Rectifier With L-Filter
5. Fullwave Uncontrolled Rectifier With L-C Filter
6. Fullwave Uncontrolled Rectifier With Voltage Doublers
7. Fullwave Controlled Rectifier With C-Filter
8. Fullwave Controlled Rectifier With L-Filter
9. Fullwave Controlled Rectifier With L-C Filter
EE6302: ADVANCED POWER ELECTRONIC CIRCUITS
REQUIRED COURSE

Pre-requisite: Nil

Course Outcomes:
CO1: Acquire knowledge about analysis and design of Load Commutated CSI and PWM CSI
CO2: Acquire knowledge about analysis and design of series Inverters.
CO3: Acquire knowledge about analysis and design of Switched Mode Rectifiers and APFC
CO4: Acquire knowledge about analysis and design of isolated and nonisolated Switched Mode DC to DC Converters
CO5: Acquire knowledge about analysis and design of Resonant Converters

Total hours: 42 Hrs.

Module 1
(8 hours)
Special Inverter Topologies - Current Source Inverter. Ideal Single Phase CSI operation, analysis and waveforms - Analysis of Single Phase Capacitor Commutated CSI.
Series Inverters. Analysis of Series Inverters. Modified Series Inverter. Three Phase Series Inverter

Module 2
(12 hours)
Switched Mode Rectifier - Operation of Single/Three Phase bilateral Bridges in Rectifier Mode. Control Principles. Control of the DC Side Voltage. Voltage Control Loop. The inner Current Control Loop. Single phase and three phase boost type APFC and control, Three phase utility interphases and control

Module 3
(10 hours)
Module 4 (12 hours)


Textbooks and References:
1. Ned Mohan et.al “Power electronics: converters, applications, and design” John Wiley and Sons, 2006
EE6304: ADVANCED DIGITAL SIGNAL PROCESSING
REQUIRED COURSE

Pre-requisite: Nil

Course outcomes:
CO1: Acquire knowledge about the time domain and frequency domain representations as well as analysis of discrete time signals and systems
CO2: Acquire knowledge about the design of techniques for IIR and FIR filters and their realization structures.
CO3: Acquire knowledge about the finite word length effects in implementation of digital filters.
CO4: Acquire knowledge about the various linear signal models and estimation of power spectrum of stationary random signals
CO5: Acquire knowledge about the design of optimum FIR and IIR filters.

Total hours: 42 Hrs

Module 1 Discrete Time Signals, Systems and Their Representations (10 hours)
Discrete time signals- Linear shift invariant systems- Stability and causality- Sampling of continuous timesignals- Discrete time Fourier transform- Discrete Fourier series- Discrete Fourier transform- Z-transform-Properties of different transforms- Linear convolution using DFT- Computation of DFT

Module 2 Digital Filter Design and Realization Structures (10 hours)
Design of IIR digital filters from analog filters- Impulse invariance method and Bilinear transformation method- FIR filter design using window functions- Comparison of IIR and FIR digital filters- Basic IIR and FIR filter realization structures- Signal flow graph representations
Module 3 Analysis of Finite Word-length Effects

Quantization process and errors- Coefficient quantisation effects in IIR and FIR filters- A/D conversion noise- Arithmetic round-off errors- Dynamic range scaling- Overflow oscillations and zero input limitcycles in IIR filters

Module 4 Statistical Signal Processing


Textbooks and References :

6. Abraham Peled and Bede Liu, Digital Signal Processing, John Wiley and Sons, 1976
EE6306: POWER ELECTRONIC DRIVES
REQUIRED COURSE

Pre-requisites: None

Course Outcomes:
CO1: Develop capability to choose a suitable Motor and Power Electronic Converter package from a description of drive requirement – involving load estimation, load cycle considerations, thermal aspects and motor-converter matching
CO2: To learn about various DC and AC machines used in drives.
CO3: Acquire detailed knowledge of Electrical Motor operation using Generalized machine theory.
CO4: To understand the working and design of various converters used in Electrical Drives.

Total hours: 42 Hrs

Module – 1 (10 hours)
Introduction to Motor Drives - Components of Power Electronic Drives – Criteria for selection of Drive components - Match between the motor and the load - Thermal consideration - Match between the motor and the Power Electronics converter - Characteristics of mechanical systems - stability criteria

Module – 2 (11 hours)

Module – 3 (12 hours)
Induction Motor Drives - Basic Principle of operation of 3 phase motor - Equivalent circuit - MMF space harmonics due to fundamental current - Fundamental spatial mmf distributions due to time harmonics - Simultaneous effect of time and space harmonics - Speed control by varying stator frequency and voltage - Impact of non-sinusoidal excitation on induction motors - Variable frequency converter classifications - Variable frequency PWM-VSI drives - Variable frequency square wave VSI drives - Variable frequency CSI drives - Comparison of variable frequency drives - Line frequency variable voltage drives - Soft start of induction motors - Speed control by static slip power recovery - Vector control of 3 phase squirrel cagemotors - Principle of operation of vector control.

Module – 4 (9 hours)

Synchronous Motor Drives - Introduction - Basic principles of synchronous motor operation methods of control - Operation with field weakening - Load commutated inverter drives. PMSM drives, Switched reluctance Drive.

Textbooks and References:

EE6308: FACTS AND CUSTOM POWER
REQUIRED COURSE

Pre-requisite: Nil

Course Outcomes:
CO2: To introduce the student to various Static VAr Compensation Schemes like Thyristor/GTO Controlled Reactive Power Systems, PWM_Inverter based Reactive Power Systems and their controls.
CO3: To develop analytical modeling skills needed for modeling and analysis of such Static VAr systems with a view towards Control Design.
CO5: Introduce the student to various UPFC Systems, Converters used in them and their control.
CO6: To develop analytical modeling skills needed for modeling and analysis of UPFC systems with a view towards Control Design.
CO7: To introduce the student to various Custom Power Systems, Modeling of such systems and Control Design for them.

Total hours: 42 Hrs

Module 1 (10 hours)

Reactive power compensation – shunt and series compensation principles – reactive compensation at transmission and distribution level – Static versus passive VAr Compensators –

**Module 2**

(10 Hours)

Static shunt compensators: SVC and STATCOM - Operation and control of TSC, TCR and STATCOM - Compensator control - Comparison between SVC and STATCOM.

Static series compensation: TSSC, SSSC - Static voltage and phase angle regulators - TCVR and TCPAR - Operation and control - Applications.

