CURRICULUM AND SYLLABUS

for

M.Tech Programme

in

Industrial Power and Automation

Industrial Power Group

DEPARTMENT OF ELECTRICAL ENGINEERING

NATIONAL INSTITUTE OF TECHNOLOGY CALICUT

NIT CAMPUS PO, CALICUT KERALA, INDIA 673601

Curriculum and Syllabus for
M. Tech (Industrial Power and Automation)
Department of Electrical Engineering

DEPARTMENT OF ELECTRICAL ENGINEERING

NATIONAL INSTITUTE OF TECHNOLOGY CALICUT

VISION

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

MISSION

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

INDUSTRIAL POWER AND AUTOMATION

Electrical engineering is the largest field in the Engineering profession, approximately one thirds of the world's engineers belong to electrical engineering. The current industrial scenario for an Electrical Engineer demands to have a detailed knowledge about Modern Electric drives, Process control methodology, SCADA systems, Plant Automation, Load / Power factor controllers etc. used in industries as it is a necessity for integrating these devices and systems with Electric Power Control.

Industrial Power Group is one of the leading research group in the Department of Electrical Engineering at the National Institute of Technology Calicut. The main objective of the group is to develop new technologies in the field of Industrial Power and Automation and equip engineers with them. It is an interdisciplinary group with faculty, students, and research scholars from different departments of NIT Calicut.

Industrial power Group of NIT Calicut offers Master's course on Industrial Power and Automation (IPA), previously known as Computer Controlled Industrial Power (CCIP), which provides sufficient theoretical and field experience on the above systems to the electrical engineers. Various research and consultancy projects are also under taken by the Industrial Power group.

The post graduate program in Industrial Power and Automation admits students with B.Tech degree in Electrical Engineering, Electrical and Electronics Engineering, Electrical Instrumentation, and Applied Instrumentation with GATE qualification in either Electrical Engineering or Instrumentation Engineering. This program also admits sponsored candidate from Industries, Research Institutions and Educational Institution.

DEPARTMENT OF ELECTRICAL ENGINEERING

CURRICULUM FOR M TECH IN INDUSTRIAL POWER AND AUTOMATION

This programme is offered in four semesters. Minimum Requirements for the M Tech Degree is 60 credits.

Semester 1

S.No	Code	Title	L	T	P/S	C
1	MA6003	Mathematical Methods for Power Engineering	3	0	-	3
2	EE6401	Energy Auditing & Management	3	0	-	3
3	EE6301	Power Electronic Circuits	3	0	-	3
4	EE6403	Computer Controlled Systems	3	0	-	3
5		Elective -1	3	0	-	3
6		Elective –2	3	0	-	3
7	EE6491	Industrial Power & Automation Laboratory	-	-	3	2
Total credits			18	0	3	20

Semester 2

S.No	Code	Title	L	T	P/S	C
1	EE6402	Process Control and Automation	3	0	-	3
2	EE6404	Industrial Load Modelling & Control	3	0	-	3
3	EE6306	Power Electronic Drives	3	0	-	3
4	EE6406	Industrial Instrumentation	3	0	-	3
5	Elective -1		3	0	-	3
6	Elective -2		3	0	-	3
7	EE6492	Mini Project	-	-	3	1
8	EE6194	Seminar	-	-	3	1
Total credits			18	0	6	20

Semester 3

S.No	Code	Title	L	T	P/S	C
1	EE7491	Main Project -1	0	0	16	7
2	EE7493	Industrial Training	Minimum 20 days			1
Total credits			0	0	16	8

Semester 4

S.No	Code	Title	L	T	P/S	C
1	EE7492	Main Project -2	0	0	24	12
Total credits			0	0	24	12

Note:- EE7493 Industrial Training shall be completed during summer vacation and will be credited in 3rd semester along with major project -1.

LIST OF ELECTIVES

S.NO	TITLE	CREDIT
1	EE6421 Advanced Microcontroller Based Systems	3
2	EE6422 Engineering Optimization	3
3	EE6423 Industrial Communication	3
4	EE6424 Robotic Systems and Applications	3
5	EE6426 Distribution Systems Management and Automation	3
6	EE6428 SCADA Systems & Applications	3
7	EE6101 Dynamics of Linear Systems	3
8	EE6102 Optimal and Adaptive Control	3
9	EE6103 Applied Instrumentation	3
10	EE6104 Advanced Instrumentation	3
11	EE6121 Data Acquisition and Signal Conditioning	3
12	EE6122 Biomedical Instrumentation	3
13	EE6123 Performance Modelling of Systems I	3
14	EE6124 Performance Modelling of Systems -II	3
15	EE6125 Digital Control Systems	3
16	EE6129 Artificial Neural Network and Fuzzy Systems	3
17	EE6201 Computer Methods in Power Systems	3
18	EE6204 Digital Protection of Power Systems	3
19	EE6221 Distributed Generation	3
20	EE6222 Power Quality	3
21	EE6302 Advanced Power Electronics Circuits	3
22	EE6303 Dynamics of Electrical Machines	3
23	EE6304 Advanced Digital Signal Processing	3
24	EE6308 FACTS and Custom Power	3
25	EE6321Power Semiconductor Devices & Modeling	3
26	EE6322 Static VAR Controllers and Harmonic Filtering	3
27	EE6327 Linear and Digital Electronics	3
28	ME6412 Design and analysis of energy systems	3
29	ME6421 Direct Energy Conversion Systems	3
30	ME6423 Energy Policies for Sustainable Development	3
31	ME6427 Energy Efficient Buildings	3
32	ME6428 Integrated Energy Systems	3
33	ME6311 Industrial Automation and Robotics	3
34	MA7165 Statistical Digital Signal Processing	3
35	MA7169 Applied Fuzzy Logic and Fuzzy sets	3
36	MA8163 Advanced Operations Research	3
37	MA 8167 Design Of Experiments	3
38	MA 7160 Simulation And Modelling	3
39	MA 7166 Statistical Methods For Quality Management	3
40	MA8154 Wavelets Theory	3
41	EC6421 Image & Video Processing	3

Note: (1)Electives: Any other approved course of NITC senate offered in the Institute can also be credited with the approval from the Programme Coordinator.
(2) List of Electives offered in each semester will be announced by the Dept.

Programme Educational Objectives of
M. Tech (Industrial Power and Automation)

Department Mission	PEO1	PEO2	PEO3	PEO4
To offer high quality programs in the field of electrical engineering, to train students to be successful both in professional career as well as higher studies and to promote excellence in teaching, research, collaborative activities and contributions to the society	To prepare post graduate students to excel in technical profession, industry and/or higher education by providing a strong foundation.	To transform engineering students to expert engineers and managers so that they could comprehend, analyze, design and create novel products and solutions to Engineering problems that are technically sound, economically feasible and socially acceptable.	To train students to exhibit professionalism, keep up ethics in their profession and relate engineering issues to a broader social context.	To develop communication skills and team work and to nurture multidisciplinary approach in problem solving.
Quality Education	✓	✓		
Professional Career	✓	✓	✓	✓
Higher Education	✓			✓
Research	✓	✓		✓
Social Responsibility		✓	✓	✓

Programme Outcomes of M. Tech (Industrial Power and Automation)

PO	IPA	Graduate Attributes of NBA
PO1	Acquire technical competence, comprehensive knowledge and understanding the methodologies and technologies of industrial / process automation, principles and practices of energy management.	Scholarship of Knowledge
PO2	Ability to apply the knowledge of mathematics, science, engineering and technology. Understand in detail, analyse, formulate and solve the issues pertaining to the application of automation technologies in a range of industrial settings.	Critical Thinking
PO3	Acquiring the ability to identify, investigate, understand and analyse complex problems pertaining to power management and automation in industries and identify effective solution strategies for implementation.	Problem Solving
PO4	Inculcate the role of research in developing and maintaining knowledge of the state-of-the-art in various technologies and automation in industries. Acquire the skill to design, develop and modify systems in hardware and software platforms to meet desired needs within realistic constraints.	Research Skill
PO5	Create, select and apply appropriate techniques, resources, modern engineering and IT tools to complex engineering activities in the field of automation, control and energy management.	Usage of modern
PO6	Acquire the capacity to understand and summarize complex information pertaining to various fields of engineering in industries. Function effectively as an individual, and as a member or leader in a team.	Collaborative and Multidisciplinary work
PO7	Acquire the skill to develop specifications, implement and critically assess projects and their outcomes. Demonstrate management, leadership and entrepreneurial skills, and apply these to one's own work, as a member and a leader in a team to manage projects in multidisciplinary environments	Project Management and Finance
PO8	Ability to communicate effectively in both oral and written contexts in the form of technical papers, project reports, design documents and seminar presentations.	Communication
PO9	Recognize the need for, and acquire the ability to engage in self-improvement through continuous professional development and life-long learning to maintain an up-to-date knowledge of contemporary issues in various fields of engineering.	Life-long Learning
PO10	Apply and commit to professional ethics and responsibilities of engineering practice. Understand the importance of sustainability and cost effectiveness in design and development of engineering solutions for industries and their impacts in societal and environmental context. Demonstrate awareness of societal, safety, health, legal and cultural issues relevant to professional engineering practice.	Ethical Practices and Social Responsibility
PO11	Impart an eagerness to conduct investigation and research on chosen field of study and thus keep moving towards being adaptive, self-reliant and self-evaluative.	Independent and Reflective Learning

DEPARTMENT OF ELECTRICAL ENGINEERING
M TECH IN INDUSTRIAL POWER AND AUTOMATION
BRIEF SYLLABUS

MA6003: MATHEMATICAL METHODS FOR POWER ENGINEERING

REQUIRED COURSE

L	T	P	C
3	0	0	3

Pre-requisite: Nil

Total hours: 42 Hrs

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

EE6401: ENERGY AUDITING & MANAGEMENT

REQUIRED COURSE

Pre-requisite: Nil

Total hours: 42 Hrs

L	T	P	C
3	0	0	3

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

EE6301: POWER ELECTRONIC CIRCUITS

REQUIRED COURSE

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

EE6403: COMPUTER CONTROLLED SYSTEMS

REQUIRED COURSE

Pre-requisite: Nil

Total hours: 42 Hrs

L	T	P	C
3	0	0	3

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

EE6491: INDUSTRIAL POWER & AUTOMATION LABORATORY

REQUIRED COURSE

Pre-requisite: Nil

Total hours: 42 Hrs

L	T	P	C
0	0	3	2

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

EE6402: PROCESS CONTROL & AUTOMATION

REQUIRED COURSE

Pre-requisite: EE6403 Computer Controlled Systems

Total hours: 42 Hrs

L	T	P	C
3	0	0	3

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

EE6404: INDUSTRIAL LOAD MODELLING & CONTROL

REQUIRED COURSE

L	T	P	C
3	0	0	3

Pre-requisite: MA6003 Mathematical methods for power engineering

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

REQUIRED COURSE

L	T	P	C
3	0	0	3

Pre-requisite: Nil

Total hours: 42 Hrs

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

EE6306: POWER ELECTRONIC DRIVES

REQUIRED COURSE

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.

EE6421: ADVANCED MICROCONTROLLER BASED SYSTEMS

ELECTIVE COURSE

L	T	P	C
3	0	0	3

Pre-requisite: Nil

Total hours: 42 Hrs

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

EE6422: ENGINEERING OPTIMIZATION

ELECTIVE COURSE

Pre-requisite: Nil

Total hours: 42 Hrs

L	T	P	C
3	0	0	3

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

EE6423: INDUSTRIAL COMMUNICATION

ELECTIVE COURSE

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.

EE6424: ROBOTIC SYSTEMS AND APPLICATIONS

ELECTIVE COURSE

L	T	P	C
3	0	0	3

Pre-requisite: Nil

Total hours: 42 Hrs

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

EE6426: DISTRIBUTION SYSTEMS MANAGEMENT AND AUTOMATION

ELECTIVE COURSE

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

ELECTIVE COURSE

L	T	P	C
3	0	0	3

Pre-requisite: Nil

Total hours: 42 Hrs

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

EE6101: DYNAMICS OF LINEAR SYSTEMS

ELECTIVE COURSE

Pre-requisite: Nil

Total hours: 42 Hrs

L	T	P	C
3	0	0	3

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

EE6102: OPTIMAL AND ADAPTIVE CONTROL

ELECTIVE COURSE

L	T	P	C
3	0	0	3

Pre-requisite: Nil

Total hours: 42 Hrs

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

EE6103: APPLIED INSTRUMENTATION

ELECTIVE COURSE

Pre-requisite: Nil

Total hours: 42 Hrs

L	T	P	C
3	0	0	3

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

EE6104: ADVANCED INSTRUMENTATION

ELECTIVE COURSE

Pre-requisite: Nil

Total hours: 42 Hrs

L	T	P	C
3	0	0	3

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

EE6121: DATA ACQUISITION & SIGNAL CONDITIONING

ELECTIVE COURSE

Pre-requisite: Nil

Total hours: 42 Hrs

L	T	P	C
3	0	0	3

Data Acquisition Systems(DAS) - Objectives - General configurations - Transducers - Signal Conditioning - Instrumentation amplifiers - Noise Reduction Techniques in Signal Conditioning- Transmitters -Piezoelectric Couplers- Nyquist's Sampling Theorem-classification and types of filters - Design of Filters- Butterworth Approximation-Narrow Bandpass and Notch Filters and their application in DAS-Analog-to-Digital Converters(ADC)-Multiplexers and demultiplexers -Digital-to-Analog Conversion(DAC)- Data transmission systems- Modulation techniques and systems-Telemetry systems- Study of a representative DAS Board-Interfacing issues with DAS Boards- Software Drivers, Virtual Instruments, Modular Programming Techniques-Bus standard for communication between instruments - Software Design Strategies for DAS.

