Department of Electrical Engineering

Curriculum for M Tech in Power Systems (EED)

Semester 1

Sl. No	Code	Title	L	T	P/S	C
1	MA6003	Mathematical Methods for Power Engineering	3	0	-	3
2	EE6201	Computer Methods in Power Systems	3	0	-	3
3	EE6301	Power Electronics Circuits	3	0	-	3
4		Elective -1	3	0	-	3
5		Elective -2	3	0	-	3
6		Elective –3	3	0	-	3
7	EE6291	Power Systems Lab	-	-	3	2
Total credits			**18**	**0**	**3**	**20**

Semester 2

Sl. No	Code	Title	L	T	P/S	C
1	EE6202	Power System Dynamics and Control	3	0	-	3
2	EE6204	Digital Protection of Power systems	3	0	-	3
3	EE6308	FACTS and Custom Power	3	0	-	3
4	EE6426	Distribution Systems Management & Automation	3	0	-	3
5		Elective -1	3	0	-	3
6		Elective –2	3	0	-	3
7	EE6294	Seminar	-	-	3	1
8	EE6292	Mini Project	-	-	3	1
Total credits			**18**	**0**	**3**	**20**

Semester 3

Sl. No	Code	Title	L	T	P/S	C
1	EE7291	Main Project -1	0	0	16	8
Total credits			**0**	**0**	**16**	**8**

Semester 4

Sl. No	Code	Title	L	T	P/S	C
1	EE7292	Main Project -2	0	0	24	12
Total credits			**0**	**0**	**24**	**12**

LIST OF ELECTIVES

Sl. No	Code	Title	Credits
1	EE6221	Distributed Generation	3
2	EE6222	Power Quality	3
3	EE6223	High Voltage Engineering I	3
4	EE6224	High Voltage Engineering II	3
5	EE6101	Dynamics of Linear Systems	3
6	EE6102	Optimal and Adaptive Control	3
7	EE6103	Applied Instrumentation	3
8	EE6122	Biomedical Instrumentation	3
9	EE6129	Artificial Neural Networks and Fuzzy Systems	3
10	EE6302	Advanced Power Electronic Circuits	3
11	EE6303	Dynamics of Electrical Machines	3
12	EE6304	Advanced Digital Signal Processing	3
13	EE6306	Power Electronic Drives	3
14	EE6321	Power Semiconductor Devices and Modelling	3
15	EE6322	Static VAR Controllers and Harmonic Filtering	3
16	EE6323	Digital Simulation of Power Electronic Systems	3
17	EE6401	Energy Auditing & Management	3
18	EE6402	Process Control & Automation	3
19	EE6404	Industrial Load Modelling & Control	3
20	EE6406	Industrial Instrumentation	3
21	EE6421	Advanced Microcontroller Based Systems	3
22	EE6422	Engineering Optimization	3
23	EE6423	Industrial Communication	3
24	EE6428	SCADA Systems & Applications	3
25	EE6503	Power System Transients	3

****Any other subject offered in the Institute with approval from the Programme Coordinator

Department of Electrical Engineering

Curriculum for M Tech in Power Systems

Brief & detailed Syllabus

MA6003: Mathematical Methods for Power Engineering

Pre-requisite: Nil

L	T	P	C
3	0	0	3

Total hours: 42 Hrs.

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

EE6201: Computer Methods in Power Systems

Pre-requisite: Nil

L	T	P	C
3	0	0	3

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

EE6202: Power System Dynamics and Control

Pre-requisite: Nil

L	T	P	C
3	0	0	3

Total hours: 42 Hrs.

AGC, AVR, AGC in Deregulated systems-Transient Stability Problem-System Modelling, SI Approach for large multi-machine power systems- Transient stability enhancement methods- Power System Model For Low Frequency Oscillation Studies- Eigen value analysis- PSS models- SSR-countermeasures-benchmarkmodels- Voltage Stability Problem- System Modelling -Static and Dynamic Analysis-Voltage Collapse Proximity Indices. Voltage Stability Improvement Methods

EE6204: Digital Protection of Power Systems

Pre-requisite: Nil

L	T	P	C
3	0	0	3

Total hours: 42 Hrs.