Static series compensation – GCSC, TSSC, TCSC and Static synchronous series compensators and their control - SSR and its damping

**Module 3**

(9 Hours)


**Module 4**

(10 Hours)

Power quality problems in distribution systems, harmonics, loads that create harmonics, modeling, harmonic propagation, series and parallel resonances, mitigation of harmonics, passive filters, active filtering – shunt, series and hybrid and their control – voltage swells, sags, flicker, unbalance and mitigation of these problems by power line conditioners - IEEE standards on power quality.

**Textbooks and References:**

EE6394 SEMINAR
REQUIRED COURSE

Pre requisites: Nil

Course outcomes:
CO1: To study the recent and old research papers for understanding of an emerging technologies in the field of power electronics, in the absence of a text book. Summarize the objective the paper and review the effectiveness
CO2: To identify promising new directions of various cutting edge technologies
CO3: To impart skills in preparing a detailed report describing the reviewed topic
CO4: To effectively communicate by making an oral presentation before an evaluation committee

Individual students will be asked to choose a topic in any field of Power Electronics, preferably from outside the M.Tech syllabus and give seminar on the topic for about thirty minutes. A committee consisting of at least three faculty members specialized on different fields of engineering will assess the presentation of the seminars and award the marks to the students. Each student will be asked to submit two copies of a write up of the seminar talk – one copy will be returned to the student after duly certifying by the Chairman of the assessing committee and the other copy will be kept in the departmental library.
EE6392 MINI PROJECT
REQUIRED COURSE

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Pre requisites: Nil

Course outcomes:
CO1: To enable the engineering post graduate student to undertake individual mini research projects in the area of power electronics under the guidance of a regular faculty.
CO2: To enable the post graduate student to develop a complete small design and implement the projects in a hardware prototype/experimental setup and obtain the experimental results.
CO3: To impart skills in preparing a detailed design report describing the relevance of the project, modeling aspects, methodologies and analysis of the results.
CO4: To effectively communicate by making an oral presentation before an evaluation committee.

The mini project can be analytical / simulation/design or fabrication in any of the areas in Power Electronics. Project must be done by individual student under any faculty of the Electrical Engineering Department as the guide. A faculty coordinator will coordinate project work of all students. The mini project is usually allotted by the Dept at the beginning of 2nd semester and preferably shall be completed before the end of 2nd semester.

The project work is evaluated by a committee consisting of the concerned guide and two/three faculty members in the concerned area of the project nominated by the HOD. The faculty coordinator of the project will be a member of the evaluation committee all the projects. The mode of presentation, submission of the report, method of evaluation, award of grades etc will be decided by the evaluation committee. Students shall submit both soft and hard copies (required number of copies) of project report.
in the prescribed form to the department and library after incorporating all the corrections and changes suggested by the evaluation committee.

EE7391 MAIN PROJECT -1
REQUIRED COURSE

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Pre requisites: Nil

Course outcomes:
CO1: Provides an opportunity to pursue their interest in power electronics through design, research, theoretical and experimental approach.
CO2: To enable the students to identify a topic of interest and complete the preliminary work of undertaking case studies, data collection and feasibility studies.
CO3: Students get guidance to formulate and develop a design proposal and to effectively communicate the same.
CO4: To effectively communicate by making an oral presentation of the progress of work before an evaluation committee

The project work will be a design project / experimental project in the areas of Power Electronics. The assessment of the project will be done at the end of the semester by a committee consisting of three or four faculty members specialized in various fields of Electrical Engineering. The students will present their project work before the committee. The complete project report is not expected at the end this semester. However a 30-40 page typed report based on the work done will have to be submitted by the students to the assessing committee. The Department level evaluation shall have 50% weight in the final grading- 50% weight will be given to the assessment by the individual guide. Marks will be reported based on 100 as maximum. Result shall be finalized at the Department level.
Pre requisites: Nil

Course outcomes:
CO1: To enable the students to develop comprehensive solution to issues identified in previous semester work and to meet the requirements as stated in project proposal.
CO2: To inculcate the ability to synthesize the results of the detailed analytical studies conducted, lay down validity and design criteria, interpret the result for application to the power electronic design problems.
CO3: To report the concept and detailed design solution and to effectively communicate the thesis rationale and publish in reputed journals/conference.

The project work is evaluated in two stages. The first stage assessment of the project will be done at the end of third semester and the final stage assessment at the end of fourth semester. Evaluation will be done by a committee consisting of the concerned guide and two/three faculty members in the concerned area of the project nominated by the Programme Coordinator. The program Coordinator of the M.Tech Stream will be a member of the evaluation committee of the projects. The mode of presentation, submission of the report, method of evaluation, award of grades etc will be decided by the evaluation committee. Students shall submit both soft and hard copies (required number of copies) of project report
in the prescribed form to the department and library after incorporating all the corrections and changes suggested by the evaluation committee. The Department level evaluation shall have 70% weight in the final grading of which 50% weight will be given to the assessment by the individual guide. Remaining 30% marks is awarded in the external evaluation with an external examiner nominated by the Program Coordinator and approved by the HoD. Final marks will be reported based on 100 as maximum.

EE6321: POWER SEMICONDUCTOR DEVICES AND MODELING
ELECTIVE COURSE

Pre-requisite: Nil

Course outcomes:
CO1: To learn the basics of power semiconductor switches.
CO2: To understand the working of various types of converters and application of them.
CO3: To understand and design the drive circuits for various Power Semiconductor Switches.
CO4: To learn to model the converters and semiconductor switches.
CO5: To learn about the control of various power semiconductor switches.

Total hours: 42 Hrs

Module 1

Gate Turnoff Thyristor (GTO) . Basic Structure and Operation . GTO Switching Characteristics . GTO Turn on Transient . GTO Turn off Transient . Minimum ON and OFF State times . Maximum Controllable Anode Current . Overcurrent protection of GTOs
Module 2 (12 hours)


Insulated Gate Bipolar Transistors (IGBTs) - Basic Structure and Operation - Latch up IGBT Switching Characteristics - Resistive Switching Specifications - Clamped Inductive Switching Specifications - IGBT Turn on Transient - IGBT Turn off Transient - Current Tailing - Ratings of MOSFETs - FBSOA and RBSOA Curves - Switching Losses - Minimum ON and OFF State times - Switching Frequency Capability - Overcurrent protection of IGBTs - Short Circuit Protection - Snubber Requirements and Snubber Design.

Module 3 (12 hours)
New power semiconductor devices - Thermal design of power electronic equipment - Modelling of power semiconductors (principles) - Simulation tools

Module 4 (12 hours)

Text Books and References:
EE6322: STATIC VAR CONTROLLERS & HARMONIC FILTERING
ELECTIVE COURSE

Pre-requisites: Nil

Course outcomes:


CO2: To introduce the student to various single phase and three-phase Static VAr Compensation Schemes and their controls.