EE6122: BIOMEDICAL INSTRUMENTATION

ELECTIVE COURSE

Pre-requisite: Nil

Total hours: 42 Hrs

L	T	P	C
3	0	0	3

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

EE6123: PERFORMANCE MODELLING OF SYSTEMS – I
ELECTIVE COURSE

Pre-requisite: Nil
Total hours: 42 Hrs

L	T	P	C
3	0	0	3

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

EE6124: PERFORMANCE MODELLING OF SYSTEMS – II
ELECTIVE COURSE

L	T	P	C
3	0	0	3

Pre-requisite: Nil
Total hours: 42 Hrs

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

EE6125: DIGITAL CONTROL SYSTEMS
ELECTIVE COURSE

L	T	P	C
3	0	0	3

Pre-requisite: Nil
Total hours: 42 Hrs

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

EE6129: ARTIFICIAL NEURAL NETWORKS AND FUZZY SYSTEMS

ELECTIVE COURSE

L	T	P	C
3	0	0	3

Pre-requisite: Nil

Total hours: 42 Hrs

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

EE6201: COMPUTER METHODS IN POWER SYSTEMS

ELECTIVE COURSE

L	T	P	C
3	0	0	3

Pre-requisite: Nil

Total hours: 42 Hrs

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

EE6204: DIGITAL PROTECTION OF POWER SYSTEMS

ELECTIVE COURSE

L	T	P	C
3	0	0	3

Pre-requisite: Nil

Total hours: 42 Hrs

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

EE6221: DISTRIBUTED GENERATION

ELECTIVE COURSE

L	T	P	C
3	0	0	3

Pre-requisite: Nil

Total hours: 42 Hrs

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

EE6222: POWER QUALITY

ELECTIVE COURSE

L	T	P	C
3	0	0	3

Pre-requisite: Nil

Total hours: 42 Hrs

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

EE6302: ADVANCED POWER ELECTRONIC CIRCUITS

ELECTIVE COURSE

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

ELECTIVE COURSE

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

ELECTIVE COURSE

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.

EE6308: FACTS AND CUSTOM POWER

ELECTIVE COURSE

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

ELECTIVE COURSE

L	T	P	C
3	0	0	3

Pre-requisite: Nil

Total hours: 42 Hrs

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

EE6322: STATIC VAR CONTROLLERS & HARMONIC FILTERING

ELECTIVE COURSE

L	T	P	C
3	0	0	3

Pre-requisite: Nil

Total hours: 42 Hrs

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

EE6327: LINEAR AND DIGITAL ELECTRONICS

ELECTIVE COURSE

Pre-requisite: Nil

Total hours: 42 Hrs

L	T	P	C
3	0	0	3

BJT and MOSFET Differential amplifiers and their analysis, Properties of ideal Opamps, Dominant pole compensation – internal and external compensation. The IOA model of an Opamp, analysis and design of standard linear applications of Opamps Sinusoidal oscillators using Opamps Active filtering – Butterworth low pass filter functions -– Sallen and Key second order LP section Butterworth high pass filters –- multiple feedback single OPAMP LPF, HPF and BPF – State variable active filter, Regenerative Comparators, Monostable and Astable using Opamps, PLL and applications.
Time division multipliers - Analog switches - sample and hold amplifier – D/A conversion - successive approximation ADC - Basic digital circuits: Arithmetic Circuits, multiplexers and demultiplexers, decoders and encoders. Combinational circuit design using Multiplexer, ROM, PAL, PLA.

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

ME6412 DESIGN AND ANALYSIS OF ENERGY SYSTEMS

ELECTIVE COURSE

Pre-requisite: Nil

Total hours: 42 Hrs

L	T	P	C
3	0	0	3

Engineering design fundamentals. Workable and optimum systems. Economic evaluation. Heat exchanger design and optimization. Pressure drop and pumping power. Pump characteristics. Pump system operation. Fans and nozzles. Modeling and simulation principles. Modeling of thermodynamic properties. Dynamic behavior of thermal systems. Introduction to knowledge based system design.

ME6421 DIRECT ENERGY CONVERSION

ELECTIVE COURSE

Pre-requisite: Nil

Total hours: 42 Hrs

L	T	P	C
3	0	0	3

Basic science of energy conversion. Thermodynamic considerations. Photovoltaic conversion. Types, construction and operating characteristics of solar cells. Typical layouts for solar cell and current developments. Thermoelectric and thermionic converters. MHD. Electrochemical conversion. Fuel cell types and design. Wind energy conversion systems. OTEC. Wave and tidal energy conversion.

ME6423 ENERGY POLICIES FOR SUSTAINABLE DEVELOPMENT

ELECTIVE COURSE

Pre-requisite: Nil

Total hours: 42 Hrs

L	T	P	C
3	0	0	3

Energy policies of India. Energy paradigms. Energy policies and development. Critical analysis. Influence of energy use on environment. Indian environmental degradation. Energy conservation schemes. Economic aspects of energy audit. Depreciation methods in energy saving equipments. Social cost benefit analysis. Computation of IRR and ERR. Advanced models in energy planning. Energy planning case studies

ME6427 ENERGY EFFICIENT BUILDINGS

ELECTIVE COURSE

Pre-requisite: Nil

Total hours: 42 Hrs

L	T	P	C
3	0	0	3

Climate and shelter – Historic buildings – Modern architecture – Energy estimates and site planning – Integrative Modeling methods and building simulation - Principles of energy conscious building design –Day lighting – Water heating and photovoltaic systems – Advances in thermal insulation – Heat gain/loss through building components – Solar architecture - Passive solar heating and cooling – Computer packages for thermal design of buildings and performance prediction – Monitoring and instrumentation of passive buildings – Control systems for energy efficient buildings –Integration of emerging technologies – Intelligent building design principles.

ME6428 INTEGRATED ENERGY SYSTEMS

ELECTIVE COURSE

Pre-requisite: Nil

Total hours: 42 Hrs

L	T	P	C
3	0	0	3

Energy consumption pattern – Projection of energy demands – Possible substitution of conventional sources – Modern technological options – Introduction to hybrid and integrated energy systems – Total energy concept and waste heat utilization.-Modeling and Optimal design of Integrated energy systems – Load matching and scheduling – Various possibilities to build hybrid systems – Problems associated with integrated energy systems – Performance analysis.- Integration of various power generation systems – Feasibility studies – Site selection – Related social, economic and technical problems – Special role of wind and biogas systems – Future prospects and case studies.

ME6311 INDUSTRIAL AUTOMATION AND ROBOTICS

ELECTIVE COURSE

Pre-requisite: Nil

Total hours: 42 Hrs

L	T	P	C
3	0	0	3

Introduction to automation- Architecture of industrial automation systems-Manufacturing plants and operations- Industrial control Systems- Process, Discrete manufacturing industries- Fluid Power and Electrical Actuators- Piezoelectric Actuator- Introduction to Robotics- Classification of Robots and Characteristics-Kinematics for manipulator-Frames and Transformations-Forward and inverse Kinematics-DH representation-Derivation of forward and Inverse kinematic equations

MA 7165 STATISTICAL DIGITAL SIGNAL PROCESSING

ELECTIVE COURSE

L	T	P	C
3	0	0	3

Pre-requisite: Nil

Total hours: 56 Hrs

Discrete-Time Random Processes: Random Variables, Random Processes- Signal Modeling: The Least Squares Method, The Pade Approximtion, Prony's Method, Finite Data Records, Stochastic Models.-Lattice Filters and Wiener Filtering: The FIR Lattice Filter, Split Lattice Filter, IIR Lattice Filters, Stochastic Modeling,- Spectrum Estimation: Nonparametric Methods, Minimum Variance Spectrum Estimation.

MA7169 APPLIED FUZZY LOGIC AND FUZZY SETS

ELECTIVE COURSE

L	T	P	C
3	0	0	3

(Prerequisite: Artificial Neural Network and Fuzzy Systems)

Total hours: 42 Hrs

Crisp sets an overview – the notion of fuzzy sets-– methods of generating membership functions – defuzzification methods- operations on fuzzy sets - Fuzzy numbers- arithmetic operations on intervals- arithmetic operations on fuzzy numbers- fuzzy equations- crisp and fuzzy relations- Fuzzy measures – belief and plausibility measures – probability measures. Classical logic : an overview – fuzzy logic – approximate reasoning - other forms of implication operations- fuzzy pattern recognition – fuzzy control systems.

MA 8163 ADVANCED OPERATIONS RESEARCH

ELECTIVE COURSE

L	T	P	C
3	0	0	3

(Prerequisite: Linear programming)

Total hours: 42 Hrs

Mathematical preliminaries. Maximum and Minimum-Quadratic forms-Gradient and Hessian matrices- Nonlinear programming- Unconstrained optimization-Search methods- Hooke and Jeeve's Method –Optimal gradient method-Newtons method- Optimization with inequality constraints- Kuhn-Tucker conditions- Quadratic programming- Separable programming-Frank and wolfe's method-Kelley'cutting plane method- Integer linear programming-Gomory's cutting plane method-Branch and Bound Algorithm- Travelling salesesman problem- knapsack problem- Introduction to optimization software.

MA 8167 DESIGN OF EXPERIMENTS

ELECTIVE COURSE

L	T	P	C
3	0	0	3

(Pre-requisite: Statistical Methods)

Total hours: 42 Hrs

Introduction, Randomization, replication, local control, one way and two way classification with unequal and equal number of observations per cell (with / without interactions). 2k Full factorial experiments: diagramatic presentation of main effects and first and second order interactions-3k designs: contrasts for linear and quadratic effects,- Response surface methodology (RSM): linear and quadratic model, stationary point, Central composite designs(CCD), Taguchi methods: concept of loss function, S/N ratio, orthogonal arrays, triangular tables, linear graphs, inner and outer arrays.Random effect models and mixed models. Restricted and unrestricted mixed models. Nested and split-plot designs.

MA 7160 SIMULATION AND MODELLING

ELECTIVE COURSE

L	T	P	C
3	0	0	3

(Pre-requisite: Statistical Methods)

Total hours: 56hrs

Introduction to system simulation- Computer simulation and its applications. Continuous system simulation- Modelling continuous systems, simulation of continuous systems. Discrete system simulation- Evaluation of Simulation Experiments and Simulation Languages - Evaluation of simulation experiments- Confidence intervals for terminating simulation runs - Simulation Languages: Programming Considerations – General features of GPSS- SIMSCRIPT and SIMULA. Simulation of Queuing Systems- Simulation of Stochastic Network - Introduction: Simulation of PERT Network – Definition of network diagrams,

MA 7166 STATISTICAL METHODS FOR QUALITY MANAGEMENT

ELECTIVE COURSE

L	T	P	C
3	0	0	3

(Pre-requisite: Statistical Methods)

Design and analysis of experiments : Introduction to design and analysis of experiments. Single Factor design and Analysis of Variance. Basic Definitions and Principles, The Two-Factor Factorial Design, The General Factorial Design, Fitting Response Curves and Surfaces-Statistical process control: Chance and assignable causes of quality variation, setting up of operating control charts for RandX, Control charts for X and S, Control charts for individual measurements, moving average control charts- The cumulative-sum control charts, Reliability Statistics: Reliability definition, availability, reliability bathtub curve, estimating MTBF, reliability prediction, confidence interval for MTBF, Baye's theorem applications, non-parametric and related test designs, hazard function, Weibul distribution,

MA8154 WAVELETS THEORY

ELECTIVE COURSE

L	T	P	C
3	0	0	3

(Pre-requisite:Nil)

Total Hours: 42

Vector spaces and Bases, Linear transformation, - Basic Properties of Discrete Fourier Transforms , Translation invariant Linear Transforms ,The Fast Fourier Transforms.- Construction of wavelets on Z_N ,The Haar system, Shannon Wavelets, Real Shannon wavelets Daubechies's D_6 wavelets on Z_N- Wavelets on Z**:** l^2 (Z), Complete orthonormal sets in Hilbert spaces , and Fourier series- Wavelets on R : L^2 (R) and approximate identities , The Fourier transform on R , Multiresolution analysis , Construction of MRA .

EC6421: IMAGE & VIDEO PROCESSING

ELECTIVE COURSE

L	T	P	C
3	0	0	3

Pre-requisite: Nil

Total hours: 42

Image representation-Two dimensional orthogonal transforms - Image enhancement - Edge detection - Image Restoration- Image Segmentation -Fundamental concepts of image compression - Lossless Compression - Lossy compression: Transform coding - Image compression standards. Video Processing: Representation of Digital Video, Video Compression, Video coding standards

DEPARTMENT OF ELECTRICAL ENGINEERING
M TECH IN INDUSTRIAL POWER AND AUTOMATION
DETAILED SYLLABUS

MA6003: MATHEMATICAL METHODS FOR POWER ENGINEERING

REQUIRED COURSE

L	T	P	C
3	0	0	3

Pre-requisite: Nil

Total hours: 42 Hrs

Course Assessment Methods:

2 Tests	:	20 marks each
Tutorial Test	:	10 marks
End Exam	:	50 marks
Total	:	100 marks
Grading	:	Relative

Course outcomes:

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

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

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

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

CO5: Acquire knowledge about stochastic processes and their classification.

