# SWARNANDHRA

**COLLEGE OF ENGINEERING & TECHNOLOGY**

**(Autonomous)**

**Seetaramapuram, Narsapur-534280, W.G. Dt.**

**Andhra Pradesh, India.**

# COURSE STRUCTURE

**R-19 REGULATION**

**(CHOICE BASED CREDIT SYSTEM)**

## Power Electronics (PE)

for

## Master of Technology (M. Tech)

(Applicable from batches admitted in AY: 2019-2020

**SWARNANDHRA COLLEGE OF ENGINEERING & TECHNOLOGY**
**Seetaramapuram, Narsapur-534280**
**Department of Electrical and Electronics Engineering**

## SEMESTER-I

| S. No. | Course Code | Course Title | L | P | C | IM | EM | TM |
|---|---|---|---|---|---|---|---|---|
| 1 | 19PE1T01 | Electrical Machine Modeling and Analysis | 3 | - | 3 | 30 | 70 | 100 |
| 2 | 19PE1T02 | Analysis of Power Electronic Converters | 3 | - | 3 | 30 | 70 | 100 |
| 3 | | **Elective – I** | 3 | - | 3 | 30 | 70 | 100 |
| 4 | | **Elective-II** | 3 | - | 3 | 30 | 70 | 100 |
| 5 | 19GE1T01 | Research Methodology and IPR | 2 | - | 2 | 30 | 70 | 100 |
| 6 | | **Audit Course -1** | 2 | - | - | 50 | - | 50 |
| 7 | 19PE1L01 | Machine Modelling and Analysis Lab | - | 4 | 2 | 30 | 70 | 100 |
| 8 | 19PE1L02 | Power Electronics Converters Lab | - | 4 | 2 | 30 | 70 | 100 |
| | | **Total** | **16** | **8** | **18** | **260** | **490** | **750** |

| **Elective-I** | | **Elective-II** | |
|---|---|---|---|
| 19PE1E01 | HVDC Transmission | 19PE1E04 | Optimization Techniques |
| 19PE1E02 | Modern Control Theory | 19PE1E05 | Smart Grid Technologies |
| 19PE1E03 | Switched Mode Power Conversion | 19PE1E06 | Special Machines |

## SEMESTER-II

| S. No. | Course Code | Course Title | L | P | C | IM | EM | TM |
|---|---|---|---|---|---|---|---|---|
| 1 | 19PE2T01 | Power Electronics for Renewable Energy Systems | 3 | - | 3 | 30 | 70 | 100 |
| 2 | 19PE2T02 | Electrical Drive | 3 | - | 3 | 30 | 70 | 100 |
| 3 | | **Elective-III** | 3 | - | 3 | 30 | 70 | 100 |
| 4 | | **Elective-IV** | 3 | - | 3 | 30 | 70 | 100 |
| 5 | 19PE2P01 | Mini Project with Seminar | - | 4 | 2 | 50 | - | 50 |
| 6 | | **Audit Course -2:** | 2 | - | - | 50 | 0 | 50 |
| 7 | 19PE2L01 | Renewable Energy Systems Lab | - | 4 | 2 | 30 | 70 | 100 |
| 8 | 19PE2L02 | Advanced Power Converters and Drives Lab | - | 4 | 2 | 30 | 70 | 100 |
| | | **Total** | **16** | **8** | **18** | **280** | **420** | **700** |

| **Elective-III** | | **Elective-IV** | |
|---|---|---|---|
| 19PE2E07 | FACTS Controller | 19PE2E10 | Artificial Intelligence Techniques |
| 19PE2E08 | Digital Controllers | 19PE2E11 | Distributed Generation |
| 19PE2E09 | Custom Power devices | 19PE2E12 | Hybrid Electric Vehicles |