CO3: To develop analytical modeling skills needed for modeling and analysis of such Static VAr systems with a view towards Control Design.

CO4: Acquire knowledge about the fundamental principles of Passive and Active Harmonic Filtering in Power Systems.

CO5: Introduce the student to various single-phase and three-phase active harmonic filtering systems employing Current-regulated PWM VSI and their control.

CO6: To develop analytical modeling skills needed for modeling and analysis of such Active Harmonic Filtering systems with a view towards Control Design.

Total hours: 42 Hrs

Module – 1

(10 hours)

Module – 2
(11 hours)

Static Reactive Power Compensators and their control. Shunt Compensators, SVCs of Thyristor Switched and Thyristor Controlled types and their control, STATCOMs and their control, Series Compensators of Thyristor Switched and Controlled Type and their Control, SSSC and its Control, Sub-Synchronous Resonance and damping, Use of STATCOMs and SSSCs for Transient and Dynamic Stability Improvement in Power Systems

Module – 3
(12 hours)


Module – 4
(9 hours)


Text Books and References:

EE6323: DIGITAL SIMULATION OF POWER ELECTRONIC SYSTEMS  
ELECTIVE COURSE

Pre-requisite: Nil

Course outcomes:

CO1: To develop mathematical model of power electronic switches and electrical machines.

CO2: To study software packages PSpice, Matlab Simulink &Saber for the simulation of Power Electronic Systems.

CO3: Develop capability to design and simulate power electronic systems using PSpice.

CO4: Develop capability to design and simulate power electronic systems using Matlab Simulink.

CO5: Develop capability to design and simulate power electronic systems using Saber

Total hours: 42 Hrs

Module 1  (10 hours)

Equations – Computer Solution of State Equations - Explicit Integration method - Implicit Integration method.

Module 2 (10 Hours)


Module 3 (10 Hours)


Module 4 (12 Hours)

Design Creation and Simulation with SaberDesigner - Placing the Parts - Editing the Symbol - Properties - Wiring the Schematic - Modifying Wire Attributes - Performing a Transient and DC Analysis – Placing Probes in the Design - Performing AC Analysis and Invoking SaberScope - Analyzing waveforms with SaberScope - Performing Measurements on a waveform - Varying a Parameter - Displaying the Parameter Sweep Results - Measuring a Multi-Member Waveform - Simulation Examples of Power Electronic Systems.

Text Books and References:

4. Getting Started with SaberDesigner (Release 5.1), An Analogy Inc.
5. Guide to Writing MAST Template (Release 5-1), Analogy Inc.
EE6324: ADVANCED CONTROL OF PWM INVERTER FED INDUCTION MOTORS
ELECTIVE COURSE

Pre-requisite: Nil

Course Outcome:
CO1: To develop dynamic model of induction machines different frames of reference.
CO2: To understand principles of field oriented (vector) control of induction machines.
CO3: Develop capability to analyze the effects of machine parameter variations on the performance of induction machine fed drives.
CO4: To understand the principles of sensor-less speed control of induction machines.
CO5: To design a vector controlled induction machine drive system

Total Hours: 42Hrs

Module 1 (12 hours)

Rotor-flux oriented control of current-regulated induction machine - Dynamic model of IM in rotor-fluxcoordinates. Indirect rotor-flux oriented control of IM - Direct rotor-flux oriented control of IM. 

Methodsto estimation of rotor-flux

Module 2 (10 hours)


Module 3 (10 hours)

Parameter sensitivity, selection of flux level, and field weakening - Parameter detuning in steady-state operation. Parameter detuning during dynamics. Selection of flux level. Control strategies for used in the over-speed region.

Module 4 (10 hours)

Principles for speed sensor-less control - Principles for speed sensor-less control. Sensor-less methods for scalar control. Sensor-less methods for vector control. Introduction to observer-based techniques

Textbooks and References:

EE6325: SWITCHED MODE AND RESONANT CONVERTERS
ELECTIVE COURSE

Pre-requisites: Nil

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Course outcomes:

CO1: Acquire knowledge about the principles of operation of non-isolated and isolated hard-switched DC-DC converters

CO2: Acquire knowledge on various loss components in a switched mode converter and choice of switching frequency with a view towards design of such converters

CO3: Acquire knowledge on magnetics in switched mode converters and design of high frequency inductors and transformers with a DC bias.

CO4: Introduce voltage mode and current mode control of DC-DC converters and familiarization with various controller ICs available in the market.
CO5: Introduce the student to large-signal modeling and small signal modeling of hard- Z switched converters, development of transfer functions and design of error amplifiers.

CO6: Introduce the student to transient control in hard-switched converters by use of proper wiring practices, judicious component selection and various snubbers.

CO7: Introduce the student to resonant mode converters and their operation and control.

Total Hours: 42 Hours

Module 1 (11 hours)
Buck, Boost, Buck-Boost SMPS Topologies . Basic Operation- Waveforms - modes of operation - switching stresses - switching and conduction losses - optimum switching frequency - practical voltage, current and power limits - design relations - voltage mode control principles.

Module 2 (10 hours)
Voltage Mode Control of SMPS . Loop Gain and Stability Considerations . Shaping the Error Amp frequency Response . Error Amp Transfer Function . Transconductance Error Amps . Study of popular PWM Control Ics (SG 3525, TL 494, MC34060 etc.)

Module 3 (10 hours)
Module 4: (11 hours)


Text Books and References:


EE6327: LINEAR AND DIGITAL ELECTRONICS

ELECTIVE COURSE

Pre-requisites: Nil

Course outcomes:

CO1: To provide a detailed understanding of operation of BJT and CMOS operational amplifiers with special emphasis on non-ideal effects like offsets, finite impedance levels, finite gain bandwidth product, slew rate, PSRR etc.

CO2: To develop capability in designing various linear applications of opamps, various filters, sinusoidal oscillators etc., such that the student’s design-preparedness to carry out projects in Power Electronics will be enhanced.

CO3: To develop capability in designing various nonlinear applications of opamps and comparators such as regenerative comparators, waveform generators, precision
rectifiers, log-antilog amps etc., such that the student's design-preparedness to carry out projects in Power Electronics will be enhanced.

**CO4:** To develop capability in designing with VCOs, VFCs, FVCs, PLLs, ADCs, DACs, IC Multipliers/Dividers, OTAs etc., such that the student's design-preparedness to carry out projects in Power Electronics will be enhanced.