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

EE6221: Distributed Generation

Pre-requisite: Nil

L	T	P	C
3	0	0	3

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

Pre-requisite: Nil

L	T	P	C
3	0	0	3

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

EE6223: High Voltage Engineering I

Pre-requisite: Nil

L	T	P	C
3	0	0	3

Total hours: 42 Hrs.

Brief Syllabus: Generation of High voltages. AC voltages. DC voltages. Generation of Impulse voltages and currents. Measurement of high voltages and currents-DC, AC and impulse voltages and currents-DSO.factors affecting measurements. Hall effect generators. Digital techniques in HV measurements, Measurement of electric field. Sources of EMI, Principles of EMC. Introduction to relevant national and international standards, Layout and clearances as well as shielding and grounding of HV lab, Safety regulations for high voltage tests, Calibration of HV measuring instruments.

EE6224: High Voltage Engineering II

Pre-requisite: EE6223: High Voltage Engineering I

L	T	P	C
3	0	0	3

Total hours: 42 Hrs.

Insulation materials and systems. Outdoor insulation. Semi conducting ceramic glazes AC and impulse voltage flashover studies on a string of insulators, RIV and corona studies on insulator strings. High voltage testing - High current testing, Composite stress testing, Breakdown in gas and gas mixtures. Breakdown in liquid dielectrics. Breakdown in solid dielectrics. Dielectric Formalism, Equivalent circuits. Phenomenological theory of ageing. Statistical models for Insulation failure. Need for diagnostics and condition monitoring. Newer methods of fault identification and diagnostics. insulation degradation.

EE6291: Power Systems Lab

Pre-requisite: Nil

L	T	P	C
0	0	3	2

Total hours: 42 Hrs.

Formation of incidence matrices and bus admittance matrix of a power network using MATLAB, Power flow analysis of standard test systems using ETAP/Power world Simulator/Mipower/MATLAB packages, Short-circuit analysis of standard test systems using ETap/Power world Simulator/Mipower/MATLAB packages, Transient stability analysis of standard test systems using ETap/Power world Simulator/Mipower/MATLAB packages, Performance analysis of a three-phase synchronous machine in the isolated and grid connected modes of operation, SCADA Transmission Module Experiments in Remote/Local Modes, SCADA Transmission Module Experiments in Remote/Local Modes

EE6101: Dynamics of Linear Systems

Pre-requisite: Nil

L	T	P	C
3	0	0	3

Total hours: 42 Hrs.

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 - stabilisation 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

L	T	P	C
3	0	0	3

Total hours: 42 Hrs.

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

EE6103: Applied Instrumentation

L	T	P	C
3	0	0	3

Pre-requisite: Nil

Total hours: 42 Hrs.

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

EE6122: Biomedical Instrumentation

Pre-requisite: Nil

L	T	P	C
3	0	0	3

Total hours: 42 Hrs.

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

EE6129: Artificial Neural Networks and Fuzzy Systems

Pre-requisite: Nil

L	T	P	C
3	0	0	3

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.

EE6301: Power Electronic Circuits

L	T	P	C
3	0	0	3

Pre-requisite: Nil

Total hours: 42 Hrs.

D.C.chopper circuits, Line Frequency Diode Rectifiers Three Phase half wave rectifier with resistive load . Three phase full wave rectifier . Line Frequency Phase-Controlled Rectifiers and Inverters .Single Phase Input Line Current Harmonics and Power Factor- Inverter Mode of Operation - Three Phase . Half Wave Controlled rectifier with RL Load . Half Controlled Bridge with RL Load . Fully Controlled Bridge with RL Load . Input Side Current Harmonics and Power Factor - Dual Converters Switch-Mode dc-ac 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

L	T	P	C
3	0	0	3

Pre-requisite: Nil

Total hours: 42 Hrs.

