University of Pune

B. E. Electrical Engineering 2008 - Course (w.e.f. 2011)

SEMESTER - I									
Sr No	**Subject code**	**Subject Title**	**Teaching Scheme**		**Exam. Scheme**				**Total Marks**
			L	**P**	**P**	**TW**	**PR**	**OR**	
1.	403141	PLC and SCADA Applications	04	02	100	25	50	--	175
2.	403142	Power System Operation and Control	04	02	100	25	--	50	175
3.	403143	Elective – I	04	--	100	--	--	--	100
4.	403144	Elective – II	04	--	100	--	--	--	100
5.	403145	Control System – II	04	02	100	50	--	50	200
6.	403146	Project	--	02	--	--	--	--	--
			20	**08**	**500**	**100**	**150**		**750**

SEMESTER - II									
Sr No	**Subject code**	**Subject Title**	**Teaching Scheme**		**Exam. Scheme**				**Total Marks**
			L	**P**	**P**	**TW**	**PR**	**OR**	
1.	403147	Switchgear and Protection	04	02	100	25	--	50	175
2.	403148	Industrial Drives and Control	04	02	100	25	50	-	175
3.	403149	Elective – III	04	02	100	25	--	25	150
4.	403150	Elective – IV	04	--	100	--		--	100
5.	403146	Project	--	06	--	100	--	50	150
			16	**12**	**400**	**175**	**175**		**750**

Elective – I (403143)

a) Robotics and Automation
b) Power Quality
c) Illumination Engineering
d) Project Management

Elective – II (403144)

Restructuring and Deregulation
Embedded System
EHV Transmission
Smart Grid

Elective – III (403149)

a) VLSI Design
b) High Voltage Engineering
c) Digital Signal Processing
d) ANN and its Applications in Electrical Engineering

Elective – IV (403150)

Modelling of Electrical System
Renewable Energy System
Digital Control System
Open Elective

Chairman,
Board of Studies
Electrical Engineering
University of Pune

403141: PLC and SCADA Application

Teaching Scheme
Lectures: 4 Hrs./Week
Practical: 2 Hrs./Week

Examination Scheme
Theory: 100 Marks
Practical: 50 Marks
Term Work: 25 Marks

Unit I **(8)**

Introduction to PLC: Definition & History of PLC, Overall PLC system, PLC Input & Output modules, central processing unit, CPUs & Programmer/monitors, Solid state memory, the processor, Input modules (Interfaces), Power supplies, PLC advantages & disadvantages. Selection criteria for PLC.

Unit II (8)

Programming of PLC: Programming equipments, proper construction of PLC ladder diagram, Basic components & their symbols in ladder diagram, Fundamentals of ladder diagram, Boolean logic & relay logic, and analysis of rungs.
Input ON/OFF switching devices, Input analog devices, Output ON/OFF devices, Output analog devices, programming ON/OFF Inputs to produce ON/OFF outputs.

Unit III (8)

Advanced PLC Function: Analog PLC operation, PID control of continuous processes, simple closed loop systems, problems with simple closed loop systems, closed loop system using Proportional, Integral & Derivative (PID), PLC interface, and Industrial process example.
Motors Controls: AC Motor starter, AC motor overload protection, DC motor controller, Variable speed (Variable Frequency) AC motor Drive.

Unit IV (8)

SCADA Systems: Introduction and definitions of SCADA, Fundamental principles of modern SCADA systems, SCADA system evolution.
Basic SCADA system Architecture: Human Machine Interface, Master Terminal Unit, Remote Terminal Unit. SCADA data transfer through PLCC.
Communication Technologies, Communication system components, SCADA Communication in an electrical power system.
SCADA system desirable Properties, Real Time System, SCADA server, SCADA functions.

Unit V (8)

SCADA Architecture: First generation - Monolithic, Second generation - Distributed, Third generation – Networked Architecture, Intelligent Electronic Devices.
Operation and control of interconnected power system, Automatic substation control, SCADA configuration, Energy management system, system operating states, system security, State estimation, SCADA system security issues overview.
SCADA systems in the critical Infrastructure: Petroleum Refining Process, Conventional Electric Power Generation, water Purification System, Chemical Plant.

Unit VI (8)

The Evolution of SCADA Protocols: Overview of Open systems interconnection (OSI) Model, Functions of OSI Model Layers, OSI Protocols, Functions of Transmission control protocol / Internet protocol (TCP/IP) Layers, TCP/IP protocol, DNP3 protocol, IEC61850 layered architecture, Control and Information Protocol (CIP), DeviceNet, ControlNet, EtherNet/IP, Flexible Function Block process (FFB), Process Field bus (Profibus), The Security Implications of the SCADA protocols.

List of Experiments:

Note: Minimum 10 experiments should be conducted.

a) Experiment No. 1, 2, and 3 is compulsory.

b) Any 2 experiments should be conducted from experiment number 4 to 9.

c) Any 5 experiments should be conducted from experiment number 10 to 17.

1) a) Interfacing of lamp & button with PLC for ON & OFF operation.
   b) Performed delayed operation of lamp by using push button.
2) a) Multiple push button operation with delayed lamp for ON/OFF operation.
   b) Combination of counter & timer for lamp ON/OFF operation.
3) Set / Reset operation: one push button for ON & other push button for OFF operation.
4) DOL starter & star delta starter operation by using PLC.
5) PLC based temperature sensing using RTD.
6) PLC based thermal ON/OFF control.
7) Interfacing of Encoder with PLC (Incremental/Decremental)
8) PLC based speed, position measurement system.
9) Development of Dynamos & relating with parameters of PLC.
10) PLC interfaced with SCADA & status read/command transfer operation.
11) Parameter reading of PLC in SCADA.
12) Alarm annunciation using SCADA.
13) Reporting & trending in SCADA system.
14) Tank level control by using SCADA.
15) Temperature monitoring by using SCADA.
16) Speed control of Machine by using SCADA.
17) Pressure control by using SCADA.

Industrial Visit:

Compulsory visit to SCADA and PLC based automation industry.

Text Books:

1) Gary Dunning, "Introduction to Programmable Logic Controllers", Thomson, 2nd Edition
2) John R. Hackworth, Frederick D., Hackworth Jr., "Programmable Logic Controllers Programming Methods and Applications"
3) John W. Webb, Ronald A. Reis, "Programmable Logic Controllers: Principles and Application", 5th Edition
4) Ronald L. Krutz, "Securing SCADA System", Wiley Publishing
5) Stuart A Boyer, "SCADA supervisory control and data acquisition"

Reference Books:

1) Batten G. L., "Programmable Controllers", McGraw Hill Inc., Second Edition
2) Bennett Stuart, "Real Time Computer Control", Prentice Hall, 1988
3) Doebelin E. O., "Measurement Systems", McGraw-Hill International Editions, Fourth Edition, 1990
4) Gordan Clark, Deem Reynders, "Practical Modem SCADA Protocols"
5) Krishna Kant, "Computer Based Industrial Control", PHI
6) M. Chidambaram, "Computer Control of Process", Narosha Publishing
7) P. K. Srivstava, "Programmable Logic Controllers with Applications", BPB Publications
8) Poppovik Bhatkar, "Distributed Computer Control for Industrial Automation", Dekkar Publications
9) S. K. Singh, "Computer Aided Process Control", PHI
10) Sunil S. Rao, "Switchgear and Protections", Khanna Publication
11) Webb J. W, "Programmable Controllers", Merrill Publishing Company, 1988

403142: Power System Operation and Control

Teaching Scheme
Lectures: 4 Hrs./Week
Practical: 2 Hrs./Week

Examination Scheme
Theory: 100 Marks
Oral: 50 Marks
Term Work: 25 Marks

Unit I (10)

Power System Stability: Introduction to stability, dynamics of synchronous machine, swing equation, power angle equation and curve, types of power system stability (concepts of steady state, transient, dynamic stability), equal area criterion, applications of equal area criterion (sudden change in mechanical input, effect of clearing time on stability, critical clearing angle, short circuit at one end of line, short circuit away from line ends and recloser), solution of swing equation by point by point method, concept of multimachine stability, methods to improve steady state and transient stability, numerical based on equal area criteria.

Unit II (08)

Reactive Power management: Necessity of reactive power control, reactive power generation by a synchronous machine, effect of excitation, loading capability curve of a generator, compensation in power system (series and shunt compensation using capacitors and reactors), concept of sub synchronous resonance, synchronous condenser.

Unit III (08)

FACTs Technology: Problems of AC transmission system, evolution of FACTs technology, principle of operation, circuit diagram and applications of SVC, TCSC, STATCOM and UPFC.

Unit IV (10)

Economic load dispatch and unit commitment:

A) Economic load dispatch: Introduction ,revision of cost curve of thermal and hydropower plant, plant scheduling method, equal incremental cost method, method of lagrange multiplier (neglecting transmission losses), B_{mn} coefficient , economic scheduling of thermal plant considering effect of transmission losses, penalty factor, numerical.

B) Unit commitment:-
Concept of unit commitment, constraints on unit commitment – spinning reserve, thermal and hydro constraints, methods of unit commitment – priority list and dynamic programming.

Unit V (08)

Automatic generation and control: Concept of AGC, complete block diagram representation of load-frequency control of an isolated power system, steady state and dynamic response, control area concept, two area load frequency control, load frequency control with generation rate constraints (G.R.C.S.), effect of speed governor dead band on A.G.C., digital load frequency controller.

Unit VI (06)

Energy Control: Interchange of power between interconnected utilities, economy interchange evaluation, interchange evaluation with unit commitment, types of interchange, capacity and diversity interchange, energy banking, emergency power interchange, inadvertent power exchange, power pools.

List of Experiments:

Note:- Perform experiment 1 or 2 and any seven from 3 to 11 using software

1. To determine Steady state Stability of synchronous motor (performance).
2. To determine Steady state stability of medium transmission line (performance).
3. To plot swing curve by Point by Point method for transient stability analysis.
4. To apply equal area criteria for analysis stability under sudden rise in mechanical power input.
5. To apply equal area criteria for stability analysis under fault condition.
6. To study reactive power compensation using any device by professional software.
7. To study lagrange multiplier technique for economic load dispatch by Professional software.
8. To develop dynamic programming method for unit commitment by professional software.
9. To study load frequency control using approximate and exact model by professional software.
10. To study load frequency control with integral control by professional software.
11. To study the two area load frequency control.

