ACADEMIC REGULATIONS & COURSE STRUCTURE

For

POWER ELECTRONICS (PE)
POWER AND INDUSTRIAL DRIVES (P&ID)
POWER ELECTRONICS AND ELECTRICALDRIVES (PE &ED)
POWER ELECTRONICS AND DRIVES (PE&D)
POWER ELECTRONICS AND SYSTEMS (PE&S)
ELECTRICAL MACHINES AND DRIVES (EM&D)

(Applicable for batches admitted from 2016-2017)

JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY: KAKINADA
KAKINADA - 533 003, Andhra Pradesh, India

I Semester

S. No.	Subject	L	P	Credits
1	Electrical Machine Modeling & Analysis	4	--	3
2	Analysis of Power Electronic Converters	4	--	3
3	Power Electronic Control of DC Drives	4	--	3
4	Flexible AC Transmission Systems	4	--	3
5	**Elective – I** i. Modern Control Theory ii. Power Quality ii. Optimization Techniques	4	--	3
6	**Elective – II** i. Energy Auditing, Conservation and Management ii. Artificial Intelligence Techniques iii. HVDC Transmission	4	--	3
7	Simulation Laboratory	--	4	2
Total Credits				**20**

II Semester

S. No.	Subject	L	P	Credits
1	Switched Mode Power Conversion	4	--	3
2	Power Electronic Control of AC Drives	4	--	3
3	Digital Controllers	4	--	3
4	Custom Power devices	4	--	3
5	**Elective – III** i. Renewable Energy Systems ii. Reactive Power Compensation & Management iii. Electrical Distribution Systems	4	--	3
6	**Elective – IV** i. Smart Grid Technologies ii. Special Machines iii Programmable Logic Controllers & Applications	4	--	3
7	Power Converters & Drives Laboratory	--	4	2
Total Credits				**20**

III Semester

S. No.	Subject	L	P	Credits
1	Comprehensive Viva-Voce	**--**	**--**	2
2	Seminar – I	--	--	2
3	Project Work Part - I	--	--	16
Total Credits				**20**

IV Semester

S. No.	Subject	L	P	Credits
1	Seminar – II	--	--	2
2	Project Work Part - II	--	--	18
Total Credits				**20**

I Year - I Semester

L	P	C
4	0	3

ELECTRICAL MACHINE MODELING & ANALYSIS
(Common to PE, P&ID, PE&ED, PE&D, PE&S, EM&D)

Prerequisites: Electrical machines & Special machines.

Course Educational Objectives:

- To know the concepts of generalized theory of electrical machines.
- To represent the DC and AC machines as Basic Two Pole machine.
- To model the electrical machines with voltage, current, torque and speed equations.
- To investigate the steady state and transient behaviour of the electrical machines.
- To understand the dynamic behaviour of the AC machines.

UNIT – 1: Basic concepts of Modeling

Basic Two-pole Machine representation of Commutator machines, 3-phase synchronous machine with and without damper bars and 3-phase induction machine, Kron's primitive Machine-voltage, current and Torque equations.

UNIT – II: DC Machine Modeling

Mathematical model of separately excited D.C motor – Steady State analysis-Transient State analysis-Sudden application of Inertia Load-Transfer function of Separately excited D.C Motor-Mathematical model of D.C Series motor, Shunt motor-Linearization Techniques for small perturbations

UNIT- III: Reference frame theory&Modeling of single phase Induction Machines

Linear transformation-Phase transformation - three phase to two phase transformation (abc to $\alpha\beta0$) and two phase to three phase transformation $\alpha\beta0$ to abc - -Power equivalence-Mathematical modeling of single phase induction machines.

UNIT – IV: Modeling of three phase Induction Machine

Generalized model in arbitrary reference frame-Electromagnetic torque-Derivation of commonly used Induction machine models- Stator reference frame model-Rotor reference frame model-Synchronously rotating reference frame model-state space model with flux linkages as variables

UNIT –V: Modeling of Synchronous Machine& Special machines

Synchronous machine inductances –voltage equations in the rotor's dq0 reference frame-electromagnetic torque-current in terms of flux linkages-three synchronous machine model-modeling of PM Synchronous motor, modeling of BLDC motor, modeling of Switched Reluctance motor

Course Outcomes:

After completion of this course the students will be able to:

- Apply knowledge of behaviour of DC motors to model and analyse for different applications.
- Analyse the characteristics of different types of DC motors to design suitable controllers
- Apply the knowledge of reference frame theory for AC machines to model the induction andSynchronous machines.
- Evaluate the steady state and transient behaviour of induction and synchronous machines toPropose the suitability of drives for different industrial applications
- Analyse the 2-Phase induction machines using voltage and torque equations to differentiate the behaviour and to propose their applications in real world.

Reference Books:

1. Electric Motor Drives - Modeling, Analysis& control -R.Krishnan- Pearson Publications- 1st edition -2002
2. Analysis of Electrical Machinery and Drive systems – P.C.Krause, Oleg Wasynczuk, Scott D.Sudhoff – Second Edition-IEEE Press.
3. Dynamic simulation of Electric machinery using Matlab / Simulink –CheeMunOng-Prentice Hall
4. P.S.Bhimbra,'' Generalised theory of Electrical Machines''-Fifth edition,Khanna publishers.

I Year - I Semester

L	P	C
4	0	3

ANALYSIS OF POWER ELECTRONIC CONVERTERS
(Common to PS, PSC&A, PSE, PS&C, APS, EPE, PE&ES, PE&PS, PE, P&ID, PE&ED, PE&D, PE&S, EM&D)

Prerequisites: Power switching devices, characteristics & Commutation techniques.

Course Educational Objectives:

- To study the operation of AC voltage converters and controllers.
- To study the necessity requirement of power factor correction for converter circuits.
- To study the operation of inverters with and without PWM controller.
- To study the operation of different types of multilevel inverters.

UNIT-I AC voltage Controllers

Single Phase AC Voltage Controllers with PWM control only –synchronous tap changers - Three Phase AC Voltage controllers-Analysis of Controllers with star and delta connected resistive, resistive –inductive loads-Effects of source and load inductances–Application- numerical problems.

UNIT –II AC-DC converters

Single phase full and half Converters with inductive load– Power factor improvements: Extinction angle control-symmetrical angle control - single phase sinusoidal PWM-Single phase series converters- numerical problems - Three Phase full and half Converter with inductive load– harmonic analysis -Power factor improvements-three phase PWM-twelve pulse converters-numerical problems

UNIT-III Power Factor Correction Converters

Single-phase single stage boost power factor corrected rectifier, power circuit principle of operation, and steady state- analysis, three phase boost PFC converter

UNIT –IV PWM Inverters

single phase full bridge inverters - sinusoidal PWM – modified PWM – phase displacement Control – Trapezoidal, staircase, stepped, harmonic injection and delta modulation – numerical problems - Three-Phase Inverters- Sinusoidal PWM- 60^0 PWM- Third Harmonic PWM- Space Vector Modulation- Comparison of PWM Techniques-current source inverters-Variable dc link inverter - numerical problems

UNIT V: Multi level inverters

Multilevel Concept, Types of Multilevel Inverters- Diode-Clamped Multilevel Inverter, Features of Diode-Clamped Inverter, Improved Diode-Clamped Inverter- Flying-Capacitors Multilevel Inverter-Features of Flying-Capacitors Inverter- Cascaded Multilevel Inverter- Principle of Operation- Features of Cascaded Inverter- Switching Device Currents-DC-Link Capacitor Voltage Balancing- Features of Multilevel Inverters- Comparisons of Multilevel Converters

Course Outcomes: After completion of this course the students will be able to:

- Analyze the operation of phase controlled converters and AC voltage converters.
- Analyze the requirements of power factor correction in converter circuits.
- Describe and analyse the operation of 3-phase inverters with and without PWM techniques.
- Describe principles of operation and features of multilevel inverters.

