Department of Electrical Engineering
M Tech in Industrial Power and Automation (EED)
Brief & Detailed Syllabus

MA6003: Mathematical Methods for Power Engineering

Pre-requisite: Nil

Total hours: 42 Hrs

c	T	P	C
3	0	0	3

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.

EE6401: Energy Auditing & Management

Pre-requisite: Nil

Total hours: 42 Hrs

c	T	P	C
3	0	0	3

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

c	T	P	C
3	0	0	3

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

Pre-requisite: Nil

Total hours: 42 Hrs

c	T	P	C
3	0	0	3

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

Total hours: 42 Hrs

c	T	P	C
3	0	0	3

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

c	T	P	C
3	0	0	3

Pre-requisite: Nil

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

L	T	P	C
3	0	0	3

Pre-requisite: Nil

Total hours: 42 Hrs

Basic Computer Organization, Assembly Language Programming, Stack and Subroutines. Interrupts, DMA, Intel 8051, PIC 16F877, Digital Signal Processor (DSP) - Architecture – Programming, Microcontroller development for motor control applications, stepper motor control using micro controller

EE6422: Engineering Optimization

Pre-requisite: Nil

Total hours: 42 Hrs

L	T	P	C
3	0	0	3

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

EE6423: Industrial Communication

c	T	P	C
3	0	0	3

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:

L	T	P	C
3	0	0	3

Pre-requisite: Nil

Total hours: 42 Hrs

Mathematics of Spatial Descriptions and Transformations-Robot definition, Robot classification. Robotic system components, Different orientation descriptions, Manipulator Kinematics and Mechanics of Robot Motion, Velocity Transformations, Static Forces Transformations, Manipulator Dynamics, Trajectory Planning, Inverse dynamics control, Robot controller architectures, Robot Sensing and Vision Systems, Introduction to Intelligent Robots, Robots in manufacturing automation.

EE6426: Distribution Systems Management and Automation

L	T	P	C
3	0	0	3

Pre-requisite: Nil

Total hours: 42 Hrs

Distribution Automation System, Integration of Distributed Generation and Custom Power components in distribution systems, Electrical System Design, Electrical Safety and Earthing Practices, Communication Systems for Control and Automation, Power Quality and Custom Power, Deregulated Systems.

EE6428: SCADA Systems and Applications

Pre-requisite: Nil

Total hours: 42 Hrs

L	T	P	C
3	0	0	3

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

L	T	P	C
3	0	0	3

Microcontroller Experiments, Programmable Logic Controller, Experiments, Performance Comparison of Centrifugal Pump by Throttling and VFD , Speed Control of Induction Motor using DSP, SCADA Experiments, DCS Experiments, Eddy Current Drive Experiments , Power Quality Experiments.

EE6101: Dynamics of Linear Systems

Pre-requisite: Nil

Total hours: 42 Hrs

L	T	P	C
3	0	0	3

State variable representations of systems - transfer function and transfer function matrix - solutions of state equations – observability and controllability - minimal realization of MIMO systems - analysis of linear time varying systems - the concepts of stability - Lyapunov stability analysis - Lyapunov function and its properties - controllability by state variable feedback - Ackerman's Formula - stabilization by output feedback - asymptotic observers for state measurement - observer design - state space representation of discrete systems - solution of state equations, controllability and observabilty - stability analysis using Lyapunov method - state feedback of linear discrete time systems- design of observers - MATLAB Exercises.

EE6102: Optimal and Adaptive Control

Pre-requisite: Nil

Total hours: 42 Hrs

L	T	P	C
3	0	0	3

Optimal control problem –- fundamental concepts and theorems of calculus of variations – Euler - Language equation and external of functional - the vibrational 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

L	T	P	C
3	0	0	3

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

L	T	P	C
3	0	0	3

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

L	T	P	C
3	0	0	3

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

L	T	P	C
3	0	0	3

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

EE6123: Performance Modelling of Systems – I

Pre-requisite: Nil

Total hours: 42 Hrs

L	T	P	C
3	0	0	3

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

L	T	P	C
3	0	0	3

Pre-requisite: Nil

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

L	T	P	C
3	0	0	3

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

L	T	P	C
3	0	0	3

Pre-requisite: Nil

Total hours: 42 Hrs

Biological foundations - ANN models - network architectures - learning processes - single layer and multilayer perceptURS - least mean square algorithm - back propagation algorithm - applications in engineering problems - fuzzy sets - fuzzy set operations - membership functions - fuzzy to crisp conversion - fuzzification and defuzzification methods - applications in engineering problems - fuzzy control systems - fuzzy logic controllers with examples - special forms of fuzzy logic models - classical fuzzy control problems - image processing - adaptive fuzzy systems - hybrid systems.

EE6201: Computer Methods in Power Systems

L	T	P	C

3	0	0	3

Pre-requisite: Nil

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

L	T	P	C
3	0	0	3

Pre-requisite: Nil

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

L	T	P	C
3	0	0	3

Pre-requisite: Nil

Total hours: 42 Hrs

Principle of renewable energy systems-technical and social implications- solar energy conversion methods- analysis-economics-applications- solar thermal power generation, Direct energy conversion-Photovoltaic system- Lighting and water pumping applications. Biofuels- Fuel cells-MHD. Wind energy-wind mills. applications- economics of wind power. OTEC-Tidal power sources and applications. Micro and mini hydel power. Hybrid Energy Systems.

EE6222: Power Quality

L	T	P	C
3	0	0	3

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

L	T	P	C

Pre-requisite: Nil

Total hours: 42 Hrs

3	0	0	3

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 Inverters . Basic Concepts . Single Phase Inverters. PWM Principles . Sinusoidal Pulse Width Modulation in Single Phase Inverters . Three Phase Inverters -Three Phase Square Wave /Stepped Wave Inverters . 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

EE6302: Advanced Power Electronic Circuits

Pre-requisite: Nil

Total hours: 42 Hrs

L	T	P	C
3	0	0	3

Special Inverter Topologies -Series Inverters . Switched Mode Rectifier - Single phase and three phase boost type APFC and control, Three phase utility interphases and control-Buck, Boost, Buck-Boost SMPS Topologies . modes of operation –Push-Pull and Forward Converter Topologies - Voltage Mode Control.-Half and Full Bridge Converters . Flyback Converter . Introduction to Resonant Converters . . Load Resonant Converter . Zero Voltage Switching Clamped Voltage Topologies . Resonant DC Link Inverters with Zero Voltage Switching . High Frequency Link Integral Half Cycle Converter.

EE6303: Dynamics of Electrical Machines

Pre-requisite: Nil

Total hours: 42 Hrs

L	T	P	C
3	0	0	3

Electro dynamical Equations and their Solution . Linearisation of the Dynamic Equations and Small Signal Stability. The Primitive 4 Winding Commutaor Machine- The Commutator Primitive Machine The Complete Voltage Equation of Primitive 4 Winding Commutator Machine . The Torque Equation . Analysis of Simple DC Machines using the Primitive Machine Equations. The Three Phase Induction Motor . Transformed Equations . Different Reference Frames for Induction Motor Analysis Transfer Function Formulation. The Three Phase Salient Pole Synchronous Machine . Parks Transformation- Steady State Analysis . Large Signal Transient -Small Oscillation Equations in State Variable form .Dynamical Analysis of Interconnected Machines . Large Signal Transient Analysis using Transformed Equations . The DC Generator/DC Motor System . The Alternator /Synchronous Motor System . The Ward-Leonard System

EE6304: Advanced Digital Signal Processing

Pre-requisite: Nil

Total hours: 42 Hrs

L	T	P	C
3	0	0	3

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- Dynamic range scaling- Overflow oscillations and zero input limit cycles in IIR filters Statistical signal processing Linear Signal Models -Power spectrum estimation- Spectral analysis of deterministic signals . Estimation of power spectrum of stationary random signals-Optimum linear filters-Optimum signal estimation-Mean square error estimation-Optimum FIR and IIR filters.fuzzy systems - hybrid systems.

EE6306: Power Electronic Drives

L	T	P	C
3	0	0	3

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

L	T	P	C
3	0	0	3

Pre-requisite: Nil

Total hours: 42 Hrs

Steady-state and dynamic problems in AC systems –Power flow control - Benefits of FACTS Transmission line compensation- Uncompensated line -shunt and series compensation -Reactive power compensation – shunt and series compensation principles VAr Compensators –Static shunt compensators: SVC and STATCOM -Static series compensation: TSSC, SSSC - TCVR and TCPAR- Operation and Control - GCSC,TSSC, TCSC and Static synchronous series compensators and their control - Unified Power Flow Controller: Modelling and analysis of FACTS Controllers – simulation of FACTS controllers -Power quality problems in distribution systems, mitigation of harmonics, passive filters, active filtering – shunt , series and hybrid and their control - power line conditioners- IEEE standards on power quality.