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

L	T	P	C
3	0	0	3

Pre-requisite: Nil

Total hours: 42 Hrs.

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

L	T	P	C
3	0	0	3

Pre-requisite: Nil

Total hours: 42 Hrs

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

Pre-requisite: Nil

L	T	P	C
3	0	0	3

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

Pre-requisite: Nil

L	T	P	C
3	0	0	3

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

EE6323: Digital Simulation of Power Electronic Systems

Pre-requisite: Nil

L	T	P	C
3	0	0	3

Total hours: 42 Hrs

Principles of Modeling Power Semiconductor Devices - Macromodels versus Micromodels - Modelling of Control Circuits for Power Electronic Switches. Computer - Review of Graph Theory as applied to Electrical Networks - Circuit Analysis Software MicroSim PSpice A/D - Statistical Analyses - Simulation Examples of Power Electronic systems.-MicroSim PSpice A/D - MATLAB SIMULINK in Power system.-Design Creation and Simulation with SaberDesigner - Analysing waveforms with SaberScope

EE6401: Energy Auditing & Management

Pre-requisite: Nil

L	T	P	C
3	0	0	3

Total hours: 42 Hrs

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

EE6402: Process Control & Automation

Pre-requisite: Nil

L	T	P	C
3	0	0	3

Total hours: 42 Hrs

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

EE6404: Industrial Load Modelling & Control

Pre-requisite: Nil

L	T	P	C
3	0	0	3

Total hours: 42 Hrs

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

EE6406: Industrial Instrumentation

Pre-requisite: Nil

L	T	P	C
3	0	0	3

Total hours: 42 Hrs

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

EE6421: Advanced Microcontroller Based Systems

Pre-requisite: Nil

L	T	P	C
3	0	0	3

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

L	T	P	C
3	0	0	3

Total hours: 42 Hrs

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

EE6423: Industrial Communication

L	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

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

L	T	P	C
3	0	0	3

Total hours: 42 Hrs

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

MA6003: Mathematical Methods for Power Engineering

Pre-requisite: Nil

L	T	P	C
3	0	0	3

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

EE6201: Computer Methods in Power Systems

Pre-requisite: Nil

L	T	P	C
3	0	0	3

Total hours: 42 Hrs.

Module 1: (11 hours)

System Graph . Loop, Cutest 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.

EE6202: Power System Dynamics and Control

Pre-requisite: Nil

L	T	P	C
3	0	0	3

Total hours: 42 Hrs.

Module 1: (11 hours)

Generation Control Loops . AVR Loop . Performance And Response . Automatic Generation Control of Single Area And Multi Area Systems . Static And Dynamic Response Of AGC Loops . Economic Dispatch And AGC, AGC in a Deregulated Environment, Recent advances in AGC

Module 2: (11 hours)

Transient Stability Problem . Modeling Of Synchronous Machine, Loads, Network, Excitation Systems, Turbine And Governing Systems, FACTS and HVDC Systems, Trapezoidal Rule Of Numerical Integration Technique For Transient Stability Analysis, Simultaneous Implicit Approach for Transient Stability Analysis of Multi-machine Systems, Data For Transient Stability Studies . Transient Stability Enhancement Methods.

Module 3: (11 hours)

Low Frequency Oscillations . Power System Model For Low Frequency Oscillation Studies, Eigen value Analysis, Improvement Of System Damping With Supplementary Excitation Control, Standard models for PSS representation- Introduction To Sub Synchronous Resonance And Countermeasures, IEEE Benchmark models for SSR studies

Module 4: (9 hours)

Voltage Stability Problem . Real And Reactive Power Flow In Long Transmission Lines . Effect Of ULTC And Load Characteristics On Voltage Stability . Voltage Stability Limit . Voltage Stability Assessment Using PV Curves . System Modelling-Static and Dynamic Analysis-Voltage Collapse Proximity Indices . Voltage Stability Improvement Methods.