Reference books:

1. Power Electronics-Md.H.Rashid –Pearson Education Third Edition- First IndianReprint-2008
2. Power Electronics- Ned Mohan, Tore M.Undelan and William P.Robbins –John Wiley& Sons -2nd Edition.
3. Power Electronics – Lander –Ed.2009
4. Modern power Electronics and AC Drives – B.K.Bose
5. Power Converter Circuits – William Shepherd & Li Zhang-Yes Dee Publishing PvtLtd.

I Year - I Semester

L	P	C
4	0	3

POWER ELECTRONIC CONTROL OF DC DRIVES
(Common to PE, P&ID, PE&ED, PE&D, PE&S, EM&D)

Prerequisites: Power Electronics & DC Machines.

Course Educational Objectives:

- To study the operation of Phase Controlled Converters based DC drives in four quadrants.
- To study modeling concepts of AC – DC converters fed drive components.
- To study the operation of DC- DC converter fed DC drives.
- To study the operation of closed loop control based DC-DC converters fed DC drives.

UNIT-I Introduction on single phase convertor fed DC motor drive:
Basic power electronic drive system, components, stability of power electronic drive, single phase full-convertor and half-convertor fed dc drives for continuous and discontinuous mode of operation. Four quadrant operation of drive using dual convertor.

UNIT-II Three phase AC-DC convertor fed DC motor drive:
Three phase full-convertor and half-convertor fed dc drives for continuous and discontinuous mode of operation. Four quadrant operation of drive using three phase dual convertor. Pulsating torque

UNIT-III Modeling of AC-DC convertor fed DC drive components & design of controller:
Transfer function of Dc motor and load, convertor, current and speed controllers, current and speed feedback elements. Design of current controller and speed controller. Closed loop two quadrant DC motor drive, closed loop four quadrant DC motor drive, introduction to simulation of DC motor drive.

UNIT-IV DC-DC convertor fed DC motor drive:
Four quadrant DC-DC convertor fed dc motor drive, steady state analysis of DC-DC convertor dc motor drive, pulsating torques.

UNIT-V Closed loop operation of DC-DC convertor fed dc motor drive:
Design of current controller, design of speed controller, modeling of current and speed controller, introduction to simulation of speed controlled dc motor drive.

Course Outcomes:

After completion of this course the students will be able to:

- Analyse single phase and three phase converter fed DC drives.
- Analyse the two quadrants and four quadrant controls of DC motor drives.
- Develop the mathematical models of DC drive components.
- Analyse the four quadrant and closed loop control of DC-DC converter fed DC drive.

Reference Books:

1. Electrical Motor Drives Modeling, Analysis and Control – R. Krishna, Prentice Hall India.
2. Power Semiconductor Controlled Drives – G.K. Dubey.Prentice Hall India.
3. Power Electronics and Motor control – Shepherd, Hulley, Liang-II Edition, Cambridge University Press.
4. Power electronic circuits, devices and applications – M.H.Rashid – PHI.

I Year - I Semester

L	P	C
4	0	3

FLEXIBLE AC TRANSMISSION SYSTEMS
(Common to PE, P&ID, PE&ED, PE&D, PE&S, EM&D)

Prerequisites: Concepts on Power Electronics and Power Systems

Course Educational Objectives:

- To study the performance improvements of transmission system with FACTS.
- To study the effect of static shunt compensation.
- To study the effect of static series compensation.
- To study the effect of UPFC.

UNIT 1 : FACTS concepts, Transmission interconnections, power flow in an AC System, loading capability limits, Dynamic stability considerations, importance of controllable parameters, basic types of FACTS controllers, benefits from FACTS controllers.

UNIT 2 : Basic concept of voltage and current source converters, comparison of current source converters with voltage source converters.

Static shunt compensation : Objectives of shunt compensation, midpoint voltage regulation, voltage instability prevention, improvement of transient stability, Power oscillation damping, methods of controllable var generation, variable impedance type static var generators, switching converter type var generators, hybrid var generators.

UNIT 3 :SVC and STATCOM : The regulation and slope transfer function and dynamic performance, transient stability enhancement and power oscillation damping, operating point control and summary of compensation control.

UNIT 4 : Static series compensators : Concept of series capacitive compensation, improvement of transient stability, power oscillation damping, functional requirements. GTO thyristor controlled series capacitor (GSC), thyristor switched series capacitor (TSSC), and thyristor controlled series capacitor (TCSC), control schemes for GSC, TSSC and TCSC.

UNIT 5 : Unified Power Flow Controller: Basic operating principle, conventional transmission control capabilities, independent real and reactive power flow control, comparison of the UPFC to series compensators and phase angle regulators.

Course Outcomes:

After completion of the course, the student will be able to:

- Know the performance improvement of transmission system with FACTS.
- Get the knowledge of effect of static shunt and series compensation.
- Know the effect of UPFC.
- Determine an appropriate FACTS device for different types of applications.

Reference Books :

1. "Understanding FACTS Devices" N.G.Hingorani and L.Guygi, IEEE Press. Indian Edition is available:--Standard Publications
2. Sang.Y.Hand John.A.T, "Flexible AC Transmission systems" IEEE Press (2006).
3. HVDC & FACTS Controllers: applications of static converters in power systems- Vijay K.Sood- Springer publishers

I Year - I Semester

L	P	C
4	0	3

MODERN CONTROL THEORY
(Common to PS, PSC&A, PSE, PS&C, APS, EPE, PE&ES,

PE&PS, PE, P&ID, PE&ED, PE&D, PE&S, EM&D)

(Elective-I)

Prerequisites: Control Systems, differential equations.

Course Educational Objectives:

- To facilitate the evolution of state variable approach for the analysis of control systems.
- To examine the importance of controllability and observability in modern control engineering.
- To enable students to analyze various types of nonlinearities & construction of trajectories using describing functions and phase plane analysis.
- To study the analysis of stability and instability of continuous time invariant system

UNIT –1: State Variable Analysis

The concept of state – State Equations for Dynamic systems – State diagram - Linear Continuous time model for physical systems – Existence and Uniqueness of Solutions to Continuous – Time State Equations – Solutions – Linear Time Invariant Continuous – Time State Equations – State transition matrix and it's properties

UNIT – 2: State Variable Techniques

General concept of Controllability - General concept of Observability Controllability tests for Continuous &Time Invariant systems - Observability tests for Continuous &Time Invariant systems - Controllability and Observability of state model in Jordan Canonical form - Controllability and Observability Canonical forms of State model – State feedback controller design through pole assignment.

UNIT – 3: Non Linear Systems – I

Introduction – Non Linear Systems – Types of Non – Linearities – Saturation – Dead – Zone – Backlash – Jump Phenomenon etc; - Singular Points – Introduction to Linearization of nonlinear systems, properties of Non Linear Systems – Describing function – describing function analysis of nonlinear systems- Stability analysis of Non – Linear systems through describing functions.

UNIT – 4: Non Linear Systems – II

Introduction to phase – plane analysis, Method of Isoclines for Constructing Trajectories, singular points, phase – plane analysis of nonlinear control systems.

UNIT – 5: Stability Analysis

Stability in the sense of Lyapunov, Lyapunov's stability and Lyapunov's instability theorems – Stability Analysis of the Linear Continuous time invariant systems by Lyapunov second method – Generation of Lyapunov functions – Variable gradient method – Krasooviski's method.

Course Outcomes:

After completion of this course the students will be able to:

- Understanding the state variable approach is suitable for higher order.
- To analyze the concepts of controllability and observability.
- To analyze the various non-linearities through describing functions and phase plane analysis.
- Typical issues of stability and instability of continuous time invariant systems.

Reference Books :

1. Modern Control System Theory by M. Gopal – New Age International – 1984
2. Modern Control Engineering by Ogata. K – Prentice Hall – 1997
3. Nonlinear systems, Hassan K. Klalil, Prentice Hall, 1996
4. Modern control systems, Richard C. Dorf and Robert H. Bishop, 11^{th} Edition, Pearson Edu, India, 2009

POWER QUALITY
(Common to PE&PS, PE, P&ID, PE&ED, PE&D, PE&S, EM&D)

(Elective I)

Prerequisites: Knowledge on electric circuit analysis, power systems and power electronics.

