MA6003: Mathematical Methods for Power Engineering

Pre-requisite: Nil

Total hours: 42 Hrs.


EE6401: Energy Auditing & Management

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

Pre-requisite: Nil

Total hours: 42 Hrs


EE6403: Computer Controlled Systems

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 Modelling & Control

Pre-requisite: Nil

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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

Pre-requisite: Nil

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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

Pre-requisite: Nil

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Total hours: 42 Hrs


EE6422: Engineering Optimization

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Pre-requisite: Nil

Total hours: 42 Hrs


EE6423: Industrial Communication

Pre-requisite: Nil

Total hours: 42 Hrs

Characteristics of Communication Networks, OSI Model, Theoretical basis for data communication, Direct link Networks, Ethernet (IEEE 802.3); Token Rings (IEEE 802.5 & FDDI); Address Resolution Protocol-IEEE 802.11 LAN’s- architecture and media access protocols, wireless LAN, Network layer series and routing, The transport layer, SCADA networks, Remote Terminal Unit (RTU), Intelligent Electronic Devices (IED) - Communication Network, IEC 61850, various industrial communication technologies, wired and wireless methods and fiber optics, open standard communication protocols.

EE6424: Robotic Systems and Applications

Pre-requisite: Nil

Total hours: 42 Hrs


EE6426: Distribution Systems Management and Automation

Pre-requisite: Nil

Total hours: 42 Hrs

EE6428: SCADA Systems and Applications

Pre-requisite: Nil
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.

EE6491: Industrial Power & Automation Laboratory

Pre-requisite: Nil
Total hours: 42 Hrs


EE6101: Dynamics of Linear Systems

Pre-requisite: Nil
Total hours: 42 Hrs.


EE6102: Optimal and Adaptive Control
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

**EE6103: Applied Instrumentation**

Pre-requisite: Nil

Total hours: 42 Hrs.

Generalized performance characteristics of measuring systems-general static and dynamic characteristics-mathematically models-general concepts of transfer functions related to instrumentation system. Response of general form of instruments to different types of inputs like periodic, transient and random signals, their characteristics etc. Study, analysis etc of modulation and demodulation problems of instrumentation systems. Design considerations of instrumentation systems.

**EE6104: Advanced Instrumentation**

Pre-requisite: Nil

Total hours: 42 Hrs.

Instrumentation to process control-rationales for mathematical modeling-transfer function models and related aspects-advanced performance modeling tools and characteristics- definitions and analytical techniques-roll of digital computers in modern instrumentation systems and their related hardware-computer aided instrumentation systems- hardware and their functions-different measurements and instrumentation related problems related to micro and nano technology.

**EE6121: Data Acquisition & Signal Conditioning**

Pre-requisite: Nil

Total hours: 42 Hrs.

Data Acquisition Systems(DAS) - Objectives - General configurations - Transducers - Signal Conditioning - Instrumentation amplifiers - Noise Reduction Techniques in Signal Conditioning-Transmitters -Piezoelectric Couplers- Nyquist’s Sampling Theorem- classification and types of filters - Design of Filters- Butterworth Approximation-Narrow Bandpass and Notch Filters and their application in
DAS-Analog-to-Digital Converters (ADC)-Multiplexers and demultiplexers -Digital-to-Analog 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

Pre-requisite: Nil

Total hours: 42 Hrs.


EE6123: Performance Modelling of Systems – I

Pre-requisite: Nil

Total hours: 42 Hrs.

General operational characteristics – dynamic response and frequency response studies- general concepts in set theory- terminology functions- combinatorics - brief theory of bags etc-algorithms-graphs having multiple edges-Euler cycles-the shortest path problems-active graph theory concepts of concurrency-conflict-dead lock problems etc. popular extensions like Petri nets-s-net etc.