Industrial Visit:

At least one industrial visit should be arranged to Load Dispatch Center / Power Station Control Room.

Text Books:

1. Abhijit Chakrabarti, Sunita Halder, "Power System Analysis Operation and Control", Prentice Hall of India
2. I. J. Nagrath, D. P. Kothari, "Modern Power System Analysis", Tata McGraw Hill Publishing Co. Ltd.
3. P. S. R. Murthy, "Power System Operation & Control", Tata McGraw Hill Publishing Co. Ltd.
4. P. S. R. Murthy, "Operation & Control in Power System", B. S. Publication

Reference Books:

1. Allen J. Wood, Bruce F. Wollenberg "Power Generation, Operation, and Control", Wiley India Edition.
2. "Electrical Power System Handbook", IEEE Press
3. Hingorani, "Understanding FACTs" IEEE Press
4. Olle I. Elgerd, "Electrical Energy System Theory", 2nd Edition, Tata McGraw Hill Publishing Co. Ltd.
5. Prabha Kundur " Power system stability and control" Tata McGraw Hill
6. R. Mohan Mathur, Rajiv K. Varma, "Thyrister based FACTs controller for Electrical transmission system', John Wiley & Sons Inc.

403143 Elective – I: a) Robotics and Automation

Teaching Scheme
Lectures: 4 Hrs./Week

Examination Scheme
Theory: 100 Marks

Unit I **(8)**

Introduction: Basic concept of automation, types of automation: fixed, flexible & programmable and their comparative study. Introduction to NC and CNC machines – Basic concept, block diagram difference and comparison with robots, advantages, disadvantages.

A brief history, definition, laws of Robotics, Robot like devices such as prostheses, exoskeletons, robot manipulator etc.

Basic structure, links & joints, types of joints, types of links, specifications: degrees of freedom (DOF), accuracy, repeatability, spatial resolution, compliance, load carrying capacity, speed of response, work volume, work envelope, reach etc., end effectors (Wrist), concept of: yaw, pitch and roll. Motion conversion: Rotary to rotary, rotary to linear and vice versa.

Unit II **(8)**

Anatomy of robots: Overview of a robot manipulator system – basic components of robot, robot as a cell controller and as a peripheral device, overview of robot applications in industrial automation.

Types of end effectors: Grippers and tools.

Robot classification: according to Co-ordinate system: Cartesian, cylindrical, spherical, SCARA, Articulated, Control Method: Servo controlled & non-servo controlled, their comparative study, Form of motion: P-T-P (point to point), C-P (continuous path), pick and place etc. and their comparative study, Drive Technology: Hydraulic, Pneumatic, Electric (stepper motor, D.C. servo motor) in detail with selection criteria.

Unit III **(8)**

Homogeneous Coordinate, Translational Transformation, Rotational Transformation, coordinate reference frames, Effect of pre and post multiplication of transformation, Concept of Homogeneous transformation, Different Euler angle systems, Singularities in Euler angles.

Unit IV **(8)**

Forward Kinematics: Denavit-Hartenberg (D-H) representation of kinematic chains. Rules for establishing link co-ordinate frames. Forward solution of robotic manipulator for STANFORD Robot, Puma Robot, Puma Robot. Forward solution for simple robot systems.

Inverse Kinematics: Concept of Inverse Kinematics, difficulties in the inverse solution, inverse solution by direct approach, Geometric approach and numericals based on direct approach.

Unit V **(8)**

Robot Dynamics: Lagrange's Equation, Kinetic and potential energy Equations, Euler-Lagrange analysis for a single prismatic joint working against gravity and single revolute joint. Equation of motion, Newton-Euler formulations.

Manipulator Differential Motion: Concept of linear and angular velocity, Relationship between transformation matrix and angular velocity, manipulator Jacobean, Jacobean for prismatic and revolute joint, Jacobean Inverse, Singularities.

Control of Robot manipulator: joint position controls (JPC), resolved motion position controls (RMPC) & resolved motion rate control (RMRC).

Unit VI **(8)**

Programming of Industrial Robots: Concept of on-line and off line programming, three levels of robot programming such as specialized manipulation languages, Robot library for an existing

computer language, Robot library for a new general purpose language. Classification of robot specific languages on the basis of hardware level, point-to-point level, the motion level and structured programming level.
Industrial Applications of Robots: Welding, Spray-painting, Grinding, Handling of rotary tools, Parts handling/transfer, Assembly operations, parts sorting, parts inspection, Potential applications in Nuclear and fossil fuel power plant etc. (Details for the above applications are selection criterion of robots, sensors used, selection of drives and actuators, methods of control, peripheral devices used etc).

Industrial Visit:
At least one industrial visit should be arranged supporting the classroom teaching and student should submit a report on that industrial robot application including selection of drive, actuators, sensors, method of control etc.

Text Books:

1. K. S. Fu, R. C. Gonzalez, C. S. G. Lee, "Robotics: Control Sensing, Vision and Intelligence", International Edition, McGraw Hill Book Co.
2. Mikell P. Groover, Mitchell Weiss, Roger N. Nagel, Nicholas G. Odrey, "Industrial Robotics: Technology, Programming and Applications", McGraw Hill Book Company
3. Richard D. Klafter, Thomas A. Chemielewski, Michael Neign, "Robotic Engineering – An Integral Approach", Prentice Hall of India Pvt. Ltd., New Delhi. Eastern Economy Edition

Reference Books:

1. John J. Craig, "Introduction to Robotics: Mechanics and Control", Pearson Education
2. R. K. Mittal, I. J. Nagrath, "Robotics and Control", Tata McGraw Hill Publishing Company Ltd., New Delhi
3. Robert J. Schilling, "Fundamentals of Robotics: Analysis and Control", Prentice Hall of India, New Delhi

403143 Elective – I: b) Power Quality

Teaching Scheme
Lectures: 4 Hrs./Week

Examination Scheme
Theory: 100 Marks

Unit I **(6)**

Introduction: Importance of power quality, terms and definitions of power quality as per IEEE Std. 1159, such as transients, short and long duration voltage variations, interruptions, short and long voltage fluctuations. Symptoms of poor power quality. Definitions and terminology of grounding. Purpose of grounding. Good grounding practices and problems due to poor grounding.

Unit II **(6)**

RMS voltage variations in power system and voltage regulation, per unit system, complex power. Subdivision of voltage variations in power system. Long duration and short duration voltage variations, over voltage, under voltage, voltage sags, swells, imbalance, transient and flicker. Principle of regulating the voltage. Basic power flow and voltage drop. Various devices used for voltage regulation and impact of reactive power management. Various causes of voltage flicker and their effects. Short term (Pst) and long term (Plt) flicker. Various means to reduce flicker.

Unit III **(7)**

Voltage Sag and Interruptions: Definitions of voltage sag and interruptions. Voltage sags vs interruptions. Economic impact of voltage sag. Major causes and consequences of voltage sags. Voltage sag characteristics i.e. magnitude, duration, phase angle jump, point on wave initiation and point on wave recovery, missing voltage. Voltage sag assessment. Influence of fault location and fault level on voltage sag. Area of vulnerability. Assessment of equipment sensitivity to voltage sags. Voltage sag requirements for computer equipment, CBEMA, ITIC, SEMI F 47 curves. Representation of the results of voltage sag analysis. Voltage sag indices. Mitigation measures for voltage sags, such as UPS, DVR, SMES, CVT etc. utility solutions and end user solutions.

Unit IV **(7)**

Waveform Distortion: Definition of harmonics, interharmonics, sub harmonics. Causes and effect of harmonics on all equipments. Voltage vs current distortion. Overview of Fourier analysis. Harmonic indices. A.C. quantities under nonsinusoidal conditions. Tripplen harmonics, characteristics and non characteristics harmonics. Harmonics series and parallel resonances. Consequences of harmonic resonance. K-rated transformer. Principles for controlling harmonics. Reducing harmonic currents in loads, Study of different types of tuned and de-tuned filters, Active filter topologies. Harmonic study procedure. Computer tools for harmonic analysis. Locating sources of harmonics. Harmonic filtering, passive and active filters. Modifying the system frequency response. IEEE 519-1992 harmonic standard.

Unit V **(6)**

Transient Over Voltages: What are transients, their sources and effects? Impulsive transients due to lightning. Transient velocity, surge impedance and the effect of line terminations. Capacitor switching transients. Magnification of capacitor switching transient. Basic principles of over voltage protection. Various devices used for over voltage protection. Load switching related transient problems. Computer tools for transient analysis. Study of transient voltage surge suppressor and types based on their application for Electrical Distribution systems of sensitive Electronic Equipments, communication systems and LAN systems.

Unit VI **(6)**

Power Quality Monitoring: Need of power quality monitoring and approaches followed in power quality monitoring (Reactive and proactive approach). Power quality monitoring objectives and requirements. Initial site survey. Selection of monitoring equipments and use of various equipments required for power quality monitoring. Study of connection of power quality monitor, selection of monitoring location and period. Requirement of power quality monitor to monitor various power quality parameters. System wide and discrete power quality monitoring. Setting thresholds on monitors, various techniques of data collection and analysis. Selection of transducers.

Text Books:

1. J. Arrillaga, M. R. Watson, S. Chan, "Power System Quality Assessment", John Wiley and Sons
2. M. H. J. Bollen, "Understanding Power Quality Problems, Voltage Sag and Interruptions", New York: IEEE Press, 2000, Series on Power Engineering
3. R. C. Dugan, Mark F. McGranghan, Surya Santoso, H. Wayne Beaty, "Electrical Power System Quality", 2nd Edition, McGraw Hill Publication

Reference Books:

1. Enriques Acha, Manuel Madrigal, "Power System Harmonics: Computer Modeling & Analysis", John Wiley and Sons Ltd.
2. Ewald F. Fuchs, Mohammad A. S. Masoum, "Power Quality in Power Systems and Electrical Machines"
3. G. J. Heydt, "Electric Power Quality", Stars in a Circule Publications
4. IEEE Std. 519-1992, IEEE recommended practices and requirements for harmonics control in electrical power system

403143 Elective – I: c) Illumination Engineering

Teaching Scheme
Lectures: 4 Hrs./Week

Examination Scheme
Theory: 100 Marks

Unit I **(6)**

Importance of Lighting in Human Life: Optical systems of human eye ,Dependence of human activities on light, performance characteristics of human visual system, External factors of vision-visual acuity, contrast ,sensitivity, time illuminance, color, visual perception, optical radiation hazards, Good and bad effects of lighting & perfect level of illumination, Artificial lighting as substitute to natural light, Ability to control natural light, Production of light, physics of generation of light, Properties of light, Quantification & Measurement of Light.