Course Educational Objectives:

- To understand significance of power quality and power quality parameters.
- To know types of transient over voltages and protection of transient voltages.
- To understand harmonics, their effects, harmonic indices and harmonic minimization techniques.
- To understand long duration voltage variation and flicker
- To know power quality aspects in distributed generation.

UNIT-1 Introduction
Overview of Power Quality - Concern about the Power Quality - General Classes of Power Quality Problems – Transients -Long-Duration Voltage Variations - Short-Duration Voltage Variations - Voltage Unbalance - Waveform Distortion - Voltage fluctuation - Power Frequency Variations - Power Quality Terms - Voltage Sags and Interruptions - Sources of Sags and Interruptions – Nonlinear loads.

UNIT-2 Transient Over Voltages
Source of Transient Over Voltages - Principles of Over Voltage Protection - Devices for Over Voltage Protection - Utility Capacitor Switching Transients - Utility Lightning Protection - Load Switching Transient Problems - Computer Tools for Transient Analysis

UNIT-3 Harmonic Distortion and solutions
Voltage vs. Current Distortion - Harmonics vs. Transients - Power System Quantities under Nonsinusoidal Conditions - Harmonic Indices – Sources of harmonics - Locating Sources of Harmonics – System Response Characteristics - Effects of Harmonic Distortion – Interharmonics - Harmonic Solutions Harmonic Distortion Evaluation - Devices for Controlling Harmonic Distortion - Harmonic Filter Design - Standards on Harmonics

UNIT- 4 Long Duration Voltage Variations
Principles of Regulating the Voltage - Device for Voltage Regulation - Utility Voltage Regulator Application - Capacitor for Voltage Regulation - End-user Capacitor Application - Regulating Utility Voltage with Distributed Resources – Flicker

UNIT-5 Distributed Generation and Power Quality
Resurgence of Distributed Generation - DG Technologies - Interface to the Utility System - Power Quality Issues - Operating Conflicts - DG on Low Voltage Distribution Networks - Interconnection standards - Wiring and Grounding - Typical Wiring and Grounding Problems - Solution to Wiring and grounding Problems

Course Outcomes:

After completion of this course the students will be able to:

- Have the knowledge on causes of power quality, power quality parameters.
- Understand sources of transient over voltages and providing protection to transient over voltages.
- Understand effects of harmonics, sources of harmonics and harmonic minimization.
- Analyze long duration voltage variations and regulation of voltage variations.
- Describe power quality aspects in distributed generation and develop solutions to wiring and grounding problems.

Reference Books :

1. Electrical Power Systems Quality, Dugan R C, McGranaghan M F, Santoso S, and Beaty H W, Second Edition, McGraw-Hill, 2002.
2. Power Quality Primer, Kennedy B W, First Edition, McGraw-Hill, 2000.
3. Understanding Power Quality Problems: Voltage Sags and Interruptions, Bollen M H J, First Edition, IEEE Press; 2000.
4. Power System Harmonics, Arrillaga J and Watson N R, Second Edition, John Wiley & Sons, 2003.
5. Electric Power Quality control Techniques, W. E. Kazibwe and M. H. Sendaula, Van Nostrad Reinhold, New York.
6. Power Quality c.shankaran, CRC Press, 2001
7. Harmonics and Power Systems –Franciso C.DE LA Rosa-CRC Press (Taylor & Francis)
8. Power Quality in Power systems and Electrical Machines-EwaldF.fuchs, Mohammad A.S. Masoum-Elsevier

OPTIMIZATION TECHNIQUES
(Common to PE, P&ID, PE&ED, PE&D, PE&S, EM&D, PE&PS)

(Elective I)

Prerequisites: Concepts of engineering mathematics and mathematical methods.

Course Educational Objectives:

- To define an objective function and constraint functions in terms of design variables, and then state the optimization problem.
- To state single variable and multi variable optimization problems, without and with constraints.
- To explain linear programming technique to an optimization problem, define slack and surplus variables, by using Simplex method.
- To study and explain nonlinear programming techniques, unconstrained or constrained, and define exterior and interior penalty functions for optimization problems.
- To introduce evolutionary programming techniques.
- To introduce basic principles of Genetic Algorithms and Partial Swarm Optimization methods.

UNIT – I:
Introduction and Classical Optimization Techniques:
Statement of an Optimization problem – design vector – design constraints – constraint surface – objective function – objective function surfaces – classification of Optimization problems.
Single variable Optimization – multi variable Optimization without constraints – necessary and sufficient conditions for minimum/maximum – multivariable Optimization with equality constraints.Solution by method of Lagrange multipliers – multivariable Optimization with inequality constraints – Kuhn – Tucker conditions.

UNIT – II:
Linear Programming
Standard form of a linear programming problem – geometry of linear programming problems – definitions and theorems – solution of a system of linear simultaneous equations – pivotal reduction of a general system of equations – motivation to the simplex method – simplex algorithm - Duality in Linear Programming – Dual Simplex method.

UNIT – III:
Nonlinear Programming:
Unconstrained cases - One – dimensional minimization methods: Classification, Fibonacci method and Quadratic interpolation method - Univariate method, Powell's method and steepest descent method.
Constrained cases - Characteristics of a constrained problem, Classification, Basic approach of Penalty Function method; Basic approaches of Interior and Exterior penalty function methods. Introduction to convex Programming Problem.

UNIT – IV:

Introduction to Evolutionary Methods:

Evolutionary programming methods - Introduction to Genetic Algorithms (GA)– Control parameters –Number of generation, population size, selection, reproduction, crossover and mutation – Operator selection criteria – Simple mapping of objective function to fitness function – constraints – Genetic algorithm steps – Stopping criteria –Simple examples.

UNIT – V:

Introduction to Swarm Intelligence Systems:

Swarm intelligence programming methods - Basic Partial Swarm Optimization – Method – Characteristic features of PSO procedure of the global version – Parameters of PSO (Simple PSO algorithm – Operators selection criteria – Fitness function constraints) – Comparison with other evolutionary techniques – Engineering applications of PSO.

Course Outcomes:

After completion of this course the students will be able to:

- State and formulate the optimization problem, without and with constraints, by using design variables from an engineering design problem.
- Apply classical optimization techniques to minimize or maximize a multi-variable objective function, without or with constraints, and arrive at an optimal solution.
- Formulate a mathematical model and apply linear programming technique by using Simplex method. Also extend the concept of dual Simplex method for optimal solutions.
- Apply gradient and non-gradient methods to nonlinear optimization problems and use interior or exterior penalty functions for the constraints to derive the optimal solutions.
- Able to apply Genetic algorithms for simple electrical problems.
- Able to solve practical problems using PSO.

Text Books

1. "Engineering optimization: Theory and practice"-by S. S.Rao, New Age International (P) Limited, 3rd edition, 1998.
2. Soft Computing with Matlab Programming by N.P.Padhy&S.P.Simson, Oxford University Press – 2015

Reference Books:

1. **"**Optimization methods in operations Research and Systems Analysis" by K.V.Mital and C.Mohan, New Age International (P) Limited, Publishers, 3rd edition, 1996.
2. Genetic Algorithms in search, optimization, and Machine Learning by David E.Goldberg,ISBN:978-81-7758-829-3, Pearsonby Dorling Kindersley (India) Pvt. Ltd.
3. "Operations Research: An Introduction" by H.A.Taha, PHI pvt. Ltd., 6th edition.
4. Linear Programming by G.Hadley.,Narosa Publishers.

I Year - I Semester

L	P	C
4	0	3

ENERGY AUDITING, CONSERVATION&MANAGEMENT
(Common to PE, P&ID, PE&ED, PE&D, PE&S, EM&D)

(Elective II)

Perquisites: Concepts of utilization of electrical energy, electrical machines and electrical measurements.