EE6124: Performance Modelling of Systems – II

Pre-requisite: EE6123: Performance Modelling of Systems - I

Total hours: 42 Hrs

Modeling philosophies and related aspects like degrees of freedom-algorithm for the development of models-modeling tools and applied systems-performance modeling - Petri nets models-s-net models-basic definitions and analytical techniques standard problems like synchronizations mutual exclusions- dining philosophies problems-etc. dynamic graphical models of supercomputers-computer communication systems- super computer computer pipeline-computer communication network and process control systems etc.

EE6125: Digital Control Systems
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 bilinear transformation - Root locus based design - Digital PID controllers - Dead beat control design - Case study examples using MATLAB - State variable models - Controllability and Observability - Response between sampling instants using state variable approach - Pole 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.

EE6129: Artificial Neural Networks and Fuzzy Systems

Pre-requisite: Nil

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Total hours: 42 Hrs


EE6201: Computer Methods in Power Systems

Pre-requisite: Nil

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Total hours: 42 Hrs.

Power flow analysis - Sparsity Oriented and Optimal Ordering - Fault Analysis - Power System Optimization - Optimal Load flow solution - Optimum reactive power dispatch - Scheduling of hydrothermal systems - AI Techniques applied to power Systems - Power system security - Contingency analysis - state estimation

EE6204: Digital Protection of Power Systems

Pre-requisite: Nil

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Total hours: 42 Hrs.

Protective Relaying - Classification – numerical; Basic elements of digital protection – signal conditioning - FFT and Wavelet based algorithms - Relay Schematics and Analysis - Protection of Power System Equipment - Generator, Transformer, Transmission Systems, Busbars, Motors; Pilotwire and Carrier
Current Schemes, Integrated and multifunction protection schemes -SCADA based protection systems- FTA, Testing of Relays.

**EE6221: Distributed Generation**

**Pre-requisite: Nil**

**Total hours: 42 Hrs.**


**EE6222: Power Quality**

**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-SVC and STATCOM - Active Harmonic Filtering- Dynamic Voltage Restorers for sag, swell and flicker problems. - Grounding and wiring-introduction

**EE6301: Power Electronic Circuits**

**Pre-requisite: Nil**

**Total hours: 42 Hrs.**

EE6302: Advanced Power Electronic Circuits

Pre-requisite: Nil

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Total hours: 42 Hrs.


EE6303: Dynamics of Electrical Machines

Pre-requisite: Nil

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Total hours: 42 Hrs.


EE6304: Advanced Digital Signal Processing

Pre-requisite: Nil

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Total hours: 42 Hrs.

EE6306: Power Electronic Drives

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 squirrel cage motors - Synchronous Motor Drives - load commutated inverter drives. PMSM Drives, Switched reluctance Drive.

EE6308: FACTS and Custom Power

Pre-requisite: Nil

Total hours: 42 Hrs


EE6321: Power Semiconductor Devices and Modeling

Pre-requisite: Nil

Total hours: 42 Hrs

EE6322: Static Var Controllers & Harmonic Filtering

Pre-requisite: Nil

Total hours: 42 Hrs


EE6327: Linear and Digital Electronics

Pre-requisite: Nil

Total hours: 42 Hrs


MA6003: Mathematical Methods for Power Engineering

Pre-requisite: Nil

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)


References

8. Simmons D M, Non Linear Programming for Operations Research, PHI, 1975

EE6401: Energy Auditing & Management

Pre-requisite: Nil

Total hours: 42 Hrs

Objective: Understanding, analysis and application of electrical energy management-measurement and accounting techniques-consumption patterns-conservation methods-application in industrial cases.

Module 1: (9 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)

Transformer Loading/Efficiency analysis, Feeder/cable loss evaluation, case study.


Peak Demand controls- Methodologies-Types of Industrial loads-Optimal Load scheduling-case study.