References

1. P. Kundur, .Power System Stability And Control., McGraw Hill, New York, 1994.

2. A.J. Wood, B.F. Wollenberg, .Power Generation, Operation And Control., John Wiley And Sons, New York, 1984, 2nd Edition: 1996.

3.O.I. Elgard, .Electric Energy System Theory: An Introduction., II Edition, McGraw Hill, New York, 1982.

4. K.R. Padiyar, .Power System Dynamics,Stability And Control., Interline Publishing (P) Ltd., Bangalore, 1999

5. M A Pai, D P Sen Gupta, K R Padiyar, "Small Signal Analysis of Power Systems", Narosa Series in Power and Energy Systems, 2004

6. Leonard L Grigsby, "Power Systems", Electrical Power Engineering Handbook, CRC Press, New York, 2007.

7. C. Van Custem, T. Vournas, .Voltage Stability Of Electric Power Systems., Rlever Academic Press (U.K.), 1999.

8. Yao-Nan-Yu, .Electric Power System Dynamics. Academic Press, 1983

9. J. Arrilaga, C.P. Arnold, B.J. Harker, .Computer Modeling Of Electrical Power Systems., Wiley, New York, 1983.

10. I.J. Nagrath, O.P. Kothari, .Power System Engineering., Tata McGraw Hill Publishing Co. Ltd., New Delhi, 1994.

EE6204: Digital Protection of Power Systems

L	T	P	C
3	0	0	3

Pre-requisite: Nil

Total hours: 42 Hrs.

Module 1: (8 hours)

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

Module 2: (12 hours)

Basic elements of digital protection –signal conditioning- conversion subsystems- relay units-sequence networks-fault sensing data processing units- FFT and Wavelet based algorithms: least square and differential equation based algorithms-travelling wave protection schemes;

Relay Schematics and Analysis- Over Current Relay- Instantaneous/Inverse Time –IDMT Characteristics; Directional Relays; Differential Relays- Restraining Characteristics; Distance Relays: Types-Characteristics;

Module 3: (14 hours)

Protection of Power System Equipment - Generator, Transformer, Transmission Systems, Busbars, Motors; Pilotwire and Carrier Current Schemes;

System grounding –ground faults and protection; Load shedding and frequency relaying; Out of step relaying ; Re-closing and synchronizing

Module 4: (8 hours)

Integrated and multifunction protection schemes -SCADA based protection systems- FTA; Testing of Relays.

References

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

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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

L	T	P	C
3	0	0	3

Pre-requisite: Nil

Total hours: 42 Hrs.

Module 1: (10 hours)

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

Module 2: (12 hours)

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

Module 3: (10 hours)

Wind energy. characteristics-power extraction- types of wind machines .dynamics matching- performance of wind generators .wind mills -applications- economics of wind power

Module 4: (10 hours)

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

References

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

L	T	P	C
3	0	0	3

Total hours: 42 Hrs.

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

EE6223: High Voltage Engineering I

L	T	P	C
3	0	0	3

Pre-requisite: Nil

Total hours: 42 Hrs.