Module 1: **Linear Algebra (10 hours)**

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

Module 2: Optimisation Methods I (11 hours)

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

Module 3: Optimisation Methods II (10 hours)

Non Linear Programming preliminaries, Unconstrained Problems ,Search methods , Fibonacci Search, Golden Section Search, Constrained Problems , Lagrange method ,Kuhn-Tucker conditions

Module 4: Operations on Random Variables (11 hours)

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

References

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

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

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

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

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

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

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

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

EE6401: ENERGY AUDITING & MANAGEMENT

REQUIRED COURSE

L	T	P	C
3	0	0	3

Pre-requisite: Nil

Total hours: 42 Hrs

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

Course Assessment Methods:

2 Tests	:	15 marks each
Course Project/Assignment	:	20marks
End Exam	:	50 marks
Total	:	100 marks
Grading	:	Relative

Course outcomes:

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

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

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

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

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

CO6: Acquire knowledge about cogeneration - types and schemes, optimal operation of cogeneration plants with case studies.

CO7: Acquire knowledge about variable frequency drives, soft starters, and eddy current drives.

CO8: Acquire knowledge about energy conservation in motors, pumps, fans, compressors, transformers, geysers, lighting schemes, air conditioning, refrigeration, cool storage.

CO9: Gain hands-on experiences by encouraging students to conduct a walkthrough audit in various industries.

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)

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

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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)

EE6301: POWER ELECTRONIC CIRCUITS

REQUIRED COURSE

Pre-requisite: Nil

Total hours: 42 Hrs

L	T	P	C
3	0	0	3

Course Assessment Methods:

2 Tests	:	20 marks each
Assignment	:	10 marks
End Exam	:	50 marks
Total	:	100 marks
Grading	:	Absolute

Course outcomes:

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

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

CO3: Acquire knowledge about various types of controlled rectifiers

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

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

Module 1: (11 hours)

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

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

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

Module 2: (10 hours)

Line Frequency Phase-Controlled Rectifiers and Inverters .Single Phase - Half Wave Controlled Rectifier with R , RL , RL with Flywheel diode loads . Full Wave Controlled Rectifier with various kinds of loads . Half Controlled and Full Controlled Bridges with passive and active loads - Input Line Current Harmonics and Power Factor- Inverter Mode of Operation - Three Phase . Half Wave Controlled rectifier with RL Load . Half Controlled Bridge with RL Load . Fully Controlled Bridge with RL Load . Input Side Current Harmonics and Power Factor - Dual Converters . Circulating Current Mode and Non-Circulating Current Mode .

Module 3: (10 hours)

Switch-Mode dc-ac Inverters . Basic Concepts . Single Phase Inverters. PWM Principles . Sinusoidal Pulse Width Modulation in Single Phase Inverters . Choice of carrier frequency in SPWM . Spectral Content of output . Bipolar and Unipolar Switching in SPWM - Blanking

Time Maximum Attainable DC Voltage Switch Utilization .Reverse Recovery Problem and Carrier Frequency Selection . Output Side Filter Requirements and Filter Design - Ripple in the Inverter Output - DC Side Current. - Three Phase Inverters -Three Phase Square Wave /Stepped Wave Inverters . Three Phase SPWM Inverters . Choice of Carrier Frequency in Three Phase SPWM Inverters . Output Filters . DC Side Current . Effect of Blanking Time on Inverter Output Voltage .

Module 4: (11 hours)

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

References

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

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

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

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

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

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

EE6403: COMPUTER CONTROLLED SYSTEMS

REQUIRED COURSE

L	T	P	C
3	0	0	3

Pre-requisite: Nil

Total hours: 42 Hrs

2 Tests	:	20 marks each
Tutorial/Course lab/Assignment	:	10 marks
End Exam	:	50 marks
Total	:	100 marks
Grading	:	Relative

Course outcomes:

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

CO2: Study of fundamentals of PLC and its architecture.

CO3: Learn the PLC programming fundamentals, process logic and human machine interface.

CO4: Understand SCADA architecture and communication protocols.

CO5: Study DCS architecture and configuration.

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

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

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

Module 1: Multivariable Control (12 hours)

Multivariable control- Basic expressions for MIMO systems- Singular values- Stability norms- Calculation of system norms- Robustness- Robust stability- H^2 / H^∞ Theory- Solution for design using H^2 / H^∞ - Case studies. Interaction and decoupling- Relative gain analysis- Effects of interaction- Response to disturbances- Decoupling- Introduction to batch process control.

Module 2: Programmable Logic Controllers (10 hours)

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

Module 3: Large Scale Control System (12 hours)

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

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

Module 4: Real Time Systems (8 hours)

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

References

1. Shinskey F.G., Process control systems: application , Design and Tuning, McGraw Hill International Edition ,Singapore,1988.
2. Be.langer P.R. , Control Engineering: A Modern Approach, Saunders College Publishing , USA, 1995.
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4. Laplante P.A., Real Time Systems: An Engineer.s Handbook, Prentice Hall of India Pvt. Ltd., New Delhi, 2002.
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EE6402: PROCESS CONTROL & AUTOMATION

REQUIRED COURSE

L	T	P	C
3	0	0	3

Pre-requisite: EE6403 Computer Controlled Systems

Total hours: 42 Hrs

Course Assessment Methods:

2 Tests	:	20 marks each
Assignment/Tutorial	:	10 marks
End Exam	:	50 marks
Total	:	100 marks
Grading	:	Relative

Course Outcomes:

CO1: Learn and familiarize with the technologies which typically exist in an industrial facility.

CO2: Acquire knowledge about process modelling, process dynamics and process instrumentation.

CO3: Acquire knowledge about transfer function, state space models, time series models and development of empirical models from process data.

CO4: Acquire knowledge about various control strategies – feedback, feed forward, cascade, ratio control, state feedback, LQR problem, pole placement and preparation of P & I diagrams.

CO5: Acquire knowledge about controller design, tuning and trouble shooting.

CO6: Acquire knowledge about process control of MIMO systems, control loop interactions, singular value analysis, decoupling control and real time optimization.

CO7: Acquire knowledge about advanced control strategies – Model predictive control, Adaptive control, Inferential Control and Batch process control.

CO8: Acquire knowledge about plant wide control design, instrumentation for process monitoring and statistical process control.

CO9: Acquire knowledge about fuzzy logic in process control, comparison of various types of control with examples on software.

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 software.

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.

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

EE6404: INDUSTRIAL LOAD MODELLING & CONTROL

REQUIRED COURSE

L	T	P	C
3	0	0	3

Pre-requisite: MA6003 Mathematical Methods for Power Engineering

Total hours: 42 Hrs

Course Assessment Methods:

2 Tests	:	15 marks each
CBT	:	10 marks
Assignment	:	10 marks
End Exam	:	50 marks
Total	:	100 marks
Grading	:	Relative

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

Course Outcomes:

CO1: Acquire knowledge about load control techniques in industries and its application.

CO2: Acquire knowledge about different types of industrial processes and optimize the process using tools like LINDO and LINGO.

CO3: Acquire knowledge about load management to reduce demand of electricity during peak time.

CO4: Analyse and understand different energy saving opportunities in industries.

CO5: Acquire knowledge about reactive power control in industries and analyse different power factor improvement methods.

CO6: Learn mathematical modelling and profiling of various loads such as cool storage, cooling and heating loads.

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

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EE6406: INDUSTRIAL INSTRUMENTATION

REQUIRED COURSE

L	T	P	C
3	0	0	3

Pre-requisite: Nil

Total hours: 42 Hrs

Course Assessment Methods:

2 Tests	:	20 marks each
Tutorial/Assignment	:	10 marks
End Exam	:	50 marks
Total	:	100 marks
Grading	:	Relative

Course Outcomes:

CO1: To get basic knowledge about industrial measurement system and different elements involved in it.

CO2: Acquire knowledge about sensors and transducers for different industrial variables like torque, pressure, etc.

CO3: Acquire knowledge about signal conditional circuits like amplifiers, filters, ADC, etc. for working industrial measurement systems.

CO4: Impart knowledge about static and response characteristics of first order and higher order system.

CO5: To get familiarize with the operation and applications in measurement systems of servo motors,

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

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

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

EE6491: INDUSTRIAL POWER & AUTOMATION LABORATORY

REQUIRED COURSE

Pre-requisite: Nil

Total hours: 42 Hrs

L	T	P	C
0	0	3	2

Course Assessment Methods:

Internal (60 Marks)

Pre-Experiment viva	:	10 marks
Assignment	:	10 marks
Record update	:	5 marks
Attendance	:	5 marks
Written Exam based on the Experiments	:	30 marks

External (40 Marks)

Lab Performance	:	20 Marks
Overall Viva	:	20 Marks
Grading	:	Absolute

Course Outcomes:

CO1: Familiarize with different industrial power and automation equipment and acquire hands on experience on them through various experiments.

CO2: Acquire knowledge about the working of SCADA system and conduct various experiments on transmission and distribution module to learn the basic operations of SCADA.

CO3: Control of batch process reactor, AC servo motor speed, lift plant model and material handling system using programmable logic controller.

CO4: Comparison of performance of centrifugal pump by throttling and variable frequency drive.

CO5: Control of pneumatic stamping system and conveyor sorting system with colour sensing fibre unit using programmable logic controller.

CO6: Reactive power compensation of a transmission line using STATCOM and voltage compensation using SSSC in solar panel and wind generator based FACTS setup.

CO7: Speed Control of AC, DC and BLDC Motors using digital signal processor.

CO8: Generation of PWM signal and saw-tooth signal using 80196 microcontroller and stepper motor speed control using 8051.

CO9: Use of LabVIEW to simulate the response of a DC motor based on the mathematical model derived from the physical model of the system

CO10: Perform the traction test on linear induction motor and speed control of eddy current drives.

CO11: Develop a real time program in LabVIEW and run it on real time hardware target using compact field point.

CO12: Familiarization of master & slave DCS controllers, feed- forward controller, split – range controller, cascade controller and multiple input multiple output system.

List of Compulsory Experiments:

1. SCADA Experiments
   a) SCADA- Transmission Module RTU in Local and Remote Mode.
      a. Ferranti Effect
      b. VAR Compensation (Series and Shunt)
      c. Transmission Line Modelling
   b) SCADA- Distribution Module RTU in Local and Remote Mode.
      a. Load Shedding
      b. Transformer Loading
      c. Study of Communication Link
2. PLC Programming Experiments
   a) Water Level Control
   b) Control of Batch Process Reactor
   c) Lift Control
   d) Speed Control of AC Servo Motor
   e) Automatic Star Delta Starter of Three Phase Induction Motor
3. AC Servo Motor Control using dSPACE
4. Energy Management in Centrifugal pumps by Variable Frequency Drive.
5. DSP Programming Experiments

   a. Speed control of BLDC motor (2812/2407 kit).
   b. Speed control of Induction motor (2812/2407 kit).
   c. Speed control of DC motor (2812/2407 kit).
6. Stepper Motor speed control and step angle control using 8051 Microcontroller.
7. Measuring Force and thrust of a Linear Induction Motor.
8. Measurement of breaking Torque for Eddy Current Control drive.
9. Simulation of Pick and Place Robot in robot studio software and implementation in ABB IRB 1200
10. Vector control drive for 3 phase Induction motor using FPGA.
11. 1 HP Switched Reluctance Motor with Eddy Current loading arrangement.
12. Level Control of tank using Cascade Controller.
13. Level Control of tank using Split Range Controller.
14. Feed forward Control for various disturbances in the temperature process control.
15. Distributed Control Systems application and logic operations with master and slave controllers.
16. Conveyor Sorting System with color sensing fiber unit by using PLC and DCS.
17. Stamping Process by using Programmable Logic Controller and DCS.
18. MIMO system for multiple level, flow and temperature controls.
19. STATCOM and FACTS based Experiments.
    a. Reactive Power Compensation using solar and wind based STATCOM.
    b. Power Factor Compensation and Voltage Regulation using three phase FACTS controller.
20. Experiments on LabVIEW and MATLAB.
    a. State Space Modeling of DC motor in MATLAB and LabVIEW.
    b. PID, fuzzy and fuzzy-PID controller based speed control of dc motor in MATLAB.
    c. PID Controller based speed control of DC motor in LabVIEW.

List of Desirable Experiments:

1. Testing of Numerical Overload Relay
2. Study of Common Industrial Communication Protocols
3. Effect of voltage control on a three phase Induction motor.
4. Speed control of three phase Induction motor by variable frequency method.

5. Process Interaction Observation in MIMO system
6. Level Control in Two tank Interacting Systems.
7. Cascade Control of Temperature Process tank.
8. Measuring Voltage and Current of the Microgrid using NI-myDAQ.
9. Solar, Wind based Load Voltage Regulation using cRIO.
10. Modeling and Simulation of FACT devices.

Reference

1. Lab manual /, Hand books of SCADA/DCS

2. Stuart A. Boyer: SCADA-Supervisory Control and Data Acquisition, Instrument Society of America Publications,USA,2004

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

EE6306: POWER ELECTRONIC DRIVES

REQUIRED COURSE

Pre-requisite: Nil

Total hours: 42 Hrs

L	T	P	C
3	0	0	3

Course Assessment Methods:

2 Tests	:	20 marks each
Assignment	:	10 marks
End Exam	:	50 marks
Total	:	100 marks
Grading	:	Absolute

Course Outcomes:

CO1: Develop capability to choose a suitable Motor and Power Electronic Converter package from a

description of drive requirement – involving load estimation, load cycle considerations, thermal

aspects and motor-converter matching

CO2: To learn about various DC and AC machines used in drives.

CO3: Acquire detailed knowledge of Electrical Motor operation using Generalized machine theory.

CO4: To understand the working and design of various converters used in Electrical Drives.