EE6321: Power Semiconductor Devices and Modeling

L	T	P	C
3	0	0	3

Pre-requisite: Nil

Total hours: 42 Hrs

Power Diodes, Thyristors, Triacs, Gate Turnoff Thyristor (GTO). V-I Characteristics . Turn on Process Snubber Requirements and Snubber Design. Power BJTs . Basic Structure and I-V Characteristics FBSOA and RBSOA Curves. Switching Characteristics Snubber Requirements for BJTs and Snubber Design - Switching Aids.Power MOSFETs - Basic Structure . V-I Characteristics . Turn on Process . Turn on Transient Turn off Transient dv/dt limitations . Gating Requirements . Gate Charge - Ratings of MOSFETs. FBSOA and RBSOA Curves . -Snubber Requirements .Insulated Gate Bipolar Transistors (IGBTs) . Basic Structure and Operation .Latch up IGBT Switching Characteristics IGBT Turn on Transient . IGBT Turn off Transient- Snubber Requirements and Snubber Design. New power semiconductor devices . Thermal design of power electronic equipment . Modelling of power semiconductors (principles) . Simulation tools. Gating Requirements for Thyristor, Component

Temperature Control and Heat Sinks . Modelling of power diode - Modelling of power MOSFET - Modelling of bipolar transistor - Modelling of IGBT

EE6322: Static Var Controllers & Harmonic Filtering

L	T	P	C
3	0	0	3

Pre-requisite: Nil

Total hours: 42 Hrs

Fundamentals of Load Compensation , Power Qulity Issues - Sources of Harmonics in Distribution Systems and Ill Effects .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 l, SSSC and its Control, Sub-Synchronous Resonance Transient and Dynamic Stability Improvement in Power Systems - Converters for Static Compensation . Standard Modulation Strategies -GTO Inverters . Multi-Level Inverters)-Passive Harmonic Filtering. Single Phase Shunt Filter and its Control, Three Phase Active Filtering and their control Hybrid Filtering using Shunt Active Filters . Series Active Filtering in Harmonic Cancellation Mode. Series Active Filtering in Harmonic Isolation Mode . Dynamic Voltage Restorer and its control. Power Quality Conditioner

EE6327: Linear and Digital Electronics

L	T	P	C
3	0	0	3

Pre-requisite: Nil

Total hours: 42 Hrs

BJT and MOSFET Differential amplifiers and their analysis, Properties of ideal Opamps, Dominant pole compensation – 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 – Butterworth low 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 Sate Machine –Counters-Ripple Counters – Ring Counters – Shift registers counter design. Asynchronous sequential logic: Analysis and Design

MA6003: Mathematical Methods for Power Engineering

L	T	P	C
3	0	0	3

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)

Random Variables, Distributions and Density functions, Moments and Moment generating function, Independent Random Variables, Marginal and Conditional distributions, Conditional Expectation, Elements of stochastic processes, Classification of general stochastic processes.

References

1. Kenneth Hoffman and Ray Kunze, Linear Algebra,2nd Edition, PHI, 1992.

2. Erwin Kreyszig, Introductory Functional Analysis with Applications, John Wiley & Sons, 2004.

3. Irwin Miller and Marylees Miller, John E. Freund's Mathematical Statistics, 6th Edn, PHI, 2002.

4. J. Medhi, Stochastic Processes, New Age International, New Delhi., 1994

5. A Papoulis, Probability, Random Variables and Stochastic Processes, 3rd Edition, McGraw Hill, 2002

6. John B Thomas, An Introduction to Applied Probability and Random Processes, John Wiley, 2000

7. Hillier F S and Liebermann G J, Introduction to Operations Research, 7th Edition, McGraw Hill, 2001

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

EE6401: Energy Auditing & Management

L	T	P	C
3	0	0	3

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.

Reactive Power management-Capacitor Sizing-Degree of Compensation-Capacitor losses-Location-Placement-Maintenance, case study.

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

Lighting- Energy efficient light sources-Energy conservation in Lighting Schemes- Electronic ballast-Power quality issues-Luminaries, case study.

Module 4: (11 hours)

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

Electric loads of Air conditioning & Refrigeration-Energy conservation measures- Cool storage. Types-Optimal operation-case study; Electric water heating-Gysers-Solar Water Heaters- Power Consumption in Compressors, Energy conservation measures; Electrolytic Process; Computer Controls- software-EMS

References

1. Handbook on Energy Audit and Environment Management , Y P Abbi and Shashank Jain, TERI, 2006

2. Handbook of Energy Audits Albert Thumann, William J. Younger, Terry Niehus, 2009

3. Giovanni Petrecca, .Industrial Energy Management: Principles and Applications., The Kluwer international series -207,1999

4. Anthony J. Pansini, Kenneth D. Smalling, .Guide to Electric Load Management., Pennwell Pub; (1998)

5. Howard E. Jordan, .Energy-Efficient Electric Motors and Their Applications., Plenum Pub Corp; 2nd edition (1994)

6. Turner, Wayne C., .Energy Management Handbook., Lilburn, The Fairmont Press, 2001

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8. IEEE Bronze Book- .Recommended Practice for Energy Conservation and cost effective planning in Industrial facilities., IEEE Inc, USA. 2008

9. Albert Thumann, P.W, -.Plant Engineers and Managers Guide to Energy Conservation. - Seventh Edition-TWI Press Inc, Terre Haute, 2007

10. Donald R. W., .Energy Efficiency Manual., Energy Institute Press, 1986

11. Partab H., 'Art and Science of Utilisation of Electrical Energy', Dhanpat Rai and Sons, New Delhi. 1975

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13. NESCAP-Guide Book on Promotion of Sustainable Energy Consumption, 2004

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15. IEEE Recommended Practices for Energy Management in Industrial and Commercial Facilities

16. Guide to Energy Management, Sixth Edition , Barney L. Capehart (Author), Wayne C. Turner (Author), William J. Kennedy, Fairmont Press; 6 edition (April 23, 2008)

17. Energy Efficiency Manual: for everyone who uses energy, pays for utilities, designs and builds, is interested in energy conservation and the environment, Donald R. Wulfinghoff, Energy Institute Press (March 2000)

18. Handbook of Energy Audits, Seventh Edition, Albert Thumann., William J. Younger, Fairmont Press; 7 edition (November 12, 2007)

19. Certified Energy Manager Exam Secrets Study Guide: CEM Test Review for the Certified Energy Manager Exam CEM Exam Secrets Test Prep Team Mometrix Media LLC (2009)

20.Handbook of Energy Engineering, Sixth Edition Albert Thumann , D. Paul Mehta Fairmont Press; 6 edition (June 24, 2008)

EE6402: Process Control & Automation

L	T	P	C
3	0	0	3

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

1. Seborg, D.E., T.F. Edgar, and D.A. Mellichamp, Process Dynamics and Control, John Wiley , 2004

2. Johnson D Curtis, Instrumentation Technology, (7th Edition) Prentice Hall India, 2002.

3. Bob Connel, Process Instrumentation Applications Manual, McGrawHill, 1996.

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10. K. Krishnaswamy, Process Control, New Age International, 2007

EE6403: Computer Controlled Systems

L	T	P	C

3	0	0	3

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^∞ Theory- Solution for design using H^2 / H^∞ - 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 Commnication 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

1. Shinskey F.G., Process control systems: application , Design and Tuning, McGraw Hill International Edition ,Singapore,1988.
2. Be.langer P.R. , Control Engineering: A Modern Approach, Saunders College Publishing , USA, 1995.
3. Dorf, R.C. and Bishop R. T. , Modern Control Systems , Addison Wesley Longman Inc., 1999
4. Laplante P.A., Real Time Systems: An Engineer.s Handbook, Prentice Hall of India Pvt. Ltd., New Delhi, 2002.
5. Constantin H. Houpis and Gary B. Lamont, Digital Control systems, McGraw Hill Book Company, Singapore, 1985.
6. Stuart A. Boyer: SCADA-Supervisory Control and Data Acquisition, Instrument Society of America Publications,USA,1999
7. Gordon Clarke, Deon Reynders:Practical Modern SCADA Protocols: DNP3, 60870.5 and Related Systems, Newnes Publications, Oxford, UK,2004
8. Efim Rosenwasser, Bernhard P. Lampe, Multivariable computer-controlled systems: a transfer function approach, Springer, 2006

EE6404: Industrial Load Modelling & Control

L	T	P	C
3	0	0	3

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

1 C.O. Bjork " Industrial Load Management - Theory, Practice and Simulations", Elsevier, the Netherlands, 1989.

2. C.W. Gellings and S.N. Talukdar, . Load management concepts. IEEE Press, New York, 1986, pp. 3-28.

3. Various Authors, " Demand side management - Alternatives", IEEE Proceedings on DSM , Oct 1985

4. Y. Manichaikul and F.C. Schweppe ," Physically based Industrial load", IEEE Trans. on PAS, April 1981

5. H. G. Stoll, "Least cost Electricity Utility Planning., Wiley Interscience Publication, USA, 1989.

6. I.J.Nagarath and D.P.Kothari, .Modern Power System Engineering. , Tata McGraw Hill publishers, New Delhi, 1995.

7. Cogeneration as a means of pollution control and energy efficiency in Asia 2000. Guide book by UNESC for ASIA and the Pacific , Book No: ST/ESCAP/2026, UNESCAP, Bangkok

8. IEEE Bronze Book- .Recommended Practice for Energy Conservation and cost effective planning in Industrial facilities., IEEE Inc, USA.

9. ASHRAE Handbooks-1997-2000, American Society of Heating, Refrigerating and Air-conditioning Engineers Inc., Atlanta, GA.

10. Richard E. Putman, industrial energy systems: analysis, optimization, and control, ASME Press, 2004

EE6406: Industrial Instrumentation

L	T	P	C
3	0	0	3

-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)

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)

Servo drives – servo drive performance criteria – servomotors shaft sensors and coupling – sensors for servo drives – servo control loop design issues- stepper motor drives types and characteristics – hybrid stepper motor – permanent magnet stepper motor – hybrid and permanent magnet motors – single and multi step responses.