Course Educational Objectives:

- To learn principle of energy audit as well as management for industries and utilities and buildings.
- To study the energy efficient motors and lighting.
- To learn power factor improvement methods and operation of different energy instruments.
- To compute depreciation methods of equipment for energy saving.

UNIT I: Basic Principles of Energy Audit

Energy audit- definitions, concept , types of audit, energy index, cost index ,pie charts, Sankey diagrams, load profiles, Energy conservation schemes- Energy audit of industries- energy saving potential, energy audit of process industry, thermal power station, building energy audit

UNIT II: Energy Management –I

Principles of energy management, organizing energy management program, initiating, planning, controlling, promoting, monitoring, reporting. Energy manger, Qualities and functions, language, Questionnaire – check list for top management

UNIT III: Energy Efficient Motors and Lighting

Energy efficient motors , factors affecting efficiency, loss distribution , constructional details , characteristics – variable speed , variable duty cycle systems, RMS hp- voltage variation-voltage unbalance- over motoring- motor energy audit. Good lighting system design and practice, lighting control, lighting energy audit

UNIT IV: Power Factor Improvement and energy instruments

Power factor – methods of improvement , location of capacitors , Power factor with non-linear loads, effect of harmonics on p.f. , p.f motor controllers – Energy Instruments- watt meter, data loggers, thermocouples, pyrometers, lux meters, tongue testers ,application of PLC's

UNIT V: Economic Aspects and their computation

Economics Analysis-Depreciation Methods, time value of money, rate of return, present worth method, replacement analysis, lifecycle costing analysis – Energy efficient motors. Calculation of simple payback method, net present worth method- Power factor correction, lighting – Applications of life cycle costing analysis, return on investment.

Course Outcomes: After completion of this course the students will be able to:

- Perform energy audit in different organizations.
- Recommend energy efficient motors and design good lighting system.
- Understand advantages to improve the power factor.
- Evaluate the depreciation of equipment.

Reference Books:

1. Energy management by W.R. Murphy & G. Mckay Butter worth, Heinemann publications.
2. Energy efficient electric motors by John .C. Andreas, Marcel Dekker Inc Ltd-2nd edition, 1995-
3. Energy management by Paul o' Callaghan, Mc-graw Hill Book company-1st edition, 1998
4. Energy management hand book by W.C.Turner, John wiley and sons
5. Energy management and good lighting practice : fuel efficiency- booklet12-EEO

ARTIFICIAL INTELLIGENCE TECHNIQUES
(Common to PE&PS, PE, P&ID, PE&ED, PE&D, PE&S, EM&D)
(Elective-II)

Prerequisites: Basic knowledge on human biological systems, concept of optimization and electrical engineering.

Course Educational Objectives:

- To have knowledge on concept of neural network.
- To know different types of neural networks and training algorithms.
- To understand the concept of genetic algorithm and its application in optimization.
- To have the knowledge on fuzzy logic and design of fuzzy logic controllers.
- To know the applications of AI Techniques in power electronics and DC drives.

UNIT – 1: Introduction to Neural Networks
Introduction, Humans and Computers, Biological Neural Networks, Historical development of neural network, Terminology and Topology, Biological and artificial neuron models, Basic learning laws.

UNIT- 2:Feed Forward Neural Networks
Introduction, Perceptron models: Discrete, continuous and multi-category, Training algorithms: Discrete and Continuous Perceptron Networks, Perceptron convergence theorem, Limitations and applications of the Perceptron model, Generalized delta learning rule, Feedforward recall and error back propagation training-Radial basis function algorithms-Hope field networks

UNIT -3: Genetic algorithms &Modelling-introduction-encoding-fitness function-reproduction operators**-**genetic operators-cross over and mutation-generational cycle-convergence of genetic algorithm

UNIT – 4:Classical and Fuzzy Sets
Introduction to classical sets - properties, operations and relations; Fuzzy sets, membership, Uncertainty, operations, properties, fuzzy relations, cardinalities, membership functions.
Fuzzy Logic System Components-Fuzzification, Membership value assignment, development of rule base and decision making system, defuzzification to crisp sets, defuzzification methods.

UNIT-5: Application of AI Techniques: Design of PI controller for speed control of DC motor using neural networks and fuzzy logic-PWM Controllers -Selected harmonic elimination PWM-Space vector PWM using neural network.

Course Outcomes: After completion of this course, students will be able to

- Understand neural networks and analyze different types of neural networks.
- Design training algorithms for neural networks.
- Develop algorithms using genetic algorithm for optimization.
- Analyze and designfuzzy logic systems.
- Apply AI Techniques in power electronics and DC drives.

Reference Books:

3. Neural Networks, Fuzzy logic, Genetic algorithms: synthesis and applications by Rajasekharan andPai – PHI Publication.
4. Introduction to Artificial Neural Systems - Jacek M. Zuarda, Jaico Publishing House, 1997.
5. Modern Power Electronics and AC Drives –B.K.Bose-Pearson Publications
6. Genetic Algorithms- David E Goldberg. Pearson publications.

HVDC TRANSMISSION
(Common to PS, PSC&A, PSE, PS&C, APS, EPE, PE&ES, HVE, PSHVE, PE&PS, PE, P&ID, PE&ED, PE&D, PE&S, EM&D)

(Elective II)

Prerequisites: Knowledge on Power Electronics, Power Systems and High Voltage Engineering

Course Educational Objectives:

- To learn various schemes of HVDC transmission.
- To learn about the basic HVDC transmission equipment.
- To learn the control of HVDC systems.
- To be exposed to the interaction between HVAC and HVDC system.
- To be exposed to the various protection schemes of HVDC engineering.

UNIT -1: Limitation of EHV AC Transmission, Advantages of HVDC Technical economical reliability aspects. HVDC Transmission: General considerations, Power Handling Capabilities of HVDC Lines, Basic Conversion principles, static converter configuration. Types of HVDC links-Apparatus and its purpose.

UNIT-2: Static Power Converters: 6-pulse bridge circuit and 12-pulse converters, converter station and Terminal equipment, commutation process, Rectifier and inverter operation, equivalent circuit for converter – special features of converter transformers. Comparison of the perform of diametrical connection with 6-pulse bridge circuit

UNIT-3 : Control of HVDC Converters and systems : constant current, constant extinction angle and constant Ignition angle control. Individual phase control and equidistant firing angle control, DC power flow control. Factors responsible for generation of Harmonics voltage and current harmonics effect of variation of α and μ. Filters Harmonic elimination.

UNIT-4 : Interaction between HV AC and DC systems – Voltage interaction, Harmonic instability problems and DC power modulation. Development of DC circuit Breakers, Multi-terminal DC links and systems; series, parallel and series parallel systems, their operation and control.

UNIT -5 : Transient over voltages in HV DC systems : Over voltages due to disturbances on DC side, over voltages due to DC and AC side line faults. Converter faults and protection in HVDC Systems: Converter faults, over current protection - valve group, and DC line protection, circuit breakers. Over voltage protection of converters, surge arresters.

Course Outcomes:

After completion of this course the students will be able to:

- Understand the various schemes of HVDC transmission.
- Understand the basic HVDC transmission equipment.
- Understand the control of HVDC systems.
- Understand the interaction between HVAC and HVDC system.
- Understand the various protection schemes of HVDC engineering.

Reference Books:

1. S Kamakshaih and V Kamaraju:HVDC Transmission- MG hill.
2. K.R.Padiyar : High Voltage Direct current Transmission, Wiley Eastern Ltd., New Delhi – 1992.
3. E.W. Kimbark : Direct current Transmission, Wiley Inter Science – New York.
4. J.Arillaga : H.V.D.C.Transmission Peter Peregrinus ltd., London UK 1983
5. Vijay K Sood :HVDC and FACTS controllers:Applications of static converters in power systems by, Kluwer Academic Press.