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

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EE6192: MINI PROJECT

REQUIRED COURSE

L	T	P	C
0	0	3	1

Pre-requisite: Nil

Total hours: -42hours

Course Assessment Methods:

Midterm evaluation : 30 marks

(Problem identification, Objective, Relevance, Literature survey/Research gap, circuit design, model development)

End semester evaluation : 70 marks

(Presentation, Simulation , hardware , test results, report, outcome, future scope)

Grading : Relative

Course outcomes:

CO1: The student must be able to identify Industrial applications of different electrical & electronic systems, learnt in previous courses.

CO2: The student must be able to design & simulate systems.

CO3: The student must be able to implement successfully & test systems, within a specific time frame.

CO4: The student must be able to prepare documents using proper documentation tools.

The mini project can be analytical / simulation/design or and fabrication in any of the areas in Industrial Automation, Industrial drives, control system, Embedded system, and Robotics. Project must be done by individual. A faculty coordinator will coordinate project work of all students. The mini project is usually allotted by the Dept at the beginning of 2nd semester and preferably shall be completed before the end of 2nd semester. The project work is evaluated by a committee consisting of two/three faculty members in the concerned area of the project nominated by the HOD. The faculty coordinator of the project will be a member of the evaluation committee all the projects. The mode of presentation, submission of the report, method of evaluation, award of grades etc will be decided by the evaluation committee. Students shall submit both soft and hard copies (required number of copies) of project report in the prescribed form to the department and library after incorporating all the corrections and changes suggested by the evaluation committee.

EE7491: MAJOR PROJECT I & EE7492: MAJOR PROJECT II

REQUIRED COURSE

Pre-requisite: Nil

Total hours: -30hours/week

L	T	P	C
0	0	16+24	7+12

Course Assessment Methods:

Midterm evaluation : 30 marks

(Problem identification, Objective, Relevance, Literature survey/Research gap, circuit design, model development)

End semester evaluation : 70 marks

(Presentation, Simulation, hardware, test results, report, outcome, future scope)

Grading : Relative

Course outcomes:

CO1: The candidate/student must be able to identify a problem in a given research area.

CO2: The student must be able to make use of the technical knowledge gained from previous courses, in design of a system.

CO3: The student must be able to apply project management skills (scheduling work, procuring parts, and documenting expenditures and working within the confines of a deadline).

CO4: The candidate must acquire System integration skills, Documentation skills, Project management skills, Problem solving skills.

CO5: The candidate must acquire skills to design, implement, test & troubleshoot Electrical, Electronic & Automation systems.

CO6: The candidate must develop presentation skills & professionalism.

CO7: The student must be able to understand industrial problems and suggest possible solutions.

The project work is done and evaluated in two stages. The first stage will be completed in 3rd semester and its assessment will be done at the end of third semester. The second stage will be completed in 4th semester and the assessment is done at the end of fourth semester. Evaluation will be done by a committee consisting of the concerned guide and two/three faculty members in the concerned area of the project nominated by the Programme Coordinator. The program Coordinator of the M.Tech Stream will be a member of the evaluation committee of the projects. The mode of presentation, submission of the report, method of evaluation, award of grades etc will be decided by the evaluation committee. Students shall submit both soft and hard copies (required number of copies) of project report in the prescribed form to the department and library after incorporating all the corrections and changes suggested by the evaluation committee. The Department level evaluation shall have 70% weight in the final grading of which 50% weight will be given to the assessment by the individual guide. Remaining 30% marks is awarded in the external evaluation with an external examiner nominated by the Program Coordinator and approved by the HOD. Final marks will be reported based on 100 as maximum.

EE6494 SEMINAR

REQUIRED COURSE

Pre-requisite: Nil

Total hours: -42hours

L	T	P	C
0	0	3	1

Course Assessment Methods:

Abstract submission	: 5 marks
Presentation (PPT Clarity/Audibility Presentation Skill)	:30 marks
Subject Knowledge	: 25 marks
Discussion/delivery	: 10 marks
Conclusion & Report	: 30 marks
Total	: 100 marks
Grading	: Relative

Course outcomes:

CO1: To study research papers for understanding emerging technologies in the field of power systems, in the absence of a text book, to summarize and review them.

CO2: To identify promising new directions of various cutting edge technologies.

CO3: To impart skills in preparing detailed report describing the reviewed topic.

CO4: To effectively communicate by making an oral presentation before an evaluation committee.

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

EE7493: INDUSTRIAL TRAINING

REQUIRED COURSE

Total hours: Minimum 20 days

EE7493 Industrial Training shall be completed during summer vacation and will be credited in 3rd semester along with major project -1. The 20 days of training in a reputed industry helps the students to familiarize with the dynamic environment in an industry to identify issues/problems and suggest improvements/solutions.

Course Assessment Methods:

Students will select a reputed industry for the training from the approved list of industries. Minimum days of training is 20. During which students shall make a detailed study of the plant/process, identify a specified area/process which needs improvements, he/she shall go in detail in the selected process with hands on experience, identify the problems and solutions for improvements, discuss with the plant engineers/officials, implementation if possible, conclude and report to plant manager. A certificate from the plant officials shall be enclosed with the report.

Evaluation : 100 marks

(Study of the plant process, Problem identification, Solution strategies, Suggestions from plant officials, implementation steps: 70 marks

Presentation, results, report, outcome: 30 marks)

Grading : Relative

Course outcomes:

CO1: The candidate must become familiar with the dynamic environment in an industry/project site.

CO2: The candidate must become familiar with the different processes in Industry.

CO3: The candidate must become familiar with the management & administrative, non-technical operations/divisions in an industry.

CO4: The student must be able to identify issues/problems in the industry and suggest improvements/solutions.

CO5: The student must familiarize himself/herself with the etiquette/mannerism/self-discipline followed by professionals.

CO6: The candidate must familiarize with the people management skills, of supervisory/managers, in the industry.

EE6421: ADVANCED MICROCONTROLLER BASED SYSTEMS

ELECTIVE COURSE

L	T	P	C
3	0	0	3

Pre-requisite: Nil

Total hours: 42 Hrs

Course Assessment Methods:

2 Tests	:	20 marks each
Assignment/Tutorials /course lab	:	10 marks
End Exam	:	50 marks
Total	:	100 marks
Grading	:	Relative

Course Outcomes:

CO1: To familiarize the fundamental concepts of computer organization and its architecture.

CO2: To expose the students to the fundamentals of micro-controllers viz.68HC11, 8051 and 8096.

CO3: To impart knowledge on PIC micro-controller and to introduce FPGA.

CO4: To develop skill in simple applications development with programming 8051 and PIC.

CO5: To introduce the concept of Programmable Logic Controller and its features.

Module 1 (10hours)

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
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7. Micro chip datasheets for PIC16F877

EE6422: ENGINEERING OPTIMIZATION

ELECTIVE COURSE

Pre-requisite: Nil

Total hours: 42 Hrs

L	T	P	C
3	0	0	3

Course Assessment Methods:

2 Tests	:	20 marks each
Tutorials/Assignment	:	10 marks
End Exam	:	50 marks
Total	:	100 marks
Grading	:	Relative

Course Outcomes:

CO1: The course will concentrate on the mathematical and numerical techniques of optimization as applied to engineering problems and to apply the mathematical results and numerical techniques of optimization theory to concrete Engineering problems.

CO2: Provide the students with a strong background in optimization which can be complemented by more specialized courses in Mathematics and make them capable of creating, solving and analysing the case studies.

CO3: Introduce the concepts of Linear Program modelling, explore the mathematical properties of general linear programming problems and obtaining the solution linear programming problems using the appropriate techniques

CO4: Formulation real-world problems as Linear Programming models, the theory and applications of the simplex method and its extensions such as the revised simplex and dual simplex algorithms in solving the standard LP problem and the related dual problem, and interpretation of the results obtained.

CO5: Application of linear programming in engineering applications minimum cost flow problem, network problems-transportation, assignment & allocation, scheduling etc.

CO6: Introduction to nonlinear programming and modelling techniques as well as solution algorithms and to find the best possible solution in nonlinear decision models.

CO7: Brief review of the most important model types and solution approaches followed by a more detailed discussion of deterministic optimization algorithms.

CO8: Solution of nonlinear programming using basic decent methods such as Fibonacci & Golden section search, gradient methods, Newton Method, Lagrange multiplier method, Quasi-Newton method, separable convex programming Frank and Wolfe method and its engineering Applications.

CO9: Derivation and uses of the Kuhn-Tucker first order necessary conditions for optimality, second order optimality conditions, saddle points, and the Lagrangian dual problem, basic theorems on convex functions, sets, and problems.

CO10: Solving complex problems by breaking them down into simpler sub-problems using dynamic programming and study the theory and practice of dynamic programming with special emphasis in problem formulation and computational efficiency.

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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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

ELECTIVE COURSE

L	T	P	C
3	0	0	3

Pre-requisite: Nil

Total hours: 42 Hrs

Course Assessment Methods:

2 Tests	:	20 marks each
Tutorials/ Assignment	:	10 marks
End Exam	:	50 marks
Total	:	100 marks
Grading	:	Relative

Course outcomes:

CO1: To develop a comprehensive understanding of the industrial data communication systems.

CO2: To educate on the basic concepts of inter-networking and serial communications.

CO3: To provide a fundamental understanding of common principles, various standards and protocol stack in networking

CO4: To introduce industrial Ethernet and wireless communication.

CO5: To familiarize the SCADA communication network and other open standard communication Protocols.

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.

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EE6424: ROBOTICS SYSTEMS AND APPLICATIONS

ELECTIVE COURSE

L	T	P	C
3	0	0	3

Pre-requisite: Nil

Total hours: 42 Hrs

Course Assessment Methods:

2 Tests	:	20 marks each
Tutorials/ Assignment	:	10 marks
End Exam	:	50 marks
Total	:	100 marks
Grading	:	Relative

Course outcomes:

CO1: Learn the mathematics of spatial descriptions and transformations

CO2: Acquire knowledge about robot definition, classification, robot system components that combines embedded hardware, software and mechanical systems

CO3: Learn manipulator kinematics and mechanics of robot motion, forward and inverse kinematic transformation of position, forward and inverse kinematic transformation of velocity, end effector force transformations

CO4: Learn about manipulator dynamics, transformation of acceleration, trajectory planning, Lagrangian formulation, Newton-Euler equations of motion, robot control architectures

CO5: Acquire knowledge about robot sensing and vision systems

CO6: Acquire knowledge about robot programming languages

CO7: Acquire knowledge about artificial intelligence techniques in robotics

CO8: Learn about various robotics applications and their associated components and control systems in manufacturing, construction, service, etc.

Module 1: (8 hours)

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

Module 2: (12 hours)

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

Module 3: (13 hours)

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

Module 4: (9 hours)

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

References

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

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

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

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

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

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

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

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

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

EE6426: DISTRIBUTION SYSTEMS MANAGEMENT AND AUTOMATION

ELECTIVE COURSE

L	T	P	C
3	0	0	3

Pre-requisite: Nil

Total hours: 42 Hrs

Course Assessment Methods:

2 Tests	:	20 marks each
Tutorials/Assignment	:	10 marks
End Exam	:	50 marks
Total	:	100 marks
Grading	:	Absolute

Course Outcomes:

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

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

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

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

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

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

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

ELECTIVE COURSE

Pre-requisite: Nil

Total hours: 42 Hrs

L	T	P	C
3	0	0	3

Course Assessment Methods:

2 Tests	:	20 marks each
Tutorials/Assignments	:	10 marks
End Exam	:	50 marks
Total	:	100 marks
Grading	:	Absolute

Course Outcomes:

CO1: Describe the basic tasks of Supervisory Control Systems (SCADA) as well as their typical applications

CO2: Acquire knowledge about SCADA architecture, various advantages and disadvantages of each system

CO3: Acquire knowledge about single unified standard architecture IEC 61850

CO4: Acquire knowledge about SCADA system components: remote terminal units, PLCs, intelligent electronic devices, HMI systems, SCADA server

CO5: Acquire knowledge about SCADA communication, various industrial communication technologies, open standard communication protocols

CO6: Learn and understand about SCADA applications in transmission and distribution sector, industries etc.

CO7: Gain knowledge and understanding for the design and implementation of a SCADA system

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

EE6101: DYNAMICS OF LINEAR SYSTEMS

ELECTIVE COURSE

Pre-requisite: Nil

Total hours: 42 Hrs

L	T	P	C
3	0	0	3

Course Assessment Methods:

2 Tests	:	15 marks each
Assignment	:	20 marks
End Exam	:	50 marks
Total	:	100 marks
Grading	:	Absolute

Course outcomes:

CO1: Acquire knowledge of linear system modeling, analysis and design so as to obtain the ability to apply the same to engineering problems in a global perspective.

CO2: Acquire knowledge on carrying out detailed stability analysis of both linear and nonlinear systems with a view to extend this knowledge for controller design to achieve stability of systems.

CO3: Acquire knowledge to design observers and controllers for linear systems so as to be able to implement the methodology for practical control systems.

CO4: Acquire knowledge of discrete time linear systems modeling, analysis and design so as to obtain the ability to apply the same to practical engineering problems in today's world of hybrid systems.

CO5: Acquire knowledge to develop and utilize modern software tools for analysis and design of linear continuous and discrete time systems.

CO6: Acquire ability to extend the knowledge in analysis and design to systems of multidisciplinary nature.