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## SEMESTER-III

| S. No. | Sub.Code | Subject Title | L | P | C | IM | EM | TM |
|---|---|---|---|---|---|---|---|---|
| 1. | | **Elective-IV** | 3 | - | 3 | 30 | 70 | 100 |
| 2. | | **Open Elective** | 3 | - | 3 | 30 | 70 | 100 |
| 3. | - | Project Phase-I | - | - | 10 | | | |
| | | **Total** | | | **16** | **60** | **140** | **200** |

| **Elective-V** | |
|---|---|
| 19PE3E13 | Electrical Distribution Systems |
| 19PE3E14 | Reactive Power Compensation and Management |
| 19PE3E15 | Power Quality |

## SEMESTER-IV

| S. No. | Sub. Code | Subject Title | L | P | C | IM | EM | TM |
|---|---|---|---|---|---|---|---|---|
| 1 | 19PE4P01 | Project Phase-II | - | - | 16 | - | - | - |
| | | **Total** | | | **16** | | | |

| **Open Elective** | | |
|---|---|---|
| **S.No** | **Subject Code** | **Subject** |
| 1 | 19GM3O01 | Business Analytics |
| 2 | 19GM3O02 | Industrial Safety |
| 3 | 19GM3O03 | Operations Research |
| 4 | 19GM3O04 | Cost Management of Engineering Projects |
| 5 | 19GM3O05 | Composite Materials |
| 6 | 19GM3O06 | Waste to Energy |

| **Audit Course 1 & 2** | | |
|---|---|---|
| **S.No** | **Subject Code** | **Subject** |
| 1 | 19GEXM01 | English for Research Paper Writing |
| 2 | 19GEXM02 | Disaster Management |
| 3 | 19GEXM03 | Sanskrit for Technical Knowledge |
| 4 | 19GEXM04 | Value Education |
| 5 | 19GEXM05 | Constitution of India |
| 6 | 19GEXM06 | Pedagogy Studies |
| 7 | 19GEXM07 | Stress Management by yoga |
| 8 | 19GEXM08 | Personality Development Through Life Enlightenment Skills |

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| **Semester-I** | | L | T | P | C |
|---|---|---|---|---|---|
| **19PE1T01** | **ELECTRICAL MACHINE MODELING AND ANALYSIS** | **3** | **-** | **-** | **3** |

**Course Outcomes:** ***After successful completion of this course, students should be able to:***

CO1 : Apply knowledge of behavior of DC motors to model and analyze for different applications.
CO2 : Analyze the characteristics of different types of DC motors to design suitable controllers
CO3 : Apply the knowledge of reference frame theory for AC machines to model the induction and Synchronous machines.
CO4 : Evaluate the steady state and transient behavior of induction and synchronous machines to Propose the suitability of drives for different industrial applications
CO5 : Analyze the 2-Phase induction machines using voltage and torque equations to differentiate the behavior and to propose their applications in real world.

**SYLLABUS**

**UNIT-I : 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 αβ0) and two phase to three phase transformation αβ0 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.

**Text Books:**

1. Dynamic simulation of Electric machinery using Matlab / Simulink – CheeMunOngPrentice Hall
2. P.S.Bhimbra,'' Generalised theory of Electrical Machines''-Fifth edition,Khanna publishers.

**Reference Books:**

1. Electric Motor Drives - Modeling, Analysis& control -R.Krishnan- Pearson Publications1st edition -2002
2. Analysis of Electrical Machinery and Drive systems – P.C.Krause, Oleg Wasynczuk, Scott D.Sudhoff – Second Edition-IEEE Press.

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| **Semester-I** | | L | T | P | C |
|---|---|---|---|---|---|
| **19PE1T02** | **ANALYSIS OF POWER ELECTRONIC CONVERTERS** | **3** | **-** | **-** | **3** |

**Course Outcomes:** ***After successful completion of this course, students should be able to***

CO1 : Analyze the operation of phase controlled converters and AC voltage converters.

CO2 : Analyze the requirements of power factor correction in converter circuits.

CO3 : Describe and analyze the operation of 3-phase inverters with and without PWM techniques

CO4 : Describe principles of operation and features of multilevel inverters.

## SYLLABUS

### 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

**Text Books:**

3. Electric Motor Drives - Modeling, Analysis& control -R.Krishnan- Pearson Publications1st edition -2002
4. Analysis of Electrical Machinery and Drive systems – P.C.Krause, Oleg Wasynczuk, Scott D.Sudhoff – Second Edition-IEEE Press.