I Year - I Semester

L	P	C
0	4	2

SIMULATION LABORATORY
(Common to PE, P&ID, PE&ED, PE&D, PE&S, EM&D)

Prerequisites: Concepts of Power Electronics & Closed loop control.

Course Educational Objectives:

- To understand the characteristics of Thyristor MOSFET & IGBT by simulation.
- To understand the operation of power electronics converters by simulation.
- To understand how to implement PWM techniques in simulation.
- To understand and analyse the speed control of AC motors in open and closed loop in simulation.

Any 10 of the following experiments are to be conducted.

List of experiments:

1. Switching characteristics simulation analysis of Thyristor, MOSFET,IGBT .
2. Simulation analysis of single phase full converter using R-L load, R-L-E load with and without LC Filter.
3. Simulation analysis of Three phase full converter using R-L-E Load.
4. Simulation analysis of single phase AC Voltage controller with PWM control for RL load.
5. Simulation analysis of three phase AC Voltage controller using RL load.
6. Simulation analysis of single phase inverter with sinusoidal PWM control forR& RL – loads.
7. Simulation analysis of Three phase inverter with Sinusoidal PWM control for R& RL - Loads.
8. Simulation analysis of Buck, Boost& Buck-Boost DC-DC converters.
9. Simulation analysis of three phase converter fed DC motor.
10. Development of mathematical model and simulation analysis of induction machines under balanced and symmetrical conditions for the following
    a. dq model in synchronous reference frame
    b. dq model in stator reference frame
    c. dq model in rotor reference frame
11. Simulation analysis of Volts/Hz closed-loop speed control of an induction motor drive.
12. Simulation analysis of Open-loop Volts/Hz control of a synchronous motor drive.
13. Simulation analysis of Speed control of a permanent magnet synchronous motor.
14. Simulation analysis of Capacitor-start capacitor-run single-phase induction motor.

COURSE OUTCOMES: After completion of this course the students will be able to:

- Analyse the characteristics of power semiconductor devices in simulation.
- Analyse the operation of various power electronic converters in simulation.
- Analyse and implementing the speed controlling techniques for AC machines in simulation.
- Analyse and implementing PWM techniques in simulation.

I Year - II Semester

L	P	C
4	0	3

SWITCHED MODE POWER CONVERSION
(Common to PE, P&ID, PE&ED, PE&D, PE&S, EM&D, PE&PS)

Perquisites: Concepts of electrical circuit analysis and power electronics.

Course Educational Objectives:

- To understand the control operation of non-sinusoidal DC-DC converters.
- To understand the basic operation of resonant converters.
- To understand the control operation of isolated DC-DC converters.
- To understand the control schemes of DC-DC converters and designing of magnetic components.
- To understand the modeling and control design of switch mode conversion based on linearization.
- To understand how to analyse the switch mode converters using small-signal analysis.

UNIT-I: Non-isolated switch mode converters:
Control of DC-DC converters, Buck converters, Boost converters, Buck-Boost converter, CUK Converter, Converter realization with nonideal components.

UNIT-II: Resonant converters:
Basic resonant circuit concepts, series resonant circuits, parallel resonant circuits, zero current switching Quasi-resonant buck converter, zero current switching Quasi-resonant boost converter, zero voltage switching Quasi-resonant buck converter, zero voltage switching Quasi-resonant boost converter

UNIT-III: Isolated switch-mode converters:
Forwarded converter, fly back converter, Push-pull converter, half-bridge converter, full bridge converter

UNIT-IV: Control schemes of switching converters:
Voltage-mode control, Current-mode control, control scheme for resonant converters, proportional integral controller.
Magnetic design consideration: Transformers design, DC inductor and capacitor design.

UNIT-V: Modeling& Control design based on linearization:
Formulation of averaged models for buck and boost converters average circuits models, small – signal analysis and linearization.
Control design based on linearization: Transfer function of converters, control design, large signal issues in voltage-mode & current-mode control.

Course Outcomes:
After completion of this course the students will be able to:

- Analyse the control operation of non-isolated switch mode converters.
- Analyse the operation of resonant converters and soft switching.
- Analyse the operation of isolated switch mode converters.
- Analyse the control schemes for resonant converters and design of magnetic components.
- Analyse the design of non-isolated switch mode converters based on linearization.
- Analyse the switch mode converters with small signal analysis.

Reference Books:

1. Power Electronics – IssaBataresh, Jhonwilley publications,2004
2. Power switching converters-simonang, alejandro olive, CRC Press (Taylor &franicsgroup).
3. Elements of Power Electronics – Philip T. Krein, Oxford University press.
4. Power Electronics: converters Applications & Design – Mohan, Undeland, Robbins-Wiley publications

I Year - II Semester

L	P	C
4	0	3

POWER ELECTRONIC CONTROL OF AC DRIVES
(Common to PE, P&ID, PE&ED, PE&D, PE&S, EM&D)

Perquisites: Concepts of power electronics, electrical machines and closed loopcontrol.

Course Educational Objectives:

- To analyse the VSI fed induction motor drive.
- To study the performance of different types of BLDC motor drives.
- To study different traction drives.
- To know the operation and control of switched reluctance motor & stepper motor.

UNIT-I: 3-phase induction motor drives – Part 1

Analysis of IM fed from non-sinusoidal supply, harmonic equivalent circuit, transient analysis – starting and plugging; variable frequency control, torque-slip relation, starting torque and braking torque, closed-loop VSI fed IM drive. Slip-ring IM control, closed-loop speed control with static rotor resistance, closed-loop speed control by using slip power recovery scheme.

UNIT-II: 3-phase induction motor drives – Part 2

Concept of space vector, vector control of IM: direct or feed-back vector control, flux vector estimation, indirect or feed forward vector control, vector control of line side PWM converter, stator flux oriented vector control, vector control of converter fed inverter drive.

UNIT-III: Synchronous motor and BLDC motor drives

Variable frequency control of synchronous motor, closed-loop control of inverter fed synchronous motor drive. Permanent magnet synchronous motor drive. BLDC motor drives, VSI fed BLDC motor drives, back emf, phase current and torque waveforms, control of BLDC motors with sensors, sensor-less control of BLDC motors

UNIT-IV: Traction drives

Motors employed in railway traction and road-vehicles, control of railway traction dc motors using ac-dc converters, control of railway traction ac motors using ac-dc and dc-ac converters, power electronic control circuits of electric vehicles and hybrid electric vehicles

UNIT-V: Switched reluctance and stepper motor drives

Switched reluctance motor operation and control: modes of operation, converter circuits closed-loop speed control. Stepper motor characteristics drive circuits for uni-polar and bipolar stepper motors.

Course Outcomes: After completion of this course the students will be able to:

- Explain operation of induction motor and analyse speed control of AC drivesbyVSIfed drives.
- Understand vector control of induction motors.
- Understand operation of traction drives.
- Analyse control schemes to synchronous motor drives.
- Understand control of switched reluctance motor & stepper motor.

Reference Books:

1. “Electric motor drives, modeling, analysis and control”, R. Krishnan, PHI Publishers
2. “Control of electric drives”, W. Leonhard, Springer Verilog
3. “Vector control of AC machines”, ArindamGhosh, Gerard Ledwich
4. “Power Electronics: Converters,Application and design” ,Mohan, Undeland and Robbins, Wiley Publications.
5. “Urban transport and hybrid electric vehicles”, Edited by SerefSoylu, Published online, 18 Aug 2010. Available:http://www.intechopen.com/books/urban-transport-and-……..
6. “Power control of AC motors”, J.M.D. Murphy and F. G. Turnbul
7. “Power semiconductor drives”, G. K. Dubey, Printice Hall International
8. “Fundamentals of electric drives”, G. K. Dubey, Narosa Publishing House

I Year - II Semester

L	P	C
4	0	3

DIGITAL CONTROLLERS
(Common to PE, P&ID, PE&ED, PE&D, PE&S, EM&D)

Prerequisites: Basic concepts of switching theory & logic design and fundamentals of micro controllers.