Unit II **(10)**

Light Source:

Lamp materials: Filament, glass, ceramics, gases, phosphors and other metals and non-metals.
Discharge Lamps: Theory of gas Discharge phenomena, lamp design considerations, characteristics of low and high mercury and sodium vapor lamps, Low Vapor Pressure discharge lamps - Mercury Vapour lamp, Fluorescent Lamp, Compact Fluorescent Lamp (CFL), High Vapour Pressure discharge lamps - Mercury Vapour lamp, Sodium Vapour lamp, Metal halide Lamps, Solid Sodium Argon Neon lamps, SOX lamps, Electro luminescent lamps, LEDs characteristics, features and applications, LASERS, characteristics, features and applications, non-lighting lamps, Induction lamps. Optical fiber, its construction as a light guide, features and applications

Unit III **(8)**

Electrical Control of Light Sources:

Ballast and ignitors for different HID lamps, design considerations of Electromagnetic and Electronic ballast for TL and HID lamps, Ballast material, Dimming.

Photometric Control of Light Sources and their Quantification:

Luminaries design considerations, optical control schemes, design procedure of reflecting and refracting type of luminaries. Lighting Fixture types, use of reflectors and refractors, physical protection of lighting fixtures, types of lighting fixtures according to installation type, types of lighting fixtures according to photometric usages, ingress protection code, luminaries standard. Indian standard recommendations.

Unit IV **(10)**

Factors of Good Lighting Design:

Indoor Lighting Design: Zonal cavity method for general lighting design, coefficient of utilization determination for zonal cavities and different shaped ceilings. Using COU (coefficient of utilization), using beam angles and polar diagrams, glare calculations. Typical applications: office, educational facility, theatre, residential, hospital. Indian Standard recommendation for indoor lighting, selection criteria for selection of lamps and luminaries, design consideration and design procedure. (problems on COV, beam angles and polar diagrams).

Unit V **(7)**

Outdoor Lighting Design: Road classifications according to BIS, pole arrangement, terminology, lamp and luminaire selection, different design procedures, beam lumen method, point by point method, isolux diagram, problems on point by point method.

Energy Efficient Lighting: Comparison between different light sources, comparison between different control gears, overcoming problems in energy efficient lighting, payback calculation, life cycle costing, (problems on payback calculations, life cycle costing).

Unit VI **(7)**

Solar Lighting: Day Lighting, Photovoltaic Lighting
Emergency Lighting: Central Systems, Stand alone systems
Cold Lighting: Concept, Method of generation – Optical Fiber cable (OFC), filters, Application
Switching Control for Lighting
Typical Lighting Project Design: New projects, Retrofits

Text Books:

1. H. S. Mamak, "Book on Lighting", Publisher International lighting Academy
2. Joseph B. Murdoch, "Illumination Engineering from Edison's Lamp to Lasers"
3. M. A. Cayless, A. M. Marsden, "Lamps and Lighting"

Reference Books:

1. "BIS, IEC Standards for Lamps, Lighting Fixtures and Lighting", Manak Bhavan, New Delhi
2. D. C. Pritchard, "Lighting", 4th Edition, Longman Scientific and Technical, ISBN 0-582-23422-0
3. Elmer, "Design of Reflectors"
4. "IES Lighting Handbook", (Reference Volume 1984), Illuminating Engineering Society of North America
5. "IES Lighting Handbook", (Application Volume 1987), Illuminating Engineering Society of North America

403143 Elective – I: d) Project Management

Teaching Scheme
Lectures: 4 Hrs./Week

Examination Scheme
Theory: 100 Marks

Unit I **(6)**

Introduction: Introduction to Project Management, Need for project Management, Categories and characteristics of project Management, Project life cycle and phases (Conception phase, Definition phase, Execution Phase and operation phase), Project Appraisal (Technical, commercial, Economic and managerial), Project Organization (Functional, Product and matrix).

Unit II **(8)**

Project Costing and Control: Project Selection, financial concepts of Projects, various cost associated with Project, R.O.I., Project cost estimation, financial evaluation of Project, Budgeting and allocation of budgets, analysis of returns, profitability index, Project cost control, causes of Project Failures.

Unit III **(10)**

Project Scheduling: Gantt chart and its application, AOA (Activity on Arrow diagram), AON (Activity on Node) Diagram, Precedence diagramming methods (PDM), Critical Path Method (CPM), Programme evaluation and Review Technique (PERT), GERT (Graphical Evaluation and Review Technique), Resource allocation, Line of Balancing and crashing the network.

Unit IV **(8)**

Project Cost Estimating and Budgeting: Introduction cost estimating: Cost estimating process, Factors of cost escalation, Elements of budgets and estimates, Project cost accounting systems, Cost scheduling and budgetary control.

Unit V **(8)**

Project Quality Management: The processes of project quality management, Quality planning, assurance and control, Quality of procured items, Techniques of quality assurance and control, project execution and control, International Project Management.

Unit VI **(8)**

Project Risk Management: Introduction, Managing risks in projects, Measurement and assessment of risk, Sources of risks. Risk: - Adjusted discount rate method, certainly equivalent method, correlation coefficient, portfolio risks, diversible & non diversible risks, CAPM (Capital Asset pricing model) case studies of project management, computer aided project management.

Text Books:

1. K. Nagarajan, "Project Management", 5th Edition, New Age International Publishers, 2010
2. Prasanna Chandra, "Projects: planning, analysis, selection, implementation and review", 4th Edition, Tata McGraw Hill Publishing Co. Ltd, New Delhi, 1995
3. Rosy Burke, "Project Management: planning and control technique", Wiley India, 2003
4. S. Chaudhary, "Project Management", Tata McGraw Hill, 1988

Reference Books:

1. J. R. Meredith, S. J. Mantel, "Project Management: A managerial approach", Wiley India, 2010
2. John M. Nicholas, Herman Steyn, "Project Management", 3rd Edition, Elsevier Inc., 2008
3. Samuel Mantel, Jr. J. R. Meredith, S. M. Scafer, M. M. Sutton, M. R. Copalan, "Project Management" 1st Edition, 2011

403144 Elective – II: a) Restructuring and Deregulation

Teaching Scheme
Lectures: 4 Hrs./Week

Examination Scheme
Theory: 100 Marks

Unit I **(8)**

Power Sector in India: Evolution of integrated, monopoly, state electricity boards (SEBs), introduction to various institutions in Indian power sector such as CEA, planning commission, PFC, Ministry of Power, state and central Governments, REC, financial institutions, PTC, utilities and their roles, challenges before Indian power sector, electricity act 2003 and various National policies and guidelines under the act, introduction to Indian Energy Exchange and its working.

Unit II **(8)**

Power Sector Economics: Introduction to various concepts such as capital cost, debt and equity, depreciation, fixed and variable costs, working capital, profitability indices, net present value, life cycle cost etc, typical cost components of utilities such as return in equity, depreciation, interest and finance charges, O and M expenses etc and their determinants, introduction to average, marginal and avoided costs, tariff setting principles and choice of the rate structure, concepts of subsidy and cross-subsidy.

Unit III **(8)**

Power Sector Regulation: Role of regulation and evolution of regulatory commissions in India, types and methods of regulation (rate of return regulation, performance based regulation, incentive regulation, benchmarking or yardstick regulation), the regulatory process in India (composition of RCs, selection, authority, regulatory decision making process), non price issues in regulation such as externalities (environment etc.), service quality, consumer service, social equity, transparency and public participation in regulatory process.

Unit IV **(8)**

Introduction to Power Sector Restructuring and Market Reform: Introduction, models based on energy trading or structural models – monopoly, single buyer, wholesale competition, retail competition etc, ring fencing or accounting separations, models based on contractual arrangements – pool model, bilateral dispatch, pool and bilateral trades, multilateral trades, ownership models (public sector – state owned and municipal utilities, co-operatives, private sector, public-private partnership), rationale behind reforms, competition for the market vs competition in the market, International experience with electricity reform – Latin America, The Nordic Pool, UK, USA, China and India (Orissa, AP and Maharashtra), The California Energy Crisis.

Unit V **(8)**

Competitive Electricity Markets: Trading **–** electricity marketplaces, rules that govern the electricity markets, peculiarity of electricity as a commodity, various models of trading arrangements – integrated trading model, wheeling trading model, decentralized trading model.
Retail Competition **–** retail access framework, competing retailers, metering and accounting issues, technological aspects of competition. Impact of market reform on regulation and externalities (environment, social equity etc.)

Unit VI **(8)**

Transmission Planning and Pricing: Transmission planning in the era of market structure, transmission rights and pricing, different methods of transmission pricing, different transmission services (ancillary services etc.) congestion issues and management, grid codes, transmission

ownership and control - Transo and ISO, transmission pricing and model in India – availability based tariff (ABT), role of load dispatch centers (LDCs), open access.