Module 4: (11 hours)

Cogeneration-Types and Schemes-Optimal operation of cogeneration plants-case study;


References

EE6402: Process Control & Automation

Pre-requisite: Nil

Total hours: 42 Hrs

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- Pole placement -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 loop interactions-Real-time optimization-Simulation using softwares

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 in Process Control-Introduction to OPC-Introduction to environmental issues and sustainable development relating to process industries. Comparison of performance different types of control with examples on softwares

References


EE6403: Computer Controlled Systems

Pre-requisite: Nil

Total hours: 42 Hrs

Module 1: Multivariable Control (12 hours)

Multivariable control- Basic expressions for MIMO systems- Singular values- Stability norms- Calculation of system norms- Robustness- Robust stability- H^2 / H^\infty Theory- Solution for design using H^2 / H^\infty - Case studies. Interaction and decoupling- Relative gain analysis- Effects of interaction- Response to disturbances- Decoupling- Introduction to batch process control.
Module 2: Programmable Logic Controllers (10 hours)

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

Module 3: Large Scale Control System (12 hours)

SCADA: Introduction, SCADA Architecture, Different Communication Protocols, Common System Components, Supervision and Control, HMI, RTU and Supervisory Stations, Trends in SCADA, Security Issues

DCS: Introduction, DCS Architecture, Local Control (LCU) architecture, LCU languages, LCU - Process interfacing issues, communication facilities, configuration of DCS, displays, redundancy concept - case studies in DCS.

Module 4: Real Time Systems (8 hours)

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.

References

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

EE6404: Industrial Load Modelling & Control

Pre-requisite: Nil

Total hours: 42 Hrs

Objective: Analysis and application of load control techniques in Industries.
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;

References


EE6406: Industrial Instrumentation

Pre-requisite: Nil

Total hours: 42 Hrs

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 Industrial instruments.

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 forcing functions such as step, sinusoidal etc. to zero, first, second third and higher orders of systems.

Module 3: (12 hours)


Module 4: (10 hours)


References

EE6421: Advanced Microcontroller Based Systems

Pre-requisite: Nil

Total hours: 42 Hrs

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)
Instructions in Microcontrollers - Interfaces - Introduction to Development of a Microcontroller Based System - Concept of a Programmable Logic Controller (PLC) - Features and Parts in a PLC unit.

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. Microchip datasheets for PIC16F877

EE6422: Engineering Optimization

Pre-requisite: Nil

Total hours: 42 Hrs

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-Langrange multiplier methods-checking convergence- Engineering applications

Module 4: (10 hours)

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.

References


EE6423: Industrial Communication

Pre-requisite: Nil

Total hours: 42 Hrs

Module 1: (10 hrs)

Characteristics of Communication Networks- Traffic characterisation and Services- Circuit Switched and Packet Switched Networks- Virtual circuit Switched networks- OSI Model- Protocol Layers and Services- The physical layer-Theoretical basis for data communication- signalling and modulation-multiplexing- Transmission media-Physical interface and protocols

Module 2: (10 hrs)

The transport layer- Connectionless transport-UDP –TCP- Congestion control - Network layer series and routing- internet protocol (IP) - Network layer addressing- hierarchical addresses-address resolution-services- Datagram- virtual circuits- routing algorithm (Bellman Ford,Dijkstra)

Module 3: (10 hrs)

Direct link Networks: Framing; Error detection; Reliable transmission; Multiple access protocols; Concept of LAN- Ethernet LAN – Ethernet frame structure-Ethernet (IEEE 802.3); Token Rings (IEEE 802.5 & FDDI); Address Resolution Protocol- IEEE 802.11 LAN’s- architecture and media access protocols, hubs, bridges, switches, PPP, ATM, wireless LAN

Module 4: (12 hrs)

Introduction to industrial networks – SCADA networks - Remote Terminal Unit (RTU), Intelligent Electronic Devices (IED) - Communication Network, SCADA Server, SCADA/HMI Systems - single unified standard architecture -IEC 61850 - SCADA Communication: various industrial communication technologies -wired and wireless methods and fiber optics, open standard communication protocols

References

4. Keshav, .An engineering approach to computer networking, Addison-Wesley, 1999
EE6424: Robotics Systems and Applications

Pre-requisite: Nil

Total hours: 42 Hrs

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: (9 hours)

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.

References


   Engineers, UK, 1996.

   Hall India, 1996.