**Reference Books:**

1. Dynamic simulation of Electric machinery using Matlab / Simulink – CheeMunOngPrentice Hall
2. P.S.Bhimbra,'' Generalised theory of Electrical Machines''-Fifth edition,Khanna publishers.

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| **Semester-I** | | L | T | P | C |
|---|---|---|---|---|---|
| **19PE1E01** | **HVDC TRANSMISSION (Elective-I)** | **3** | **-** | **-** | **3** |

**Course Outcomes:** ***After successful completion of this course, students should be able to***

CO1 : Understand state of the art HVDC technology

CO2 : Learn the methods to carry out modeling of HVDC system

CO3 : Analyze the HVDC system for frontier-area power flow regulation

CO4 : Analyze the Transient over voltages in HV DC systems

**SYLLABUS**

**UNIT-I : Introduction**

Limitation of EHV AC Transmission .Advantages of HVDC Technical economical reliability aspects. H.V.D.C. Transmission: General considerations, Power Handling Capabilities of HVDC Lines, Basic Conversion principles, static converter configuration. Types of HVDC links-Apparatus and its purpose. Digital techniques in HV measurements

**UNIT-II : 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 diametrical connection with 6-pulse bridge circuit.

**UNIT-III : 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 á and µ. Filters Harmonic elimination, Control of MTDC systems

**UNIT-IV : Interaction between HV AC and DC systems**

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. Modelling of HVDC systems

## UNIT-V : 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.

**Text Books:**

1. K.R.Padiyar, High Voltage Direct current Transmission, Wiley Eastern Ltd., New Delhi,

   1992

2. E.W. Kimbark, Direct current Transmission, Wiley Inter Science – New York. 1971

**Reference Books:**

1. J.Arillaga, H.V.D.C.Transmission Peter Peregrinus ltd., London UK 1983
2. E.Uhlman, Power Transmission by Direct Current, Springer Verlag, Berlin Helberg, 1985

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| **Semester-I** | | L | T | P | C |
|---|---|---|---|---|---|
| **19PE1E02** | **MODERN CONTROL THEORY (Elective-I)** | **3** | **-** | **-** | **3** |

**Course Outcomes:** ***After successful completion of this course, students should be able to***

| | | |
|---|---|---|
| **CO1** | : | Understand the concepts of basics and modern control system for the real time analysis |
| **CO2** | : | Understand the concepts of state variables analysis. |
| **CO3** | : | Understand the design of control systems |
| **CO4** | : | Analyze the concept of stability for nonlinear systems and their categorization. |

**SYLLABUS**

**UNIT-I : MATHEMATICAL PRELIMINARIES AND STATE VARIABLE ANALYSIS**

Fields, Vectors and Vector Spaces – Linear combinations and Bases – Linear Transformations and

Matrices – Scalar Product and Norms – Eigen values, Eigen Vectors and a Canonical form representation of Linear systems – The concept of state – State space model of Dynamic systems –

Time invariance and Linearity – Non uniqueness of state model – State diagrams for Continuous-Time State models - Existence and Uniqueness of Solutions to Continuous-Time State Equations – Solutions of Linear Time Invariant Continuous-Time State Equations – State transition matrix and it's properties. Complete solution of state space model due to zero input and due to zero state.

**UNIT-II : CONTROLLABILITY AND OBSERVABILITY**

General concept of controllability – Controllability tests, different state transformations such as diagonalization, Jordon canonical forms and Controllability canonical forms for Continuous-Time Invariant Systems – General concept of Observability – Observability tests for Continuous-Time Invariant Systems – Observability of different State transformation forms.

**UNIT-III : STATE FEEDBACK CONTROLLERS AND OBSERVERS**

State feedback controller design through Pole Assignment, using Ackkermans formula– State observers: Full order and Reduced order observers.