**CO5:** To develop design capability in designing combinational digital circuits using MUX, ROM, PLA, PAL etc., such that the students will be better prepared to carry out projects in Power Electronics will be enhanced.

**CO6:** To develop design capability in designing synchronous and asynchronous sequential digital circuits such that the students' design-preparedness to carry out projects in Power Electronics will be enhanced.

**Total Hours: 42 Hours**

**Module 1 (15 Hours)**

BJT and MOSFET Differential amplifiers and their analysis, Offset behaviour, Current sources for biasing inside a BJT/MOS IC – Properties of ideal Opamps, Internal description of a BJT Opamp, slew rate, internal description of a two stage MOS Opamp, Internal description of a Folded Cascode MOS Opamp, Dominant pole compensation – internal and external compensation. The IOA model of an Opamp, principle of virtual short, Offset model for an Opamp, analysis and design of standard linear applications of Opamps Reference diodes and voltage references, linear voltage regulators Sinusoidal oscillators using Opamps Active filtering – Butterworth low pass filter functions - low pass filter specifications - Order and cut off frequency of Butterworth function from low pass specifications – Sallen and Key second order LP section - gain adjustment in Butterworth LP filters - Butterworth high pass filters – Second order wide band and narrow band band pass filters - multiple feedback single OPAMP LPF, HPF and BPF State variable active filter, Universal active filter.

**Module 2 (8 Hours)**

Regenerative Comparators, Comparator ICs, Square-Triangle – ramp generation, sine wave shaping, Function generator ICs, VCO Circuits, VFCs and FVCs and applications, Monostable and Astable using Opamps, PLL and applications. Precision rectification, Log and Anti-log amplifiers, IC multipliers, Transconductance multiplier/divider, Time division multipliers Analog switches - sample and hold amplifier – Data conversion fundamentals - D/A conversion – weighed resistors DAC - R/2R ladder DAC - current switching DAC - A/D conversion - quantiser characteristics - single slope and dual slope ADCs - successive approximation ADC - simultaneous ADC

**Module 3 (9 Hours)**

Basic digital circuits: Review of number systems and Boolean algebra - Simplification of functions using Karnaugh map - Boolean function implementation. Examples of useful digital circuits:
Arithmetic Circuits, Comparators and parity generators, multiplexers and demultiplexers, decoders and encoders.
Combinational logic design: Combinational circuit design using Multiplexer, ROM, PAL, PLA.
Introduction to Sequential circuits: Latches and flip-flops (RS, JK, D, T and Master Slave) - Design of aclocked flip-flop – Flip-flop conversion - Practical clocking aspects concerning flip-flops.

Module 4 (10 Hours)

Design and analysis of sequential circuits: General model of sequential networks - State diagrams – Analysis and design of Synchronous sequential Finite Sate Machine – State reduction – Minimization and design of the next state decoder.
Counters: Design of single mode counters and multimode counters – Ripple Counters – Ring Counters – Shift registers counter design.
Practical design aspects: Timing and triggering considerations in the design of synchronous circuits – Setup time - Hold time – Clock skew.

Text Books and References:
1. Sedra & Smith: Microelectronic Circuits, Oxford University Press, 2004
5. Clayton G.B: Operational Amplifiers, ELBS, 2002

EE6102: OPTIMAL AND ADAPTIVE CONTROL
ELECTIVE COURSE

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Pre-requisites: Nil

Course outcomes:
CO1: Acquire knowledge in the mathematical area of ‘calculus of variation’ so as to apply the same for solving optimal control problems.

CO2: Acquire knowledge of problem formulation, performance measure and mathematical treatment of optimal control problems so as to apply the same to engineering control problems with the possibility to do further research in this area.

CO3: Acquire knowledge on solving optimal control design problems by taking into consideration the physical constraints on practical control systems.

CO4: Acquire knowledge to obtain optimal solutions to controller design problems taking into consideration the limitation on control energy in the real practical world.

CO5: Acquire knowledge to develop and utilize modern software tools for design and analysis of optimal control problems.

CO6: Acquire knowledge in model reference adaptive control system design and to extend this knowledge to other areas of model following control with the idea of pursuing research in this area.

**Total hours: 42 Hrs.**

**Module 1:**

(12 hours)


**Module 2:**

(10 hours)


**Module 3:**

(10 hours)


**Module 4:**

(10 hours)

Model Reference Adaptive systems (MRAS) - the need for MRAS - an over view of adaptive control
systems - mathematical description of MRAS - design hypothesis - equivalent representation of MRAS - introduction to design method based on the use of Liapunov function – design and simulation of variable structure adaptive model following control

**Text Books and References:**


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**EE6121 DATA ACQUISITION & SIGNAL CONDITIONING**

**ELECTIVE COURSE**

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**Pre-requisites:** Nil

**Course outcomes:**

**CO1:** Understand the objectives and configurations of data acquisition systems

**CO2:** Learn the working and characteristics of transducers

**CO3:** Learn about signal conditioning systems and noise reduction techniques

**CO4:** Acquire knowledge on filtering & sampling techniques and filter design

**CO5:** Acquire knowledge on signal conversion (analog to digital and digital to analog) techniques

**CO6:** Understand various data transmission techniques
CO7: Learn various interfacing techniques and standards for communication between instruments

Total hours: 42 Hrs.

Module 1: Transducers & Signal Conditioning (11 hours)


Module 2: Filtering and Sampling (10 hours)


Module 3: Signal Conversion and Transmission (10 hours)

Analog-to-Digital Converters (ADC) - Multiplexers and demultiplexers - Digital multiplexer - A/D Conversion - Conversion Processes - Speed, Quantization Errors - Successive Approximation ADC - Dual Slope ADC - Flash ADC - Digital-to-Analog Conversion (DAC) - Techniques, Speed, Conversion Errors, Post Filtering - Weighted Resistor, R-2R, Weighted Current type of DACs - Multiplying Type DAC - Bipolar DACs - Data transmission systems - Schmitt Trigger - Pulse code formats - Modulation techniques and systems - Telemetry systems.

Module 4: Digital Signal Transmission And Interfacing (11 hours)

DAS Boards - Introduction. Study of a representative DAS Board - Interfacing Issues with DAS Boards, I/O vs Memory Addressing, Software Drivers, Virtual Instruments, Modular Programming Techniques for Robust Systems, Bus standard for communication between instruments - GPIB (IEEE-488bus) - RS-
232CUSB-4-to-20mA current loop serial communication systems. Communication via parallel port.
Interrupt-based Data Acquisition. Software Design Strategies - Hardware Vs Software Interrupts -
Foreground/ background Programming Techniques - Limitations of Polling. Circular Queues

Text Books and References:

EE6122: BIOMEDICAL INSTRUMENTATION
ELECTIVE COURSE

Pre-requisites: Nil

Course outcomes:
CO1: Provide the students with an insight into the physiological system of the body and also an understanding on the generation of various bioelectric signals like ECG, EEG and EMG, their characteristic features and concepts of transduction.
CO2: Provide the students with an understanding of the various techniques and clinical instruments available for the measurement of various physiological parameters.
CO3: Provide the students the fundamentals of medical instrumentation along with their working principle.
CO4: Equip the students with research potential so that the principles of engineering and basic sciences shall be applied to improve the existing design and make it more economical and biocompatible for the betterment of mankind.