Text Books:

1. "Deregulation in Power Industry", Proceedings of a course under Continuing Education Programme held by Department of Electrical Engineering, Indian Institute of Technology, Bombay.
2. "Know Your Power", A citizens Primer On the Electricity Sector, Prayas Energy Group, Pune

Reference Books:

1. Bhanu Bhushan, "ABC of ABT - A primer on Availability Tariff"
2. Central Electricity Regulatory Commission, Regulations and Orders - www.cercind.org
3. Electric Utility Planning and Regulation, Edward Kahn, American Council for Energy Efficient Economy
4. Electricity Act 2003 and National Policies – www.powermin.nic.in
5. Maharashtra Electricity Regulatory Commission Regulations and Orders - www.mercindia.com
6. Paper "The real challenges in Power sector Restructuring: Instilling Public Control Through TAP", Prayas Energy Group, Energy for Sustainable Development, September 2001, www.prayaspune.org
7. Privatization or Democratization The Key to the Crises in the Electricity Sector - The Case of Maharashtra 2002, www.prayaspune.org
8. Regulation in infrastructure Services: Progress and the way forward - TERI, 2001
9. Sally Hunt, "Making Competition Work in Electricity", 2002, John Wiley Inc
10. Various publications, reports and presentations by Prayas, Energy Group, Pune www.prayaspune.org

Website:

1. www.cercind.org
2. www.iexindia.com
3. www.mercindia.com
4. www.powerexindia.com
5. www.prayaspune.org

403144 Elective – II: b) Embedded System

Teaching Scheme
Lectures: 4 Hrs./Week

Examination Scheme
Theory: 100 Marks

Unit I **(8)**

Introduction to Embedded Systems: Embedded Systems & its applications, components, classifications Categories of embedded systems, overview of ES Architecture, software in embedded system, Design Process in ES, Microcontroller- characteristics and features, overview of Atmel, Microchip. Examples in ES, DSP, RISC examples-ARM, PIC 16F877 & 18F452, DSP processors, RISC CISC with examples.

Unit II **(8)**

Embedded system hardware:

ADC- Types, sample and hold, real parts, microprocessor interfacing, clocked interfaces, serial interfaces.

Sensors- Temperature sensors, optical sensors, motion sensors, strain gauges, and their interfacing with microcontroller through ADC. Interfacing of switches and matrix keypad to microcontroller.

Unit III **(8)**

Analog output Interfacing

Solenoids- Relay control and clamping, pick/hold heaters, LED, LCD, DAC, actuators.

Motors- i) Stepper motors- bipolar and unipolar operation, half-stepping and micro-stepping, driving steppers, motor drive ICs (L62D1 & LM18200), ii) DC motors- driving dc motors, BLDC motor & its driving, DC motor controller ICs (LM628 & LM629).

Unit IV **(8)**

Programming Concepts: Interprocessor communication and synchronization of process, tasks, threads, scheduling, device drivers for embedded devices, RPC Functions, States Data, ISRS, Concepts of semaphores, Message queue, mailbox

Unit V **(8)**

Real Time Operating System Concept: Architecture of kernel, task scheduler, ISR, Semaphores, mailbox, message queues, pipes, events, timers, memory management, RTOS services in contrast with traditional OS. Overview of comemertial RTOS like Vxworks & RT Linux.

Unit VI **(8)**

Case Study of Embedded System: Case study of embedded system like digital camera, smart card, flight simulation and control.

Text Book:

Rajkamal, "Embedded Systems", TMH

Reference Books:

1. Frank Vahid, "Embedded System Design", Prentice Hall Publication
2. J. W. Valvano, "Embedded Microcomputer Systems: Real time interfacing", Brooks/Cole, 2000
3. Stuart R. Ball, "Analog Interfacing to Embedded Microprocessor Systems", Newnes Publication 2004

403144 Elective – II: c) E H V Transmission

Teaching Scheme
Lectures: 4 Hrs./Week

Examination Scheme
Theory: 100 Marks

Unit I **(8)**

EHV AC transmission lines- Need for EHV transmission lines. Transmission line trends and Preliminaries. Standard transmission voltages. Average values of line parameters. Power handling capacity and line loss. Examples on Giant power pools and number of lines. Cost of transmission lines and equipments. Mechanical consideration in line performance. Traveling wave equations, Transmission, Reflection, Attenuation and Distortion of traveling waves.

Unit 2 **(8)**

Calculation of line and ground parameters: Resistance of conductors. Temperature rise of conductors and current carrying capacity. Properties of bundled conductors. Inductance of EHV line configurations. Line capacitance calculations. Sequence inductances and capacitances. Line parameters for modes of propagation. Resistance and inductance of ground return.

Unit 3 **(8)**

Voltage gradient of conductors: Electrostatics. Field of a point charge and its properties, Field of a sphere gap, Field of line charges and their properties, Corona inception gradient, charge potential relations for multi-conductor lines, Maximum charge condition on three phase line.
Surface voltage gradient on conductors –single conductor, 2 conductors and multi conductor bundle, maximum surface voltage gradient, Mangolt formula, design of cylindrical cage for corona gradients.

Unit 4 **(8)**

Electrostatic and Magnetic fields of EHV lines: Electric shock and threshold currents. Capacitance of long object. Effect of high electrostatic fields on Humans, Animals and Plants. Electrostatic induction in unenergized circuit of a double circuit line. Induced voltage in insulated ground wires. Magnetic field effects.

Unit 5 **(8)**

Analysis of HVDC converters: Three phase and six phase converter circuits, voltage and current waveforms and ratios, apparent power factor and utilization factor, delay angle, transformer rating, pulse number, commutation group, Graetz circuit, overlap, advance angle and extinction angle, analysis of two and three valve conduction mode, equivalent commutation resistance, reactive power requirements of HVDC converters.

Unit 6 **(8)**

Control of HVDC converters: Principle of dc link control, Converter control characteristics, Reactive power requirement of HVDC converters Influence of AC systems strength on AC/DC system interaction. Short circuit ratio, reactive power and AC system strength Problem with low effective short circuit ratio, Solution to problem with weak systems, Effective inertia constant, forced commutation.

Text Books:

1. Kimbark, “HVDC Transmission” John Willy & Sons Publication
2. Rakoshdas Begamudre, “Extra High Voltage AC Transmission Engineering” New Age International P. Ltd. Publishers
3. S. Rao, “EHV AC and DC Transmission” Khanna Publication

Reference Books:

1. Arrillaga, “HVDC Transmission” 2nd Edition, IEE London Publication
2. Narain. G. Hingorani, Gyugyi, “Understanding of FACTS Concept and Technology”, John Wiley & Sons Publication
3. P. Kundur, “HVDC Transmission” Mc Graw Hill Publication
4. Padiyar, “HVDC Transmission” 1st Edition, New Age International Publication

403144 Elective – II: d) Smart Grid

Teaching Scheme
Lectures: 4 Hrs./Week

Examination Scheme
Theory: 100 Marks

Unit I **(8)**

Introduction to Smart Grid: Evolution of Electric Grid, Concept of Smart Grid, Definitions, Need of Smart Grid, Functions of Smart Grid, Opportunities & Barriers of Smart Grid, Difference between conventional & smart grid, Concept of Resilient & Self Healing Grid, Present development & International policies in Smart Grid. Case study of Smart Grid. CDM opportunities in Smart Grid.

Unit II **(8)**

Smart Grid Technologies: Part 1: Introduction to Smart Meters, Real Time Prizing, Smart Appliances, Automatic Meter Reading(AMR), Outage Management System(OMS), Plug in Hybrid Electric Vehicles(PHEV), Vehicle to Grid, Smart Sensors, Home & Building Automation, Phase Shifting Transformers.

Unit III **(8)**

Smart Grid Technologies: Part 2: Smart Substations, Substation Automation, Feeder Automation. Geographic Information System(GIS), Intelligent Electronic Devices(IED) & their application for monitoring & protection, Smart storage like Battery, SMES, Pumped Hydro, Compressed Air Energy Storage, Wide Area Measurement System(WAMS), Phase Measurement Unit(PMU).

Unit IV **(8)**

Microgrids and Distributed Energy Resources: Concept of microgrid, need & applications of microgrid, formation of microgrid, Issues of interconnection, protection & control of microgrid. Plastic & Organic solar cells, Thin film solar cells, Variable speed wind generators, fuelcells, microturbines, Captive power plants, Integration of renewable energy sources.

Unit V **(8)**

Power Quality Management in Smart Grid: Power Quality & EMC in Smart Grid, Power Quality issues of Grid connected Renewable Energy Sources, Power Quality Conditioners for Smart Grid, Web based Power Quality monitoring, Power Quality Audit.

Unit VI **(8)**

Information and Communication Technology for Smart Grid: Advanced Metering Infrastructure (AMI), Home Area Network (HAN), Neighborhood Area Network (NAN), Wide Area Network (WAN). Bluetooth, ZigBee, GPS, Wi-Fi, Wi-Max based communication, Wireless Mesh Network, Basics of CLOUD Computing & Cyber Security for Smart Grid. Broadband over Power line (BPL). IP based protocols.

Text Books:

1. Ali Keyhani, Mohammad N. Marwali, Min Dai “Integration of Green and Renewable Energy in Electric Power Systems”, Wiley
2. Clark W. Gellings, “The Smart Grid: Enabling Energy Efficiency and Demand Response”, CRC Press
3. Janaka Ekanayake, Nick Jenkins, Kithsiri Liyanage, Jianzhong Wu, Akihiko Yokoyama, “Smart Grid: Technology and Applications”, Wiley
4. Jean Claude Sabonnadière, Nouredine Hadjsaïd, “Smart Grids”, Wiley Blackwell

5. Peter S. Fox Penner, “Smart Power: Climate Changes, the Smart Grid, and the Future of Electric Utilities”, Island Press; 1 edition 8 Jun 2010
6. S. Chowdhury, S. P. Chowdhury, P. Crossley, “Microgrids and Active Distribution Networks.” Institution of Engineering and Technology, 30 Jun 2009
7. Stuart Borlase, “Smart Grids (Power Engineering)”, CRC Press

Reference Books:

1. Andres Carvallo, John Cooper, “The Advanced Smart Grid: Edge Power Driving Sustainability: 1”, Artech House Publishers July 2011
2. James Northcote, Green, Robert G. Wilson “Control and Automation of Electric Power Distribution Systems (Power Engineering)”, CRC Press
3. Mladen Kezunovic, Mark G. Adamiak, Alexander P. Apostolov, Jeffrey George Gilbert “Substation Automation (Power Electronics and Power Systems)”, Springer
4. R. C. Dugan, Mark F. McGranghan, Surya Santoso, H. Wayne Beaty, “Electrical Power System Quality”, 2nd Edition, McGraw Hill Publication
5. Yang Xiao, “Communication and Networking in Smart Grids”, CRC Press

403145: Control Systems – II

Teaching Scheme
Lectures: 4 Hrs./Week
Practical: 2 Hrs./Week

Examination Scheme
Theory: 100 Marks
Oral: 50 Marks
Term Work: 50 Marks

Unit I **(7)**

Compensation Technique: Approaches and preliminary consideration. Design of Linear Control System, Common compensating network, Transfer function of Lag, Lead and Simple lag-lead network. Design using Bode diagram. Physical realization of compensators using active and passive elements.