## UNIT-IV : NON-LINEAR SYSTEMS

Introduction – Non Linear Systems - Types of Non-Linearities – Saturation – Dead-Zone - Backlash –Jump Phenomenon etc; Linearization of nonlinear systems, Singular Points and its types– Describing function–describing function of different types of nonlinear elements, – Stability analysis of Non-Linear systems through describing functions. Introduction to phase-plane analysis, Method of Isoclines for Constructing Trajectories, Stability analysis of nonlinear systems based on phase-plane method.

## UNIT-V : STABILITY ANALYSIS

Stability in the sense of Lyapunov, Lyapunov's stability and Lypanov'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.

**Text Books:**

1. M.Gopal, Modern Control System Theory, New Age International - 1984
2. Ogata. K, Modern Control Engineering, Prentice Hall - 1997 Elements of Power Electronics – Philip T. Krein, Oxford University press.

**Reference Books:**

1. N K Sinha, Control Systems, New Age International – 3rd edition.
2. Donald E.Kirk, Optimal Control Theory an Introduction, Prentice - Hall Network series – First edition.

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| **Semester-I** | | L | T | P | C |
|---|---|---|---|---|---|
| **19PE1E03** | **SWITCHED MODE POWER CONVERSION (Elective-I)** | **3** | **-** | **-** | **3** |

**Course Outcomes:** ***After successful completion of this course, students should be able to***

CO1 : Analyze the control operation of non-isolated switch mode converters.

CO2 : Analyze the operation of resonant converters and soft switching.

CO3 : Analyze the operation of isolated switch mode converters.

CO4 : Analyze the control schemes for resonant converters and design of magnetic components.

**SYLLABUS**

**UNIT-I : Non-isolated switch mode converters**

Control of DC-DC converters, Buck converters, Boost converters, Buck-Boost converter, CUK Converter, Converter realization with non-ideal 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.

**Text Books:**

1. Power Electronics – Issa Bataresh, Jhonwilley publications, 2004.
2. Power switching converters-simonang, alejandro olive, CRC Press (Taylor &Franics group).

**Reference Books:**

1. Elements of Power Electronics – Philip T. Krein, Oxford University press.
2. Power Electronics: converters Applications & Design – Mohan, Undeland, Robbins-Wiley publications

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| **Semester-I** | | L | T | P | C |
|---|---|---|---|---|---|
| **19PE1E04** | **OPTIMIZATION TECHNIQUES** (Elective-II) | **3** | **-** | **-** | **3** |

**Course Outcomes:** ***After successful completion of this course, students should be able to***

CO1 : Understand the concepts of various optimization techniques

CO2 : Develop concepts of Linear Programming

CO3 : Understand the concepts Unconstrained and Constrained Nonlinear Programming

CO4 : Analyze micro grids and distributed generation systems.

CO5 : Analyze the computational procedure of dynamic programming.

**SYLLABUS**

**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.

**UNIT-III : UNCONSTRAINED NONLINEAR PROGRAMMING**

One – dimensional minimization methods: Classification, Fibonacci method and Quadratic interpolation method. Univariate method, Powell's method and steepest descent method.

**UNIT-IV : CONSTRAINED NONLINEAR PROGRAMMING**

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-V : DYNAMIC PROGRAMMING**

Dynamic programming multistage decision processes – types – concept of sub optimization and the principle of optimality – computational procedure in dynamic programming – examples illustrating the calculus method of solution – examples illustrating the tabular method of solution.

**Text Books:**

1. "Engineering optimization: Theory and practice"-by S. S.Rao, New Age International (P) Limited, 3rd edition, 1998.
2. "Introductory Operations Research" by H.S. Kasene & K.D. Kumar,

**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. "Operations Research: An Introduction" – by H.A. Taha, PHI Pvt. Ltd., 6th edition

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| **Semester-I** | | L | T | P | C |
|---|---|---|---|---|---|
| **19PE1E05** | **SMART GRID TECHNOLOGIES** (Elective-II) | **3** | **-** | **-** | **3** |

**Course Outcomes:** ***After successful completion of this course, students should be able to***

CO1 : Understand smart grids and analyze the smart grid policies and developments in smart grids.
CO2 : Develop concepts of smart grid technologies in hybrid electrical vehicles etc.
CO3 : Understand smart substations, feeder automation, GIS etc.
CO4 : Analyze micro grids and distributed generation systems.
CO5 : Analyze the effect of power quality in smart grid and to understand latest developments in ICT for smart grid.