Total hours: 42 Hrs.

Module 1:  
(12 hours)

Module 2:  
(10 hours)

Module 3:  
(10 hours)

Module 4:  
(10 hours)
Measurement of PH, PCO2, PO2 - radiotherapy – Cobalt 60 machine – medical linear accelerator machine – audiometry - electrical safety in hospitals

Text Books and References:

3. Cromwell Leslie, Biomedical instrumentation and measurements, PHI, 1980
EE6125 DIGITAL CONTROL SYSTEMS
ELECTIVE COURSE

Pre-requisites: Nil

Course outcomes:

CO1: Acquire knowledge about the modeling of Digital Control Systems
CO2: Acquire knowledge about analysis of digital control systems in the z-domain as well as state space domain
CO3: Acquire knowledge about classical techniques for design of digital controllers with case study examples using MATLAB
CO4: Acquire knowledge about techniques based on state-space for design of digital controllers with case study examples using MATLAB

CO5: Acquire knowledge about the finite wordlength effects on system performance.

Total Hours: 42

Module 1: Introduction to Digital Control systems (11 hours)

Data conversion and quantisation - Sampling process- Mathematical modeling- Data reconstruction and filtering of sampled signals- Hold devices- z transform and inverse z transform - Relationship between s-plane and z-plane- Difference equation - Solution by recursion and z-transform- Discretisation Methods

Module 2: Analysis of Digital Control Systems (10 hours)

Digital control systems- Pulse transfer function - z transform analysis of closed loop and open loop systems- Modified z- transfer function- Multirate z-transform - Stability of linear digital control systemsStability tests- Steady state error analysis- Root loci - Frequency domain analysis- Bode plots-Nyquist plots- Gain margin and phase margin.

Module 3: Classical Design of Digital Control Systems (10 hours)

Cascade and feedback compensation by continuous data controllers- Digital controllers-Design using bilinear transformation- Root locus based design- Digital PID controllers- Dead beat control design- Case study examples using MATLAB

Module 4: Advanced Design of Digital Control Systems (11 hours)

State variable models- Interrelations between z- transform models and state variable modelsControllability and Observability - Response between sampling instants using state variable approachPole placement using state feedback – Servo Design- State feedback with Integral Control-Deadbeat Control by state feedback and deadbeat observers- Dynamic output feedback- Effects of finite wordlength on controllability and closed loop pole placement- Case study examples using MATLAB.

Textbooks and References:

5. K. Ogata, Discrete Time Control Systems, Addison-Wesley Longman Pte. Ltd., Indian Branch ,Delhi,1995
Pre-requisites: Nil

Course outcomes:

CO1: To introduce the basic model of an artificial neuron and its relationship to biological neurons.
CO2: Acquire knowledge about the learning methods and training of the artificial neural networks.
CO3: Attack problems like weather forecasting, finger print identification, and optical character recognition using ANN.
CO4: Control applications like system identification, Parameter optimization, feedback controller design etc.
CO5: To understand the fuzzy logic and develop fuzzy rule based systems and its applications.
Total hours: 42 Hrs.

Module 1: (10 hours)

Biological foundations, ANN models, Types of activation function, Introduction to Network architectures: Multi Layer Feed Forward Network (MLFFN), Radial Basis Function Network (RBFN), Recurring Neural Network (RNN)

Module 2: (10 hours)

Learning process. Supervised and unsupervised learning. Error-correction learning, Hebbian learning, Boltzmen learning, Single layer and multilayer perceptrons, Least mean square algorithm, Back propagation algorithm, Applications in forecasting and pattern recognition and other engineering problems.

Module 3: (10 hours)

Fuzzy sets. Fuzzy set operations. Properties, Membership functions, Fuzzy to crisp conversion. fuzzification and defuzzification methods, applications in engineering problems.

Module 4: (12 hours)

Fuzzy control systems. Introduction, simple fuzzy logic controllers with examples, special forms of fuzzy logic models, classical fuzzy control problems, inverter pendulum, image processing, home heating system. Adaptive fuzzy systems, hybrid systems.

Text Books and References:

EE6204: DIGITAL PROTECTION OF POWER SYSTEMS
ELECTIVE COURSE

Pre-requisite: Nil

Course Outcomes:

CO1: The student must be capable of demonstrating the difference between electromechanical and digital relays, and he/she is also introduced to the mathematical relationships and numerical techniques used in digital protection.

CO2: The student must know the basic working of instrument transformers and their selection for a specific protection scheme design.

CO3: The student must have a clear understanding of the different mechanisms of circuits breakers and their selection for each of protection scheme design.
CO4: The candidate must have an understanding of the concept of different types of relay, including differential relay, ohm relay, mho relay, directional relay, distance relay, reactions relay etc. and their selection for each protection scheme design.

CO5: The candidate must be capable of designing different protection schemes including over current protection scheme, directional over current protection scheme, differential protection scheme, distance protection scheme and protection scheme for distributed generation especially renewable energy system etc.

CO6: The student must understand the basic principles of power system protection coordination.

Total hours: 42 Hrs.

Module 1 (8 hours)
Protective Relaying - Qualities of relaying - Definitions - Codes - Standards; Characteristic Functions; Classification – analog-digital- numerical; schemes and design - factors affecting performance – zones and degree of protection; faults - types and evaluation; Instrument transformers for protection.

Module 2 (12 hours)
Basic elements of digital protection – signal conditioning - conversion subsystems - relay units - sequencing networks - fault sensing data processing units - FFT and Wavelet based algorithms; least square and differential equation based algorithms - travelling wave protection schemes; Relay Schematics and Analysis - Over Current Relay - Instantaneous/Inverse Time – IDMT Characteristics; Directional Relays; Differential Relays- Restraining Characteristics; Distance Relays: Types - Characteristics;

Module 3 (14 hours)
Protection of Power System Equipment - Generator, Transformer, Transmission Systems, Busbars, Motors; Pilotwire and Carrier Current Schemes; System grounding – ground faults and protection; Load shedding and frequency relaying; Out of step relaying; Re-closing and synchronizing.