Unit II (8)

State Space Analysis: Review of state space analysis, Concept of diagonalization, eigen values, eigenvectors, diagonalization of system matrices with distinct and repeated eigen values, Vander Monde matrix.

Solution of homogeneous and non-homogeneous state equation, state transition matrix, its properties, various methods to determine e^{At} Laplace inverse transform, Caley-Hamilton technique, Infinite power series method, Taylor's series expansion technique.

Unit III (9)

Design of Control System Using State Space Technique: Definition of controllability & observability, controllability & observability matrices, condition for controllability & observability from the system matrices in canonical form, Jordan canonical form, effect of pole zero cancellation on the controllability & observability of the system, duality property. Pole placement design by state feedback. State observer, design of full order observer.

Unit IV (7)

PID Controllers: Design specifications in time domain and frequency domain. Time design of P, PI and PID control. Frequency domain design of P, PI and PID control. Tunning of PID controller. Ziegler-Nichol method.

Unit V (8)

Non linear System Analysis: Introduction, qualitative analysis of nonlinearities in real life, classification, common type of non-linearities, peculiar behavior of nonlinear system- response, jump resonance, limit cycle: stable and unstable, amplitude as function of frequency oscillation, non linear spring mass system, sub harmonic oscillation, asynchronous quenching, frequency entrainment etc.

Introduction to describing function, describing function of ideal relay, relay with dead zone and saturation nonlinearities, Stability analysis with describing function, Limitations.

Unit VI (9)

Stability of Nonlinear System: Introduction to phase plane method, singular point, construction of phase plane trajectory of a second order system using delta method and phase portrait, calculation of time from phase plane trajectory, phase portrait, stability analysis from phase plane.

Liapunov's Stability analysis- Liapunov's Stability, asymptotic stability, instability, positive definiteness, negative definiteness, positive semi definiteness, negative semi definiteness, indefiniteness. Methods of constructing Liapunov's function for nonlinear systems, use of Liapunov's theory for control system design.

List of Experiments:

Minimum 8 experiments from the following list.

1. Linear analysis of DC position control system using simulink.
2. Phase plane analysis of nonlinear system using simulink.
3. Software programming for determination of STM.
4. Software programming for determination of controllability and observability of state model of a given system.
5. Software programming for determination eigen values & eigen vector of system metrics.
6. Software programming for determination of state space representation for given transfer function.
7. Assignment problem to draw phase plane trajectory.
8. Assignment problem to decide stability, amplitude & frequency of limit cycle using describing function method.
9. Software programming to design system by pole placement through state feedback.
10. Software programming to obtain transfer function from state model.
11. Assignment problems optimal control theory.
12. Observer design using MATLAB.
13. To design Lead and Lag compensator and to obtain the characteristic by simulation using Software.

Text Book:

I. J. Nagrath, M. Gopal "Control System Engineering", 5th Edition. New Age International Publishers

Reference Books:

1. Benjamin C. Kuo, "Automatic Control Engineering", Prentice Hall of India Pvt. Ltd.
2. K. Ogata, "Modern Control Engineering", Prentice Hall of India Pvt. Ltd.
3. M. Gopal, "Digital Control Engineering", Wiley Eastern, 1988
4. M. N. Bandyopadhyan, "Control Engineering – Theory and Practice", Prentice Hall of India Ltd. Delhi

403147: Switchgear and Protection

Teaching Scheme
Lectures: 4 Hrs./Week
Practical: 2 Hrs./Week

Examination Scheme
Theory: 100 Marks
Oral: 50 Marks
Term Work: 25 Marks

Unit I **(8)**

Fundamentals of Arc Interruption: Current interruption in AC circuit breaker, high & low resistance principles, arc interruption theories, arc voltage, recovery voltage, derivation and definition of restriking voltage and RRRV, current chopping, interruption of capacitive current, resistance switching.

Unit II (8)

Circuit Breaker: Different ratings of circuit breaker (like rated voltage, rated current, rated frequency, rated breaking capacity - symmetrical and unsymmetrical breaking, making capacity, rated interrupting duties, rated operating sequence, short time rating). Classification of high voltage circuit breaker. Working and constructional features of ABCB, SF_6 and VCB - advantages, disadvantages and applications. Auto reclosing.

Unit III (8)

Fundamentals of Protective Relaying: Need for protective system, nature & causes of fault, types of faults, effects of faults, evolution of protective relaying, zones of protection, primary & backup protection, essential qualities of protective relaying. Trip circuit of circuit breaker, zones of protection. Various operating principles of protection- over current, directional over current, differential, distance, induction type relay, torque equation in induction type relay, current and time setting in induction relay.

Unit IV (7)

Static and Digital Relaying: Overview of Static relay, block diagram, operating principal, merits & demerits of static relay. Numerical Relays :-Introduction ,Block diagram of numerical relay, Sampling theorem, Anti –Aliasing Filter, Least square method for estimation of phasor, concept of Discrete Fourier transform to estimate the phasor, Block diagram of PMU.

Unit V **(9)**

A) Transformer Protection: Types of faults in transformer. Percentage differential protection in transformers, Inrush phenomenon, percentage differential relay with harmonic restraint. Restricted E/F protection. Incipient faults, buchholz relay. Phenomenon of over fluxing in transformer, protection against over fluxing. Realisation of numerical differential relay for transformer protection.

B) Generator Protection: Various faults, abnormal operating conditions- stator faults, longitudinal percentage differential scheme and transverse percentage differential scheme. Rotor faults- abnormal operating conditions, inter turn fault, unbalance loading, over speeding, loss of excitation, protection against loss of excitation using offset Mho relay, loss of prime mover. Digital protection scheme based on injection of sub-synchronous component in rotor circuit.

C) Bus bar Protection: Differential protection of bus bars. Selection of C.T. ratios for bus bar protection. High impedance differential relay.

Unit VI **(8)**

A) **Feeder protection:** Time graded and current graded system protection of three phase feeder using over current relays.

B) Transmission line: Over current protection for transmission lines, Introduction to distance protection, impedance relay, reactance relay, mho relay & quadrilateral relays. Pilot wire protection with distance relay, setting and co-ordination of distance relay, Effect of arc resistance, load encroachment and power swing on performance of distance relay. Realization of distance relays using numerical relaying algorithm, Introduction to Wide Area Measurement (WAM) system.

List of Experiments:

Minimum 8 Experiments from the following list.

1. Study of switchgear testing kit.
2. Study of Fuse & MCB & testing of MCB.
3. Study & testing of contactors.
4. Study & characteristics of ACB.
5. Study & characteristics of thermal overload relay.
6. Characteristics of IDMT relay/Induction to digital over current relay.
7. Characteristics of impedance relay/Digital Impedance relay.
8. Percentage differential protection of transformer.
9. Merz - Price protection of alternator.
10. Study of various LT switchgears like ELCB, timers. Overview of co-ordination of ratings of LT switchgear.
11. Study & testing of MCCB.
12. Protection of Transmission line using Impedance relay.

Industrial Visit:

Report on industrial visit to switchgear training centre / switchgear / relay manufacturing unit / 132 kV switchyard.

Text Books:

1. S. Rao, "Switchgear Protection and Power Systems", Khanna Publications
2. Y. G. Paithankar, S. R. Bhide, "Fundamentals of Power System Protection", Prentice Hall of India

Reference Books:

1. A. G. Phadke, J. S. Thorp, "Computer Relaying for Power System" Research Studies Press LTD, England (John Willy & Sons Inc New York)
2. A Web course on "Digital Protection of Power System" by Prof. Dr S. A. Soman, IIT Mumbai
3. Badri Ram, D. N. Vishwakarma, "Power System Protection and Switchgear", Tata McGraw Hill Publishing Co. Ltd.
4. Blackburn, "Protection of Power System"

403148: Industrial Drives and Control

Teaching Scheme
Lectures: 4 Hrs./Week
Practical: 2 Hrs./Week

Examination Scheme
Theory: 100 Marks
Term Work: 50 Marks
Practical: 50 Marks

Unit I **(8)**

Electrical Drives: Definition, Advantages of electrical drives, Components of Electric drive system, Selection Factors, Types of Electrical Drives (DC & AC). Motor-Load Dynamics, Speed Torque conventions and multi quadrant operation, Equivalent values of drive parameters.
Load Torque Components, Nature and classification of Load Torques, Constant Torque and Constant Power operation of a Drive. Steady state stability, Load equalization by using flywheel.

Unit II (8)

Electrical Braking: Electrical braking methods, characteristics of DC Motors: Rheostatic, Plugging, and Regenerative.
Electrical braking method of three phase induction motor: DC Dynamic Braking, Plugging, Regenerative Braking, AC Rheostatic braking, motor braking methods using static devices.
Closed loop control of drives: current limit control, torque control and speed control.

Unit III (8)

Solid State Controlled D.C. Motors: Single phase and three phases fully controlled converter drives and performance of converter fed separately excited DC Motor for starting and speed control operations. Chopper controlled drives for separately excited and series DC Motor operations. Closed loop speed control of DC motor below and above base speed.

Unit IV (8)

Solid State Controlled Induction Motors: Thyristorised stator voltage control (using ac regulators, for fixed frequency variable voltage control), Transistorised stator frequency control: V/f control, voltage source inverter (VSI) control, Steady State Analysis, current source inverter (CSI) control, Regenerative braking and multi quadrant operation of Induction motor drives, relative merits and demerits of VSI and CSI for induction motor drives. Closed loop speed control of CSI drives.

Unit V (8)

Energy Saving Techniques:
Calculation of time and energy loss in transient operations: Starting, Speed variation and Braking.
Energy Saving in starting of Induction Motor Drive: Static rotor resistance control,
Slip Power recovery schemes: Static Sherbius Drive, Static Kramer Drive
Energy Saving in running of Induction Motor Driving Pump and Blower: Consideration of load torque characteristics and energy saving calculations.
Power Rating: Selection criteria of motors, motor duties, inverter duty motors.
Load diagram, Heating and cooling, Thermal Resistance, determination of HP rating of motor based on duty cycle, derating of motor, effect of harmonic current and voltage harmonics, short time rating.
Energy Conservation in Electrical drives, Energy efficient operations of drives.
Electrical drive systems and components, requirements of drive installation, interlocking operations and protection.