References

1. Ernest O. Doebelin Measurement systems applications and design, McGraw – Hill International Editions, McGraw- Hill Publishing Company, 1990

. Patric F. Dunn University of Notre Dame, Measurement and Data Analysis for engineering and science, Mc Graw Hill Higher education, 1995

3. Randy Frank, Understanding Smart Sensors, Artec House Boston. London, 2000

4. Muhamad H Rashid, Power electronics handbook, ACADEMIC PRESS, 2007

5. K Krishnaswamy, Industrial Instrumentation, New Age International Publishers, New Delhi, 2003

6. Gregory K. McMillan, Douglas M. Considine , Process/Industrial Instruments and Controls Handbook,5th Edition, Mc Graw Hill 1999

7. Steve Mackay, Edwin Wright, John Park, Practical Data Communications for Instrumentation and Control, Newness Publications, UK, 2003

8. John O Moody, Paros J Antsaklis, Supervisory Control of discrete event systems using petrinets, PHI, 2002

9. James L Peterson, Petrinet theory and modeling of system, 1981

EE6421: Advanced Microcontroller Based Systems

Pre-requisite: Nil

Total hours: 42 Hrs

L	T	P	C
3	0	0	3

Basic Computer Organization - Accumulator Based Processors - Architecture - Memory Organizations - I/O Organizations - Assembly Language Programming - Addressing - Operations - Stack and Subroutines . Interrupts - DMA - Stages of Microprocessor based Program Development.

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)

PIC 16F877- Architecture - Memory Interfacing - Interfacing I/O devices - Instruction Set - Serial I/O and Data Communication. Digital Signal Processor (DSP) - Architecture – Programming. Introduction to FPGA.

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

1. John.F.Wakerly: Microcomputer Architecture and Programming, John Wiley and Sons 1981

2. Ramesh S.Gaonker: Microprocessor Architecture, Programming and Applications with the 8085, Penram International Publishing (India), 1994

3. Raj Kamal: The Concepts and Features of Microcontrollers, Wheeler Publishing, 2005

4. Kenneth J. Ayala, The 8051 microcontroller, Cengage Learning, 2004

5. John Morton, The PIC microcontroller: your personal introductory course, Elsevier, 2005

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

Pre-requisite: Nil

Total hours: 42 Hrs

L	T	P	C
3	0	0	3

Module 1: (11 hours)

Concepts of optimization: Engineering applications-Statement of optimization problem-Classification - type and size of the problem.

Classical Optimization Techniques: Single and multi variable problems-Types of Constraints .Semi definite case-saddle point.

Linear programming: Standard form-Geometry of LP problems-Theorem of LP-Relation to convexity - formulation of LP problems - simplex method and algorithm -Matrix form- two phase method.

Duality- dual simplex method- LU Decomposition. Sensitivity analysis .Artificial variables and complementary solutions-QP.

Engineering Applications: Minimum cost flow problem, Network problems-transportation, assignment & allocation, scheduling . Karmarkar method-unbalanced and routing problems.

Module 2: (11 hours)

Nonlinear programming: Non linearity concepts-convex and concave functions- non-linear programming - gradient and Hessian.

Unconstrained optimization: First & Second order necessary conditions-Minimisation & Maximisation-Local & Global convergence-Speed of convergence.

Basic decent methods: Fibonacci & Golden section search - Gradient methods - Newton Method-Lagrange multiplier method - Kuhn-tucker conditions . Quasi-Newton method- separable convex programming - Frank and Wolfe method, Engineering Applications.

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

1. David G Luenberger, .Linear and Non Linear Programming., 2nd Ed, Addison-Wesley Pub.Co.,Massachusetts, 2003

2. W.L.Winston, .Operation Research-Applications & Algorithms.,2nd Ed., PWS-KENT Pub.Co.,Boston, 2007

3. S.S.Rao, .Engineering Optimization., 3rd Ed.,New Age International (P) Ltd,New Delhi, 2007

4. W.F.Stocker, .Design of Thermal Systems., 3rd Ed., McGraw Hill, New York. 1990

5. G.B.Dantzig, .Linear Programming and Extensions. Princeton University Press, N.J., 1963.

6. L.C.W.Dixton,. Non Linear Optimisation: theory and algorithms. Birkhauser, Boston, 1980

7. Bazarra M.S., Sherali H.D. & Shetty C.M., .Nonlinear Programming Theory and Algorithms., John Wiley,New York,1979.

8 A. Ravindran, K. M. Ragsdell, G. V. Reklaitis, Engineering Optimization: Methods And Applications, Wiley, 2008

9 Godfrey C. Onwubolu, B. V. Babu, New optimization techniques in engineering, Springer, 2004

10. Kalyanmoy Deb,.Optimisation for Engineering Design-Algorithms and Examples., Prentice Hall India-1998

EE6423: Industrial Communication

L	T	P	C
3	0	0	3

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

1. Karanjith S.Siyan, .Inside TCP/IP., 3rd edition, Techmedia, 1998

2. Alberto,Leon,Garcia, Indra, and Wadjaja, .Communication networks., Tata Mc Graw Hill,2000

3. James F Kurose.Keith W Ross, .Computer networking A Top down Approach featured internet, Pearson Education, 2003.

4. Keshav, .An engineering approach to computer networking, Addison-Wesley, 1999

5. Radia Perlmal, .Interconnections second edition, Addison Wesley, 2000

6. Douglas E comer, .Inter networking with TCP/IP, Vol 1, Prentice Hall India, 1999.

7. Andrew S. Tannebaum, .Computer Networks., Fourth Edition., Prentice Hall,2003

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

9. Gordon Clarke, Deon Reynders: Practical Modern SCADA Protocols: DNP3, 60870.5 and Related Systems, Newnes Publications, Oxford, UK,2004

10. Afritech Panel, Industrial communication, Afritech, 2006

11. Michael William Ivens, The practice of industrial communication, Business Publications, 1963

12. Richard Zurawski, The industrial communication technology handbook, CRC Press, 2005

13. Raimond Pigan, Mark Metter, Automating with PROFINET: Industrial Communication Based on Industrial Ethernet, Publicis Publishing 2008

EE6424: Robotics Systems and Applications

L	T	P	C
3	0	0	3

Pre-requisite: Nil

Total hours: 42 Hrs

Module 1: (8 hours)

Mathematics of Spatial Descriptions and Transformations-Robot definition. Robot classification. Robotic system components- Notations- Position definitions- Coordinate frames - Different orientation descriptions - Free vectors- Translations, rotations and relative motion - Homogeneous transformations.

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

1. Fu, K.S., R.C. Gonzalez, C.S.G. Lee, Robotics: Control, Sensing, Vision & Intelligence, McGrawHill, 1987.

2. Craig, John J., Introduction to Robotics: Mechanics & Control, 2nd Edition, Pearson Education, 1989.

3. Gray J.O., D.G. Caldwell(Ed), Advanced Robotics & Intelligent machines, The Institution of Electrical Engineers, UK, 1996.

4. Groover, Mikell P., Automation, Production Systems & Computer Integrated manufacturing, Prentice hall India, 1996.

5. Groover Mikell P., M. Weiss, R.N. Nagel, N.G. Odrey, Industrial Robotics, McGrawHill, 1986.

6. Janakiraman, P.A., Robotics & Image Processing, Tata McGrawHill, 1995.

7. Sciavicco, L., B. Siciliano, Modelling & Control of Robot Manipulators, 2nd Edition, Springer Verlag, 2000.

8. Robin R. Murphy, "An introduction to AI Robotics", MIT Press, 2008

9. Oliver Brock, Jeff Trinkle and Fabio Ramos, "Robotics-Science and Systems" Vol. IV, MIT Press 2009

EE6426: Distribution Systems Management and Automation

L	T	P	C
3	0	0	3

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

1. James Northcote – Green, Robert Wilson, "Control and Automation of Electrical Power Distribution Systems", CRC Press, New York, 2007.

2. Turan Gonen: .Electric Power Distribution System Engineering. McGraw Hill Company. 1986

3. M.V Deshpande: .Electrical Power System Design. Tata-McGraw Hill, 1966

4. IEEE Press: IEEE Recommended practice for Electric Power Distribution for Industrial Plants, published by IEEE, Inc., 1993

5. Pansini, Electrical Distribution Engineering, The Fairmont Press, Inc., 2007

6. Pabla H S.: .Electrical Power Distribution Systems.. Tata McGraw Hill. 2004

7. IEEE Standerd 739 . Recommended Practice for Energy Conservation and Cost Effective Planning in Industrial Facilities. 1984

8. G H Heydt .Electric Power Quality. McGram Hill, 2007

9. Wilson K. Kazibwe and Musoke H Semdaula .Electric Power Quality Control Techniques.. Van Nostarand Reinhold New York, 2006

10. Lakervi & E J Holmes .Electricity distribution network design., 2nd Edition Peter Peregrimus Ltd. 1995

EE6428: SCADA Systems and Applications

Pre-requisite: Nil

Total hours: 42 Hrs

L	T	P	C
3	0	0	3

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**: V**arious 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

2. Gordon Clarke, Deon Reynders: Practical Modern SCADA Protocols: DNP3, 60870.5 and Related Systems, Newnes Publications, Oxford, UK,2004

3. William T. Shaw, Cybersecurity for SCADA systems, PennWell Books, 2006

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

L	T	P	C
3	0	0	3

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

3. K. Krishnaswamy, Process Control, New Age International, 2007

EE6101: Dynamics of Linear Systems

Pre-requisite: Nil

Total hours: 42 Hrs

L	T	P	C
3	0	0	3

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)

The concepts of stability- absolute stability and BIBO Stability - eigen values of state matrix - equilibrium states - Lyapunov stability theorems - stability analysis using Lyapunov's first method and second method - Lyapunov function and its properties

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)

Difference equation model for LTIV systems - impulse response model - transfer function model - discrete state space representation - solution of state equations - controllability and observabilty - stability analysis using Lyapunov method - state feedback of linear discrete time systems- Design of Observers-MATLAB Exercises.