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

ELECTIVE COURSE

L	T	P	C
3	0	0	3

Pre-requisite: Nil

Total hours: 42 Hrs

Course Assessment Methods:

2 Tests	:	20 marks each
Assignment	:	10 marks
End Exam	:	50 marks
Total	:	100 marks
Grading	:	Relative

Course outcomes:

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

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

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

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

CO5: Acquire knowledge to develop and utilize modern software tools for design and analysis of optimal control problems.
CO6: Acquire knowledge in model reference adaptive control system design and to extend this knowledge to other areas of model following control with the idea of pursuing research in this area.

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

ELECTIVE COURSE

L	T	P	C
3	0	0	3

Pre-requisite: Nil

Total hours: 42 Hrs

Course Assessment Methods:

2 Tests	:	20 marks each
Assignment	:	10 marks
End Exam	:	50 marks
Total	:	100 marks
Grading	:	Relative

Course outcomes:

CO1: To get knowledge about general modeling principles and degrees of freedom of modeling.

CO2: Acquire knowledge about modeling of automated manufacturing system and their performance measures.

CO3: To explore with petrinet and S-net models.

CO4: To get familiarize with engineered data acquisition and processing system.

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

EE6104: ADVANCED INSTRUMENTATION

ELECTIVE COURSE

Pre-requisite: Nil

Total hours: 42 Hrs

L	T	P	C
3	0	0	3

Course Assessment Methods:

2 Tests	:	20 marks each
Assignment	:	10 marks
End Exam	:	50 marks
Total	:	100 marks
Grading	:	Relative

Course outcomes:

CO1: Acquire knowledge about the fundamental concepts of measurement systems.

CO2: Acquire knowledge about the static and dynamic characteristics of measuring instruments.

CO3: Get familiarize with the mathematical modeling and time response of first order and second order measurement systems.

CO4: Study and analysis of amplitude modulation of measurements and the design consideration of such amplitudes modulated measurement systems.

CO5: Acquire knowledge about the requirements to ensure accurate measurements.

Module 1: (11 hours)

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

Module 2: (11 hours)

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

Module 3: (10 hours)

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

Module 4: (10 hours)

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

References

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

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

EE6121: DATA ACQUISITION & SIGNAL CONDITIONING

ELECTIVE COURSE

Pre-requisite: Nil

Total hours: 42 Hrs

L	T	P	C
3	0	0	3

Course Assessment Methods:

2 Tests	:	20 marks each
Assignment	:	10 marks
End Exam	:	50 marks
Total	:	100 marks
Grading	:	Relative

Course outcomes:

CO1: Understand the objectives and configurations of data acquisition systems

CO2: Learn the working and characteristics of transducers

CO3: Learn about signal conditioning systems and noise reduction techniques

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

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

CO6: Understand various data transmission techniques

CO7: Learn various interfacing techniques and standards for communication between instruments

Module 1: Transducers & Signal Conditioning (11 hours)

Data Acquisition Systems(DAS)- Introduction . Objectives of DAS . Block Diagram Description of DAS- General configurations - Single and multichannel DAS-Transducers for the measurement of motion, force, pressure, flow, level, dc and ac voltages and currents (CTs, PTs for supply frequency as well as high frequency, Hall Effect Current Sensors, High Voltage Sensors , Optosensors, Rogowski Coil, Ampflex Sensors etc.) - Signal Conditioning: Requirements - Instrumentation amplifiers: Basic characteristics . Chopped and Modulated DC

Amplifiers-Isolation amplifiers - Opto couplers - Buffer amplifiers .Noise Reduction Techniques in Signal Conditioning- Transmitters .Optical Fiber Based Signal Transmission-Piezoelectric Couplers- Intelligent transmitters.

Module 2: Filtering and Sampling (10 hours)

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

Module 3: Signal Conversion and Transmission (10 hours)

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

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

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

References

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

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

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

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

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

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

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

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

EE6122: BIOMEDICAL INSTRUMENTATION

ELECTIVE COURSE

L	T	P	C
3	0	0	3

Pre-requisite: Nil

Total hours: 42 Hrs

Course Assessment Methods:

2 Tests	:	20 marks each
Assignment	:	10 marks
End Exam	:	50 marks
Total	:	100 marks
Grading	:	Relative

Course outcomes:

CO1: Provide the students with an insight into the physiological system of the body and also an understanding on the generation of various bioelectric signals like ECG, EEG and EMG, their c haracteristic features and concepts of transduction.

CO2: Provide the students with an understanding of the various techniques and clinical instruments available for the measurement of various physiological parameters.

CO3: Provide the students the fundamentals of medical instrumentation along with their working principle.

CO4: Equip the students with research potential so that the principles of engineering and basic sciences shall be applied to improve the existing design and make it more economical and biocompatible for the betterment of mankind.

Module 1: (12 hours)

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

Module 2: (10 hours)

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

Module 3: (10 hours)

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

Module 4: (10 hours)

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

References

1. Geddes & Baker , Principles of applied biomedical instrumentation Wiley Inter science , 3rd edition, 1975
2. R S Khandpur, Hand book of Biomedical instrumentation, TMH,4th edition, 1987
3. Cromwell Leslie, Biomedical instrumentation and measurements, PHI, 1980
4. Brown Carr, Introduction to Biomedical equipment technology , Printice Hall, 1981
5. John Enderle, Introduction to Biomedical engineering , Academic Press, 2005
6. Joseph D Bronzino, Biomedical engineering hand book, CRC Press, 2000
7. Metin Akay (editor), Wiley encyclopedia of biomedical engineering , Wiley, 2003

EE6123: PERFORMANCE MODELLING OF SYSTEMS – I

ELECTIVE COURSE

Pre-requisite: Nil

Total hours: 42 Hrs

L	T	P	C
3	0	0	3

Course Assessment Methods:

2 Tests	:	20 marks each
Assignment	:	10 marks
End Exam	:	50 marks
Total	:	100 marks
Grading	:	Relative

Course outcomes:

CO1: Acquire knowledge about the general operational characteristics and frequency response studies of instruments.

CO2: Acquire basic knowledge about set theory and different operations involved in it.

CO3: Acquire basic knowledge about general graph theory and different components involved it.

CO4: Acquire basic knowledge about active graph theory and hence to study petrinet and S-net graphs.

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

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

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

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

Module 3: General Graph Theory (10 hours)

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

Module 4: Active Graph Theory (12 hours)

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

References

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

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

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

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

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

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

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

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

EE6124: PERFORMANCE MODELLING OF SYSTEMS – II

ELECTIVE COURSE

Pre-requisite: Nil

Total hours: 42 Hrs

L	T	P	C
3	0	0	3

Course Assessment Methods:

2 Tests	:	20 marks each
Assignment	:	10 marks
End Exam	:	50 marks
Total	:	100 marks
Grading	:	Relative

Course outcomes:

CO1: Acquire knowledge about modeling philosophies of different systems.

CO2: Acquire knowledge about modeling tools such as petrinet and S-net.

CO3: To develop a model of automated manufacturing systems using petrinet and S-net tools.

CO4: Familiarization of modeling with active graph theory and enable the students to model the standard problems like dining philosophers problem and readers/writers problem.

CO5: To give an insight to popular extensions of petrinet and S-net theory and different case studies.

Module 1: Modelling Philosophies (10 hours)

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

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

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

Module 3: Active Graphical Modelling Tools (10 hours)

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

Module 4: Analysis of Modelling Tools (12 hours)

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

References

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

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

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

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

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

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

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

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

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EE6125: DIGITAL CONTROL SYSTEMS

ELECTIVE COURSE

Pre-requisite: Nil

Total hours: 42 Hrs

L	T	P	C
3	0	0	3

Course Assessment Methods:

2 Tests	:	20 marks each
Assignment	:	10 marks
End Exam	:	50 marks
Total	:	100 marks
Grading	:	Relative

Course outcomes:

CO1: Acquire knowledge about the modeling of Digital Control Systems

CO2: Acquire knowledge about analysis of digital control systems in the z-domain as well as state space domain

CO3: Acquire knowledge about classical techniques for design of digital controllers with case study examples using MATLAB

CO4: Acquire knowledge about techniques based on state-space for design of digital controllers with case study examples using MATLAB

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

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

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

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

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

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

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

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

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

References

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

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

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

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EE6129: ARTIFICIAL NEURAL NETWORKS AND FUZZY SYSTEMS

ELECTIVE COURSE

Pre-requisite: Nil

Total hours: 42 Hrs

L	T	P	C
3	0	0	3

Course Assessment Methods:

2 Tests	:	20 marks each
Assignment	:	10 marks
End Exam	:	50 marks
Total	:	100 marks
Grading	:	Relative

Course outcomes:

CO1: To introduce the basic model of an artificial neuron and its relationship to biological neurons.

CO2: Acquire knowledge about the learning methods and training of the artificial neural networks.

CO3: Attck problems like weather forecasting, finger print identification, and optical character recognition using ANN.

CO4: Control applications like system identification, Parameter optimization, feedback controllerdesign etc.

CO5: To understand the fuzzy logic and develop fuzzy rule based systems and its applications.

Module 1: (10 hours)

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

Module2:(10hours)

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

Module3:(10hours)

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

Module4:(12hours)

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

References

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

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

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

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

EE6201: COMPUTER METHODS IN POWER SYSTEMS

ELECTIVE COURSE

Pre-requisites: Nil
Course Assessment Methods:

L	T	P	C
3	0	0	3

2 Tests	:	15marks each
Assignment	:	20 marks
End Exam	:	50 marks
Total	:	100 marks
Grading	:	Absolute

Course outcomes:

CO1: To enable students to do load flow analysis on large scale AC, DC and AC-DC power system using digital techniques

CO2: To enable students to do short circuit analysis on large scale power systems using digital techniques

CO3: To enable the students to conduct optimal scheduling of hydro-thermal systems and Unit commitment. To make them aware of economic reactive power dispatch and the application of AI.

CO4: To enable the students to do contingency analysis using network sensitivity method and AC Power Flow Method and to conduct security constrained economic dispatch. To make them aware of power system state estimation and its solution methodologies.

Module 1: (11 hours)

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

Module 2: (10 hours)

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

Module 3: (11 hours)

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

Module 4: (10 hours)

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

References

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

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

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

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

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

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

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

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

EE6204: DIGITAL PROTECTION OF POWER SYSTEMS

ELECTIVE COURSE

L	T	P	C
3	0	0	3

Pre-requisite: Nil

Total hours: 42 Hrs

Course Assessment Methods:

2 Tests	:	20 marks each
Assignment	:	10 marks
End Exam	:	50 marks
Total	:	100 marks
Grading	:	Relative

Course outcomes:

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

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

CO3: The student must have a clear understanding of the different mechanisms of circuits breakers and their selection for each of protection scheme design.

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

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

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

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

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

EE6221: DISTRIBUTED GENERATION

ELECTIVE COURSE

L	T	P	C
3	0	0	3

Pre-requisite: Nil

Total hours: 42 Hrs

Course Assessment Methods:

2 Tests	:	20 marks each
Assignment	:	10 marks
End Exam	:	50 marks
Total	:	100 marks
Grading	:	Relative

Course outcomes:

CO1: Create awareness among students about technologies which are suitable for Microgrid application

CO2: Enable students to understand various Distributed Generation technologies

CO3: To impart the knowledge of Storage technologies to form the autonomous renewable energy sources

CO4: Equip the students with knowledge and understanding of various possible mechanisms about grid connected and autonomous renewable energy projects

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

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EE6222: POWER QUALITY

ELECTIVE COURSE

L	T	P	C
3	0	0	3

Pre-requisite: Nil

Total hours: 42 Hrs

Course Assessment Methods:

2 Tests	:	20 marks each
Assignment	:	10 marks
End Exam	:	50 marks
Total	:	100 marks
Grading	:	Relative

Course outcomes:

CO1: To introduce the student to the power quality issues, measures and standards.

CO2: Acquire knowledge about the harmonics, harmonic introducing devices and effect of harmonics on system equipment and loads

CO3: To develop analytical modeling skills needed for modeling and analysis of harmonics in networks and components

CO4: To introduce the student to active power factor correction based on static VAR compensators and its control techniques

CO5: To introduce the student to series and shunt active power filtering techniques for harmonic cancellation and isolation

CO6: Acquire knowledge about the NEC grounding requirements and solutions to grounding and wiring problems

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

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5. IEEE and IEE Papers from Journals and Conference Records

EE6302: ADVANCED POWER ELECTRONIC CIRCUITS

ELECTIVE COURSE

Pre-requisite: Nil

Total hours: 42 Hrs

L	T	P	C
3	0	0	3

Course Assessment Methods:

2 Tests	:	20 marks each
Assignment	:	10 marks
End Exam	:	50 marks
Total	:	100 marks
Grading	:	Relative

Course outcomes:

CO1: Acquire knowledge about analysis and design of Load Commutated CSI and PWM CSI

CO2: Acquire knowledge about analysis and design of series Inverters.

CO3: Acquire knowledge about analysis and design of Switched Mode Rectifiers and APFC

CO4: Acquire knowledge about analysis and design of isolated and non isolated Switched Mode DC to DC Converters

CO5: Acquire knowledge about analysis and design of Resonant Converters

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

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2. Rashid “Power Electronics” Prentice Hall India 2007.

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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

ELECTIVE COURSE

Pre-requisite: Nil

Total hours: 42 Hrs

L	T	P	C
3	0	0	3

Course Assessment Methods:

2 Tests	:	20 marks each
Assignment	:	10 marks
End Exam	:	50 marks
Total	:	100 marks
Grading	:	Relative

Course outcomes:

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

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

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

Module 1: (12 hours)

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

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

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

EE6304: ADVANCED DIGITAL SIGNAL PROCESSING

ELECTIVE COURSE

Pre-requisite: Nil

Total hours: 42 Hrs

L	T	P	C
3	0	0	3

Course Assessment Methods:

2 Tests	:	20 marks each
Assignment	:	10 marks
End Exam	:	50 marks
Total	:	100 marks
Grading	:	Relative

Course outcomes:

CO1: Acquire knowledge about the time domain and frequency domain representations as well as analysis of discrete time signals and systems

CO2: Acquire knowledge about the design of techniques for IIR and FIR filters and their realization structures.