Module 1: (11 hours)

Generation of High voltages, AC voltages: cascade transformers-series resonance circuits DC voltages: voltage doubler-cascade circuits-electrostatic machines

Module 2: (11 hours)

Generation of Impulse voltages and currents: single stage and multistage circuits-wave shaping-tripping and control of impulse generators Generation of switching surge voltage and impulse currents

Module 3: (10 hours)

Measurement of high voltages and currents-DC,AC and impulse voltages and currents-DSO-electrostatic and peak voltmeters-sphere gaps-factors affecting measurements-potential dividers(capacitive and resistive)-series impedance ammeters-rogowski coils-hall effect generators Digital techniques in HV measurements, Measurement of electric field

Module 4: (10 hours)

Sources of EMI, Principles of EMC, Filtering, Shielding, Grounding techniques, Introduction to relevant national and international standards, Layout and clearances as well as shielding and grounding of HV lab, Safety regulations for high voltage tests, Calibration of HV measuring instruments, Traceability of HV measurements

References

1. M. S. Naidu, V. Kamaraju, "High Voltage Engineering", McGraw-Hill, 1995.

2. M. Khalifa, "High Voltage Engineering: Theory and Practice", Dekker, 1990.

3. H. M. Ryan, "High Voltage Engineering and Testing", Peter Peregrinus, 1994.

4. Kuffel and Zaengal .High Voltage Engineering.., Newnes,2000

5. Kuffel and Abdulla.M. .High Voltage Engineering, Pergamon press, 1998

6. Wadhwa C L., .High Voltage Engineering.., Wiley Eastern Limited, NewDelhi,1994

7. Relevant IS standards and IEC standards

8. Ott, H.W.,`Noise Reduction Techniques in Electronic Systems', John Wiley, New York, 1989.

EE6224: High Voltage Engineering II

Pre-requisite: EE6223: High Voltage Engineering I

L	T	P	C
3	0	0	3

Total hours: 42 Hrs.

Module 1: (11 hours)

Insulation materials and -systems: insulation systems in practice, dielectric losses, ageing and life expectancy.
Outdoor insulation: materials, ageing, diagnostic, polymeric materials (EPDM, SIR), semi conducting ceramic glazes AC and impulse voltage flashover studies on a string of insulators, RIV and corona studies on insulator strings High voltage testing - dry, wet and pollution testing, High current testing, Composite stress testing,

Module 2: (11 hours)

Breakdown in gas and gas mixtures-breakdown in uniform and non uniform fields-Paschens law-Townsends criterion-streamer mechanism-corona discharge-breakdown in electro negative gases. Breakdown in liquid dielectrics-suspended particle mechanism. Breakdown in solid dielectrics-intrinsic, streamer, thermal.

Module 3: (11 hours)

Dielectric Formalism, Equivalent circuits, intrinsic dielectric strength, mechanisms of electrical and thermal breakdown in solids, dielectric relaxation in condensed matter Phenomenological theory of ageing, mechanisms of ageing under electrical, thermal and combined stresses, Accelerated ageing tests, Statistical models for Insulation failure, Ageing data analysis, Ageing and failure due to partial discharges, Ageing in multi component insulation systems.

Module 4: (11 hours)

Need for diagnostics and condition monitoring, on-line/on-site testing, diagnostic tools. Transformer impulse test, neutral current method, digital techniques, data acquisition, principles and problems, TF and CF method, winding structure, natural frequencies, newer methods of fault identification and diagnostics PD measurement, background, analysis, calibration, digital PD measurement, PD as a diagnostic tool, PD signal, noise reduction methods, PD pattern, fault discrimination, and insulation degradation

References

1. M. S. Naidu, V. Kamaraju, "High Voltage Engineering", McGraw-Hill, 1995.

2. M. Khalifa, "High Voltage Engineering: Theory and Practice", Dekker, 1990.

3. H. M. Ryan, "High Voltage Engineering and Testing", Peter Peregrinus, 1994.

4. Kuffel and Zaengal .High Voltage Engineering.., Newnes,2000

5. Kuffel and Abdulla.M. .High Voltage Engineering, Pergamon press, 1998

6. Wadhwa C L., .High Voltage Engineering.., Wiley Eastern Limited, NewDelhi,1994

7. Relevant IS standards and IEC standards

8. Bottcher C.J.F., Theory of Electric Polarisation, Elsevier Publication, 1962,

9. Whitehead S., Dielectric Breakdown of solids, Oxford Univ. Press, Clarendon. 1953

10. Mann N.R. Scholar R.E. and Singaporewalla N.D., Methods of Statistical Analysis and Life Data, John Wiley and Sons, New York, 1974.