EE6426: Distribution Systems Management and Automation

Pre-requisite: Nil

Total hours: 42 Hrs
Module 1: (10 Hours)

Distribution Automation System: Necessity, System Control Hierarchy- Basic Architecture and implementation Strategies for DA- Basic Distribution Management System Functions- Outage management-

Integration of Distributed Generation and Custom Power components in distribution systems- Distribution system Performance and reliability calculations

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

References


EE6428: SCADA Systems and Applications

Pre-requisite: Nil

Total hours: 42 Hrs

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/HMI Systems

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

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
EE6491: Industrial Power & Automation Laboratory

Pre-requisite: Nil

Total hours: 42 Hrs

List of Experiments

Cycle I

1 Microcontroller Experiments
   a) 8051 Experiments
      1) Stepper Motor Control
   b) 80196 Experiments
      1) Generation of PWM Signal
      2) Generation of Saw Tooth Signal

2 Programmable Logic Controller Experiments
   a) Batch Process Reactor Control
   b) Lift Control and AC Servomotor Control

3. Performance Comparison of Centrifugal Pump by Throttling and VFD

4 Speed Control of Induction Motor using DSP

Cycle II

5 SCADA Experiments
   a) Experiments on Transmission Module
   b) Experiments on Distribution Module

6 DCS Experiments
   a) Interfacing of DCS with analog processes
   b) Interfacing of DCS with digital processes
   c) Interfacing of DCS with hybrid processes
7 Eddy Current Drive Experiments

8 Power Quality Experiments
   a) PQ Effects of Starters on Induction Motor
   b) PQ Testing of UPS

9 Desired Experiments

Reference
1. Lab manual /, Hand books of SCADA/DCS
2. Stuart A. Boyer: SCADA-Supervisory Control and Data Acquisition, Instrument Society of America Publications, USA, 2004

EE6101: Dynamics of Linear Systems

Pre-requisite: Nil

Total hours: 42 Hrs.

Module 1: State Space Analysis (11 hours)
State variable representations of systems- transfer function and transfer function matrix from state variable form - solutions of state equations – state transition matrix - modal decompositions - observability and controllability - minimal realizations of MIMO systems - analysis of linear time varying systems.

Module 2: Lyapunov Stability Analysis (9 hours)

Module 3: Control Design Techniques (11 hours)
State variable feedback – controller design - Ackerman’s Formula - stabilisation by state and output feedback - observers for state measurement – observer design - combined observer-controller compensators - reduced order observer - observability under feedback and invariant zeros - Design of stable systems using Lyapunov method - MATLAB Exercises.

Module 4: Linear Discrete Time Systems (11 hours)

References


EE6102: Optimal and Adaptive Control

Pre-requisite: Nil

Total hours: 42 Hrs.

Module 1: (12 hours)


Module 2: (10 hours)

The variational approach to solving optimal control problems - necessary conditions for optimal control using Hamiltonian – Different boundary condition equations for solving the optimal control problem –
closed loop control for linear regulator problem - linear tracking problem – Pontryagin’s minimum principle - state inequality constraints - minimum time problems - minimum control effort problems.

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

References


EE6103: Applied Instrumentation

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Pre-requisite: Nil

Total hours: 42 Hrs.

Module 1: (10 hours)

Module 2: (10 hours)


Module 3: (10 hours)

Roll for digital computer system in process control. Distributed instrumentation and control system. General purpose digital data acquisition and control hardware.

Module 4: (12 hours)


References


EE6104: Advanced Instrumentation

Pre-requisite: Nil

Total hours: 42 Hrs.

Module 1: (11 hours)


Module 2: (11 hours)

Static characteristics of measurement system computer aided calibration and measurement. concepts of development of software. Dynamic characteristics. Mathematical Models. General concepts of transfer functions (with special reference to measuring system). classification of instruments based on their order and their dynamic response and frequency response studies.
Module 3: (10 hours)

Response of general form of instruments to various input (a) periodic (b) transient. Characteristics of random signals. Measurement system response to random inputs.