References

1. Thomas Kailath, Linear Systems, Prentice Hall Inc., Englewood Cliffs, N.J. 1980.

2. K. Ogata, State Space Analysis of Control Systems, Prentice Hall Inc., Englewood Cliffs, N.J., 1965.

3. K. Ogata, Modern Control Engineering, (second edition) , Prentice Hall Inc., Englewood Cliffs, N.J., 1990.

4. M.Gopal, Digital Control and State Variable Methods, Tata McGraw Hill Publishing Company Ltd., New Delhi, 1997.

5. C.T. Chen, Linear System Theory and Design, New York: Holt Rinehart and Winston ,1984.

6. R.C. Dorf, and R. T. Bishop, Modern Control Systems, Addison Wesley Longman Inc., 1999.

7. Eronini,Umez- Eronini, System Dynamics and Control, Thomson Asia Pte Ltd.,Singapore,ISBN: 981-243-113-6, 2002.

EE6102: Optimal and Adaptive Control

Pre-requisite: Nil

Total hours: 42 Hrs

L	T	P	C
3	0	0	3

Module 1: (12 hours)

Optimal control problem – open loop and closed loop form of optimal control- performance measures for optimal control problems – general form of performance measure - fundamental concepts and theorems of calculus of variations – function and functional – Extremal of functionals of a single function - Euler - Language equation and solution- extremal of functionals of several independent functions – various boundary condition equations - piecewise-smooth extremals - extremal of functionals with dependent functions – use of Lagrange multipliers - differential equation constraints – isoperimetric constraints.

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)

Dynamic programming - principle of optimality - application to multi stage decision making – application to optimal control problem – need for interpolation - recurrence relation of dynamic programming - curse of dimensionality - discrete linear regulator problem - Hamilton-Jacobi-Bellman equation - continuous linear regulator problem.

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

1. Donald E. Kirk, Optimal Control Theory, An introduction, Prentice Hall Inc., 2004
2. A.P. Sage, Optimum Systems Control, Prentice Hall, 1977
3. HSU and Meyer , Modern Control, Principles and Applications, McGraw Hill, 1968
4. Yoan D. Landu, Adaptive Control (Model Reference Approach), Marcel Dekker. 1981
5. K.K.D.Young, Design of Variable Structure Model Following Control Systems., IEEE Transactions on Automatic Control, Vol. 23, pp 1079-1085, 1978.
6. A.S.I. Zinobar, O.M.E. EI-Ghezawi and S.A. Billings, Multivariable variable structure adaptive model following control systems. . Proc. IEE., Vol. 129, Pt.D., No.1, pp 6-12, 1982

EE6103: Applied Instrumentation

Pre-requisite: Nil

Total hours: 42 Hrs

L	T	P	C
3	0	0	3

Introductory Instrumentation to process control . Modeling philosophies. The rationals for mathematical modeling dynamic versus steady state models . General modeling principles degrees of freedom in modeling . Control systems instrumentation . Transducers and transmitters . Transfer function models . Procedure for developing transfer function models.

Module 2: (10 hours)

Performance modeling . Modeling automated manufacturing system (introduction) . Role of performance modeling . Performance measures . Petrinet models . Introduction to petrinets . Basic definitions and analytical techniques. S-net models . Preliminary definition and analytical techniques.

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)

Engineered Data Acquisition and Processing System . Versatile Modular System Emphasising Analog Signal Processing . Instrument Inter Connection Systems . Sensor based computerized data system. Computer Aided Experimentation . Conditional description of the computer system . Computer aided over all plan of the test sequence.

References

1. Seborg . Process dynamic control, Wiley, 2007

2. Ernest O. Doebelin . Measurement system Application and Design . McGraw Hill International Editions, 1990

3. N. Viswanathan, Y. Narahari . Performance modeling of automated manufacturing system, Prentice Hall of India Private Limited, New Delhi, 2001

4. Proceedings: Conference on Advances in computing , CADCOM 98, Allied Publishers Limited, New Delhi, India, 1999

EE6104: Advanced Instrumentation

Pre-requisite: Nil

Total hours: 42 Hrs

L	T	P	C
3	0	0	3

Module 1: (11 hours)

Generalized input . output configuration of measuring system . different methods of correction . General principles . Methods of inherent sensitivity, Principle of filtering, Method of opposing inputs.

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

1. Ernest O. Doebelin . Measurement system Application and Design . McGraw Hill International Editions, 1990

2. K.B. Klaasen : Electronic Measurement and Instrumentation, Cambridge University Press, 1996

EE6121: Data Acquisition & Signal Conditioning

Pre-requisite: Nil

Total hours: 42 Hrs

L	T	P	C
3	0	0	3

Module 1: Transducers & Signal Conditioning (11 hours)

Data Acquisition Systems(DAS)- Introduction . Objectives of DAS . Block Diagram Description of DAS- General configurations - Single and multichannel DAS-Transducers for the measurement of motion, force, pressure, flow, level, dc and ac voltages and currents (CTs, PTs for supply frequency as well as high frequency, Hall Effect Current Sensors, High Voltage Sensors , Optosensors, Rogowski Coil, Ampflex Sensors etc.) - Signal Conditioning: Requirements - Instrumentation amplifiers: Basic characteristics . Chopped and Modulated DC Amplifiers-Isolation amplifiers - Opto couplers - Buffer amplifiers .Noise Reduction Techniques in Signal Conditioning- Transmitters .Optical Fiber Based Signal Transmission-Piezoelectric Couplers- Intelligent transmitters.

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)

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-232C- USB-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

References

1. Ernest O Doeblin., Measurement Systems: Application and Design, McGraw Hill (Int. edition) 1990

2. George C.Barney, Intelligent Instrumentation, Prentice Hall of India Pvt Ltd., New Delhi, 1988.

3. Ibrahim, K.E., Instruments and Automatic Test Equipment, Longman Scientific & Technical Group Ltd., UK, 1988.

4. John Uffrenbeck, The 80x86 Family ,Design, Programming, And Interfacing, Pearson Education , Asia, 2002

5. Bates Paul, Practical digital and Data Communications with LSI, Prentice Hall of India, 1987.

6. G.B. Clayton, .Operational Amplifiers, Butterworth &Co, 1992

7. A.K Ray, Advanced Microprocessors and Peripherals, Tata McGrawHill, 1991

8. Oliver Cage, .Electronic Measurements and Instrumentation., McGraw-Hill, (Int. edition) 1975

EE6122: Biomedical Instrumentation

Pre-requisite: Nil

Total hours: 42 Hrs

L	T	P	C
3	0	0	3

Module 1: (12 hours)

Fundamentals of medical instrumentation – physiological systems of body –regulation of medical devices – origin of bio potentials – Sodium –Potassium pump –Goldman Hodgkin – Katz equation – biomedical transducers – electrode-electrolyte interface – half cell potential – ECG – 12 lead systems – heart rate variability – cardiac pacemakers – defibrillators - EMG – EEG

Module 2: (10 hours)

Measurement of cardiac out put – indicator dilution method – ultrasonic blood flow meter – electromagnetic blood flow meter – blood pressure measurement – oximetry – ear oximeter – pulse oximeter –skin reflectance oximeter -measurement on pulmonary system – spirometry –pulmonary function analyzers –ventilators

Module 3: (10 hours)

Lasers in medicine – Argon laser – Carbon dioxide laser -laser safety –X ray applications –X-ray machine – dental X-ray machine – ultra sound in medicine –electro therapy – hemodialysis –artificial kidney – dialyzers –membranes for hemodialysis

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

1. Geddes & Baker , Principles of applied biomedical instrumentation Wiley Inter science , 3rd edition, 1975

2. R S Khandpur, Hand book of Biomedical instrumentation, TMH,4th edition, 1987

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

4. Brown Carr, Introduction to Biomedical equipment technology , Printice Hall, 1981

5. John Enderle, Introduction to Biomedical engineering , Academic Press, 2005

6. Joseph D Bronzino, Biomedical engineering hand book, CRC Press, 2000

7. Metin Akay (editor), Wiley encyclopedia of biomedical engineering , Wiley, 2003

EE6123: Performance Modelling of Systems – I

Pre-requisite: Nil

Total hours: 42 Hrs

L	T	P	C
3	0	0	3

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

Input-Output configuration of measuring systems . Static characteristics . Dynamic characteristics . Mathematical models . General concepts of transfer functions . Classification of instruments based on their order . dynamic response . frequency response studies.

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

Preliminaries . Basic set theory . Terminology . Functions . Relations - Combinatorics . Theory of counting- Multiplication rule- Ordered samples and permutations-Ordered samples with and without repetitions.- Brief theory of bags .

Module 3: General Graph Theory (10 hours)

Graphs and algorithms . Concepts of Nodes and Arcs- Trees . Spanning of trees .Minimal spanning trees; Prime.s algorithm- Binary trees and tree searching- Planar graphs and Euler.s theorem- Cut sets .Adjacency /incidence matrices . Graph having multiple edges . Determination of Euler cycles- The shortest path problem.

Module 4: Active Graph Theory (12 hours)

Performance models . Petrinet graph- Concepts of places . Transitions . Arcs and Tokens .Concurrency and conflict- Deadlocks- Markings- Reachability sets-Matrx equations- Reachability problems- Popular extensions . S-Nets . Introduction to Petrinet and S Net Models.