CO3: Acquire knowledge about the finite word length effects in implementation of digital filters.

CO4: Acquire knowledge about the various linear signal models and estimation of power spectrum of stationary random signals

CO5: Acquire knowledge about the design of optimum FIR and IIR filters.

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

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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

EE6308: FACTS AND CUSTOM POWER
ELECTIVE COURSE

Pre-requisite: Nil

Total hours: 42 Hrs

L	T	P	C
3	0	0	3

Course Assessment Methods:

Tests 1 : 15 marks

Tests 2 : 20 marks

Assignment : 15 marks

End Exam : 50 marks

Total : 100 marks

Grading : Relative

Course Outcomes:

CO1: Acquire knowledge about the fundamental principles of Passive and Active Reactive Power Compensation Schemes at Transmission and Distribution level in Power Systems.

CO2: To introduce the student to various Static VAr Compensation Schemes like Thyristor/GTOControlled Reactive Power Systems, PWM_Inverter based Reactive Power Systems and their controls .

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

CO4: Acquire knowledge about the fundamental principles of Unified Power Flow Conditioner and Interline Power Flow Conditioner in Power Systems.

CO5: Introduce the student to various UPFC Systems, Converters used in them and their control.

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

CO7: To introduce the student to various Custom Power Systems, Modeling of such systems and Control Design for them

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

ELECTIVE COURSE

Pre-requisite: Nil

Total hours: 42 Hrs

L	T	P	C
3	0	0	3

Course Assessment Methods:

2 Tests	:	20 marks each
Assignment	:	10 marks
End Exam	:	50 marks
Total	:	100 marks
Grading	:	Relative

Course outcomes:

CO1: To learn the basics of power semiconductor switches.

CO2: To understand the working of various types of converters and application of them.

CO3: To understand and design the drive circuits for various Power Semiconductor Switches.

CO4: To learn to model the converters and semiconductor switches.

CO5: To learn about the control of various power semiconductor switches.

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

ELECTIVE COURSE

Pre-requisite: Nil

Total hours: 42 Hrs

L	T	P	C
3	0	0	3

Course Assessment Methods:

2 Tests	:	20 marks each
Assignment	:	10 marks
End Exam	:	50 marks
Total	:	100 marks
Grading	:	Relative

Course outcomes:

CO1: Acquire knowledge about the fundamental principles of Passive and Active Reactive Power Compensation Schemes at Transmission and Distribution level in Power Systems.

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

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

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

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

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

Module1: (10 hours)

Fundamentals of Load Compensation , Steady-State Reactive Power Control in Electric Transmission Systems , Reactive Power Compensation and Dynamic Performance of Transmission Systems . Power Qulity Issues . Sags, Sweels, Unbalance, Flicker , Distortion , Current Harmonics - Sources of Harmonics in DistributionSystems and Ill Effects .

Module 2: (10 hours)

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

Module 3: (11 hours)

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

Module 4: (11 hours)

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

References

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

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

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

EE6327: LINEAR AND DIGITAL ELECTRONICS

ELECTIVE COURSE

Pre-requisite: Nil

Total hours: 42 Hrs

L	T	P	C
3	0	0	3

Course Assessment Methods:

2 Tests	:	20 marks each
Assignment	:	10 marks
End Exam	:	50 marks
Total	:	100 marks
Grading	:	Relative

Course outcomes:

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

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

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

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

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

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

Module 1: (15 hours)

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

Module 2: (8 hours)

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

quantiser characteristics - single slope and dual slope ADCs - successive approximation ADC - simultaneous ADC

Module 3: (9 hours)

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

Module 4: (10 hours)

Design and analysis of sequential circuits: General model of sequential networks - State diagrams – Analysis and design of Synchronous sequential Finite Sate Machine – State reduction – Minimization and design of the next state decoder.

Counters: Design of single mode counters and multimode counters – Ripple Counters – Ring Counters – Shift registers counter design.

Practical design aspects: Timing and triggering considerations in the design of synchronous circuits – Set up time - Hold time – Clock skew.

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

References

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

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

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

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

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

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

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

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

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

ME6412 DESIGN AND ANALYSIS OF ENERGY SYSTEMS

ELECTIVE COURSE

L	T	P	C
3	0	0	3

Pre-requisite: Nil

Total Hours: 42Hrs

Course Assessment Methods:

2 Tests	:	20 marks each
Assignment	:	10 marks
End Exam	:	50 marks
Total	:	100 marks
Grading	:	Relative

Course outcomes:

CO1: Ability to design and analyse the performance of energy systems for engineering applications like turbo machines, heat exchangers etc.

CO2: Awareness on energy transfer process in turbo machines, formulation of governing equations of various forms and the structural and functional aspects of major components of turbo machines.

CO3: Ability to design various turbo-machines and heat exchangers for power plant applications

CO4: Ability to analyse the energy systems to improve and optimize their performance

Module I (10 hours)

Engineering design fundamentals - Designing a workable system - Economic evaluation - Fitting data and solving equations - Design optimization - Knowledge based system design.

Module II (10 hours)

Heat exchanger design calculations - Evaporators and condensers temperature concentration pressure characteristics of binary solutions - Rectifiers - Cooling towers -Pressure drop and pumping power.

Module III (10 hours)

Pump characteristics - Manufacturer's specifications - Relations among performance characteristics – Pump system operation - Cavitation prevention - Other system considerations, Fans and nozzles.

Module IV (12 hours)

Basics of Second law analysis in heat and fluid flow - Applications in thermal design - Modeling and simulation principles - Hardy-Cross method - Multi-variable, Newton-Raphson simulation method - Simulation of a gas turbine system - Simulation using differential equations - Mathematical modeling of thermodynamic properties - Steady state simulation of large systems.

References

1. Y. Jaluria: Design and Optimization of Thermal Systems, Mc Graw Hill, 1998

2. A. Bejan: Thermal Design and Optimization, John Wiley, 1995

3. W.F. Stoeker: Design of Thermal Systems, 3e, Mc Graw Hill, 1989

4. B.K. Hodge: Analysis and Design of Energy Systems, Prentice Hall, 1990

5. R.F. Boehm: Design Analysis of Thermal systems, John Wiley, 1987

6. Jones J. B. and Dugan R. E.: Engineering Thermodynamics, Prentice Hall of India, 1998

7. Yunus A. Cengel: Thermodynamics: An Engineering approach, Mc Graw Hill, 1994

8. W.J. Gajda and W.E. Biles: Engineering Modeling and Computation, Houghton Mifflin, 1980

ME6421 DIRECT ENERGY CONVERSION SYSTEMS

ELECTIVE COURSE

L	T	P	C
3	0	0	3

Pre-requisite: Nil

Total Hours: 42

Course Assessment Methods:

2 Tests	:	20 marks each
Assignment	:	10 marks
End Exam	:	50 marks
Total	:	100 marks
Grading	:	Relative

Course outcomes:

CO1: Knowledge of the underlying principles of direct energy conversion and the technological options for utilization in various end use applications

CO2: Ability to apply the principles of thermodynamics for the performance assessment of direct energy conversion systems

CO3: Awareness of futuristic technologies like MHD generators and fuel cells

CO4: Ability to design energy conversion systems based on the principles of direct energy

Module I (10 hours)

Basic science of energy conversion - Orderly and disorderly energy - Reversible and irreversible engines - Analysis of basically reversible engines - Duality of matter - Thermoelectric Vs Photoelectric phenomena - Basic thermoelectric engine - Thermoelectric materials - Applications.

Module II (10 hours)

Physics of solar photovoltaic cells - Production of solar cells - Design concept of PV cell systems - Solar cells connected in series and parallel - Voltage regulation and energy storage - Centralized and decentralized PV Systems - Maintenance of PV systems - Current developments.

Module III (12 hours)

Thermionic emission - Richardson's equation - Analysis of high vacuum thermionic converter – Gaseous converters - Introduction to MHD generators - Seeding and ionization in MHD generators - Analysis of MHD engines and MHD equations - Conversion efficiency and electrical losses in MHD power generation systems.

Module IV (10 hours)

Definition, general description, types, design and construction of fuel cells - Thermodynamics of ideal fuel cells - Practical considerations - Present status - Future energy technologies - Hydrogen energy - Nuclear fusion.

References

1. S.S.L. Chang: Energy Conversion, Prentice Hall, 1963

2. G.W. Sutton: Direct Energy Conversion, McGraw Hill, 1966

3. S.L. Soo: Direct Energy Conversion, Prentice Hall, 1968

4. S.W. Angrist: Direct Endergy Conversion, 4e, Allwyn & Bycon, 1982

5. D. Merick and R. Marshall: Energy, Present and Future Options, Vol I & II, John Wiley, 1981

6. B. Sorenson: Renewable Energy, Academic Press, 1989

7. N.B. Breiter: Electro chemical Processes in fuel Cells, Spring-Verlag, 1969

8. B. Viswanathan and M. Aulice Scibioh: Fuel Cells - Principles and Applications, Universities Press, 2006

9. G. Boyle: Renewable Energy- Power for Sustainable Future, 2e, Oxford University Press, 2004

*PS: This subject is to be handled by 50:50 sharing basis between MED & EED

ME6423 ENERGY POLICIES FOR SUSTAINABLE DEVELOPMENT

ELECTIVE COURSE

L	T	P	C
3	0	0	3

Pre-requisite: Nil

Total Hours: 42

Course Assessment Methods:

2 Tests	:	20 marks each
Assignment	:	10 marks
End Exam	:	50 marks
Total	:	100 marks
Grading	:	Relative

Course outcomes:

CO1: Awareness of energy policies, their need and significance and the implications in energy utilization

CO2: Knowledge of latest issues in the areas of climate change policies and CDM and related regulatory issues

CO3: Ability to analyze diverse scenarios linking energy utilization and environmental issues with due consideration of prevailing energy policies

CO4: Ability to apply mathematical modeling techniques for energy planning and energy policy simulation.

Module I (11 hours)

Energy policies of India - Supply focus approach and its limitations - Energy paradigms – DEFENDUS approach - End use orientation - Energy policies and development - Case studies on the effect of Central and State policies on the consumption and wastage of energy - Critical analysis - Need for renewable energy policies in India.

Module II (11 hours)

Energy and environment - Green house effect - Global warming - Global scenario - Indian environmental degradation - Environmental laws - Water (prevention & control of pollution) act 1974 - The environmental protection act 1986 - Effluent standards and ambient air quality standards - Latest development in climate change policies & CDM.

Module III (10 hours)

Energy conservation schemes - Statutory requirements of energy audit – Economic aspects of energy audit - Capital investments in energy saving equipment - Tax rebates - Advantages of 100% depreciation – India's plan for a domestic energy cap & trade scheme.

Module IV (10 hours)

Social cost benefit analysis - Computation of IRR and ERR - Advance models in energy planning – Dynamic programming models in integrated energy planning - Energy planning case studies - Development of energy management systems - Decision support systems for energy planning and energy policy simulation.

References

1. J. Goldemberg, T.B. Johansson, A.K.N. Reddy and R.H. Williams: Energy for a Sustainable World, Wiley

Eastern, 1990

2. IEEE Bronze Book: Energy Auditing, IEEE Publications, 1996

3. P. Chandra: Financial Management Theory and Practice, Tata McGraw Hill, 1992

4. Annual Energy Planning Reports of CMIE, Govt. of India

5. A.K.N. Reddy and A.S. Bhalla: The Technological Transformation of Rural Inda, UN Publications, 1997

6. A.K.N. Reddy, R.H. Williams and J.B. Johanson: Energy After Rio-Prospects and Challenges, UN

Publications, 1997

7. P. Meier and M. Munasinghe: Energy Policy Analysis & Modeling, Cambridge University Press, 1993

8. R.S. Pindyck and D.L. Rubinfeld: Economic Models and Energy Forecasts, 4e, McGraw Hill, 1998

ME6427 ENERGY EFFICIENT BUILDINGS

ELECTIVE COURSE

L	T	P	C
3	0	0	3

Pre-requisite: Nil

Total Hours: 42

Course Assessment Methods:

2 Tests	:	20 marks each
Assignment	:	10 marks
End Exam	:	50 marks
Total	:	100 marks
Grading	:	Relative

Course outcomes:

CO1: Awareness of aspects of energy conscious building design pertinent to different climate zones

CO2: Ability to perform building design with due consideration of energy saving techniques and with optimal use of solar energy

CO3: Ability to analyze the various energy transfer processes applicable to buildings and assessment of building thermal loads

CO4: Capability to use computational/simulation tools for the analysis and design of energy efficient buildings

Module I (11 hrs)

Climate and shelter – Historic buildings – Modern architecture – Examples from different climate zones – Thermal comfort – Solar geometry and shading – Heating and cooling loads – Energy estimates and site planning – Integrative Modeling methods and building simulation.

Module II (10 hrs)

Principles of Energy conscious building design – Energy conservation in buildings – Day lighting – Water heating and photovoltaic systems – Advances in thermal insulation – Heat gain/loss through building components – Solar architecture.

Module III (10 hrs)

Passive solar heating – Direct gain – thermal storage wall – Sunspace – Convective air loop – Passive cooling – Ventilation - Radiation – Evaporation and Dehumidification – Mass effect – Design guidelines.