Module 4: (10 hours)

Study and analysis of amplitude modulation of measurements and design consideration of such amplitudes modulated measurement systems. Requirements on instrument transfer function to ensure accurate measurements.

References


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EE6121: Data Acquisition & Signal Conditioning

Pre-requisite: Nil

Total hours: 42 Hrs.

Module 1: Transducers & Signal Conditioning (11 hours)


Module 2: Filtering and Sampling (10 hours)

Review of Nyquist's Sampling Theorem-Aliasing. Need for Prefiltering-First and second order filters - classification and types of filters - Low -pass, High-pass, Band-pass and Band-rejection and All Pass: Butterworth, Bessel, Chebyshev and Elliptic filters. Opamp RC Circuits for Second Order Sections-Design of Higher Order Filters using second order sections using Butterworth Approximation-Narrow Bandpass and Notch Filters and their application in DAS. Sample and Hold Amplifiers

Module 3: Signal Conversion and Transmission (10 hours)

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


References


EE6122: Biomedical Instrumentation

Pre-requisite: Nil

Total hours: 42 Hrs.

Module 1: (12 hours)


Module 2: (10 hours)

oximeter – skin reflectance oximeter - measurement on pulmonary system – spirometry – pulmonary function analyzers – ventilators

**Module 3: (10 hours)**


**Module 4: (10 hours)**

Measurement of $P_{H}$, $PCO_2$, $PO_2$ – radiotherapy – Cobalt 60 machine – medical linear accelerator machine – audiometry – electrical safety in hospitals

**References**

3. Cromwell Leslie, Biomedical instrumentation and measurements, PHI, 1980

**EE6123: Performance Modelling of Systems – I**

**Pre-requisite:** Nil

**Total hours:** 42 Hrs.

**Module 1: General Operational Characteristics (10 hours)**


**Module 2: General Concepts in Set Theory (10 hours)**


**Module 3: General Graph Theory (10 hours)**

**Module 4: Active Graph Theory (12 hours)**


**References**


**EE6124: Performance Modelling of Systems – II**

**Pre-requisite: EE6123: Performance Modelling of Systems - I**

**Total hours: 42 Hrs**

**Module 1: Modelling Philosophies (10 hours)**


**Module 2: Modelling Tools and Applied Systems (10 hours)**

Module 3: Active Graphical Modelling Tools (10 hours)


Module 4: Analysis of Modelling Tools (12 hours)


References


EE6125: Digital Control Systems

Pre-requisite: Nil

Total hours: 42 Hrs

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 systems-Stability 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 models-Controllability and Observability - Response between sampling instants using state variable approach-Pole 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.

References


EE6129: Artificial Neural Networks and Fuzzy Systems

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Pre-requisite: Nil

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 percepturs, 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.

References


EE6201: Computer Methods in Power Systems

Pre-requisite: Nil

Total hours: 42 Hrs.

Module 1: (11 hours)


Module 2: (10 hours)


Module 3: (11 hours)


Module 4: (10 hours)


References


**EE6204: Digital Protection of Power Systems**

**Pre-requisite:** Nil

**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-sequence 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.

**References**


8. Helmut Ungrad, Wilibald Winkler, Andrzej Wiszniewski, Protection techniques in electrical energy systems, Marcel Dekker, Inc. 1995

**EE6221: Distributed Generation**

Pre-requisite: Nil

**Total hours: 42 Hrs.**

**Module 1: (10 hours)**

Introduction to energy conversion, principle of renewable energy systems-technical and social implications; Solar energy, overview of solar energy conversion methods, Solar radiation components, collector-measurements-estimation; Solar water heating-Calculation-Types-analysis-economics-Applications; Solar thermal power generation

**Module 2: (12 hours)**

Direct energy conversion (DEC)- DEC devices -Photo voltaic system-Solar cells- Cell efficiency, Limitations-PV modules-Battery back up-System design-Lighting and water pumping applications; Fuel cells, types- losses in fuel cell applications; MHD generators- application of MHD generation.