References

1. Ernest O Doeblin., Measurement Systems: Application and Design, McGraw Hill (Int. edition) 1990

2. Oliver and Cage, Electronic measurements and Instrumentation , McGraw Hill Int. Editions, 1971

3. C.L. Liu, Elements of Discrete Mathematics, McGraw Hill Int. Editions, 1985.

4. Robert J. McEliece ,Robert B Ash, Carol Ash , Introduction to Discrete Mathematics, McGraw Hill Int. Editions, 1989.

5. J.L. Peterson., Petrinet Theory and Modelling of Systems , Prentice Hall Inc., Englewood Cliffs, N.J ., 1981.

6. John O. Moody ,Panos J Antsaklis, ,Supervisory Control of Discrete Event System Using Petrinets, Kluwer academic Publishers Boston/Dordrecht/ London, 1998.

7. N. Viswanathan, Y. Narahari, Performance Modelling of Automated Manufacturing Systems , Prentice Hall of India Pvt. Ltd., New Delhi,1994.

8. Proceedings : Conference on Advances in Computing CAD CAM 98 , Allied Publishers Ltd., New Delhi, India, 1999

EE6124: Performance Modelling of Systems – II

Pre-requisite: Nil

Total hours: 42 Hrs

L	T	P	C
3	0	0	3

Module 1: Modelling Philosophies (10 hours)

Modelling philosophies . Rationales for mathematical modeling . Dynamic versus steady state models . General modelling principles . Degrees of freedom in modelling Transfer function models . Procedure for developing transfer function models.

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

Performance modelling . Modelling of automated manufacturing systems . Role of performance modelling . Performance measures . Petrinet models . Introduction to Petrinet . Basic definitions and analytical techniques .
S-Net models . Preliminary definitions and analytical techniques.

Module 3: Active Graphical Modelling Tools (10 hours)

Modelling with active graph theory . General concepts . Events and conditions . Synchronisation . Mutual exclusion problems . Standard Problems - Dining philosophers problems . Readers/ writers problems .

Module 4: Analysis of Modelling Tools (12 hours)

Analysis problems of active graph . Petrinets . S-Nets . Their popular extensions . Different case studies of Petrinet and S-Net models related to super computer pipe line . Flexible manufacturing systems . Computer communication system . Computer controlled data acquisition system- computer communication network . Process control systems.

References

1. Ernest O Doeblin., Measurement Systems: Application and Design, McGraw Hill (Int. edition) 1990

2. Oliver and Cage, Electronic measurements and Instrumentation , McGraw Hill Int. Editions, 1971

3. C.L. Liu, Elements of Discrete Mathematics, McGraw Hill Int. Editions, 1985.

4. Robert J. McEliece ,Robert B Ash, Carol Ash , Introduction to Discrete Mathematics, McGraw Hill Int. Editions, 1989.

5. J.L. Peterson., Petrinet Theory and Modelling of Systems , Prentice Hall Inc., Englewood Cliffs, N.J ., 1981.

6. John O. Moody ,Panos J Antsaklis, ,Supervisory Control of Discrete Event System Using Petrinets, Kluwer academic Publishers Boston/Dordrecht/ London, 1998.

7. N. Viswanathan, Y. Narahari, Performance Modelling of Automated Manufacturing Systems , Prentice Hall of India Pvt. Ltd., New Delhi,1994.

8. Proceedings : Conference on Advances in Computing CAD CAM 98 , Allied Publishers Ltd., New Delhi, India, 1999

9. Seborg . Process dynamic control, Wiley, 2007

EE6125: Digital Control Systems

L	T	P	C

Pre-requisite: Nil

Total hours: 42 Hrs

3	0	0	3

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

1. B.C Kuo , Digital Control Systems (second Edition),Oxford University Press, Inc., New York, 1992.

2. G.F. Franklin, J.D. Powell, and M.L. Workman, Digital control of Dynamic Systems, Addison-Wesley Longman, Inc., Menlo Park, CA , 1998.

3. M. Gopal, Digital Control and State Variable Methods, Tata McGraw Hill Publishing Company, Third Edition,2009.

4. John F. Walkerly, Microcomputer architecture and Programs, John Wiley and Sons Inc., New York, 1981.

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

6. C. H. Houpis and G.B. Lamont, Digital Control Systems, McGraw Hill Book Company, 1985.

7. C.L.Philips and H.T Nagle,Jr., Digital Control System Analysis and Design, Prentice Hall, Inc., Englewood Cliffs,N.J.,1984

EE6129: Artificial Neural Networks and Fuzzy Systems

Pre-requisite: Nil

Total hours: 42 Hrs

L	T	P	C
3	0	0	3

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)

Module2:(10hours)

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

Module3:(10hours)

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

Module4:(12hours)

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

1. J.M. Zurada, .Introduction to artificial neural systems., Jaico Publishers, 1992.

2. Simon Haykins, .Neural Networks . A comprehensive foundation., Macmillan College, Proc, Con, Inc, New York, 1994.

3. D. Driankov, H. Hellendorn, M. Reinfrank, .Fuzzy Control . An Introduction. , Narora Publishing House, New Delhi, 1993.

4. H.J. Zimmermann, .Fuzzy set theory and its applications., III Edition, Kluwer Academic Publishers, London. 2001

5. G.J. Klir, Boyuan, .Fuzzy sets and fuzzy logic., Prentice Hall of India (P) Ltd., 1997.

6. Stamatios V Kartalopoulos, .Understanding neural networks and fuzzy logic .basic concepts and applications., Prentice Hall of India (P) Ltd., New Delhi, 2000.

7. Timothy J. Ross, .Fuzzy logic with engineering applications., McGraw Hill, New York.

8. Suran Goonatilake, Sukhdev Khebbal (Eds), .Intelligent hybrid systems., John Wiley & Sons, New York, 1995.

EE6201: Computer Methods in Power Systems

Pre-requisite: Nil

Total hours: 42 Hrs

L	T	P	C
3	0	0	3

Module 1: (11 hours)

System Graph . Loop, Cutset And Incidence Matrices . Y Bus Formation . Power Flow Analysis: Newton-Raphson Method . Decoupled And Fast Decoupled Methods, DC Power Flow, Sparsity And Optimal Ordering, AC-DC Load Flow Analysis

Module 2: (10 hours)

Fault Analysis : [Z_{BUS}] Building Algorithm . Sequence Matrices . Symmetrical And Unsymmetrical Short-Circuit Analysis of Large Power Systems . Phase Shift In Sequence Quantities Due To Transformers.

Module 3: (11 hours)

Power System Optimization . Unit Commitment . Priority List And Dynamic Programming Methods . Optimal Load Flow Solution . Optimal Scheduling Of Hydrothermal System. Introduction to Optimum Reactive Power Dispatch, AI Applications

Module 4: (10 hours)

Power System. Security . Factors Affecting Security . State Transition Diagram . Contingency Analysis Using Network Sensitivity Method And AC Power Flow Method, Correcting The Generation Dispatch Using Sensitivity Methods, State Estimation.

References

1. Hadi A. Sadat, .Power System Analysis., McGraw Hill Co. Ltd., India, 2000.

2. I.J. Nagarath, D.P. Kothari, Power System Engineering., Tata McGraw Hill Publishing Co. Ltd., New Delhi, 1994.

3. George L. Kusic, .Computer Aided Power System Analysis., Prentice Hall of India (P) Ltd., New Delhi, 1989.

4. A.J. Wood, B.F. Wollenberg, .Power Generation, Operation and Control., John Wiley & Sons, New York, 1984.

5. J. Arrilaga, C.P. Arnold, B.J. Harker, .Computer Modelling of Electric Power Systems. Wiley, New York, 1983.

6. A.K. Mahaianabis, D.P. Kothari, S.I. Ahson, .Computer Aided Power System Analysis & Control. Tata McGraw Hill, New Delhi, 1988.

7. B.R. Gupta, .Power System Analysis and Design., (3rd Edition), A.H. Wheeler & Co. Ltd., New Delhi, 1998.

8. O.I. Elgard, .Electric Energy System Theory : An Introduction., 2nd Edition, McGraw Hill, New York, 1982.

EE6204: Digital Protection of Power Systems

Pre-requisite: Nil

Total hours: 42 Hrs

L	T	P	C
3	0	0	3

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

1. A T John and A K Salman- Digital protection for power systems-IEE power series-15, Peter Peregrines Ltd,UK,1997

2. C.R. Mason, The art and science of protective relaying, John Wiley &sons, 2002

3. Donald Reimert, ,Protective relaying for power generation systems, Taylor & Francis-CRC press 2006

4. Gerhard Ziegler-Numerical distance protection, Siemens, 2nd ed, 2006

5. A.R.Warrington, Protective Relays, Vol .1&2, Chapman and Hall, 1973

6. T S.Madhav Rao, Power system protection static relays with microprocessor applications, Tata McGraw Hill Publication, 1994

7. Power System Protection Vol. I, II , III&IV, The Institution Of Electrical Engineers, Electricity Association Services Ltd., 1995

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

9. Badri Ram , D.N. Vishwakarma, Power system protection and switch gear, Tata McGraw Hill, 2001

10. Blackburn, J. Lewis ,Protective Relaying, Principles and Applications, Marcel Dekker, Inc., 1986. Anderson, P.M, Power System Protection,. McGraw-Hill, 1999