Module IV (11 hrs)

Energy conservation in building – Air conditioning – HVAC equipments – Computer packages for thermal design of buildings and performance prediction – Monitoring and instrumentation of passive buildings – Control systems for energy efficient buildings – Illustrative passive buildings – Integration of emerging technologies – Intelligent building design principles.

References

1. J. A. Clarke, Energy Simulation in Building Design (2e) Butterworth 2001.

2. J. K. Nayak and J. A. Prajapati Hadbook on Energy Consious Buildings, Solar Energy control MNES,2006.

3. Energy conservation Building Codes 2006; Bereau of Energy Efficiency.

4. J. R. Williams, Passive Solar Heating, Ann Arbar Science, 1983.

5. R. W. Jones, J. D. Balcomb, C. E. Kosiewiez, G. S. Lazarus, R. D. McFarland and W. O. Wray,Passive Solar Design Handbook, Vol. 3, Report of U. S. Department of Energy (DOE/CS-0127/3),1982.

6. M. S. Sodha, N. K,. Bansal, P. K. Bansal, A. Kumar and M. A. S. Malik. Solar Passive Building,Science and Design, Pergamon Press, 1986.

7. J. L. Threlkeld, Thermal Environmental Engineering, Prentice Hall, 1970.

*PS: This subject is to be handled by 50:50 sharing basis between MED & AED

ME6428 INTEGRATED ENERGY SYSTEMS

ELECTIVE COURSE

L	T	P	C
3	0	0	3

Pre-requisite: Nil

Total Hours: 42

Course Assessment Methods:

2 Tests	:	20 marks each
Assignment	:	10 marks
End Exam	:	50 marks
Total	:	100 marks
Grading	:	Relative

Course outcomes:

CO1; Awareness of basic principles of energy integration

CO2: Ability to develop mathematical models for integrated energy systems towards their design and performance assessment

CO3; Ability to apply optimization techniques for the design of integrated energy systems

CO4: Awareness of latest trends in integration of various power generation systems involving feasibility studies and consideration of techno-economic factors

Module I (10 hrs)

Energy consumption pattern – Projection of energy demands – Possible substitution of conventional sources – Modern technological options – Introduction to hybrid and integrated energy systems – Total energy concept and waste heat utilization.

Module II (11 hrs)

Modeling of Integrated energy systems – Load matching and scheduling – Various possibilities to build hybrid systems – Problems associated with integrated energy systems – Performance analysis.

Module III (11 hrs)

Optimal design of hybrid energy systems – Special optimization techniques applicable – Energy economics and cost optimization of integrated energy systems – Sample problems and case studies.

Module IV (10 hrs)

Integration of various power generation systems – Feasibility studies – Site selection – Related social, economic and technical problems – Special role of wind and biogas systems – Future prospects and case studies.

References

1. P. R. Shukla, T. K. Moulik, S. Modak and P. Deo; Strategic Management of Energy Conservation,

Oxford & IBM Publishing Co., 1993.

2. W. R. Murthy and G. McKay; Energy Management, Butherworth Heinemann, 2001.

3. S. S. Rao; Textbook on Engineering Optimization – Theory and Practice, 3rd Edition, J. Wiley, 1996.

4. R. D. Begamudre: Energy Conversion Systems, New Age Int. Pub., 2000.

5. D. Merick and R. Marshall; Energy, Present and Future Options, Vol. I & Vol. II, J. Wiley, 1981.

***PS: This subject is to be handled by 50:50 sharing basis between MED & EED**

ME6311 INDUSTRIAL AUTOMATION AND ROBOTICS

ELECTIVE COURSE

L	T	P	C
3	0	0	3

Pre-requisite: Nil

Total Hours: 42

Course Assessment Methods:

2 Tests	:	20 marks each
Assignment	:	10 marks
End Exam	:	50 marks
Total	:	100 marks
Grading	:	Absolute

Course outcomes:

CO1: Understand the basic types, levels, strategies of automation

CO2: Understand and analyse the types of continuous and discrete control systems

CO3: Ability to model robots kinematically and dynamically.

CO4: Ability to design trajectory for robot motions and implementing robot motion through programming

Module I (10 hours)

Introduction to automation-Definition, types, merits and Criticism- Architecture of industrial automation systems-Manufacturing plants and operations-automation strategies-Basic elements of automated system- Advanced Automation functions-Levels of automation.

Module II (10 hours)

Industrial control Systems- Process, Discrete manufacturing industries-Continuous and Discrete Control systems-An overview of Computer process control- Fundamentals of automated assembly system. Actuators& Sensors, Fluid Power and Electrical Actuators-Piezoelectric Actuator; Sensors for position, motion, force, Strain and temperature.

Module III (11 hours)

Introduction to Robotics-Robotics System-Classification of Robots-Robot Characteristics-Kinematics for manipulator-Frames and Transformations-Forward and inverse Kinematics-DH representation-Derivation of forward and Inverse kinematic equations for various types of Robots- Applications of Robots.

Module IV (11 hours)

Introduction to manipulator Jacobian- Tool Jacobian- Velocity Propagation from link to link-Static forces in manipulators-Jacobian in Force domain-Introduction to dynamic analysis-Lagrangian formulation-Trajectory planning-Joint space and Cartesian space.

References

1. John J Craig: Introduction to Robotics, Mechanics and control, second Edition Addison – Wesley, 1999.

2. Saeed B Niku: Introduction to Robotics, Analysis, Systems and applications. Prentice Hall India-2002.

3. Groover, Mikell. P: Automation, Production systems and Computer integrated Manufacturing –Prentice hall India-2004.

4 Mark W Spong & M Vidyasagar: Robot Dynamics and Control, John Wiley & Sons, 1989

5 K S Fu R C Gonzales, C S G Lee: Robotics Control, Sensing, Vision and Intelligence, McGraw Hill 1987

6 R P Paul: Robot Manipulators Mathematics Programming, Control, The computer control of robotic manipulators, The MIT Press 1979

7 Robert J Schilling: Fundamentals of Robotics, Analysis and Control. Printice Hall of India 1996

8 R.K.Mittal and I.J.Nagarath: Robotics and Control, TMH-2003

9 Groover, Mikel.P: CAD/CAM-Computer Aided Design and manufacturing-PHI-2000

MA 7165 STATISTICAL DIGITAL SIGNAL PROCESSING

ELECTIVE COURSE

L	T	P	C
3	0	0	3

Total hours: 56Hrs

Course Assessment Methods:

2 Tests	:	20 marks each
Assignment	:	10 marks
End Exam	:	50 marks
Total	:	100 marks
Grading	:	Relative

Course outcomes:

CO1: Acquire knowledge about random variables and random processes.

CO2: To learn about digital signal modeling and various techniques used for stochastic modeling.

CO3: Understanding and applying the concept of filtering in digital signal processing.

CO4: Acquire knowledge about theory and application of various types of filters.

CO5: To learn about parametric and nonparametric methods for spectrum estimation.

Module I: (15 hours)

Discrete-Time Random Processes: Random Variables, Random Processes, Filtering Random Processes,Spectral Factorization, Special Types of Random Processes.

Module II: (12 hours)

Signal Modeling: The Least Squares Method, The Pade Approximtion, Prony's Method, Finite Data Records, Stochastic Models.

Module III: (14 hours)

Lattice Filters and Wiener Filtering: The FIR Lattice Filter, Split Lattice Filter, IIR Lattice Filters, Stochastic Modeling, The FIR Wiener Filter, IIR Wiener Filter, Discrete Kalman Filter.

Module IV: (15 hours)

Spectrum Estimation: Nonparametric Methods, Minimum Variance Spectrum Estimation, The Maximum Entropy Method, Parametric Methods, Frequency Estimation, Principal Components Spectrum Estimation.

References:

1. M. H. Hayes; "Statistical Digital Signal Processing and Modeling", John Wiley & Sons, 2004.

2. G. J. Miao and M. A. Clements; "Digital Signal Processing and Statistical Classification", Artech House, London, 2002.

3. R. M. Gray and L. D. Davisson ; “An Introduction to Statistical Signal Processing”, Cambridge University Press, 2004.

MA7169 APPLIED FUZZY LOGIC AND FUZZY SETS

ELECTIVE COURSE

L	T	P	C
3	0	0	3

(Prerequisite: Artificial Neural Network and Fuzzy Systems)

Total Hours: 42

Course Assessment Methods:

2 Tests	:	20 marks each
Assignment	:	10 marks
End Exam	:	50 marks
Total	:	100 marks
Grading	:	Relative

Course outcomes:

CO1: This course aims at providing the basic concepts in fuzzy sets and fuzzy measures which is useful in the area of soft computing

Module I: Crisp sets and Fuzzy sets (11 hours)

Introduction – crisp sets an overview – the notion of fuzzy sets –basic concepts of fuzzy sets – membership functions – methods of generating membership functions – defuzzification methods- operations on fuzzy sets - fuzzy complement – fuzzy union – fuzzy intersection – combinations of operations – General aggregation operations.

Module II: Fuzzy arithmetic and Fuzzy relations (11 hours)

Fuzzy numbers- arithmetic operations on intervals- arithmetic operations on fuzzy numbers- fuzzy equations- crisp and fuzzy relations – binary relations – binary relations on a single set – equivalence and similarity relations – compatibility or tolerance relations.

Module III :Fuzzy measures (10 hours)

Fuzzy measures – belief and plausibility measures – probability measures – possibility and necessity measures – possibility distribution - relationship among classes of fuzzy measures.

Module IV: Fuzzy Logic and Applications (10 hours)

Classical logic : an overview – fuzzy logic – approximate reasoning - other forms of implication operations - other forms of the composition operations – fuzzy decision making –fuzzy logic in database and information systems - fuzzy pattern recognition – fuzzy control systems.

References:

1. George J Klir and Tina A Folger , Fuzzy sets, Uncertainty and Information, Prentice Hall of India, 1988.
2. H.J. Zimmerman, Fuzzy Set theory and its Applications, 4th Edition, Kluwer Academic Publishers, 2001.
3. Goerge J Klir and Bo Yuan , Fuzzy sets and Fuzzy logic: Theory and Applications Prentice Hall of India, 1997.

4. Hung T Nguyen and Elbert A Walker, First Course in Fuzzy Logic, 2nd Edition , Chapman & Hall/CRC, 1999.
5. Jerry M Mendel, Uncertain Rule – Based Fuzzy Logic Systems ; Introduction and New Directions, PH PTR, 2000.
6. John Yen and Reza Langari, Fuzzy Logic : Intelligence Control and Information, Pearson Education, 1999.
7. Timothy J Ross, Fuzzy Logic with Engineering Applications, McGraw Hill International Editions, 1997.

MA 8163 ADVANCED OPERATIONS RESEARCH

ELECTIVE COURSE

L	T	P	C
3	0	0	3

(Prerequisite: Linear programming)

Total hours: 42

Course Assessment Methods:

2 Tests	:	20 marks each
Assignment	:	10 marks
End Exam	:	50 marks
Total	:	100 marks
Grading	:	Relative

Course outcomes:

CO1: To introduce mathematical techniques which will help to understand and analyze problems in real life situations and managerial problems in industry so that resources (capitals, materials, staffing, machines etc.) may be utilized more effectively.

CO2: application of mathematical techniques to solve decision making problems in order to analyze and understand a system, for the purpose improving its performance.

Module I (12 hours)

Mathematical preliminaries. Maximum and Minimum-Quadratic forms-Gradient and Hessian matrices-Unimodal functions-Convex sets-Convex and concave functions-Mathematical programming Problems. Varieties and characteristics –Difficulties caused by nonlinearity-Role of convexity in Non linear programming- Unconstrained optimization-Search methods. Fibonacci search-Golden section search.

Module II (10 hours)

Hooke and Jeeve’s Method –Optimal gradient method-Newtons method- Constrained nonlinear optimization-Constrained optimization with equality constraints-Lagrangian method-Sufficiency conditions- Optimization with inequality constraints- Kuhn-Tucker conditions- Sufficiency Conditions

Module III (10 hours)

Quadratic programming- Separable programming-Frank and wolfe's method-Kelley'cutting plane method- Rosen's gradient projection method-Fletcher-Reeve's method-Penalty and Barrier method.

Module IV (10 hours)

Integer linear programming-Gomory's cutting plane method-Branch and Bound Algorithm-Travelling salesesman problem- knapsack problem- Introduction to optimization softwares.

References:

1.Taha.H.A. "Operation Research-An introduction"-Prentice Hall, 6th Edn, 2006.

2.Simmons.D.M. "Nonlinear Programming for Operations Research" Prentice Hall, 1993.

3.M.S.Bazaara, H.D Sherali,,C.M.Shetty- "Nonlinear Programming Theory and Algorithm"-John Wiley, 2003.

MA 8167 DESIGN OF EXPERIMENTS

ELECTIVE COURSE

(Pre-requisite: Statistical Methods)

L	T	P	C
3	0	0	3

Total hours: 42

Course Assessment Methods:

2 Tests	:	20 marks each
Assignment	:	10 marks
End Exam	:	50 marks
Total	:	100 marks
Grading	:	Relative

Course outcomes:

CO1: This course aims at introducing the Design of Experiments and analysis of variance with a perspective to apply it to different real world systems, like engineering, medical science, R&D activities etc.

CO2: To learn deferent experimental designs and basic concepts of randomization, replication, data classification, etc.

CO3: To learn 2^k Full factorial experiments, confounding of 2^k design in 2^p blocks, $p \geq 2$, Fractional factorial experiments, 3^k designs and the analysis of variance of all these designs.