**SYLLABUS**

**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 on Smart Grid. Case study of 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 : SMART GRID TECHNOLOGIES: PART 2**

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

**UNIT-IV : 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, fuel cells, micro turbines, Captive power plants, Integration

of renewable energy sources.

**UNIT-V : POWER QUALITY MANAGEMENT AND INFORMATION AND COMMUNICATION TECHNOLOGY FOR 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.

Advanced Metering Infrastructure (AMI), Home Area Network (HAN), Neighborhood Area Network (NAN), Wide Area Network (WAN).

**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

**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

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| **Semester-I** | | L | T | P | C |
|---|---|---|---|---|---|
| **19PE1E06** | **SPECIAL MACHINES** (Elective-II) | **3** | **-** | **-** | **3** |

**Course Outcomes:** ***After successful completion of this course, students should be able to***

CO1 : Understand the performance and control of stepper motors, and their applications

CO2 : Understand the theory of operation and control of Permanent Magnet Synchronous Motors and Switched reluctance motor.

CO3 : Describe the operation and characteristics of permanent magnet dc motor and Servomotors.

CO4 : Analyse the theory of travelling magnetic field and applications of linear motors.

**SYLLABUS**

**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 AND SWITCHED RELUCTANCE MOTORS**

**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.

**Text 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.

**Reference Books:**

1. Special Electrical Machines-K.Venkataratnam- University press.
2. Floyd E Saner,”Servo Motor Applications”, Pittman USA, 1993.
3. Kenjo, T and Naganori, S “Permanent Magnet and brushless DC motors”, Clarendon Press, Oxford, 1989.
4. Generalized Theory of Electrical Machines – P.S.Bimbra-Khanna publications-5th edition- 1995.

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| **Semester-I** | | L | T | P | C |
|---|---|---|---|---|---|
| **19GE1T01** | **RESEARCH METHODOLOGY AND IPR** | **2** | **-** | **-** | **2** |

**Course Outcomes:** ***After successful completion of this course, students should be able to***

CO1 : Analyze research related information and Follow research ethics

CO2 : Understand that today's world is controlled by Computer, Information Technology, but tomorrow world will be ruled by ideas, concept, and creativity.

CO3 : Understanding that when IPR would take such important place in growth of individuals & nation, it is needless to emphasis the need of information about Intellectual Property Right to be promoted among students in general &engineering in particular.

CO4 : Understand that IPR protection provides an incentive to inventors for further research work and investment in R & D, which leads to creation of new and better products, and in turn brings about, economic growth and social benefits.

**SYLLABUS**

**UNIT-I :**

Meaning of research problem, Sources of research problem, Criteria Characteristics of a good research problem, Errors in selecting a research problem, Scope and objectives of research problem. Approaches of investigation of solutions for research problem, data collection, analysis, interpretation, Necessary instrumentations. Effective literature studies approaches, analysis Plagiarism, and Research ethics.

**UNIT-II :**

Effective technical writing, how to write report, Paper Developing a Research Proposal, Format of research proposal, a presentation and assessment by a review committee.

**UNIT-III :**

Nature of Intellectual Property: Patents, Designs, Trade and Copyright. Process of Patenting and Development: technological research, innovation, patenting, development. International Scenario: International cooperation on Intellectual Property. Procedure for grants of patents, Patenting under PCT.

**UNIT-IV :**

Patent Rights: Scope of Patent Rights. Licensing and transfer of technology. Patent information and databases. Geographical Indications.

**UNIT-V :**

New Developments in IPR: Administration of Patent System. New developments in IPR; IPR of Biological Systems, Computer Software etc. Traditional knowledge Case Studies, IPR and IITs.