Unit VI (8)

Latest trends in Drives and Industrial Applications:

Latest trends in Drives: Rotor flux oriented vector control for induction motor drives.

Commutator less DC Motor (How Induction Motor is converted to Characteristics of DC Motor), AC Servo Drives.

Industrial Applications: Drives for Rolling mills (Four Quadrant Operation), Machine tools (Constant Torque Application), Textile mills (Synchronized operation of Drive in Tandem), Sugar Mills: Centrifuged Drive, Traction drives.

List of Experiments:

Term work should include minimum eight experiments with at least one on simulation and report on minimum one industrial visit.

1. Study of Electrical braking of D.C. Shunt motor (Rheostatic, Plugging).
2. Study of Electrical braking of 3 phase Induction Motor (DC Dynamic Braking, Plugging).
3. Study of Single phase converter fed separately excited D.C. motor speed control characteristics (Fully controlled /Semi controlled).
4. Study of Three phase (Fully controlled/Semi controlled) converter fed / Dual converter fed/ separately excited D.C. motor (Open Loop Control).
5. Study of Chopper fed D.C. series motor speed control characteristics.
6. Study of VSI fed 3 phase Induction motor (using V/f control PWM inverter) speed control characteristics.
7. Study of Solid state stator voltage control of 3 phase Induction motor (Using AC voltage Regulator).
8. Study of Closed loop speed control of separately excited D.C. motor/ Induction Motor.
9. Simulation of starting characteristics of D.C. / 3 phase Induction motor.
10. Simulation of an electric drive system for steady state and transient analysis.
11. Energy saving Experiment for determining percentage energy saving with damper (Conventional) Control and AC Drive Control.
12. Study of parameterization of drives (AC/DC) using manufacturer's drive manual.

Industrial Visit:

Minimum one industrial visit must be organized for drives application in industry.

Text Books:

1. G. K. Dubey, "Fundamentals of Electric Drives", 2nd Edition, Narosa Publishing House
2. N. K. De, P. K. Sen, "Electric Drives", Prentice Hall of India Eastern Economy Edition
3. S. K. Pillai, "Analysis of Thyristor Power Conditioned Motors", University Press

Reference Books:

1. K. Bose, "Modern Power Electronics and AC Drives", Pearson Education
2. Malcolm Barnes, "Practical Variable Speed Drives and Power Electronics", Newnes
3. R. Krishnan, "Electric Motor Drives – Modeling Analysis and Control", PHI India
4. V. Subrahmanyam, "Electric Drives: Concepts & Application", Tata Mc-Graw Hill

(An imprint of Elsevier)

403149 Elective – III: a) VLSI Design

Teaching Scheme
Lectures: 4 Hrs./Week
Practical: 2 Hrs./Week

Examination Scheme
Theory: 100 Marks
Term Work: 25 Marks
Oral: 25 Marks

Unit I **(8)**

Overview of Digital Logic Circuits: combinational circuits: Decoders, Multiplexer, ALU., sequential circuits: latch, flip flop – RS, JK, D, T., shift registers in SISO, SIPO, PISO, PIPO models; Counters – synchronous, Asynchronous, Ring, Finite state machine (FSM): Moore, Mealy Machines, Design applications of FSM like Traffic Light controller, Lift controller.

Unit II **(7)**

VHDL Modeling and Design Flow:
Introduction to VLSI: complete VLSI design flow (with reference to an EDA tool), IEEE Standards
VHDL Terms – Entity, architecture, Schematic, Components, Configuration.
Modeling types – Behavioral, data flow, & Structural with the help of digital functions like multiplexer, Shift Register, counter, etc.

Unit III **(7)**

VHDL Programming: sequential processing, concurrent Vs sequential statements, sub programs and packages, attributes, data types and data objects, Test benches, Synthesizable, and non synthesizable statements

Unit IV **(8)**

CMOS LOGIC Design: NAND, NOR structures, FAN IN, FAN OUT, Propagation Delay, Power dissipation and figure of merit (power delay product), Noise Margin, Voltage transfer characteristics for CMOS Inverter, comparison of CMOS and NMOS

Unit V **(8)**

Programmable Logic Devices (PLDs):
PAL, PLA, CPLD, FPGA – Architectures of these devices with the help of XILIN X 3000, XILINX 4000, XILINX COOL RUNNER CPLD
EDA tools for PLDs: Simulation, synthesis, floor planning, Place and Route (PAR), Configuration of FPGA, Boundry scan, BIST.

Unit VI **(7)**

VLSI Design Applications: Barrel shifter, signed and unsigned comparators, Carry ripple and carry look, Ahead address, Fixed- point division, serial data receiver, parallel to serial converter, playing with a seven segment display and key board, signal generators, memory design, Vending - Machine controller.

List of Experiments:
1. Simulation of 4 Bit adder.
2. Simulation of 1: 16 Multiplexer.
3. Simulation of 3 to 8 decoder.
4. Simulation of Multiple functions output using ROM or PAL or PLA.

(Any four combinational Logic assignments similar to above can be simulated.)

5. Simulation of Latches and registers with reset and clear.
6. Simulation of Counter.
7. Simulation of Shift Register.
8. Simulation of Special code to temporal code converter (Reference: shift register)

(Any four sequential logic assignments similar to above can be simulated)

9. Vending machine controller simulation.
10. Simulation of traffic light controller.

Each group of three students should implement at least one assignment from the above list.

Text Books:

1. Douglas Perry, "VHDL", Tata McGraw Hill
2. John F. Wakerly, "Digital Design, Principles and Practices", Prentice Hall Publication
3. Wolf, "Modern VLSI Design", Pearson Education

Reference Books:

1. Charles H. Roth, "Digital System Design Using VHDL", PWS Publishing Company (Thomson Learning)
2. J. Bhaskar, "VHDL Primer", 3rd Edition, Addison Wesley Longman Singapore Pte Ltd.
3. Volner A. Dedroni, "Circuit Design with VHDL", PHI Publications
4. Xilinx Data Manual "The Programmable Logic Data Book"

403149 Elective – III: b) High Voltage Engineering

Teaching Scheme
Lectures: 4 Hrs./Week
Practical: 2 Hrs./Week

Examination Scheme
Theory: 100 Marks
Term Work: 25 Marks
Oral: 25 Marks

Unit I **(8)**

Breakdown in Gases: Electrons as the best ionizers, Gases as an insulating medium, ionization and decay and attachment process, breakdown in gases, Townsend's Theory, current growth equation in presence of primary and secondary ionization processes, Townsend's breakdown criterion, primary and secondary ionization coefficients and their variation with respect to E/P, limitations of Townsend's theory, Streamer mechanism of breakdown, Paschen's Law and its limitations, Corona discharges for point plane electrode combination with positive and negative pulse application, time lag for and factors on which time lag depends, breakdown in extremely non uniform fields. Practical considerations in using gases for insulation purpose. (Numerical on Townsend's theory, Paschen's law).

Unit II **(8)**

Breakdown in Liquid and Solid Dielectrics: Pure and commercial liquids. Conduction and Breakdown in pure and commercial liquids, Breakdown mechanism in solid dielectrics: - intrinsic breakdown strength and breakdown, electromechanical breakdown and thermal breakdown. Cavity breakdown, surface discharge (treeing and tracking phenomenon), Properties of composite dielectrics, breakdown in composite dielectrics. (Numerical on determining the breakdown strength of transformer oil, solid dielectric)

Unit III **(6)**

Lightning and Switching Over Voltages and Protection: Natural causes for over voltages – Lightning Phenomenon, Over voltage due to switching surges, system faults and abnormal conditions, impulse voltage specifications- wave front and wave tail time, protection from over voltages, horn gap type lightning arrestor, Gap type and ZnO gapless lightning arrestors, specifications of lightning arrestors and its selection for given application. Principals of insulation co-ordinations on high voltage and extra high voltage power system and substation.

Unit IV **(9)**

Generation of High Voltages and Current: Generation of high ac voltages-Cascading of transformers ,series and parallel resonance system Generation of high dc voltages:- Van-de-Graff generator, variable capacitance generator, rectifier circuits , ripple ripple factor, Cascading circuits using number of stages of voltage doubler circuits-conduction and non-conduction periods Expression n for total ripple and total voltage drop, voltage regulation, optimum number of stages.

Generation of impulse voltages:-Impulse voltage definition, wave front and wave tail time. Analysis of basic R-L-C and double RC circuits. Multistage impulse generator. Modified Marx circuit. Tripping and control of impulse generators.

Generation of high ac voltage of high frequency using Tesla coil. Generation of high impulse current using R-L-C circuit and its analysis.

(Numerical on impulse generation high dc voltage generation, optimum number of stages, impulse current generation)

Unit V **(9)**

Measurement of High Voltage and High Currents and Non-destructive Testing: Various methods of measurement of Peak voltage, impulse voltage ,high dc and ac voltage measurement,

measurement of high current, cathode ray oscillographs for impulse voltage and current measurement, measurement of dielectric constant and loss factor, partial discharge measurements. (Numerical on generating voltmeter, peak voltmeter, peak reading ac voltage, sphere gap voltmeter)

Unit VI **(8)**

High Voltage Testing of Electrical Apparatus and H V Laboratories: Testing of insulators and bushings, testing of isolators and circuit breakers, testing of cables, testing of power transformers, testing of surge arresters, radio interference measurements.

Design, planning and layout of High Voltage laboratory:-Classification of H.V. laboratories, size and rating of large size High Voltage laboratory, Grounding of impulse testing laboratory.