11. Singh L.P ,Digital Protection, Protective Relaying from Electromechanical to Microprocessor, John Wiley & Sons, 1994

12. Wright, A. and Christopoulos, C, Electrical Power System Protection,. Chapman & Hall, 1993,

13. Walter A. Elmore, J. L. Blackburn, Protective Relaying Theory and Applications, ABB T&D Co. Marcel Dekker, Inc. 2004

14. Arun G. Phadke, James S. Thorp, Computer Relaying for Power Systems, Marcel Dekker, Inc 2009

EE6221: Distributed Generation

Pre-requisite: Nil

Total hours: 42 Hrs

L	T	P	C
3	0	0	3

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)

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

1. J.N.Twidell & A.D.Weir-Renewable Energy Sources, University press,Cambridge, 2001

2. Sukhatme, S.P., Solar Energy -Principles of Thermal Collection and Storage, Tata McGraw-Hill, New Delhi 1997

3. Kreith, F., and Kreider, J.F., Principles of Solar Engineering, Mc-Graw-Hill Book Co. 2000

4. S.L. Soo ,Direct Energy Conversion , Prentice Hall Publication, 1963

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

6. J. F. Manwell , J. G. McGowan, A. L. Rogers , Wind Energy Explained, John Weily & Sons Ltd 2009

7. E.J. Womack , MHD power generation engineering aspects , Chapman and Hall Publication, 2002

8. G.D. Rai, Non Conventional energy Sources, Khanna Publications ,New Delhi.1994

9. Loi Lei Lai, Tze Fun Chan, “Distributed Generation- Induction and Permanent Magnet Generators”, IEEE Press, John Wiley & Sons, Ltd., England. 2007.

EE6222: Power Quality

Pre-requisite: Nil

Total hours: 42 Hrs

L	T	P	C
3	0	0	3

Module 1: (9 hours)

Introduction-power quality-voltage quality-overview of power quality phenomena-classification of power quality issues-power quality measures and standards-THD-TIF-DIN-C-message weights-flicker factor-transient phenomena-occurrence of power quality problems-power acceptability curves-IEEE guides, standards and recommended practices.

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)

Power factor improvement- Passive Compensation . Passive Filtering . Harmonic Resonance . Impedance Scan Analysis- Active Power Factor Corrected Single Phase Front End, Control Methods for Single Phase APFC, Three Phase APFC and Control Techniques, PFC Based on Bilateral Single Phase and Three Phase Converter. static var compensators-SVC and STATCOM

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

1. G.T. Heydt, Electric power quality, McGraw-Hill Professional, 2007

2. Math H. Bollen, Understanding Power Quality Problems, IEEE Press, 2000

3. J. Arrillaga, .Power System Quality Assessment., John wiley, 2000

4. J. Arrillaga, B.C. Smith, N.R. Watson & A. R.Wood ,.Power system Harmonic Analysis., Wiley, 1997

5. IEEE and IEE Papers from Journals and Conference Records

EE6301: Power Electronic Circuits

Pre-requisite: Nil

Total hours: 42 Hrs

L	T	P	C
3	0	0	3

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

Line Frequency Diode Rectifiers . Single-Phase Diode Bridge Rectifiers with Capacitor Filter . Voltage Doubler Rectifiers . Effect of Single Phase Rectifiers on Neutral Currents in a Three Phase Four-Wire System.

Three Phase half wave rectifier with resistive load . Three phase full wave rectifier . Double Y type rectifier . Single Phase rectifiers with LC filter . LC Filter Design. Three Phase Rectifier Circuits. Input Line Current Harmonics and power factor.

Module 2: (10 hours)

Line Frequency Phase-Controlled Rectifiers and Inverters .Single Phase - Half Wave Controlled Rectifier with R , RL , RL with Flywheel diode loads . Full Wave Controlled Rectifier with various kinds of loads . Half Controlled and Full Controlled Bridges with passive and active loads - 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 . Circulating Current Mode and Non-Circulating Current Mode .

Module 3: (10 hours)

Switch-Mode dc-ac Inverters . Basic Concepts . Single Phase Inverters. PWM Principles . Sinusoidal Pulse Width Modulation in Single Phase Inverters . Choice of carrier frequency in SPWM . Spectral Content of output . Bipolar and Unipolar Switching in SPWM - Blanking Time Maximum Attainable DC Voltage Switch Utilization .Reverse Recovery Problem and Carrier Frequency Selection . Output Side Filter Requirements and Filter Design - Ripple in the Inverter Output - DC Side Current. - Three Phase Inverters -Three Phase Square Wave /Stepped Wave Inverters . Three Phase SPWM Inverters . Choice of Carrier Frequency in Three Phase SPWM Inverters . Output Filters . DC Side Current . Effect of Blanking Time on Inverter Output Voltage .

Module 4: (11 hours)

Converters for Static Compensation . Standard Modulation Strategies - Programmed Harmonic Elimination . Multi-Pulse Converters and Interface Magnetics . Multi-Level Inverters of Diode Clamped Type and Flying Capacitor Type and suitable modulation strategies -Space Vector Modulation - Minimum ripple current PWM method. Multi-level inverters of Cascade Type. Current Regulated Inverter -Current Regulated PWM Voltage Source Inverters . Methods of Current Control . Hysteresis Control . Variable Band Hysteresis Control . Fixed Switching Frequency Current Control Methods . Switching Frequency Vs accuracy of Current Regulation Areas of application of Current Regulated VSI .

References

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

2.P.C. Sen “Power Electronics” Tata McGraw Hill, 2003.

3.G.K.Dubey et.al “Thyristorised Power Controllers” Wiley Eastern Ltd., 2005

4.Dewan & Straughen “Power Semiconductor Circuits” John Wiley & Sons., 1975 .

5.M.D.Singh & K.B.Khanchandani “Power Electronics” Tata McGraw Hill., 2007

6.B. K Bose Modern Power Electronics and AC Drives. Pearson Education (Asia)., 2007,09

EE6302: Advanced Power Electronic Circuits

L	T	P	C

Pre-requisite: Nil

Total hours: 42 Hrs

3	0	0	3

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)

Buck, Boost, Buck-Boost SMPS Topologies . Basic Operation- Waveforms - modes of operation – Output voltage ripple Push-Pull and Forward Converter Topologies - Basic Operation . Waveforms - Voltage Mode Control. Half and Full Bridge Converters . Basic Operation and Waveforms- Flyback Converter . discontinuous mode operation . waveforms . Control - Continuous Mode Operation . Waveforms

Module 4: (12 Hours)

Introduction to Resonant Converters . Classification of Resonant Converters . Basic Resonant Circuit Concepts . Load Resonant Converter . Resonant Switch Converter . Zero Voltage Switching Clamped Voltage Topologies . Resonant DC Link Inverters with Zero Voltage Switching . High Frequency Link Integral Half Cycle Converter.

References

1. Ned Mohan et.al “Power electronics : converters, applications, and design” John Wiley and Sons, 2006
2. Rashid “Power Electronics” Prentice Hall India 2007.
3. G.K.Dubey et.al “Thyristorised Power Controllers” Wiley Eastern Ltd., 2005, 06.
4. Dewan & Straughen “Power Semiconductor Circuits” John Wiley & Sons., 1975.
5. G.K. Dubey & C.R. Kasaravada “Power Electronics & Drives” Tata McGraw Hill., 1993.
6. IETE Press Book Power Electronics Tata McGraw Hill, 2003
7. Cyril W Lander “Power Electronics” McGraw Hill., 2005.
8. B. K Bose “Modern Power Electronics and AC Drives” Pearson Education (Asia)., 2007
9. Abraham I Pressman “Switching Power Supply Design” McGraw Hill Publishing Company., 2001.
10. Daniel M Mitchell “DC-DC Switching Regulator Analysis” McGraw Hill Publishing Company.-1988

EE6303: Dynamics of Electrical Machines

Pre-requisite: Nil

Total hours: 42 Hrs

L	T	P	C
3	0	0	3

Module 1: (12 hours)

Electro dynamical Equations and their Solution . A Spring and Plunger System- Rotational Motion System . Mutually Coupled Coils . Lagrange.s Equation . Application of Lagrange.s Equation to Electromechanical Systems . Solution of Electrodynamical Equations by Euler.s method and Runge-Kutta method . Linearisation of the Dynamic Equations and Small Signal Stability . Differential Equations of a smooth air-gap two winding machine . A two phase machine with current excitation - Interpretation of the Average Power Conversion Conditions in terms of air-gap Magnetic Fields. The Primitive 4 Winding Commutaor Machine- The Commutator Primitive Machine . The Brush Axis and its Significance . Self and Mutually induced voltages in the stationary and commutator windings . Speed e.m.f induced in Commutator Winding . Rotational Inductance Coefficients . Sign of Speed e.m.f terms in the Voltage Equation . The Complete Voltage Equation of Primitive 4 Winding Commutator Machine . The Torque Equation . Analysis of Simple DC Machines using the Primitive Machine Equations.

Module 2: (11 hours)

The Three Phase Induction Motor . Equivalent Two Phase Machine by m.m.f equivalence . equivalent two phase machine currents from three phase machine currents . Power Invariant Phase Transformation . Voltage Transformation . Voltage and Torque Equations of the Equivalent Two Phase Machine . Commutator Transformation and its interpretation . Transformed Equations . Different Reference Frames for Induction Motor Analysis . Nonlinearities in Machine Equations . Equations under Steady State - Solution of Large Signal Transients in an Induction Machine . Linearised Equations of Induction Machine . Small Signal Stability . Eigen Values . Transfer Function Formulation.