**TEXT BOOKS:**

1. Stuart Melville and Wayne Goddard, “Research methodology: an introduction for science & engineering students”
2. Wayne Goddard and Stuart Melville, “Research Methodology: An Introduction”

**REFERENCES:**

1. Ranjit Kumar, 2nd Edition , “Research Methodology: A Step by Step Guide for beginners”
2. Halbert, “Resisting Intellectual Property”, Taylor & Francis Ltd ,2007.
3. Mayall , “Industrial Design”, McGraw Hill, 1992.
4. Niebel , “Product Design”, McGraw Hill, 1974.
5. Asimov, “Introduction to Design”, Prentice Hall, 1962.
6. Robert P. Merges, Peter S. Menell, Mark A. Lemley,“Intellectual Property in New Technological Age”, 2016.
7. T. Ramappa, “Intellectual Property Rights Under WTO”, S. Chand, 2008

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| **Semester-I** | | L | T | P | C |
|---|---|---|---|---|---|
| **19AC1M02** | **DISASTER MANAGEMENT** (Audit Course-I) | **2** | **-** | **-** | **0** |

**Course Objectives:** Students will be able to

1. Learn to demonstrate a critical understanding of key concepts in disaster risk reduction and humanitarian response.
2. Critically evaluate disaster risk reduction and humanitarian response policy and practice from multiple perspectives.
3. Develop an understanding of standards of humanitarian response and practical relevance in specific types of disasters and conflict situations.
4. Critically understand the strengths and weaknesses of disaster management approaches, planning and programming in different countries, particularly their home country or the countries they work in

**SYLLABUS**

**UNIT-I :**

**Introduction:** Disaster: Definition, Factors and Significance; Difference Between Hazard and Disaster; Natural and Manmade Disasters: Difference, Nature, Types and Magnitude.

**Disaster Prone Areas in India:** Study of Seismic Zones; Areas Prone to Floods and Droughts, Landslides and Avalanches; Areas Prone to Cyclonic and Coastal Hazards with Special Reference to Tsunami; Post-Disaster Diseases and Epidemics

**UNIT-II :**

**Repercussions of Disasters and Hazards**: Economic Damage, Loss of Human and Animal Life, Destruction of Ecosystem. Natural Disasters: Earthquakes, Volcanisms, Cyclones, Tsunamis, Floods, Droughts and Famines, Landslides and Avalanches, Man-made disaster: Nuclear Reactor Meltdown, Industrial Accidents, Oil Slicks and Spills, Outbreaks of Disease and Epidemics, War and Conflicts.

**UNIT-III :**

**Disaster Preparedness and Management:** Preparedness: Monitoring of Phenomena Triggering A Disaster or Hazard; Evaluation of Risk: Application of Remote Sensing, Data

from Meteorological and Other Agencies, Media Reports: Governmental and Community Preparedness.

**UNIT-IV :**

**Risk Assessment Disaster Risk:** Concept and Elements, Disaster Risk Reduction, Global and National Disaster Risk Situation. Techniques of Risk Assessment, Global Co-Operation in Risk Assessment and Warning, People's Participation in Risk Assessment. Strategies for Survival.

**UNIT-V :**

**Disaster Mitigation:** Meaning, Concept and Strategies of Disaster Mitigation, Emerging Trends in Mitigation. Structural Mitigation and Non-Structural Mitigation, Programs of Disaster Mitigation in India.

**TEXT BOOKS/ REFERENCES:**

1. R. Nishith, Singh AK, "Disaster Management in India: Perspectives, issues and strategies" New Royal book Company.
2. Sahni, Pardeep Et. Al. (Eds.)," Disaster Mitigation Experiences and Reflections", Prentice Hall of India, New Delhi.
3. Goel S. L., Disaster Administration and Management Text and Case Studies", Deep &DeepPublication Pvt. Ltd., New Delhi.

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| **Semester-I** | | L | T | P | C |
|---|---|---|---|---|---|
| **19PE1L01** | **MACHINE MODELLING AND ANALYSIS LAB** | **0** | **-** | **4** | **2** |

**Course Outcomes:** At the end of the course, the student is able to

1. Develop the mathematical models of various machines like, induction motor and Synchronous machines, permanent magnet synchronous motor, brushless DC motor using modeling equations.
2. Analyze the developed models in various reference frames.