List of Experiments:

Minimum eight experiments

1. Measurement of breakdown strength of solid insulating materials.
2. Breakdown of air under uniform and non-uniform field.
3. Measurement of breakdown strength of liquid insulating materials.
4. Effect of gap length on liquid insulating material.
5. Breakdown of composite dielectric material.
6. Study of impulse generator.
7. High voltage withstand test on cables/safety gloves/shoes as per IS.
8. Surface flashover on the surface of polymer insulator materials.
9. Horn gap arrangement as surge diverter.
10. Measurement audible and visible corona inception and extinction voltage.
11. Surface flashover on corrugated porcelain insulator materials.
12. Sphere gap voltmeter.
13. Development of tracks and trees on polymeric insulation.
14. Measurement of breakdown strength of gaseous dielectrics.
15. Study of output voltage waveform of multistage voltage doubler circuit on CRO.

Industrial Visit:

Industrial visit to high voltage equipment manufacturing industry.

Text Books:

1. C. L. Wadhwa, “High Voltage Engineering”, New Age International Publishers Ltd.
2. M. S. Naidu, V. Kamaraju “High Voltage Engineering”, Tata McGraw Hill Publication Co. Ltd. New Delhi

Reference Books:

1. E. Kuffel, W. S. Zaengl, J. Kuffel, “High Voltage Engineering Fundamentals”, Newnes Publication
2. Prof. D. V. Razevig Translated from Russian by Dr. M. P. Chourasia, “High Voltage Engineering”, Khanna Publishers, New Delhi
3. Ravindra Arora, Wolf Gang Mosch, “High Voltage Insulation Engineering”, New Age International Publishers Ltd. Wiley Estern Ltd.

403149 Elective – III: c) Digital Signal Processing

Teaching Scheme
Lectures: 4 Hrs./Week
Practical: 2 Hrs./Week

Examination Scheme
Theory: 100 Marks
Term Work: 25 Marks
Oral: 25 Marks

Unit I **(8)**

Classification of Signals: Analog, Discrete-time and Digital, Basic sequences and sequence operations, Discrete-time systems, Properties of D. T. Systems and Classification, Linear Time Invariant Systems, impulse response, linear convolution and its properties, properties of LTI systems: stability, causality, parallel and cascade connection, Linear constant coefficient difference equations, Eigen functions for LTI systems and frequency response, Periodic Sampling, Sampling Theorem, Frequency Domain representation of sampling, reconstruction of a band limited Signal, A to D conversion Process: Sampling, quantization and encoding.

Unit II **(8)**

Representation of Sequences by Fourier Transform, Symmetry properties of F. T., F. T. theorems: Linearity, time shifting, frequency shifting, time reversal, differentiation, convolution theorem, windowing theorem, Z-transform, ROC and its properties, Inverse z transform by inspection, partial fraction, power series expansion and complex inversion, Z transform properties: Linearity, time shifting, multiplication by exponential sequence, differentiation, conjugation, time reversal, convolution, initial value theorem, Unilateral Z-transform: solution of difference equation

Unit III **(8)**

Frequency Response of LTI Systems: Ideal frequency selective filters, magnitude and phase response, group delay, System Functions for LTI Systems: Stability and causality, inverse systems, significance of poles/zeros, Frequency Response for Rational System Functions: Frequency Response of a single zero or pole, systems with Linear phase, Generalized Linear phase systems, Four Types of GLPS

Unit IV **(8)**

Sampling the F.T., Fourier representation of finite-duration sequences: The Discrete Fourier Transform, Properties of DFT: Linearity, circular shift, duality, symmetry, Circular Convolution, Linear Convolution using DFT, Effective computation of DFT and FFT, DIT FFT, DIF FFT, Inverse DFT using FFT

Unit V **(8)**

Concept of filtering, Ideal filters and approximations, specifications, IIR filter design from continuous time filters: Characteristics of Butterworth, Cheybyshev and elliptic approximations, impulse invariant and bilinear transformation techniques, Design examples, FIR filter design using windows: properties of commonly used windows, incorporation of Generalized Linear Phase, Design Examples, Comparison of IIR and FIR Filters

Unit VI **(8)**

Block diagrams and Signal flow graph representation of LCCDE, Basic structures for IIR Systems: direct form, cascade form, parallel form, Transposed Forms, Basic Structures for FIR Systems: direct form, cascade form, structures for linear phase FIR Systems, Finite Register Length effect

Applications: Spectrum Analysis, Power factor correction, Harmonic Analysis & measurement, applications to machine control, DSP based vibration analysis system

List of Experiments:

Note: Perform the practical using C language or any other professional software.

1. Plotting of discrete time waveforms (a) Sin, (b) Unit Step, (c) Exponential.
2. Find Linear convolution
3. Find DFT & IDFT of sequence
4. Find a) Circular convolution,
   b) Using DFT IDFT method find Circular convolution,
   c) Find linear convolution using Circular convolution.
5. Plot frequency response of given system function (Magnitude & Phase)
6. DIT / DIF FET algorithm
7. Design of IIR filter (butterworth apron method).
8. Design of FIR filter (window method).
9. Study of DSP starter kit and generation of Sine wave.
10. Demo of FIR Filter implementation using DSP kit.

Text Books:

1. Mitra S., "Digital Signal Processing: A Computer Based Approach", Tata McGraw-Hill, 1998, ISBN 0-07-044705-5
2. Proakis J., Manolakis D., "Digital signal processing", 3rd Edition, Prentice Hall, ISBN 81-203-0720-8

Reference Book:

Oppenheim A., Schafer R., Buck J., "Discrete time signal processing", 2nd Edition, Prentice Hall, 2003, ISBN-81-7808-244-6

403149 Elective – III: d) ANN and its Applications in Electrical Engineering

Teaching Scheme	**Examination Scheme**
Lectures: 4 Hrs./Week	**Theory:** 100 Marks
Practical: 2 Hrs./Week	**Term Work:** 25 Marks
	Oral: 25 Marks

Unit I **(8)**

Introduction to Neural Network: Historical perspective, the biological inspiration, Types of Transfer functions, Single Neural Model, Different architecture of NN, basic MC-Lock pitts model of NN.

Unit II **(8)**

Single Layer Network; ANN Learning/ Training Algorithms: Perceptron architecture – Perceptron training algorithm, Least – Mean square algorithm, learning curves, Learning Rate Annealing techniques. Learning with a Teacher, Learning without a Teacher, Learning Tasks. Hebbian learning; Competitive learning; Boltzmann learning. Delta Rule (Gradient Descent Rule)

Unit III **(8)**

Multilayer Network: MLP (Multilayered Perceptron), Pattern Classification; Feed forward Neural Network, Back propagation algorithm. Error based BP. Limitation of Back-propagation algorithm.

Unit IV **(8)**

NN in Control Systems: NN Predictive control; NARMA-L2 (Feedback Linearization) Control; Adoptive Control; Model Reference Control

Unit V **(6)**

Associative Memory: Kohonen Organizing Maps, Recurrent network, Hopfield Networks, Radial Basis functions, Adaptive Resonance Theory.

Unit VI **(7)**

Applications of Neural Network to Electrical Engineering: Robot Applications; Control system applications; speed control of DC Motor; power system application considering Load shedding, harmonic mitigation; power planning etc.

List of Experiments:

1. Study of various Transfer functions in MATLAB.
2. Neural Network Program for classification problem using Perceptron.
3. Neural Network Program for classification problem using Hopfield Network.
4. Neural Network Program for classification problem using Hebbian Network.
5. Neural Network Program for classification problem using Back propagation.
6. Neural Network Program for classification problem using Recurrent Network.
7. Neural Network Program for classification problem using Feed-Forward Network.
8. Neural Network Program using Radial basis Function.
9. Neural Network Predictive control.

Text Books:

1. Jacek Zurada, “Introduction to Artificial Neural Network”, Jaico Publishing House India
2. James A. Anderson, “An Introduction to Neural Networks”, Practice Hall India Publication
3. Mohamed H. Hassoun, “Fundamentals of Artificial Neural Network”, Practice Hall India

4. Simon Haykin, “Neural Networks: A Comprehensive Foundation”, 2nd Edition, Pearson Education

Reference Books:

1. Kelvin Waruicke, Arthur Ekwlle, Raj Agarwal, “AI Techniques in Power System”, IEE London U.K.
2. S. N. Sivanandam, S. Sumathi, S. N. Deepa, “Introduction to Neural Network Using MATLAB 6.0”, Tata McGraw Hill
3. S. Rajsekaram, G. A. Vijayalaxmi Pai, “Neural Networks, Fuzzy Logic & Genetic Algorithms Synthesis & Applications”, Practice Hall India

403150 Elective – IV: a) Modelling of Electrical Systems

Teaching Scheme
Lectures: 4 Hrs./Week

Examination Scheme
Theory: 100 Marks

Unit I **(8)**

Modelling of synchronous machines I: Basic models, electrical equations, mechanical equations, per unit system and normalization, parks transformation, flux linkages equations voltage and current equations.

Unit II **(8)**

Modelling of synchronous machines II: Formulation of state-space equations, equivalent circuit sub transient and transient inductances and time constants, simplified model of synchronous machines, steady state equations and phasor diagram, determination of machines parameters from manufactures data.

Unit III **(8)**

Excitation system modelling: Modelling of excitation system components, modelling of complete excitation system.

Unit IV **(8)**

Modelling of induction motors I: Circuit model of a three phase induction motor, linear transformation, phase transformation, transformation to a reference frame, and two axis models for induction motor.

Unit V **(8)**

Modelling of induction motors II: Voltage and current Equations in stator reference frame, equation in rotor reference frame, equations in a synchronously rotating frame, torque equation.

Unit VI **(8)**

Line and load modelling: Transformer model, transformer with nominal turns ratio, three winding transformers model, phase shifting transformers, load modelling, constant current model, constant impedance model, constant power model, composite load, dynamic characteristics, static load modelling for load flow studies, voltage dependence of equivalent loads, derivation for equivalent load powers.