EE6291: Power Systems Lab

Pre-requisite: Nil

L	T	P	C
0	0	3	2

Total hours: 42 Hrs.

List of experiments

1) Formation of incidence matrices and bus admittance matrix of a power network using MATLAB
2) Power flow analysis of standard test systems using ETap/Power world Simulator/Mipower/MATLAB packages
3) Short-circuit analysis of standard test systems using ETap/Power world Simulator/Mipower/MATLAB packages
4) Transient stability analysis of standard test systems using ETap/Power world Simulator/Mipower/MATLAB packages
5) FACTS device modeling and analysis using PSCAD/EMTDC package.
6) Simulink modeling and analysis of automatic load frequency control of multi- area power systems.
7) Determination of synchronous machine reactance and time constant parameters
8) Performance characteristics of energy efficient induction motor
9) Operation and performance analysis of a three-phase induction machine as an induction generator in the grid connected and self excited modes
10) Performance analysis of a three-phase synchronous machine in the isolated and grid connected modes of operation.
11) SCADA Transmission Module Experiments in Remote/Local Modes
    i. Fault tests
    ii. Ferranti Effect
    iii. Transmission Loading (R/L/R-L loading)

iv. Transformer Loading (R/L/R-L loading)
v. VAR Compensation (SE/RE/Mid-point)
vi. OLTC Operation
vii. Sudden Load Rejection & Recovery studies

12) SCADA Transmission Module Experiments in Remote/Local Modes
i. Relay Coordination
ii. PF Control/ Voltage Regulation
iii. Transformer loading
iv. Demand Side Management

EE6101: Dynamics of Linear Systems

Pre-requisite: Nil

L	T	P	C
3	0	0	3

Total hours: 42 Hrs.

Module 1: State Space Analysis (11 hours)

State variable representations of systems- transfer function and transfer function matrix from state variable form – solutions of state equations – state transition matrix - modal decompositions - observability and controllability – minimal realizations of MIMO systems - analysis of linear time varying systems.

Module 2: Lyapunov Stability Analysis (9 hours)

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

L	T	P	C
3	0	0	3

Total hours: 42 Hrs.

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

L	T	P	C
3	0	0	3

Pre-requisite: Nil

Total hours: 42 Hrs.

Module 1: (10 hours)

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

EE6122: Biomedical Instrumentation

Pre-requisite: Nil

L	T	P	C
3	0	0	3

Total hours: 42 Hrs.

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

EE6129: Artificial Neural Networks and Fuzzy Systems

Pre-requisite: Nil

L	T	P	C
3	0	0	3

Total hours: 42 Hrs

Module 1: (10 hours)

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

Module 2: (10 hours)

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

Module 3: (10 hours)

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

Module 4: (12 hours)

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

References

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.

EE6301: Power Electronic Circuits

L	T	P	C
3	0	0	3

Pre-requisite: Nil

Total hours: 42 Hrs.

Module 1: (11 hours)

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

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

EE6302: Advanced Power Electronic Circuits

Pre-requisite: Nil

L	T	P	C
3	0	0	3

Total hours: 42 Hrs.

Module 1: (8 hours)

Special Inverter Topologies - Current Source Inverter . Ideal Single Phase CSI operation, analysis and waveforms - Analysis of Single Phase Capacitor Commutated CSI.

Series Inverters . Analysis of Series Inverters . Modified Series Inverter . Three Phase Series Inverter

Module 2: (12 hours)

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

Module 3: (10 hours)

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

L	T	P	C
3	0	0	3

Pre-requisite: Nil

Total hours: 42 Hrs.