Module 3: (10 hours)

The Three Phase Salient Pole Synchronous Machine . Three Phase to Two Phase Transformation . Voltage and Torque Equations in stator, rotor and air-gap field reference frames . Commutator Transformation and Transformed Equations . Parks Transformation . Suitability of Reference Frame Vs kind of Analysis to be Carried out . Steady State Analysis . Large Signal Transient Analysis . Linearisation and Eigen Value Analysis . General Equations for Small Oscillations . Small Oscillation Equations in State Variable form . Damping and Synchronizing Torques in Small Oscillation Stability Analysis . Application of Small Oscillation Models in Power System Dynamics.

Module 4: (9 hours)

Dynamical Analysis of Interconnected Machines . Machine Interconnection Matrices . Transformation of Voltage and Torque Equations using Interconnection Matrix . Large Signal Transient Analysis using Transformed Equations . Small Signal Model using Transformed Equations . The DC Generator/DC Motor System . The Alternator /Synchronous Motor System . The Ward-Leonard System . Hunting Analysis of Interconnected Machines Selection of proper reference frames for individual machines in an Interconnected System

References

1. D.P. Sengupta & J.B. Lynn, Electrical Machine Dynamics, The Macmillan Press Ltd. 1980

2. R Krishnan “Electric Motor Drives, Modeling, Analysis, and Control”, Pearson Education., 2001

3. P.C. Kraus, Analysis of Electrical Machines, McGraw Hill Book Company,1987

4. I. Boldia & S.A. Nasar,,Electrical Machine Dynamics, The Macmillan Press Ltd. 1992

5. C.V. Jones, The Unified Theory of Electrical Machines, Butterworth, London. 1967

EE6304: Advanced Digital Signal Processing

Pre-requisite: Nil

Total hours: 42 Hrs

L	T	P	C
3	0	0	3

Module1: 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)

Linear Signal Models . All pole, All zero and Pole-zero models .Power spectrum estimation- Spectral analysis of deterministic signals . Estimation of power spectrum of stationary random signals-Optimum linear filters-Optimum signal estimation-Mean square error estimation-Optimum FIR and IIR filters.

References

1. Sanjit K Mitra, Digital Signal Processing: A computer-based approach ,Tata Mc Grow-Hill edition .1998

2. Dimitris G .Manolakis, Vinay K. Ingle and Stephen M. Kogon, Statistical and Adaptive Signal Processing, Mc Grow Hill international editions .-2000

3. Alan V . Oppenheim, Ronald W. Schafer, Discrete-Time Signal Processing, Prentice-Hall of India Pvt. Ltd., New Delhi, 1997

4. John G. Proakis, and Dimitris G. Manolakis, Digital Signal Processing(third edition), Prentice-Hall of India Pvt. Ltd, New Delhi, 1997

5. Emmanuel C. Ifeachor, Barrie W. Jervis , Digital Signal Processing-A practical Approach, Addison . Wesley,1993

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

L	T	P	C
3	0	0	3

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)

D.C Motor Drives - System model motor rating - Motor-mechanism dynamics - Drive transfer function – Drives control-speed controller design-Effect of armature current waveform - Torque pulsations - Adjustable speed dc drives - Chopper fed and 1-phase converter fed drives - Effect of field weakening.

Module 2: (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 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

1. Ned Mohan ,"Power Electronics", et. al ,Wiley 2006

2. R Krishnan," Electric Motor Drives, Modeling, Analysis, and Control", Pearson Education,2001

3. G.K.Dubey & C.R.Kasaravada ,"Power Electronics & Drives", Tata McGraw Hill,1993.

4. W.Shephered, L N Hulley Cambride ,Power Electronics & Control of Motor , University Press,2005.

5. Dubey ,Power Electronics Drives ,Wiley Eastern,1993.

6. Chilikin ,M ,Electric drives , Mir publications, 2nd edition,1976

EE6308: FACTS and Custom Power

Pre-requisite: Nil

Total hours: 42 Hrs

L	T	P	C
3	0	0	3

Module 1: (10 hours)

Power flow in Power Systems – Steady-state and dynamic problems in AC systems – Voltage regulation and reactive power flow control in Power Systems – control of dynamic power unbalances in Power System - Power flow control -Constraints of maximum transmission line loading - Benefits of FACTS Transmission line compensation- Uncompensated line -shunt compensation - Series compensation -Phase angle control.

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: (11hours)

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

1. K R Padiyar, "FACTS Controllers in Power Transmission and Distribution", New Age International Publishers, 2007

2. X P Zhang, C Rehtanz, B Pal, "Flexible AC Transmission Systems- Modelling and Control", Springer Verlag, Berlin, 2006

3. N.G. Hingorani, L. Gyugyi, "Understanding FACTS: Concepts and Technology of Flexible AC Transmission Systems", IEEE Press Book, Standard Publishers and Distributors, Delhi, 2001.

4. K.S.Sureshkumar , S.Ashok , "FACTS Controllers & Applications", E-book edition, Nalanda Digital Library, NIT Calicut,2003

5. G T Heydt , Power Quality, McGraw-Hill Professional, 2007

6. T J E Miller, Static Reactive Power Compensation, John Wiley and Sons, Newyork, 1982

EE6321: Power Semiconductor Devices and Modeling

Pre-requisite: Nil

Total hours: 42 Hrs

L	T	P	C
3	0	0	3

Module 1: (11 hours)

Power Diodes . Basic Structure and I-V Characteristics . Breakdown Voltages and Control . On State Losses . Switching Characteristics . Turn on Transient . Turn off Transient . Reverse Recovery Transient . Schottky Diodes . Snubber Requirements for Diodes and Diode Snubbers.

Thyristors - Basic Structure . V-I Characteristics . Turn on Process . On State operation . Turn off process . Switching Characteristics .Turn on Transient and di/dt limitations . Turn off Transient . Turn off time and reapplied dv/dt limitations . Ratings of Thyristors . Snubber Requirements and Snubber Design.

Triacs . Basic Structure and operation . V-I Characteristics . Ratings . Snubber Requirements.

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)

Power BJTs . Basic Structure and I-V Characteristics . Breakdown Voltages and Control . Second Breakdown and its Control- FBSOA and RBSOA Curves - On State Losses . Switching Characteristics . Resistive Switching Specifications . Clamped Inductive Switching Specifications . Turn on Transient . Turn off Transient . Storage Time .Base Drive Requirements . Switching Losses . Device Protection-Snubber Requirements for BJTs and Snubber Design - Switching Aids.

Power MOSFETs - Basic Structure . V-I Characteristics . Turn on Process . On State operation . Turn off process . Switching Characteristics . Resistive Switching Specifications . Clamped Inductive Switching Specifications - Turn on Transient and di/dt limitations . Turn off Transient . Turn off time . Switching Losses . Effect of Reverse Recovery Transients on Switching Stresses and Losses - dv/dt limitations . Gating Requirements . Gate Charge - Ratings of MOSFETs. FBSOA and RBSOA Curves . Device Protection -Snubber Requirements .

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: (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

1. Ned Mohan et.al ,"Power Electronics",John Wiley and Sons,2006

2. G. Massobrio, P. Antognet," Semiconductor Device Modeling with Spice", McGraw-Hill, Inc.,1988.

3. B. J. Baliga," Power Semiconductor Devices",Thomson, 2004.

4. V. Benda, J. Gowar, D. A. Grant," Power Semiconductor Devices. Theory and Applications", John Wiley & Sons1994.99

EE6322: Static Var Controllers & Harmonic Filtering

Pre-requisite: Nil

Total hours: 42 Hrs

L	T	P	C
3	0	0	3

Module1: (10 hours)

Fundamentals of Load Compensation , Steady-State Reactive Power Control in Electric Transmission Systems , Reactive Power Compensation and Dynamic Performance of Transmission Systems .

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)

Converters for Static Compensation . Single Phase and Three Phase Converters and Standard Modulation Strategies (Programmed Harmonic Elimination and SPWM) . GTO Inverters . Multi-Pulse Converters and Interface Magnetics . Multi-Level Inverters of Diode Clamped Type and Flying Capacitor Type and suitable modulation strategies (includes SVM) . Multi-level inverters of Cascade Type and their modulation . Current Control of Inverters.

Module 4: (11 hours)

Passive Harmonic Filtering . Single Phase Shunt Current Injection Type Filter and its Control, Three Phase Three-wire Shunt Active Filtering and their control using p-q theory and d-q modelling . Three-phase four-wire shunt active filters . Hybrid Filtering using Shunt Active Filters . Series Active Filtering in Harmonic Cancellation Mode . Series Active Filtering in Harmonic Isolation Mode . Dynamic Voltage Restorer and its control . Power Quality Conditioner

References

1. T.J.E Miller Reactive Power Control in Electric Systems John Wiley & Sons,1982.

2. N.G. Hingorani & L. Gyugyi Understanding FACTS: Concepts and Technology of Flexible AC Transmission Systems. IEEE Press, 2000.

3. Ned Mohan et.al Power Electronics. John Wiley and Sons 2006

EE6327: Linear and Digital Electronics

Pre-requisite: Nil

Total hours: 42 Hrs

L	T	P	C
3	0	0	3

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)

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 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 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 – Set up time - Hold time – Clock skew.

Asynchronous sequential logic: Analysis and Design – Race conditions and Cycles – Hazards in combinational circuits – Hazard free realization.