Module 4 (8 hours)
Integrated and multifunction protection schemes - SCADA based protection systems - FTA; Testing of Relays.

Textbooks and References:


EE6222: POWER QUALITY
ELECTIVE COURSE

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Pre-requisites: Nil

Course outcomes:
CO1: To introduce the student to the power quality issues, measures and standards.
CO2: Acquire knowledge about the harmonics, harmonic introducing devices and effect of harmonics on system equipment and loads
CO3: To develop analytical modeling skills needed for modeling and analysis of harmonics in networks and components
CO4: To introduce the student to active power factor correction based on static VAR compensators and its control techniques
CO5: To introduce the student to series and shunt active power filtering techniques for harmonic cancellation and isolation
CO6: Acquire knowledge about the NEC grounding requirements and solutions to grounding and wiring problems

Total hours: 42 Hrs.

Module 1: (9 hours)

Module 2: (10 hours)
Harmonics—individual and total harmonic distortion—RMS value of a harmonic waveform—triplex harmonics—important harmonic introducing devices—SMPS—Three phase power converters—arching devices—saturable devices—harmonic distortion of fluorescent lamps—effect of power system harmonics on power system equipment and loads. Modeling of networks and components under non-sinusoidal conditions—transmission and distribution systems—shunt capacitors—transformers—electric machines—ground systems—loads that cause power quality problems—power quality problems created by drives and its impact on drives.

Module 3: (12 hours)

Module 4: (11 hours)
Active Harmonic Filtering—Shunt Injection Filter for single phase, three-phase three-wire and three-phase four-wire systems. d-q domain control of three phase shunt active filters uninterruptible power supplies constant voltage transformers-series active power filtering techniques for harmonic cancellation and isolation . Dynamic Voltage Restorers for sag, swell and flicker problems. Grounding and wiring—introduction-NEC grounding requirements—reasons for grounding—typical grounding and wiring problems—solutions to grounding and wiring problems.

Text Books and References:

EE6401 ENERGY AUDITING & MANAGEMENT
ELECTIVE COURSE

Pre-requisites: Nil

Course outcomes:
CO1: Acquire the background required for engineers to meet the role of energy managers and to acquire the skills and techniques required to implement energy management.

CO2: Identify and quantify the energy intensive business activities in an organization.

CO3: Acquire knowledge about standard methodologies for measuring energy in the workplace and energy audit instruments.

CO4: Acquire knowledge about energy efficient motors, load matching and selection of motors.

CO5: Acquire knowledge about reactive power management, capacitor sizing and degree of compensation.

CO6: Acquire knowledge about cogeneration - types and schemes, optimal operation of cogeneration plants with case studies.
CO7: Acquire knowledge about variable frequency drives, soft starters, and eddycurrent drives.
CO8: Acquire knowledge about energy conservation in motors, pumps, fans, compressors, transformers, geysers, lighting schemes, air conditioning, refrigeration, cool storage.
CO9: Gain hands-on experiences by encouraging students to conduct a walkthrough audit in various industries.

Total Hours: 42 Hours

Module 1 (12 Hours)
System approach and End use approach to efficient use of Electricity; Electricity tariff types; Energy auditing: Types and objectives—audit instruments—ECO assessment and Economic methods—specific energy analysis—Minimum energy paths—consumption models—Case study.

Module 2 (11 Hours)
Electric motors—Energy efficient controls and starting efficiency—Motor Efficiency and Load Analysis—Energy efficient/high efficient Motors—Case study; Load Matching and selection of motors. Variable speed drives; Pumps and Fans—Efficient Control strategies—Optimal selection and sizing—Optimal operation and Storage; Case study.

Module 3 (11 Hours)

Module 4 (11 Hours)

Text Books and References:
13. NESCAP-Guide Book on Promotion of Sustainable Energy Consumption, 2004
14. IEEE Bronze Book, IEEE STD 739

EE6402: PROCESS CONTROL & AUTOMATION

ELECTIVE COURSE

Pre-requisites: Nil

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Course Outcomes:

CO1: Acquire knowledge about the process modelling, control and instrumentation.

CO2: Study the effect of applying advanced control strategies to improve the process control system when working as SISO system and MIMO system

CO3: Get proficiency in multi loop and multi variable Control Systems, effect of process and controller interactions and methods to eliminate these effects.
CO4: Study and design of modern control strategies such as DMC, MPC, MRAS etc. its plant wide design giving importance to hierarchical control

CO5: Application of modern control devices in real time systems as case study

Total Hours: 42 Hours

Module 1 (10 Hours)
Process Modeling- Introduction to Process control and process instrumentation-Hierarchies in process control systems-Theoretical models-Transfer function-State space models-Time series models- Development of empirical models from process data-chemical reactor modeling-. Analysis using softwares

Module 2 (10 Hours)
Feedback & Feedforward Control- Feedback controllers-PID design, tuning, trouble shooting-Cascade control- Selective control loops-Ratio control-Control system design based on Frequency response Analysis-Direct digital design-Feedforward and ratio control-State feedback control- LQR problem-Poleplacement -Simulation using softwares-Control system instrumentation-Control valves- Codes and standards- Preparation of P& I Diagrams.

Module 3 (11 Hours)
Advanced process control-Multi-loop and multivariable control-Process Interactions-Singular value analysis-tuning of multi loop PID control systems-decoupling control-strategies for reducing control loopinteractions-Real-time optimization-Simulation using software.

Module 4: (11 Hours)
Model predictive control-Batch Process control-Plant-wide control & monitoring- Plant wide control design- Instrumentation for process monitoring-Statistical process control-Introduction to Fuzzy Logic inProcess Control-Introduction to OPC-Introduction to environmental issues and sustainable developmentrelating to process industries. Comparison of performance different types of control with examples on softwares.

Textbooks and References:


EE6403 COMPUTER CONTROLLED SYSTEMS

ELECTIVE COURSE

Pre-requisites: Nil

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Course Outcomes:

**CO1**: Study the scientific and mathematical principles and methodologies relevant to computer control of systems.

**CO2**: Study of fundamentals of PLC and its architecture.
CO3: Learn the PLC programming fundamentals, process logic and human machine interface.

CO4: Understand SCADA architecture and communication protocols.

CO5: Study DCS architecture and configuration.

CO6: Detailed analysis of case studies of PLC, SCADA and DCS.

CO7: Understand the specifications and design techniques in real time system analysis.

CO8: Study the inter task communication, synchronization and real time memory management.