Course Educational Objectives:

- To understand the architecture of PIC micro controller.
- To understand the architecture of DSP processor and their interface.
- To understand how to write the program for DSP processor using assembly Programming.
- To understand the different types of FPGA and configurations.
- To understand the basics of programming in Xilinx.

UNIT- I
PIC MICROCONTROLLERS

PIC Microcontrollers: Overview and Features, PIC 16C6X/7X, FSR(File Selection Register) [Indirect Data Memory Address Pointer], PIC Reset Actions, PIC Oscillator Connections, PIC Memory Organizations, PIC PIC 16C6X/7X Instructions, Addressing Modes, I/O Ports, Interrupts in PIC 16C61/71, PIC 16C61/71 Timers, PIC 16C71 Analog-to-Digital Converter (ADC)

UNIT - II
INTRODUCTION TO DSP

Introduction to the C2xx DSP core and code generation, The components of the C2xx DSP core, Mapping external devices to the C2xx core , peripherals and Peripheral Interface , System configuration registers , Memory , Types of Physical Memory , memory Addressing Modes , Assembly Programming using C2xx DSP, Instruction Set, Software Tools.

UNIT - III
I/O & CONTROL REGISTERS

Pin Multiplexing (MUX) and General Purpose I/O Overview, Multiplexing and General Purpose I/O Control Registers .Introduction to Interrupts, Interrupt Hierarchy, Interrupt Control Registers, Initializing and Servicing Interrupts in Software.

UNIT - IV
ADC & EVENT MANAGER

ADC Overview , Operation of the ADC in the DSP , Overview of the Event manager (EV) , Event Manager Interrupts , General Purpose (GP) Timers , Compare UNITs, Capture UNITs And Quadrature Enclosed Pulse (QEP) Circuitry , General Event Manager Information

UNIT - V
FPGA

Introduction to Field Programmable Gate Arrays – CPLD Vs FPGA – Types of FPGA , Xilinx XC3000 series , Configurable logic Blocks (CLB), Input/Output Block (IOB) – Programmable Interconnect Point (PIP) – Xilinx 4000 series – HDL programming – overview of Spartan 3E and Virtex II pro FPGA boards- case study.

Course Outcomes:
After completion of this course the students will be able to:

- Know the interfacing circuits for input and output to PIC micro controllers and DSP processors.
- Know how to write ALP for DSP processors.
- Design PWM controls for power electronic circuits using FPGA.

Reference Books:

1. Microcontrollers-Theory and Applications by Ajay V Deshmukh, McGraw Hills
2. Microcontrollers by Kennith J ayala, Thomson publishers
3. Microprocessor and Microcontrollers by Prof C.R.Sarma.
4. Hamid.A.Toliyat and Steven G.Campbell"DSP Based Electro Mechanical Motion Control " CRC Press New York , 2004.
5. XC 3000 series datasheets (version 3.1). Xilinx,Inc.,USA, 1998.
6. Wayne Wolf," FPGA based system design ", Prentice hall, 2004

I Year - II Semester

L	P	C
4	0	3

CUSTOM POWER DEVICES
(Common to PE, P&ID, PE&ED, PE&D, PE&S, EM&D, PE&PS)

Prerequisites: Concept of power electronics and concept of reactive power compensation.

Course Educational Objectives:

- To understand the various power quality issues and their effects on the distribution circuits.
- To understand principle of working of various custom power devices.
- To understand the other custom power devices and their applications to power system.

UNIT I-Introduction

Custom Power and Custom Power Devices - power quality variations in distribution circuits – Voltage Sags, Swells, and Interruptions - System Faults – Over voltages and Under voltages - Voltage Flicker - Harmonic Distortion - Voltage Notching - Transient Disturbances - Characteristics of Voltage Sags.

UNIT II-Overview of Custom Power Devices

Reactive Power and Harmonic Compensation Devices - Compensation Devices for Voltage Sags and Momentary Interruptions - Backup Energy Supply Devices - Battery UPS – Super Conducting Magnetic Energy Storage systems - Flywheel – Voltage Source Converter - Multi-level converters.

UNIT III-Reactive Power and Harmonic Compensation Devices

Var control devices - Static Var Compensator – Topologies - Direct Connected Static Var Compensation for Distribution Systems – Static Series Compensator - Static Shunt Compensator (DSTATCOM) - Interaction with Distribution Equipment and System - Installation Considerations.

UNIT IV- High-Speed Source Transfer Switches, Solid State Limiting, And Breaking Devices:

Source Transfer Switch - Static Source Transfer Switch (SSTS),- Hybrid source transfer switch – High-speed mechanical source transfer switch - Solid state current limiter - Solid state breaker .

UNIT V-Application of Custom Power Devices in Power Systems

P-Q theory – Control of P and Q – Dynamic Voltage Restorer (DVR) – Operation and control – Interline Power Flow Controller (IPFC) – Operation and control – Unified Power Quality Conditioner (UPQC) – Operation and control. Recent custom power devices.

Course Outcomes:

After completion of this course the students will be able to:

- Analyse the effect of various power quality issues in distribution system and their mitigation principles.
- Describe the operation of custom power devices for reactive power & harmonic compensation.
- Analyse high speed transfer switches.
- Analyse the operation and control of custom power devices in power system applications.

Text Books

1. Guidebook on Custom Power Devices, Technical Report, Published by EPRI, Nov 2000
2. Power Quality Enhancement Using Custom Power Devices – Power Electronics and Power Systems, Gerard Ledwich, ArindamGhosh, Kluwer Academic Publishers, 2002.

Reference Books:

1. Power Quality, C. Shankaran, CRC Press, 2001
2. Instantaneous power theory and application to power conditioning, H. Akagiet.al., IEEE Press, 2007.
3. Custom Power Devices - An Introduction, ArindamGhosh and Gerard Ledwich, Springer, 2002
4. A Review of Compensating Type Custom Power Devices for Power Quality Improvement, Yash Pal et.al., Joint International Conference on Power System Technology and IEEE Power India Conference, 2008. POWERCON 2008.

I Year - II Semester

L	P	C
4	0	3

RENEWABLE ENERGY SYSTEMS
(Common to PE, P&ID, PE&ED, PE&D, PE&S, EM&D)
(Elective-III)

Prerequisites: Basic idea of non-conventional energy sources.

Course Educational Objectives:

- To learn basic principle of renewable energy sources.
- To adoption of alternative energy sources for power generation.
- To learn alternative energy sources not based on sun.
- To the adoption and inter connection of renewable and alternative energy sources to grid.

UNIT-1

Solar Energy - Availability - Solar radiation data and measurement - Estimation of average solar radiation - Solar water heater types - Heat balance – Flat plate collector efficiency – Efficiency of heat removal - Thermo siphon flow calculation - Forced circulation calculation - Evacuated collectors - Basics of solar concentrators Solar Energy Applications - Solar air heaters – Solar Chimney - Crop driers - Passive solar system - Active solar systems - Water desalination - Output from solar still – Principle of solar ponds.

UNIT-2

Wind Energy – Nature of wind – Characteristics – Variation with height and time – Power in wind –Aerodynamics of Wind turbine – Momentum theory – Basics of aerodynamics – Aero foils and their characteristics – HAWT – Blade element theory – Prandtl's lifting line theory (prescribed wake analysis) VAWT aerodynamics – Wind turbine loads – Aerodynamic loads in steady operation – Yawed operation and tower shadow. Wind Energy Conversion System – Siting – Rotor selection – Annual energy output – Horizontal axis wind turbine (HAWT) – Vertical axis wind turbine (VAWT) – Rotor design considerations – Number of blades – Solidity - Blade profile – Upwind/Downwind – Yaw system – Tower – Braking system - Synchronous and asynchronous generators and loads – Integration of wind energy converters to electrical networks – Inverters – Control system – Requirement and strategies – Noise Applications of wind energy

UNIT-3

Biomass energy - Bio fuel classification – Examples of thermo chemical, Pyrolysis, biochemical and agrochemical systems – Energy farming – Direct combustion for heat – Process heat and electricity – Ethanol production and use – Anaerobic digestion for biogas – Different digesters – Digester sizing – Applications of Biogas - Operation with I.C.Engine

UNIT-4

Ocean Energy - OTEC Principle - Lambert's law of absorption - Open cycle and closed cycle - heat exchanger calculations – Major problems and operational experience. Tidal Power - Principles of power generation - components of power plant – Single and two basin systems – Turbines for tidal power - Estimation of energy – Maximum and minimum power ranges - tidal powerhouse.Wave Energy – Concept of energy and power from waves – Wave characteristics – period and wave velocities - Different wave energy conservation devices (Saltor duck, oscillating water column and dolphin types) – operational experience.

