**SEMESTER - I**

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**SEMESTER - II**

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**Elective – I (403143)**

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

**Elective – III (403149)**

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

**Elective – II (403144)**

- Restructuring and Deregulation
- Embedded System
- EHV Transmission
- Smart Grid

**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
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
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
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

Unit V

Unit VI
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:
2) John R. Hackworth, Frederick D., Hackworth Jr., “Programmable Logic Controllers Programming Methods and Applications”
5) Stuart A Boyer, “SCADA supervisory control and data acquisition”

Reference Books:
4) Gordan Clark, Deem Reynenders, “Practical Modern SCADA Protocols”
5) Krishna Kant, “Computer Based Industrial Control”, PHI
7) P. K. Srivstava, “Programmable Logic Controllers with Applications”, BPP Publications
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
**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
**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
**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
**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), \( B_{nm} \) 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
**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
**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

**Reference Books:**
3. Hingorani, “Understanding FACTs” IEEE Press
5. Prabha Kundur “Power system stability and control” Tata McGraw Hill
403143 Elective – I: a) Robotics and Automation

Teaching Scheme
Lectures: 4 Hrs./Week

Examination Scheme
Theory: 100 Marks

Unit I
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
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
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
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
Manipulator Differential Motion: Concept of linear and angular velocity, Relationship between transformation matrix and angular velocity, manipulator Jacobian, Jacobian for prismatic and revolute joint, Jacobian Inverse, Singularities.
Control of Robot manipulator: joint position controls (JPC), resolved motion position controls (RMPC) & resolved motion rate control (RMRC).

Unit VI
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:**

**Reference Books:**
403143 Elective – I: b) Power Quality

Teaching Scheme
Lectures: 4 Hrs./Week

Examination Scheme
Theory: 100 Marks

Unit I
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
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
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

Unit V
Unit VI


**Text Books:**

**Reference Books:**
2. Ewald F. Fuchs, Mohammad A. S. Masoum, “Power Quality in Power Systems and Electrical Machines”
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.

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

**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

**Reference Books:**
1. “BIS, IEC Standards for Lamps, Lighting Fixtures and Lighting”, Manak Bhavan, New Delhi
3. Elmer, “Design of Reflectors”
403143 Elective – I: d) Project Management

Teaching Scheme
Lectures: 4 Hrs./Week

Examination Scheme
Theory: 100 Marks

Unit I
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

Unit III
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

Unit V
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

Text Books:
3. Rosy Burke, “Project Management: planning and control technique”, Wiley India, 2003

Reference Books:
### 403144 Elective – II: a) Restructuring and Deregulation

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<td>Theory: 100 Marks</td>
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**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:**
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
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
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

Unit II
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
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
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
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 comemercial RTOS like Vxworks & RT Linux.

Unit VI
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:
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<td>Unit 3</td>
<td>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.</td>
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<tr>
<td>Unit 5</td>
<td>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.</td>
</tr>
<tr>
<td>Unit 6</td>
<td>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.</td>
</tr>
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</table>

**Text Books:**
1. Kimbark, “HVDC Transmission” John Willy & Sons Publication
Reference Books:
403144 Elective – II: d) Smart Grid

Teaching Scheme
Lectures: 4 Hrs./Week

Examination Scheme
Theory: 100 Marks

Unit I
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
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

Unit IV
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

Unit VI

Text Books:

Reference Books:

Unit I
**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
**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
**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
**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
**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
**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:

Reference Books:
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
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
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, SF6 and VCB - advantages, disadvantages and applications. Auto reclosing.

Unit III

Unit IV
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
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.

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

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.
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:

Reference Books:
2. A Web course on “Digital Protection of Power System” by Prof. Dr S. A. Soman, IIT Mumbai
Unit I


Unit II


Unit III

**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

**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

Unit VI

Latest trends in Drives and Industrial Applications:

- 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.

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.
7. Study of Solid state stator voltage control of 3 phase Induction motor (Using AC voltage Regulator).
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.

Industrial Visit:

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

Text Books:


Reference Books:

1. K. Bose, “Modern Power Electronics and AC Drives”, Pearson Education
### 403149 Elective – III: a) VLSI Design

<table>
<thead>
<tr>
<th>Teaching Scheme</th>
<th>Examination Scheme</th>
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</thead>
<tbody>
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<td>Lectures: 4 Hrs./Week</td>
<td>Theory: 100 Marks</td>
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<tr>
<td>Practical: 2 Hrs./Week</td>
<td>Term Work: 25 Marks</td>
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<tr>
<td></td>
<td>Oral: 25 Marks</td>
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#### Unit I

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

#### Unit VI
**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)

10. Simulation of traffic light controller.

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

**Text Books:**

**Reference Books:**
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
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
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
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 arrester, 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
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-Graaff 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 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
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  
2. Breakdown of air under uniform and non-uniform field.  
4. Effect of gap length on liquid insulating material.  
5. Breakdown of composite dielectric material.  
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.  
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:  

Reference Books:  
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

Unit II
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
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
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
Concept of filtering, Ideal filters and approximations, specifications, IIR filter design from continuous time filters: Characteristics of Butterworth, Chebyshev 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
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).
9. Study of DSP starter kit and generation of Sine wave.
10. Demo of FIR Filter implementation using DSP kit.

Text Books:

Reference Book:
403149 Elective – III: d) ANN and its Applications in Electrical 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
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
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
Multilayer Network: MLP (Multilayered Perceptron), Pattern Classification; Feed forward Neural Network, Back propagation algorithm. Error based BP. Limitation of Back-propagation algorithm.

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

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

Unit VI
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.
8. Neural Network Program using Radial basis Function.

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

Reference Books:
403150 Elective – IV: a) Modelling of Electrical Systems

Teaching Scheme
Lectures: 4 Hrs./Week

Examination Scheme
Theory: 100 Marks

Unit I
**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
**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
**Excitation system modelling:** Modelling of excitation system components, modelling of complete excitation system.

Unit IV
**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
**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
**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
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

Unit II

Unit III

Unit IV

Unit V

Unit VI
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:**
   Press, August 2004
5. S. Rao, Dr. B. B. Parulekar, “Energy Technology – Non Conventional, Renewable and
   Conventional”, Khanna Publication
   Systems”, Wiley Publications

**Reference Books:**
   House
3. Mili Majumdar, “Energy Efficient Buildings in India”, Published by Tata Energy Research
   Institute & MNRE
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 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:

Reference Books:
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.
9. Quality improvement systems and management.
10. Low cost automation etc.

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.