Total : 42 Hrs

**Module 1: Multivariable Control**


**Module 2: Programmable Logic Controllers**

Programmable logic controllers- Organisation- Hardware details- I/O- Power supply- CPU-StandardsProgramming aspects- Ladder programming- Sequential function charts- Man- machine interfaceDetailed study of one model- Case studies.

**Module 3: Large Scale Control System**


**Module 4: Real Time Systems**

Real time systems- Real time specifications and design techniques- Real time kernels- Inter task communication and synchronization- Real time memory management- Supervisory control-direct digital control- Distributed control- PC based automation.

**Textbooks and References:**

6. Stuart A. Boyer: SCADA-Supervisory Control and Data Acquisition, Instrument Society of America Publications, USA, 1999

EE6404: INDUSTRIAL LOAD MODELLING & CONTROL

ELECTIVE COURSE

Pre-requisite: Nil

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Course outcomes:

CO1: Acquire knowledge about load control techniques in industries and its application.
CO2: Acquire knowledge about different types of industrial processes and optimize the process using tools like LINDO and LINGO.
CO3: Acquire knowledge about load management to reduce demand of electricity during peak time.
CO4: Analyse and understand different energy saving opportunities in industries.
CO5: Acquire knowledge about reactive power control in industries and analyse different power factor improvement methods.
CO6: Learn mathematical modelling and profiling of various loads such as cool storage, cooling and heating loads.

Total Hours: 42 Hours

Module 1 (12 Hours)

Electric Energy Scenario-Demand Side Management-Industrial Load Management; Load Curves-Load Shaping Objectives-Methodologies-Barriers; Classification of Industrial Loads- Continuous and Batch processes -Load Modelling; Electricity pricing – Dynamic and spot pricing -Models;

Module 2 (10 Hours)

Direct load control- Interruptible load control; Bottom up approach- scheduling- Formulation of load models- optimisation and control algorithms - Case studies; Reactive power management in industries- controls-power quality impacts-application of filters;

Module 3 (10 Hours)

Cooling and heating loads- load profiling- Modeling- Cool storage- Types-Control strategies-Optimal operation-Problem formulation- Case studies;

Module 4 (10 Hours)

Captive power units- Operating and control strategies- Power Pooling- Operation models; Energy Banking-Industrial Cogeneration; Selection of Schemes Optimal Operating Strategies-Peak load saving-Constraints-Problem formulation- Case study; Integrated Load management for Industries;

Textbooks and References:
8. IEEE Bronze Book- "Recommended Practice for Energy Conservation and cost effective planning in Industrial facilities., IEEE Inc, USA.
EE6406: INDUSTRIAL INSTRUMENTATION
ELECTIVE COURSE

Pre-requisite: Nil

Course Outcomes:
CO1: To get basic knowledge about industrial measurement system and different elements involved in it.
CO2: Acquire knowledge about sensors and transducers for different industrial variables like torque, pressure, etc.
CO3: Acquire knowledge about signal conditional circuits like amplifiers, filters, ADC, etc. for working industrial measurement systems.
CO4: Impart knowledge about static and response characteristics of first order and higher order measurement system.
CO5: To get familiarize with the operation and applications in measurement systems of servo motors.

Total Hours: 42 Hours

Module 1 (12 hours)
Industrial measurement systems – different types of industrial variables and measurement systems elements– sensors and transducers for different industrial variables like pressure, torque, speed, temperature etc–sensor principles – examples of sensors – sensor scaling – Industrial signal conditioning systems-Amplifiers – Filters – A/D converters for industrial measurements systems –review of general Industrialinstruments.

Module 2 (8 hours)
Calibration and response of industrial instrumentation - standard testing methods and procedures – Generalized performance characteristics – static response characterization – dynamic response characterization - zero order system dynamic response characterizations – first order system dynamic response second order system dynamic response – higher order systems - Response to different forcingfunctions such as step, sinusoidal etc. to zero, first, second third and higher orders of systems.

Module 3 (12 hours)
Regulators and power supplies for industrial instrumentation – linear series voltage regulators – linear shunt voltage regulators – integrated circuit voltage regulators – fixed positive and negative voltage regulators – adjustable positive and negative linear voltage regulators – application of linear IC voltage regulators - switching regulators –single ended isolated forward regulators- half and full bridge rectifiers, pH and conductivity sensors. Piezo-electric and ultrasonic sensors and its application in process and biomedical Instrumentation. Measurement of viscosity, humidity and thermal conductivity

Module 4 (10 hours)

Textbooks and References :

7. Steve Mackay, Edwin Wright, John Park, Practical Data Communications for Instrumentation andControl, Newness Publications, UK, 2003
8. John O Moody, Paros J Antsaklis, Supervisory Control of discrete event systems using petrinets, PHI,2002
EE6421 ADVANCED MICROCONTROLLER BASED SYSTEMS
ELECTIVE COURSE

Pre-requisites : Nil

Course Outcomes:
CO1: To understand the working of advanced microprocessor/controller.
CO2: To learn how to program a processor in assembly language and develop an advanced processor based system.
CO3: To learn configuring and using different peripherals in a digital system.
CO4: To compile and debug a Program.
CO5: To generate an executable file and use it.

Total Hours: 42 Hours

Module 1 (10 Hours)

Module 2 (12 Hours)
Introduction to Microcontrollers - Motorola 68HC11 - Intel 8051 - Intel 8096 - Registers - Memories - I/O Ports - Serial Communications - Timers – Interrupts

Module 3 (10 Hours)

Module 4 (10 Hours)

Textbooks and References :
2. Ramesh S. Gaonker: Microprocessor Architecture, Programming and Applications with the 8085, Penram International Publishing (India), 1994
6. Dogan Ibrahim, Advanced PIC microcontroller projects in C: from USB to RTOS with the PIC18F Series, Elsevier, 2008
7. Micro chip datasheets for PIC16F877
EE6422: ENGINEERING OPTIMIZATION
ELECTIVE COURSE

Pre-requisites: Nil

Course Outcomes:
CO1: Understand the concept of optimization and classical methods of optimization.
CO2: Apply optimization techniques to typical engineering problems.
CO3: Learn the concepts and techniques of nonlinear and unconstrained optimization.
CO4: Acquire knowledge on direct and indirect methods for constrained optimization.
CO5: Learn the application of dynamic programming and genetic algorithms for engineering optimization.

Total Hours : 42 Hours

Module 1
(11 hours)
Concepts of optimization: Engineering applications-Statement of optimization problem-Classification -type and size of the problem.

Module 2
(11 hours)
Unconstrained optimization: First & Second order necessary conditions-Minimisation&Maximisation-Local & Global convergence-Speed of convergence.