**List of Experiments**

1. Develop a dynamic model of open loop controlled dc motor
2. Develop a dynamic model of closed loop controlled dc motor
3. Convert ABC voltages into stationary frame
4. Convert ABC voltages into synchronous frames
5. Convert ABC voltages into rotor reference frames
6. Develop dynamic model of 3-phase Induction motor and generator
7. Develop a mathematical model for V/f controlled 3-phase Induction motor
8. Develop a mathematical model for 3-phase Synchronous motor
9. Develop a mathematical model for 3-phase Permanent Magnet Synchronous motor
10. Develop a mathematical model for Brushless DC Motor
11. Develop a dynamic model for closed loop control of Induction Motor
12. Develop a dynamic model for closed loop control of Synchronous motor

**Note:** Conduct any 10 experiments from the above using any simulation tool

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| **Semester-I** | | L | T | P | C |
|---|---|---|---|---|---|
| **19PE1L02** | **POWER ELECTRONIC CONVERTERS LAB** | **0** | **-** | **4** | **2** |

**Course Outcomes:** At the end of the course, the student is able to:

3. Simulate AC-AC Converters.
4. Simulate AC-DC Converters
5. Simulate DC-DC Converters
6. Simulate DC-AC Converters
7. Analysis of various Converter topologies developed.

**List of Experiments**

**Part-A:**

1. Single Phase AC Voltage Controller Using RL Load
2. Three Phase AC Voltage Controller Using RL Load
3. Single Phase Semi Converter Using RLE Load
4. Three Phase Semi Converter Using RLE Load
5. Single Phase Full Converter Using RLE Load
6. Three Phase Full Converter Using RLE Load
7. Single Phase Inverter with PWM Controller with R-Load.
8. Three Phase Inverter with SPWM Controller with R-Load.
9. DC-DC Buck - Boost Converter
10. Space Vector PWM Converter
11. Single Phase Multilevel Inverter

**Note:** Conduct any 05 experiments from the above using any simulation tool

**Part-B:**

1. Single Phase AC Voltage Controller Using RL Load
2. Three Phase AC Voltage Controller Using RL Load
3. Single Phase Semi Converter Using RLE Load
4. Three Phase Semi Converter Using RLE Load
5. Single Phase Full Converter Using RLE Load
6. Three Phase Full Converter Using RLE Load
7. Single Phase Inverter with PWM Controller with R-Load.

8. Three Phase Inverter with SPWM Controller with R-Load.
9. DC-DC Buck - Boost Converter
10. Space Vector PWM Converter
11. Single Phase Multilevel Inverter

**Note:** Conduct any 05hardware experiments

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| SEMESTER-II | | L | T | P | C |
|---|---|---|---|---|---|
| 19PE2L01 | POWER ELECTRONICS FOR RENEWABLE ENERGY SYSTEMS | 3 | - | - | 3 |

**Course Outcomes:** ***After successful completion of this course, students should be able to***

| | | |
|---|---|---|
| CO1 | : | Understand and analyze power system operation, stability, control and protection. |
| CO2 | : | Understand and analyze power system and protection. |
| CO3 | : | Handle the engineering aspects of electrical energy generation. |
| CO4 | : | Adopt different alternate energy sources for power generation |

**SYLLABUS**

| | | |
|---|---|---|
| **UNIT-I** | **:** | **INTRODUCTION** |
| Environmental aspects of electric energy conversion: impacts of renewable energy generation on environment (cost-GHG Emission) - Qualitative study of different renewable energy resources: Solar, wind, ocean, Biomass, Fuel cell, Hydrogen energy systems and hybrid renewable energy systems. | | |
| **UNIT-II** | **:** | **ELECTRICAL MACHINES FOR RENEWABLE ENERGY CONVERSION** |
| Reference theory fundamentals -Principle of operation and analysis: IG, PMSG, SCIG and DFIG. | | |
| **UNIT-III** | **:** | **POWER CONVERTERS** |
| Solar: Block diagram of solar photo voltaic system -Principle of operation: line commutated converters (inversion-mode) - Boost and buck-boost converters- selection of inverter, battery sizing, array sizing - Wind: Three phase AC voltage controllers- AC-DC-AC converters: uncontrolled rectifiers, PWM Inverters, Grid Interactive Inverters-Matrix converters. | | |
| **UNIT-IV** | **:** | **ANALYSIS OF WIND AND PV SYSTEMS** |
| Stand alone operation of fixed and variable speed wind energy conversion systems and solar system - Grid connection Issues -Grid integrated PMSG, SCIG Based WECS, grid Integrated solar system | | |
| **UNIT-V** | **:** | **HYBRID RENEWABLE ENERGY SYSTEMS** |