References

1. Sedra & Smith: Microelectronic Circuits, Oxford University Press, 2004

2. Millman J.: Microelectronics, McGraw Hill,1999

3. Anvekar D.K. & Sonde B.S: Electronic Data Converters, Tata McGraw Hill,1994

4. Gayakwad R.A: OPAMPS & Linear Integrated Circuits, Prentice Hall of India,2002

5. Clayton G.B: Operational Amplifiers, ELBS,2002

6. Frederiksen T.M: Intuitive Operational Amplifiers, McGraw Hill,1988

7. Roth C.H., Fundamentals of Logic Design, Jaico Publishers. IV Ed, 2003

8. W. I. Fletcher, An Engineering Approach to Digital Design, Prentice-Hall, Inc., Englewood Cliffs, NJ, 1980

9. Tocci, R. J. and Widner, N. S., Digital Systems - Principles and Applications, Prentice Hall, 7th Ed, 2001

Course Outcomes:

EE6401 Energy Auditing and Management	**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 eddy current 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.

EE6402 Process Control and Automation	**CO1:** Learn and familiarize with the technologies which typically exist in an industrial facility. **CO2:** Acquire knowledge about process modelling, process dynamics and process instrumentation. **CO3:** Acquire knowledge about transfer function, state space models, time series models and development of empirical models from process data. **CO4:** Acquire knowledge about various control strategies – feedback, feed forward, cascade, ratio control, state feedback, LQR problem, pole placement and preparation of P & I diagrams. **CO5:** Acquire knowledge about PID design, tuning and trouble shooting. **CO6:** Acquire knowledge about process control of MIMO systems, control loop interactions, singular value analysis, decoupling control and real time optimization. **CO7:** Acquire knowledge about advanced control strategies – Model predictive control, Adaptive control, Inferential Control and Batch process control. **CO8:** Acquire knowledge about plant wide control design, instrumentation for process monitoring and statistical process control. **CO9:** Acquire knowledge about fuzzy logic in process control, comparison of various types of control with examples on software.

EE6403 Computer Controlled Systems	**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.

EE6404 Industrial Load Modelling and Control	**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.

EE6421 Advanced Microcontroller Based Systems	**CO1:** To familiarize the fundamental concepts of computer organization and its architecture. **CO2:** To expose the students to the fundamentals of micro-controllers viz.68HC11, 8051 and 8096. **CO3:** To impart knowledge on PIC micro-controller and to introduce FPGA. **CO4**: To develop skill in simple applications development with programming 8051 and PIC. **CO5:** To introduce the concept of Programmable Logic Controller and its features.

E6422 Engineering Optimization	**CO1:** The course will concentrate on the mathematical and numerical techniques of optimization as applied to engineering problems and to apply the mathematical results and numerical techniques of optimization theory to concrete Engineering problems. **CO2:** Provide the students with a strong background in optimization which can be complemented by more specialized courses in Mathematics and make them capable of creating, solving and analysing the case studies. **CO3:** Introduce the concepts of Linear Program modelling, explore the mathematical properties of general linear programming problems and obtaining the solution linear programming problems using the appropriate techniques **CO4:** Formulation real-world problems as Linear Programming models, the theory and applications of the simplex method and its extensions such as the revised simplex and dual simplex algorithms in solving the standard LP problem and the related dual problem, and interpretation of the results obtained. **CO5:** Application of linear programming in engineering applications minimum cost flow problem, network problems-transportation, assignment & allocation, scheduling etc. **CO6:** Introduction to nonlinear programming and modelling techniques as well as solution algorithms and to find the best possible solution in nonlinear decision models. **CO7:** Brief review of the most important model types and solution approaches followed by a more detailed discussion of deterministic optimization algorithms. **CO8:** Solution of nonlinear programming using basic decent methods such as Fibonacci & Golden section search, gradient methods, Newton Method, Lagrange multiplier method, Quasi-Newton method, separable convex programming Frank and Wolfe method and its engineering Applications. **CO9:** Derivation and uses of the Kuhn-Tucker first order necessary conditions for optimality, second order optimality conditions, saddle points, and the Lagrangian dual problem, basic theorems on convex functions, sets, and problems. **CO10:** Solving complex problems by breaking them down into simpler sub-problems using dynamic programming and study the theory and practice of dynamic programming with special emphasis in problem formulation and computational efficiency. **CO11:** Familiarization of different tools and Software packages for the solution of engineering problems

EE6423 Industrial Communication	**CO1:** To develop a comprehensive understanding of the industrial data communication systems. **CO2:** To educate on the basic concepts of inter-networking and serial communications. **CO3:** To provide a fundamental understanding of common principles, various standards and protocol stack in networking **CO4:** To introduce industrial Ethernet and wireless communication. **CO5:** To familiarize the SCADA communication network and other open standard communication Protocols.

EE6424 Robotic Systems and Applications	**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.

EE6426 Distribution System Management and Automation	**CO1:** Study the architecture and implementation strategies for distribution automation. **CO2:** Understand the functions of basic distribution management system. **CO3:** Analysis of performance and reliability of distribution systems. **CO4:** Study of electrical design aspects of industrial and commercial buildings. **CO5:** Learn about the IS codes for electrical safety and earthing practices. **CO6:** Learn the different communication systems and protocols in distributed systems. **CO7:** Study the concept of power quality and custom power.

EE6428 SCADA Systems And Applications	**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

EE6204 Digital Protection of Power Systems	**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.

EE6494 Seminar	**CO1:** The candidate/student must be able to refer, prepare and present a seminar, to improve his/her presentation skills. **CO2:** The candidate/student must be familiar with the various research areas in Electrical Engineering.

EE 7491 Major Project I & EE 7492 Major Project II	**CO1:** The candidate/student must be able to identify a problem in a given research area. **CO2:** The student must be able to make use of the technical knowledge gained from previous courses, in design of a system. **CO3:** The student must be able to apply project management skills (scheduling work, procuring parts, and documenting expenditures and working within the confines of a deadline). **CO4:** The candidate must acquire System integration skills, Documentation skills, Project management skills, Problem solving skills. **CO5:** The candidate must acquire skills to design, implement, test & troubleshoot Electrical, Electronic & Automation systems. **CO6:** The candidate must develop presentation skills & professionalism. **CO7:** The student must be able to understand industrial problems and suggest possible solutions.

EE 7493 Industrial Training	**CO1:** The candidate must become familiar with the dynamic environment in an industry/project site. **CO2:** The candidate must become familiar with the different processes in Industry. **CO3:** The candidate must become familiar with the management & administrative, non-technical operations/divisions in an industry. **CO4:** The student must be able to identify issues/problems in the industry and suggest improvements/solutions. **CO5:** The student must familiarize himself/herself with the etiquette/mannerism/self-discipline followed by professionals. **CO6:** The candidate must familiarize with the people management skills, of supervisory/managers, in the industry.

EE 6492 Mini Project	**CO1:** The student must be able to identify Industrial applications of different electrical & electronic systems, learnt in previous courses. **CO2:** The student must be able to design & simulate systems. **CO3:** The student must be able to implement successfully & test systems, within a specific time frame. **CO4:** The student must be able to prepare documents using proper documentation tools.

EE6001 Electrical Energy Systems & Management	**CO1:** The student should have knowledge of methodologies followed in energy auditing. **CO2:** The student should be able to conduct a performance evaluation of Industrial boilers, furnaces etc. by direct and indirect methods. **CO3:** The student should be capable of designing and performance analysis of heat exchangers and evaporators. **CO4:** The student should be familiar with the different types of solid, liquid and gaseous fuels, with applications, properties & limitations. **CO5:** The student should be familiar with the different alternate energy sources, the demand for energy worldwide and available resources to meet the demand. **CO6:** The student should be familiar the different energy conversion technologies. **CO7:** The student must be familiar with the methods for effective utilization of available renewable energy resources. **CO8:** The candidate should have and understanding of the different co-generation schemes in the industry and the waste heat recovery mechanisms. **CO9:** The candidate should must be familiar with electric motors, their applications & performance evaluation methods. **CO10:** The student must be familiar with terms like power factor, load sharing, load profiling, capacitor sizing, capacitor losses etc. **CO11:** The student must be familiar with the energy consumption patterns for electromechanical systems like refrigeration, compressors , air conditioning equipment, electrolytic processes, terms like power factor, load sharing, load profiling, capacitor sizing, capacitor losses etc.

EE6491 Industrial Power and Automation Laboratory	**CO1:** Familiarize with different industrial power and automation equipment and acquire hands on experience on them through various experiments. **CO2:** Acquire knowledge about the working of SCADA system and conduct various experiments on transmission and distribution module to learn the basic operations of SCADA. **CO3:** Control of batch process reactor, AC servo motor speed, lift plant model and material handling system using programmable logic controller. **CO4:** Comparison of performance of centrifugal pump by throttling and variable frequency drive. **CO5:** Control of pneumatic stamping system and conveyor sorting system with colour sensing fibre unit using programmable logic controller. **CO6:** Reactive power compensation of a transmission line using STATCOM and voltage compensation using SSSC in solar panel and wind generator based FACTS setup. **CO7:** Speed Control of AC, DC and BLDC Motors using digital signal processor. **CO8:** Generation of PWM signal and saw-tooth signal using 80196 microcontroller and stepper motor speed control using 8051. **CO9:** Use of LabVIEW to simulate the response of a DC motor based on the mathematical model derived from the physical model of the system **CO10:** Perform the traction test on linear induction motor and speed control of eddy current drives. **CO11:** Develop a real time program in LabVIEW and run it on real time hardware target using compact field point. **CO12:** Familiarization of master & slave DCS controllers, feed- forward controller, split – range controller, cascade controller and multiple input multiple output system.