CO4: To learn the Response surface methodology (RSM) - linear and quadratic model, ridge systems, Box-Behnken design, optimal designs, simplex lattice designs, simplex centroid designs etc.

CO5: To learn the Taguchi methods, Random effect models and mixed models, Restricted and unrestricted mixed models, Nested and split-plot designs.

Module I: (14 hours)

Introduction, Randomization, replication, local control, one way and two way classification with unequal and equal number of observations per cell (with / without interactions). Connectedness, balance, orthogonality, BIBD, ANOCOVA.

ModuleII: (14 hours)

2k Full factorial experiments: diagramatic presentation of main effects and first and second order interactions, model, analysis of single as well as more than one replicates, using ANOVA.

Total confounding of 2k design in 2p blocks, $p \geq 2$. Partial confounding in 2p blocks, p =2, 3. Fractional factorial experiments. Resolution of a design, (III, IV & V), aberration of a design. Plackett-Burman design.

3k designs: contrasts for linear and quadratic effects , statistical analysis of 3k design, confounding and fractional experiments in 3k design.

Module III: (14 hours)

Response surface methodology (RSM): linear and quadratic model, stationary point, Central composite designs(CCD), ridge systems, multiple responses, Concept of rotatable design, Spherical CCD, Box-Behnken design, face-centered CCD, equiradial designs, small composite designs, blocking in RSM, optimal designs, simplex lattice designs, simplex centroid designs.

Module IV: (14 hours)

Taguchi methods: concept of loss function, S/N ratio, orthogonal arrays, triangular tables, linear graphs, inner and outer arrays.

Random effect models and mixed models. Restricted and unrestricted mixed models. Nested and split-plot designs.

References:

1. John P.W.M., Linear Models, John Wiley Ltd., 1971.

2. Montgomery, D.C., Design and Analysis of Experiments, John Wiley, 2001.

3. Ogawa J., Statistical Theory of the Analysis of Experimental Design, Marcel Dekker, 1974.

4. Hicks, C.R. and Turner K.V., Fundamental Concepts in the Design of Experiments 5th Edn., Oxford university Press1999.

5. Dean A. and Voss D., Design and Analysis of Experiments. Springer-Verlag, 1999.

MA 7160 SIMULATION AND MODELLING

ELECTIVE COURSE

L	T	P	C
3	0	0	3

(Pre-requisite: Statistical Methods)

Total hours: 56

Course Assessment Methods:

2 Tests	:	20 marks each
Assignment	:	10 marks
End Exam	:	50 marks
Total	:	100 marks
Grading	:	Relative

Course outcomes:

CO1: This course aims at introducing the simulation of stochastic systems with a perspective to apply it for various stochastic system studies in the real world.

CO2: To learn deferent kinds of stochastic systems, generation of random samples, modelling and simulation of continuous systems, methodology for discrete system simulation.

CO5: To learn the Simulation of Stochastic Network - Simulation of PERT Network and applying it. The simulation of PERT network plays a vital role in planning and R&D activities.

Module I: (14 hours)

Introduction to system simulation -Introduction: Systems and models – Computer simulation and its applications. Continuous system simulation- Modelling continuous systems, simulation of continuous systems. Discrete system simulation- Methodology, event scheduling and process interaction approaches. Random number generation – testing of randomness, generation of stochastic variates, Random samples from continuous distributions – Uniform distribution, Exponential distribution m-Erlang distribution, Gamma distribution, Normal distribution, Beta distribution, Random samples from discrete distributions -Bernoulli, Discrete uniform, Binomial, Geometric and Poisson.

Module II: (14 hours)

Evaluation of Simulation Experiments and Simulation Languages - Evaluation of simulation experiments verification and validation of simulation experiments, Statistical reliability in evaluating simulation experiments – Confidence intervals for terminating simulation runs - Simulation Languages: Programming Considerations – General features of GPSS,

Module III: (14 hours)

SIMSCRIPT and SIMULA. Simulation of Queuing Systems - Introduction – Parameters of queue, formulation of queuing problems, generation of arrival pattern, generation of service pattern, simulation of single server queues, simulation of multi-server queues, simulation of tandem queues. Computer simulation of Queuing systems.

Module IV: (14 hours)

Simulation of Stochastic Network - Introduction: Simulation of PERT Network – Definition of network diagrams, forward pass computation, simulation of forward pass, backward pass computations, simulation of backward pass, determination of float and slack times determination of critical path, simulation of complete network, merits of simulation of stochastic networks. Computer simulation of PERT network.

References:

1. Deo,N ," (1989), “System Simulation and Digital Computer" , PHI, Delhi.

2. Gordan, G , (1990), "System Simulation" , PHI, Delhi.

3. Banks, J., Carson, J. S., and Nelson, B. L., (2000), “Discrete –Event System Simulation, 2nd edn., PHI, New Delhi.

4. Law, A.M. and Kelton, W.D , (1990), "Simulation Modelling and Analysis", Mc- Graw Hill.

MA 7166 STATISTICAL METHODS FOR QUALITY MANAGEMENT

ELECTIVE COURSE

L	T	P	C
3	0	0	3

(Pre-requisite: Statistical Methods)

Total Hours: 42Hrs

Course Assessment Methods:

2 Tests	:	20 marks each
Assignment	:	10 marks
End Exam	:	50 marks
Total	:	100 marks
Grading	:	Relative

Course outcomes:

CO1: This course aims at introducing the various Statistical Tools for Quality Management.

CO2: To learn about design of experiments and the application analysis of variance for decision making in R&D.

CO3: Acquire knowledge about Statistical process control and study the chance and assignable causes of quality variation.

CO4: To learn and apply various control charts for variables and attributes in quality management.

CO5: To learn about Reliability Statistics and studying the application of probability theory for reliability analysis and quality management.

Module I: (11 hours)

Design and analysis of experiments : Introduction to design and analysis of experiments. Single Factor design and Analysis of Variance. Randomized Blocks, Latin Squares and Related Designs. Introduction to Factorial Designs : Basic Definitions and Principles, The Two-Factor Factorial Design, The General Factorial Design, Fitting Response Curves and Surfaces, Blocking in a Factorial Design.

Module II: (11 hours)

Statistical process control: Chance and assignable causes of quality variation, setting up of operating control charts for RandX, Control charts for X and S, Control charts for individual measurements, Applications of variables control charts. Control charts for Attributes- control charts for Fraction nonconforming, control charts for nonconformities(defects).

Module III: (10 hours)

Cumulative sum and exponentially weighted moving average control charts- The cumulative-sum control charts, The exponentially weighted moving-average control charts, the moving average moving control charts. Statistical process control techniques, process capability analysis. Acceptance sampling for attributes.

Module IV: (10 hours)

Reliability Statistics: Reliability definition, availability, reliability bathtub curve, estimating MTBF, reliability prediction, confidence interval for MTBF, testing, system reliability, series systems, parallel systems, Baye's theorem applications, non-parametric and related test designs, hazard function, Weibul distribution, Log-normal distribution, stress- strength inference, Binomial confidence intervals, Arrhenius model, sequential testing.

References:

1. Grant E. L., and Leavenworth R. S., Statistical Quality control, 7th Ed.n; McGraw- Hill Companies Inc. 1996.

2. Montgomery D. C., Introduction to Statistical Quality Control, 3rd Edn., John Wiley and sons1997

3. Montgomery D. C., Design and Analysis of Experiments, 5th Edn., John Wiley & Sons, Inc., 2001.

4. Dovich R. A., Reliability statistics, A S Q Quality Press., 1990.

MA8154 WAVELETS THEORY
ELECTIVE COURSE

L	T	P	C
3	0	0	3

(Pre-requisite:Nil)

Total Hours: 42Hrs

Course Assessment Methods:

2 Tests	:	20 marks each
Assignment	:	10 marks
End Exam	:	50 marks
Total	:	100 marks
Grading	:	Relative

Course outcomes:

CO1: Acquire knowledge about the basic linear algebra results

CO2: Acquire knowledge about the discrete Fourier transforms and the fast Fourier transforms algorithm

CO3: Acquire knowledge about wavelets on the finite dimensional spaces.

CO4: Acquire knowledge about wavelets on the infinite dimensional spaces.

CO5: Acquire knowledge about construction of multi resolution analysis.

ModuleI: (11hours)
Vector spaces and Bases, Linear transformation, Matrices and change of basis, Inner products, Hilbert Space, Fourier transforms , Parsevl identity and Plancherel theorem, Basic Properties of Discrete Fourier Transforms , Translation invariant Linear Transforms ,The Fast Fourier Transforms.

Module II: (11 hours)
Construction of wavelets on Z_N ,The Haar system, Shannon Wavelets, Real Shannon wavelets , Daubechies's D_6 wavelets on Z_N., Examples and applications.

Module III: (11hours)
Wavelets on Z**:** l^2 (Z), Complete orthonormal sets in Hilbert spaces , and Fourier series ,The Fourier Transform and convolution on l),(2ππ−L^2 (Z) , First stage Wavelets on Z , Implementation and Examples.

Module IV: (9 hours)
Wavelets on R : L^2 (R) and approximate identities , The Fourier transform on R , Multiresolution analysis , Construction of MRA .

References:
1. Michael. W. Frazier, "An Introduction to Wavelets through Linear Algebra", Springer, Newyork, 1999.
2. Jaideva. C. Goswami, Andrew K Chan, "Fundamentals of Wavelets Theory Algorithms and Applications", John Wiley and Sons, Newyork. , 1999.
3. Yves Nievergelt, "Wavelets made easy", Birkhauser, Boston,1999.

4. G. Bachman, L.Narici and E. Beckenstein , "Fourier and wavelet analysis", Springer,

EC6421: IMAGE & VIDEO PROCESSING

ELECTIVE COURSE

L	T	P	C
3	0	0	3

Pre-requisite: Nil

Total Hours: 42Hrs

Course Assessment Methods:

2 Tests	:	20 marks each
Assignment	:	10 marks
End Exam	:	50 marks
Total	:	100 marks
Grading	:	Relative

Course outcomes:

CO1: Acquire strong mathematical skills in the theory of linear systems for analyzing and solving problems in image and video processing: Basic 2-D signal processing, 2-D Fourier and other transforms, convolution and filtering operations in 2-D.

CO2: Recognize the needs and challenges of our age, and to assess the global and social impacts of image and video processing solutions: Basic understanding of the widespread use of digital imaging and video acquisition systems; the need for effective use of scarce resources such as storage and bandwidth, and ways to provide effective use of them by data compression; social impacts and applications of object recognition systems, such as in security, entertainment and automation fields.

CO3: Identify, formulate and solve image processing problems: Modeling of digital images, degradations such as noise and motion blur and video data; derivation of conditions for optimal filtering, thresholding, coding and transmission of images and videos; analyzing and evaluating systems; the performance of image enhancement, restoration and coding algorithms through the use of both subjective and objective metrics; identifying the source of redundancy in images and exploiting this redundancy for developing efficient coding techniques.

CO4: Design and integrate components of image processing systems to satisfy given requirements: Selecting the design parameters for optimal performance of related image processing systems; designing and integrating enhancement and restoration techniques for different applications; integrating different coding tools and selecting the related coding parameters for efficient lossless and lossy image compression; designing simple object segmentation and recognition algorithms.

CO5: Use the software based modeling, simulation and design tools necessary for practical image processing applications : Design and implementation of enhancement, restoration, coding, and transformation algorithms for image and video data in MATLAB/ C++.

CO6: Acquire communication skills by conducting seminars on the latest topics relevant to the areas covered in the paper.

CO7: Explore advanced topics in the current research areas of image and video processing which will enable them to engage in lifelong learning in specific areas of interest

Module 1: (10 Hrs)

Image representation: Gray scale and colour Images, image sampling and quantization. Two dimensional orthogonal transforms: DFT, WHT, Haar transform, KLT, DCT. Image enhancement - filters in spatial and frequency domains, histogram-based processing, homomorphic filtering. Edge detection - non parametric and model based approaches, LOG filters, localisation problem.

Module 2: (10 Hrs)

Image Restoration: Degradation Models, PSF, circulant and block - circulant matrices, deconvolution, restoration using inverse filtering, Wiener filtering and maximum entropy-based methods.

Image Segmentation: Pixel classification, Bi-level thresholding, Multi-level thresholding, P-tile method, Adaptive thresholding, Spectral & spatial classification, Edge detection, Hough transform, Region growing.

Module 3: (11 Hrs)

Fundamental concepts of image compression - Compression models - Information theoretic perspective - Fundamental coding theorem - Lossless Compression: Huffman Coding- Arithmetic coding - Bit plane coding - Run length coding - Lossy compression: Transform coding - Image compression standards.

Module 4: (11 Hrs)

Video Processing: Representation of Digital Video, Spatio-temporal sampling; Motion Estimation; Video Filtering; Video Compression, Video coding standards.

References

1. 1. A. K. Jain, Fundamentals of digital image processing, Prentice Hall of India, 1989.
2. R. C. Gonzalez, R. E. Woods, Digital Image Processing, Pearson Education. II Ed.,2002
3. W. K. Pratt, Digital image processing, Prentice Hall, 1989
4. A. Rosenfold and A. C. Kak, Digital image processing, Vols. 1 and 2, Prentice Hall, 1986.
5. H. C. Andrew and B. R. Hunt, Digital image restoration, Prentice Hall, 1977
6. R. Jain, R. Kasturi and B.G. Schunck, Machine Vision, McGraw-Hill International Edition, 1995
7. A. M. Tekalp, Digital Video Processing , Prentice-Hall, 1995
8. A. Bovik, Handbook of Image & Video Processing, Academic Press, 2000