UNIT-5

Geothermal Energy - Classification- Fundamentals of geophysics - Dry rock and hot aquifer energy analysis - Estimation of thermal power - Extraction techniques - Prime movers.

Course Outcomes:

After completion of this course the students will be able to:

- Identify alternate energy sources.
- Classify and analyze different renewable energy systems.
- Adopt different alternate energy sources for power generation.
- Adopt optimally usage of different sources and interconnection with grid.

Reference Books:

1. Renewable Energy Resources / John Twidell and Tony Weir / E &F.N.Spon
2. Renewable Energy Resources Basic Principles and Applications / G.N.Tiwari and M.K.Ghosal / Narosa
3. Solar Energy - Principles of thermal collection and storage/ S.P. Sukhatme / TMH
4. Solar Energy Thermal Processes,/Duffie& Beckman
5. Solar Heating and Cooling / Kreith&Kreider, CRC press.
6. Wind Energy Handbook / Tony Burton, David Sharpe, Nick Jenkins and Ervin Bossanyi / WileyWind Electrical Systems / S.N.Bhadra, D.Kastha and S.Banerjee / Oxford
7. Biogas Technology - A Practical Hand Book / K.Khendelwal& S.S. Mahdi / McGraw-Hill.

REACTIVE POWER COMPENSATION & MANAGEMENT
(Common to PE, P&ID, PE&ED, PE&D, PE&S, EM&D, HVE, PSHVE)

(Elective III)

Prerequisites: Brief idea of power system analysis, electric traction systems and Arc furnaces

Course Educational Objectives:

- To know the basic objectives of reactive power compensation.
- To know the types of compensation and their behaviour.
- To know the mathematical modeling of reactive power compensating devices.
- To know the reactive power compensation has to be done at distribution side.
- To know the role of reactive power compensation at electric traction systems and Arc furnaces.

UNIT-1:Load Compensation
Objectives and specifications – reactive power characteristics – inductive and capacitive approximate biasing – Load compensator as a voltage regulator – phase balancing and power factor correction of unsymmetrical loads- examples.

UNIT-2: Reactive power compensation in transmission system:
Steady state -Uncompensated line – types of compensation – Passive shunt and series and dynamic shunt compensation – examples
Transient state - Characteristic time periods – passive shunt compensation – static compensations- series capacitor compensation –compensation using synchronous condensers – examples

UNIT -3:Reactive power coordination:
Objective – Mathematical modeling – Operation planning – transmission benefits – Basic concepts of quality of power supply – disturbances- steady –state variations – effects of under voltages – frequency – Harmonics, radio frequency and electromagnetic interferences

UNIT -4:Distribution side Reactive power Management:
System losses –loss reduction methods – examples – Reactive power planning – objectives – Economics Planning capacitor placement – retrofitting of capacitor banks
User side reactive power management:
KVAR requirements for domestic appliances – Purpose of using capacitors – selection of capacitors – deciding factors – types of available capacitor, characteristics and Limitations

UNIT-5: Reactive power management in electric traction systems and are furnaces:
Typical layout of traction systems – reactive power control requirements – distribution transformers- Electric arc furnaces – basic operations- furnaces transformer –filter requirements – remedial measures –power factor of an arc furnace

Course Outcomes:

After completion of this course the students will be able to:

- Learn various load compensations.
- Obtain the mathematical model of reactive power compensating devices.
- Get application of reactive power compensation in electrical traction & arc furnaces.

Reference Books:

1. Reactive power control in Electric power systems by T.J.E.Miller, John Wiley and sons, 1982
2. Reactive power Management by D.M.Tagare,Tata McGraw Hill,2004

ELECTRICAL DISTRIBUTION SYSTEMS
(Common to PE, P&ID, PE&ED, PE&D, PE&S, EM&D)

(Elective-III)

Prerequisites: Knowledge on basics of distribution systems, Compensation in electrical distribution systems, Circuit Analysis, concept of load modelling.

Course Educational Objectives:

- To learn the importance of economic distribution of electrical energy.
- To analyze the distribution networks for V-drops,P_{Loss}calculations and reactive power.
- To understand the co-ordination of protection devices.
- To impart knowledge of capacitive compensation/voltage control.
- To understand the principles of voltage control.

UNIT -1: (Residential, Commercial, Agricultural and Industrial) and their characteristics.

UNIT -2: Distribution Feeders and Substations : Design consideration of Distribution feeders: Radial and loop types of primary feeders, voltage levels, feeder-loading. Design practice of the secondary distribution system. Location of Substations : Rating of a Distribution Substation, service area with 'n' primary feeders. Benefits derived through optimal location of substations.

UNIT -3 : System analysis : Voltage drop and power loss calculations : Derivation for volt-drop and power loss in lines, manual methods of solution for radial networks, three-phase balanced primary lines, non-three-phase primary lines.

UNIT -4 : Protective devices and coordination : Objectives of distribution system protection, types of common faults and procedure for fault calculation. Protective Devices: Principle of operation of fuses, circuit reclosers, line sectionalizer and circuit breakers. Coordination of protective devices : General coordination procedure.

UNIT -5 : Capacitive compensation for power factor control: Different types of power capacitors, shunt and series capacitors, effect of shunt capacitors (Fixed and switched) power factor correction, capacitor location. Economic justification.Procedure to determine the best capacitor location. Voltage control: Equipment for voltage control, effect of series capacitors, effect of AVB/AVR, line drop compensation.

Course Outcomes:

After completion of this course the students will be able to:

- Analyze a distribution system.
- Design equipment for compensation of losses in the distribution system.
- Design protective systems and co-ordinate the devices.
- Understand of capacitive compensation.
- Understand of voltage control.

Reference Books:

1. "Electric Power Distribution System Engineering " byTuranGonen, Mc.Graw-Hill Book Company,1986.
2. Electric Power Distribution-by A.S.Pabla, Tata McGraw-Hill Publishing Company, 4th edition, 1997.
3. Electrical Distribution V.Kamaraju-McGraw Hill
4. .Handbook of Electrical Power Distribution – Gorti Ramamurthy-Universities press

I Year - II Semester

L	P	C
4	0	3

SMART GRID TECHNOLOGIES
(Common to PS, PSC&A, PSE, PS&C, APS, EPE, PE&ES, PE&PS, PE, P&ID, PE&ED, PE&D, PE&S, EM&D)
(Elective – IV)

Prerequisites: Basic knowledge on smart concept communication protocols, renewable energy systems and electronic circuits.

Course Educational Objectives:

- To understand concept of smart grid and developments on smart grid.
- To understand smart grid technologies and application of smart grid concept in hybrid electric vehicles etc.
- To have knowledge on smart substations, feeder automation and application for monitoring and protection.
- To have knowledge on micro grids and distributed energy systems.
- To know power quality aspects in smart grid.

UNIT 1

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 on Smart Grid. Case study of Smart Grid.

UNIT 2

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 3

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 4

Microgrids and Distributed Energy Resources: Concept of micro grid, 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 5

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.

Information and Communication Technology for Smart Grid: Advanced Metering Infrastructure (AMI), Home Area Network (HAN), Neighborhood Area Network (NAN), Wide Area Network (WAN).