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

L	T	P	C
3	0	0	3

Pre-requisite: Nil

Total hours: 42 Hrs

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

L	T	P	C
3	0	0	3

Total hours: 42 Hrs

Module 1: (10 hours)

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

Module 2: (11 hours)

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

L	T	P	C
3	0	0	3

Total hours: 42 Hrs

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

L	T	P	C
3	0	0	3

Total hours: 42 Hrs

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

L	T	P	C
3	0	0	3

Total hours: 42 Hrs

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

EE6323: Digital Simulation of Power Electronic Systems

L	T	P	C
3	0	0	3

Pre-requisite: Nil

Total hours: 42 Hrs

Module 1: (10 hours)

Principles of Modeling Power Semiconductor Devices - Macromodels versus Micromodels - Thyristor model - Semiconductor Device modelled as Resistance, Resistance-Inductance and Inductance-Resistance-Capacitance combination - Modelling of Electrical Machines - Modelling of Control Circuits for Power Electronic Switches. Computer Formulation of Equations for Power Electronic Systems - Review of Graph Theory as applied to Electrical Networks - Systematic method of Formulating State Equations - Computer Solution of State Equations - Explicit Integration method - Implicit Integration method.

Module 2: (10 hours)

Circuit Analysis Software MicroSim PSpice A/D - Simulation Overview - Creating and Preparing a Circuit for Simulation - Simulating a Circuit with PSpice A/D - Displaying Simulation Results - PSpice A/D Analyses - Simple Multi-run Analyses - Statistical Analyses - Simulation Examples of Power Electronic systems.

Module 3: (10 hours)

MicroSim PSpice A/D - Preparing a Schematic for Simulation - Creating Symbols - Creating - Models - Analog Behavioral Modeling - Setting Up and Running analyses - Viewing Results - Examples of Power Electronic Systems. MATLAB SIMULINK in Power system.

Module 4: (12 hours)

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

References

1. V.Rajagopalan: Computer Aided Analysis of Power Electronic Systems - Marcel Dekker, Inc,1987.

2. MicroSim PSpice A/D and Basics+: Circuit Analysis Software, User's Guide, MicroSim Corporation.

3. MicroSim Schematics: Schematic Capture Software, User's Guide, MicroSim Corporation.

4. Getting Started with SaberDesigner (Release 5.1) , An Analogy Inc.

5. Guide to Writing MAST Template (Release 5-1), Analogy Inc.

EE6401: Energy Auditing & Management

Pre-requisite: Nil

L	T	P	C
3	0	0	3

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

7. Albert Thumann , .Handbook of Energy Audits., Fairmont Pr; 5th edition (1998)

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

12. Tripathy S.C.,'Electric Energy Utilization And Conservation', Tata McGraw Hill, 1991

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

14. IEEE Bronze Book, IEEE STD 739

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

Pre-requisite: Nil

L	T	P	C
3	0	0	3

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.

4. Edgar, T.F. & D.M. Himmelblau, Optimization of Chemical Processes, McGrawHill Book Co, 1988.

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

EE6404: Industrial Load Modelling & Control

Pre-requisite: Nil

L	T	P	C
3	0	0	3

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.

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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

Pre-requisite: Nil

Total hours: 42 Hrs

Module 1: (12 hours)

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

Module 2: (8 hours)

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

Module 3: (12 hours)

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

2. 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

L	T	P	C
3	0	0	3

Total hours: 42 Hrs

Module 1: (10 Hours)

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

L	T	P	C
3	0	0	3

Total hours: 42 Hrs

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

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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

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

L	T	P	C
3	0	0	3

Total hours: 42 Hrs

Module 1: (10 hours)

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

Module 2: (11 hours)

SCADA System Components**:** Schemes- Remote Terminal Unit (RTU),Intelligent Electronic Devices (IED),Programmable Logic Controller (PLC), Communication Network, SCADA Server, SCADA/HMI Systems

Module 3: (11 hours)

SCADA Architecture**: 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