Text Books:

1) P. S. Bimbhra, “Generalized theory of electrical machines”, Khanna Publishers
2) PSR Murty, “Modeling of power system components”, BS Publications

Reference Books:

1) P. M. Anderson and A. A. Fouad, “Power System control and stability”, Wiley-India Edition
2) Paul C. Krause, Oleg Wasynezuk, Scott D. Sudhoff, “Analysis of Electric Machinery”, IEEE Press, 1995
3) Prabha Kundur, Neal J. Balu, Mark G. Lauby, “Power System Stability and Control”, Tata McGraw Hill Publishing Co. Ltd.
4) Vedam Subramanyam, “Thyristor control of Electric Drives”

403150 Elective – IV: b) Renewable Energy System

Teaching Scheme
Lectures: 4 Hrs./Week

Examination Scheme
Theory: 100 Marks

Unit I **(8)**

Distributed Generation: Electricity Generation in Transition, Distributed Generation with Fossil Fuels, Concentrating Solar Power (CSP) Technologies, Biomass for Electricity, Micro-Hydropower Systems, Fuel Cells, Fuel Cell Thermodynamics: Enthalpy, Gibbs free energy and Fuel Cell Efficiency, Types of Fuel Cells, Hydrogen Production. Economics of Distributed Resources, Economics of Distributed Resources, Energy Economics, Energy Conservation Supply Curves, Combined Heat and Power (CHP), Integrated Resource Planning (IRP) and Demand-Side Management (DSM).

Unit II **(8)**

Wind Energy Systems: Historical Development of Wind Power, Types of Wind turbine electrical generators, Power in the Wind, Impact of Tower Height, Maximum Rotor efficiency, Speed control for Maximum Power, Average Power in the wind, Wind turbine power converters, Wind Turbine Economics, Simple Estimates of Wind Turbine Energy, Specific Wind Turbine Performance Calculations, Environmental Impacts of Wind Turbines. Change in wind pattern and forecasting the power generation based on the wind pattern.

Unit III **(8)**

The Solar Resource: The Solar Spectrum, The Earth's Orbit, Altitude Angle of the Sun at Solar Noon, Solar Position at any Time of Day, Sun Path Diagrams for Shading Analysis, Solar Time and Civil (Clock) Time, Clear Sky Direct-Beam Radiation, Total Clear Sky Insolation on a Collecting Surface, Monthly Clear-Sky Insolation, Solar Radiation Measurements, Average Monthly Insolation. Direct and diffused radiation and effect on power generation- PV and Thermal.

Unit IV **(8)**

Photovoltaic Materials and Electrical Characteristics: Basic Semiconductor Physics, A Generic Photovoltaic Cell, The Simplest Equivalent Circuit for a Photovoltaic Cell From Cells to Modules to Arrays, The PV I–V Curve under Standard Test Conditions (STC), Impacts of Temperature and Insolation on I–V Curves, Shading Impacts on I–V curves, Crystalline Silicon Technologies, Single-Crystal Czochralski (CZ) Silicon, Ribbon Silicon Technologies, Cast Multicrystalline Silicon, Crystalline Silicon Modules, Thin-Film Photovoltaic, Efficiency of PV system. Methods of measurements.

Unit V **(8)**

Photovoltaic Systems: Introduction to the Major Photovoltaic System Types, Current–Voltage Curves for Loads, Grid-Connected Systems: Interfacing with the Utility, DC and AC Rated Power, The "Peak-Hours" Approach to Estimating PV Performance, Capacity Factors for PV Grid-Connected Systems¸ Grid-Connected System Sizing, Grid-Connected PV System Economics: System Trade-offs, Dollar-per-Watt Ambiguities, Amortizing Costs, Stand-Alone PV Systems, PV-Powered Water Pumping, PV systems – off grid systems and scope for inclusive growth of rural India. Grid autonomy. Bi-directions metering. Calculation of system details.

Unit VI **(8)**

Other Sustainable Energy Sources: Micro-turbine generation, Wave energy conversion systems, Tidal energy conversion systems, Nuclear energy power plants, Clean coal power

plants, Biomass to electrical energy conversion, Geo-Thermal energy harvesting, Bio-mechanical energy harvesting, Bio-chemical and photosynthesis techniques.
Environmental Issues: Global warming and climate change, Carbon trading, concept of Carbon credits, Carbon dioxide sequestration, Atmospheric pollutants, nuclear waste disposal, Impact of renewable energy sources. Kyoto Protocol, Ozone depletion.

Text Books:

1. Dr. Sukhatme, "Solar Energy", Tata McGraw Hills
2. G. D. Rai, "Non Conventional Energy Sources", Khanna Publication
3. Gilbert M. Masters, "Renewable and Efficient Electrical Power Systems", Wiley - IEEE Press, August 2004
4. Paul Gipe, "Wind Energy Comes of Age", John Wiley & Sons Inc.
5. S. Rao, Dr. B. B. Parulekar, "Energy Technology – Non Conventional, Renewable and Conventional", Khanna Publication
6. Siegfried Heier, Rachel Waddington, "Grid Integration of Wind Energy Conversion Systems", Wiley Publications

Reference Books:

1. G. N. Tiwari, Sangeeta Suneja, "Solar Thermal Engineering Systems", Narosa Publishing House
2. L. L. Freris, "Wind Energy Conversion System", Prentice Hall
3. Mili Majumdar, "Energy Efficient Buildings in India", Published by Tata Energy Research Institute & MNRE
4. Thomas Ackermann, "Wind Power in Power Systems", Wiley Publications
5. Tony Burton et al, "Wind Energy Hand Book", John Wiley & Sons Inc.

403150 Elective – IV: c) Digital Control System

Teaching Scheme
Lectures: 4 Hrs./Week

Examination Scheme
Theory: 100 Marks

Unit I **(8)**

Sampling and Reconstruction: Introduction, Configuration of the basic digital control scheme. Advantages and limitations of digital control; Sampling & Reconstruction processes, Shannon's Sampling theorem, practical aspects of choice of sampling rate.
Standard discrete test signals:- unit step, unit ramp, exponential, sinusoidal etc.
Discrete system classification:- Static/ dynamic, Time variant/Time invariant, Linear/Nonlinear, Causal/Non-causal, BIBO Stable/Unstable etc. Quantizing and quantization error; Types of Analog to Digital and Digital to Analog converter.

Unit II **(8)**

The z-Transform: Introduction, definition, z- transform of elementary functions; Important properties and theorems of z- transforms; Inverse of z- transform (IZT), IZT computation by Direct division method, Partial fraction expansion method and by Cauchy's Residue theorem. Solution of difference equation.
Pulse transfer function, General procedure for obtaining Pulse-transfer-function. Block-diagram analysis of sampled data closed loop systems.

Unit III **(8)**

Stability Analysis: Introduction, Mapping between s-plane and z-plane:-Primary strip and complementary stripes; constant frequency loci, constant damping ratio loci. Stability analysis of closed loop system in the z-plane. Jury's stability test, Stability analysis by use of Bilinear transformation and Routh Stability Criterion. Discrete system transient and steady-state response analysis.
Design based on Root-locus method: effect of sampling period on the transient response and on the stability; Design based on the frequency-response method**.**

Unit IV **(8)**

State-Space Analysis: Conversion of pulse transfer functions to state space model and vice a versa. Solution of LTI Discrete-time state equation; State Transition Matrix (STM) and properties of STM; Computation of STM by z-transform method, by power-series expansion method, by Cayley Hamilton theorem, by similarity transformation method. Discretization of continuous-time state-space equation.

Unit V **(8)**

Design Using State-Space: Controllability and observability of linear time invariant discrete – data system, Tests for controllability and observability; Principal of Duality; Effect of pole-zero cancellation; Relationship between controllability, observability and stability. Pole placement design using linear state-feedback.State estimation and full order observer design, Ackermann's formula.

Unit VI **(8)**

Digital Control System Applications
State Space Model of Digital System:- Transformation of state-space model to various(controllable, observable, diagonal, and Jordan)-canonical forms.
Digital Control System Applications:- Digital temperature control, position control, stepper motor control; Block diagram presentation and control algorithms.

Text Book:

K. Ogata, "Discrete Time Control System", 2nd Edition, PHI Learning Pvt. Ltd. 2009

Reference Books:

1. B. C. Kuo, "Digital Control Systems**",** 2nd Edition, Oxford University Press
2. M. Gopal, "Digital Control Engineering", New Age International Publishers
3. M. Gopal, "Digital Control and State Variable Methods", 3rd Edition The McGraw Hill Co.

403146: Project

Teaching Scheme
Practical: 2 Hrs./Week

Examination Scheme
Term Work: 100 Marks
Oral: 50 Marks

Project Work:
The student shall take up suitable project from various below mentioned areas. The scope of the project shall be such as to complete it within the time schedule. An individual can undertake project but maximum number of students in one group should not be more than three (only in exceptional cases a maximum four of students can be allowed by Head of the Department). The project may be of the following nature:

1. Manufacturing / Fabrication of a prototype unit including selection, concept, design, material, manufacturing the component, assembly of components, testing and performance evaluation.
2. Improvement of the existing equipment / process.
3. Computer aided design, analysis of components.
4. Problems related to productivity improvement.
5. Problems related to value engineering.
6. Problems related to material handling systems.
7. Energy audit of organization.
8. Detail cost estimation of products.
9. Quality improvement systems and management.
10. Low cost automation etc.
11. Renewable Energy.
12. Energy Conservation.
13. Software based for any application in electrical engineering.

Submission of Report:
The student shall submit the detailed report based on his/her project work to his/her internal guide. It shall include relevant circuit diagrams, graphs, photographs, specification sheets etc.

Format for the Project Report shall be as follows:

1. The report shall be neatly typed on white paper. The typing shall be of normal spacing and only on one of the "A-4" size paper.
2. The report shall be submitted with front and back cover of card paper, neatly cut and bound together with the text.
3. Front Cover: This shall have the following details in Block Capital in the following sequence:
    a) Title at the top.
    b) Followed by the names of the candidate of the project group and Exam. Seat Nos. in the next line.
    c) Name of the guide with his designation below the details of the candidates.
    d) The name of the institute and year of submission on separate lines in the end.
4. Project work approval sheet in the form of a certificate, duly signed, shall be included.
5. The format of the text of the Project report:

The synopsis shall be followed by literature survey. The report of analytical or experimental work done, if any, shall then follow.

The discussion and conclusions shall form the last part of the text. It shall be followed by nomenclature and symbols used and then acknowledgement. The bibliography shall form the last section.

The total number of typed pages, excluding cover, shall be about 50 to 100. All the pages shall be serially numbered.

Assessment:

At the end of semester I - Individual/Group must submit soft copy of progress report and give a presentation in the internal seminar it should be recorded and kept by the department and should be presented at the end of the semester II along with final report for assessment. The oral examination will be based on project work.