Course Outcomes:

After completion of this course the students will be able to:

- Understand smart grids and analyse the smart grid policies and developments in smart grids.
- Develop concepts of smart grid technologies in hybrid electrical vehicles etc.
- Understand smart substations, feeder automation, GIS etc.
- Analyse micro grids and distributed generation systems.
- Analyse the effect of power quality in smart grid and to understand latest developments in ICT for smart grid.

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. JanakaEkanayake, Nick Jenkins, KithsiriLiyanage, Jianzhong Wu, Akihiko Yokoyama,"Smart Grid: Technology and Applications", Wiley
4. Jean Claude Sabonnadière, NouredineHadjsaïd, "Smart Grids", Wiley Blackwell 19
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. MladenKezunovic, 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

SPECIAL MACHINES
(Common to PE, P&ID, PE&ED, PE&D, PE&S, EM&D)
(Elective IV)

Prerequisites: Concepts of Electrical machines.

Course Educational Objectives:

- To know the concepts of special types of electrical machines.
- To understand the different control schemes for PMSM.
- To learn about the different sensor used in brushless DC motors.
- To draw the characteristics of servo motors, tacho meters and SRM.
- To understand the concepts of linear induction motor.

UNIT I: Stepper Motors

Constructional features, Principle of operation, Modes of excitation torque production in Variable Reluctance (VR) stepping motor, Dynamic characteristics, Drive systems and circuit for open loop control, closed loop control of stepping motor.

UNIT II: Permanent Magnet Synchronous Motors (PMSM) and Switched Reluctance Motors (SRM)

PMSM: Power electronic controllers, Torque speed characteristics, Self control, Vector control, Current control

SRM: Constructional features, Principle of operation. Torque equation, Characteristics, Control Techniques, Drive concept.

UNIT III: Permanent Magnet Brushless DC Motors

Concept of electronic commutation, Hall sensors, Optical sensors, back emf detection, Multiphase Brushless motor, Square wave permanent magnet brushless motor drives, Torque and emf equation, Torque-speed characteristics, Speed control by microcontroller.

UNIT IV: Servomotors and AC Tachometers

Servomotor – Types – Constructional features – Principle of Operation – Characteristics - Control – Microprocessor based applications.

AC Tachometers: Permanent magnet ac tachometer, AC induction tachometer, Schematic diagrams, Operating principle.

UNIT V: Linear Motors

Linear Motors: Linear Induction Motor (LIM) Classification – Construction – Principle of operation – Concept of Current sheet –Goodness factor – DC Linear Motor (DCLM) types – Circuit equation – DCLM control-applications.

Course Outcomes:

After completion of this course the students will be able to:

- Analyze the characteristics of different types of PM type brushless DC motors and design suitable controllers.
- Apply the knowledge of sensors used in PMSM which can be used for controllers and synchronous machines.
- Analyze the different controllers used in electrical machines to propose the suitability of drives for different industrial applications.
- Classify the types of DC linear motors and apply the knowledge of controllers to propose their application in real world.
- Evaluate the steady state and transient behavior linear induction motors.

References Books:

1. Miller, T.J.E. "Brushless Permanent Magnet and Reluctance Motor Drives", Clarendon Press, Oxford, 1989.
2. Kenjo, T, "Stepping Motors and their Microprocessor control", Clarendon Press, Oxford, 1989.
3. Naser A and Boldea I, "Linear Electric Motors: Theory, Design and Practical Application", Prentice Hall Inc., New Jersey,1987
4. Special Electrical Machines-K.Venkataratnam- University press
5. Floyd E Saner,"Servo Motor Applications", Pittman USA, 1993.
6. Kenjo, T and Naganori, S "Permanent Magnet and brushless DC motors", Clarendon Press, Oxford, 1989.
7. Generalized Theory of Electrical Machines – P.S.Bimbra-Khanna publications-5th edition-1995

PROGAMMABLE LOGIC CONTROLLERS & APPLICATIONS
(Common to PE, P&ID, PE&ED, PE&D, PE&S, EM&D, PE&PS)

(Elective IV)

Prerequisites: Knowledge on relay logic and digital electronics.

Course Educational Objectives:

- To have knowledge on PLC.
- To acquire the knowledge on programming of PLC.
- To understand different PLC registers and their description.
- To have knowledge on data handling functions of PLC.
- To know how to handle analog signal and converting of A/D in PLC.

UNIT 1:
PLC Basics: PLC system, I/O modules and interfacing, CPU processor, programming equipment, programming formats, construction of PLC ladder diagrams, devices connected to I/O modules.

UNIT 2:
PLC Programming: Input instructions, outputs, operational procedures, programming examples using contacts and coils. Drill press operation.Digital logic gates, programming in the Boolean algebra system, conversion examples. Ladder diagrams for process control: Ladder diagrams and sequence listings, ladder diagram construction and flow chart for spray process system.

UNIT 3:
PLC Registers: Characteristics of Registers, module addressing, holding registers, input registers, output registers. PLC Functions: Timer functions and Industrial applications, counters, counter function industrial applications, Arithmetic functions, Number comparison functions, number conversion functions.

UNIT 4:
Data Handling functions: SKIP, Master control Relay, Jump, Move, FIFO, FAL, ONS, CLR and Sweep functions and their applications. Bit Pattern and changing a bit shift register, sequence functions and applications, controlling of two axis and three axis Robots with PLC, Matrix functions.

UNIT 5:
Analog PLC operation: Analog modules and systems, Analog signal processing, multi bit data processing, analog output application examples, PID principles, position indicator with PID control, PID modules, PID tuning, PID functions.

Course Outcomes:

After completion of this course the students will be able to:

- Understand the PLCs and their I/O modules.
- Develop control algorithms to PLC using ladder logic etc.
- Manage PLC registers for effective utilization in different applications.
- Handle data functions and control of two axis and their axis robots with PLC.
- Design PID controller with PLC.

Reference Books:

1. Programmable Logic Controllers – Principle and Applications by John W. Webb and Ronald A. Reiss, Fifth Edition, PHI
2. Programmable Logic Controllers – Programming Method and Applications by JR. Hackworth and F.D Hackworth Jr. – Pearson, 2004.
3. Introduction to Programmable Logic Controllers- Gary Dunning-Cengage Learning.
4. Programmable Logic Controllers –W.Bolton-Elsevier publisher.

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I Year - II Semester

L	P	C
0	4	2

POWER CONVERTERS AND DRIVES LAB

Course Educational Objectives:

- To verify the operation of various converters and also their usage in the motor speed control application.

List of experiments

1. Analysis and speed control of DC motor drive using 3-phase full Converter.
2. Analysis of a four quadrant Chopper feeding DC motor.
3. Analysis of a 3-phase A.C. Voltage controller fed to R & RL - load.
4. Analysis of Buck, Boost, Buck-Boost DC-DC converters.
5. Analysis of Single Phase IGBT based PWM Inverter connected to R & R-L load
6. Analysis of 3-phase IGBT based PWM Inverterfeeding R & R-L load.
7. Analysis and speed control of 3 phase slip ring Induction motor by Static Rotor Resistance controller.
8. Analysis of three phase SVPWM Pulse generation using PIC Micro controller/DSP processor.
9. Analysis of DSP based V/F Control of 3 phase Induction motor.
10. Analysis of vector control based speed control of three phase Induction Motor drive.

Course Outcomes:

- To analyse the working of phase controlled converters, AC voltage controllers, DC-DC converters, and PWM inverters and analyse the speed control operation of power converter fed motors.

II Year - I Semester

L	P	C
0	0	2

COMPREHENSIVE VIVA-VOCE

II Year - III Semester

L	P	C
0	0	2

SEMINAR - I

II Year - III Semester

L	P	C
0	0	16

PROJECT WORK PART - I

II Year - IV Semester

L	P	C
0	0	2

SEMINAR - II

II Year - IV Semester

L	P	C
0	0	18

PROJECT WORK PART - II