Module 3
(10 hours)
Nonlinear programming- Constrained optimization: Characteristics of constraints-Direct methods-
SLP, SQP-Indirect methods-Transformation techniques-penalty function-Lagrang Multiplier methods-checking convergence- Engineering applications.

**Module 4**

Dynamic programming: Multistage decision process- Concept of sub optimization and principle of optimality- Computational procedure- Engineering applications.

Genetic algorithms- Simulated Annealing Methods-Optimization programming, tools and Software packages.

**Textbooks and References:**

EE6424 ROBOTIC SYSTEMS AND APPLICATIONS
ELECTIVE COURSE

Pre-requisites: Nil

Course Outcomes:
CO1: Learn the mathematics of spatial descriptions and transformations
CO2: Acquire knowledge about robot definition, classification, robot system components that combines embedded hardware, software and mechanical systems
CO3: Learn manipulator kinematics and mechanics of robot motion, forward and inverse kinematic transformation of position, forward and inverse kinematic transformation of velocity, end effector force transformations
CO4: Learn about manipulator dynamics, transformation of acceleration, trajectory planning, Lagrangian formulation, Newton-Euler equations of motion, robot control architectures
CO5: Acquire knowledge about robot sensing and vision systems
CO6: Acquire knowledge about robot programming languages
CO7: Acquire knowledge about artificial intelligence techniques in robotics
CO8: Learn about various robotics applications and their associated components and control systems in manufacturing, construction, service, etc.

Total Hours: 42
Module 1: (8 hours)

Module 2: (12 hours)
Manipulator Kinematics and Mechanics of Robot Motion-Link coordinate frames- Denavit Hartenberg convention - Joint and end-effector Cartesian space-Forward kinematics transformations of position- Inverse kinematics of position-Translational and rotational velocities -Velocity Transformations-Manipulator Jacobian -Forward and inverse kinematics of velocity Singularities of robot motion-Static Forces-Transformations of velocities and static forces -Joint and End Effector force/torque transformations-Derivation for two link planar robot arm as example.

Module 3: (13 hours)
Manipulator Dynamics- Transformations of acceleration- Trajectory Planning- Control-Lagrangian formulation- Model properties - Newton-Euler equations of motion- Derivation for two link planar robot arm as example- Joint space-based motion planning - Cartesian space-based path planning Independent
joint control- Feed-forward control-Inverse dynamics control-Robot controller architectures.
Implementation problems.

**Module 4:**

Robot Sensing and Vision Systems- Sensors-Force and torque sensors-low level vision-high level vision-
Robot Programming languages-Introduction to Intelligent Robots-Robots in manufacturing automation.

**Textbooks and References:**

   Engineers, UK, 1996.
   hall India, 1996.
7. Sciavicco, L., B. Siciliano, Modelling& Control of Robot Manipulators, 2nd Edition, Springer Verlag,
   2000.
EE6426 DISTRIBUTION SYSTEMS MANAGEMENT & AUTOMATION
ELECTIVE COURSE

Pre-requisites: Nil

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Course Outcomes:

CO1: Acquire knowledge about the fundamental principles, hierarchy level, architecture, functions and implementation strategies of Distribution Automation Systems (DAS) and Distribution Management Systems (DMS).

CO2: Acquire knowledge about the fundamental concept of different power quality issues and application of Custom power devices improving power quality and about the issues relating Integration of Distributed Generation (DG) and Custom Power components in a distribution system.

CO3: Acquire ability to evaluate the performance of electrical distribution system on the basis of reliability indices calculation.

CO4: Acquire knowledge about Electrical distribution system design aspects of industrial and commercial buildings with emphasis given to Electrical Safety and Earthing Practices.

CO5: Acquire knowledge about the wireless and wired communication systems, user interface, communication protocols and architectures for control and automation of Distribution system.

CO6: Acquire knowledge about the concept of deregulated power system.

Total hours: 42 Hrs

Module 1 (10 hours)


Module 2 (10 hours)

Electrical System Design: Distribution System Design- Electrical Design Aspects of Industrial, Commercials Buildings- Electrical Safety and Earthing Practices at various voltage levels- IS codes
Module 3 (12 hours)
Communication Systems for Control and Automation - Wireless and wired Communications - DA Communication Protocols, Architectures and user interface - Case Studies

Module 4: (10 Hours)
Power Quality and Custom Power: Concept - Custom Power Devices - Operation and Applications
Deregulated Systems: Reconfiguring Power systems - Unbundling of Electric Utilities - Competition and Direct access

Text Books and References:
EE6428: SCADA SYSTEMS AND APPLICATIONS
ELECTIVE COURSE

Pre-requisites: Nil

Course outcomes:
CO1: Describe the basic tasks of Supervisory Control Systems (SCADA) as well as their typical applications
CO2: Acquire knowledge about SCADA architecture, various advantages and disadvantages of each system
CO3: Acquire knowledge about single unified standard architecture IEC 61850
CO4: Acquire knowledge about SCADA system components: remote terminal units, PLCs, intelligent electronic devices, HMI systems, SCADA server
CO5: Acquire knowledge about SCADA communication, various industrial communication technologies, open standard communication protocols
CO6: Learn and understand about SCADA applications in transmission and distribution sector, industries etc.
CO7: Gain knowledge and understanding for the design and implementation of a SCADA system

Number of Hours: 42Hrs

Module 1 (10 hours)

Introduction to SCADA: Data acquisition systems, Evolution of SCADA, Communication technologies, Monitoring and supervisory functions, SCADA applications in Utility Automation, Industries

Module 2 (11 hours)
SCADA System Components: Schemes- Remote Terminal Unit (RTU), Intelligent Electronic Devices (IED), Programmable Logic Controller (PLC), Communication Network, SCADA Server, SCADA/HMISystems

Module 3 (11 hours)

SCADA Architecture: Various SCADA architectures, advantages and disadvantages of each system - single unified standard architecture - IEC 61850. SCADA Communication: various industrial communication technologies - wired and wireless methods and fiber optics. Open standard communication protocols

Module 4 (10 hours)

SCADA Applications: Utility applications- Transmission and Distribution sector - operations, monitoring, analysis and improvement. Industries - oil, gas and water. Case studies, Implementation, Simulation Exercises

Textbooks and References:

1. Stuart A. Boyer: SCADA-Supervisory Control and Data Acquisition, Instrument Society of America Publications, USA, 2004
4. David Bailey, Edwin Wright, Practical SCADA for industry, Newnes, 2003
5. Michael Wiebe, A guide to utility automation: AMR, SCADA, and IT systems for electric power, PennWell 1999