**Module 3: (10 hours)**
Wind energy. characteristics-power extraction- types of wind machines .dynamics matching- performance of wind generators .wind mills -applications- economics of wind power

Module 4: (10 hours)

Biofuels- classification-biomass conversion process-applications; ocean thermal energy conversion systems; Tidal and wave power-applications; Micro and mini hydel power; Hybrid Energy Systems- implementation- case study

References


5. James Larminie , Andrew Dicks , Fuel Cell Systems, John Weily & Sons Ltd, 2000


EE6222: Power Quality

Pre-requisite: Nil

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-arcing 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.

References

5. IEEE and IEE Papers from Journals and Conference Records

EE6301: Power Electronic Circuits

Pre-requisite: Nil

Total hours: 42 Hrs.

Module 1: (11 hours)

D.C.chopper circuits, Type-A, B, C, D and E configurations, Analysis of Type-A chopper with R-L load. - Voltage and current commutated Choppers


Current Harmonics and power factor.

Module 2: (10 hours)


Module 3: (10 hours)


Module 4: (11 hours)


References

1. Ned Mohan et.al “Power electronics: converters, applications, and design” John Wiley and Sons, 2006


EE6302: Advanced Power Electronic Circuits

Pre-requisite: Nil

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)


Module 3: (10 hours)


Module 4: (12 Hours)


References

1. Ned Mohan et.al “Power electronics : converters, applications, and design” John Wiley and Sons, 2006


**EE6303: Dynamics of Electrical Machines**

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**Module 1: (12 hours)**


**Module 2: (11 hours)**


**Module 3: (10 hours)**


Module 4: (9 hours)


References


EE6304: Advanced Digital Signal Processing

Pre-requisite: Nil

Total hours: 42 Hrs

Module 1: Discrete Time Signals, Systems and Their Representations (12 hours)

Discrete time signals- Linear shift invariant systems- Stability and causality- Sampling of continuous time signals- 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 (9 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 (9 hours)

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 limit cycles in IIR filters
Module 4: Statistical Signal Processing (12 hours)


References


6. Abraham Peled and Bede Liu, Digital Signal Processing, John Wiley and Sons, 1976

EE6306: Power Electronic Drives

Pre-requisite: Nil

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)

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 nonsinusoidal 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 cage motors - 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.

References


EE6308: FACTS and Custom Power

Pre-requisite: Nil

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: (11 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: (10 hours)**

Unified Power Flow Controller: Circuit Arrangement, Operation and control of UPFC - Basic Principle of P and Q control - independent real and reactive power flow control - Applications - Introduction to interline power flow controller.

Modelling and analysis of FACTS Controllers – simulation of FACTS controllers

**Module 4: (11 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.

**References**


**EE6321: Power Semiconductor Devices and Modeling**

**Pre-requisite:** Nil

**Total hours:** 42 Hrs

**Module 1: (11 hours)**


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: (12hours)


Module 3: (9 hours)

New power semiconductor devices . Thermal design of power electronic equipment . Modelling of power semiconductors (principles) . Simulation tools. [9 Hours]

Module 4: (10 hours)

Gating Requirements for Thyristor, Component Temperature Control and Heat Sinks . Control of device temperature , heat transfer by conduction . transient thermal impedance - heat sinks .heat transfer by radiation and convection - Heat Sink Selection for SCRs and GTOs.

Modelling of power diode - Modelling of power MOSFET - Modelling of bipolar transistor - Modelling of IGBT

References


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

**Pre-requisite: Nil**

**Total hours: 42 Hrs**

**Module1: (10 hours)**


Power Qulity Issues . Sags, Sweels, Unbalance, Flicker , Distortion , Current Harmonics - Sources of Harmonics in DistributionSystems and Ill Effects .

**Module 2: (10 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: (11 hours)**


**Module 4: (11 hours)**


**References**

EE6327: Linear and Digital Electronics

Pre-requisite: Nil

Total hours: 42 Hrs

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 resistor 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)

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 a clocked 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 State 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 – Set up time - Hold time – Clock skew.


**References**

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