Need for Hybrid Systems- Range and type of Hybrid systems- Case studies of Wind-PV Maximum Power Point Tracking (MPPT).

**Text Books:**

1. S. N. Bhadra, D.Kastha, S.Banerjee, "Wind Electrical Systems", Oxford University Press, 2005.
2. B.H.Khan Non-conventional Energy sources Tata McGraw-hill Publishing Company, New Delhi, 2009.

**Reference Books:**

1. Rashid .M. H "Power electronics Hand book", Academic press, 2001.
2. Ion Boldea, "Variable speed generators", Taylor & Francis group, 2006.
3. Rai. G.D, "Non conventional energy sources", Khanna publishes, 1993.
4. Gray, L. Johnson, "Wind energy system", prentice hall linc, 1995.
5. Andrzej M. Trzynnadlowski, 'Introduction to Modern Power Electronics', Second edition, wiley India Pvt. Ltd, 2012.

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| SEMESTER-II | | L | T | P | C |
|---|---|---|---|---|---|
| 19PE2T02 | ELECTRICAL DRIVE | 3 | - | - | 3 |

**Course Outcomes:** ***After successful completion of this course, students should be able to***

| | | |
|---|---|---|
| CO1 | : | Develop induction motor for variable speed operations using scalar and vector control techniques. |
| CO2 | : | Identify the difference between the rotor resistance control and static rotor resistance control method and significance of slip power recovery drives. |
| CO3 | : | Develop controllers for synchronous motor and variable reluctance motor. |

**SYLLABUS**

| UNIT-I | : | RECTIFIER AND CLOSED LOOP CONTROLLED DC MOTOR |
|---|---|---|

**RECTIFIER CONTROLLED DC MOTOR:**

Separately excited DC motors and DC series motors with single phase semi converter and single phase full converter-Three-phase controlled converter, control circuit, control modeling of three phase converter – Steady state analysis of three phase converter control DC motor drive – Two quadrant, Three phase converter controlled DC motor drive – DC motor and load, converter.

**CLOSED LOOP CONTROL OF DC DRIVE:**

Current and speed controllers - Current and speed feedback – Design of controllers – Motor equations – filter in the speed feedback loop speed controller – current reference generator – current controller and flow chart for simulation – Harmonics and associated problems – sixth harmonics torque.

| UNIT-II | : | CHOPPER CONTROLLED DC MOTOR DRIVES |
|---|---|---|

Principle of operation of the chopper – Chopper with other power devices – model of the chopper –input to the chopper – steady state analysis of chopper controlled DC motor drives –

**Closed loop operation:** Speed controlled drive system – current control loop – pulse width modulated current controller – hysteresis current controller – modeling of current controller – design of current controller.

| | | |
|---|---|---|
| **UNIT-III** | **:** | **CONTROL OF INDUCTION MOTOR** |

Introduction to motor drives – Torque production – Equivalent circuit analysis – Speed – Torque

Characteristics with variable voltage operation Variable frequency operation constant v/t operation –Variable stator current operation – Induction motor characteristics in constant torque and field

Weakening regions.

**STATOR SIDE CONTROL**

Scalar control – Voltage fed inverter control – Open loop volts/Hz control – speed control slip regulation– speed control with torque and flux control – current controlled voltage fed inverter drive

**ROTOR SIDE CONTROL OF INDUCTION MOTOR DRIVES**

Slip power recovery drives – Static Kramer Drive – Phasor diagram – Torque expression – speed control of Kramer Drive – Static Scheri bus Drive – modes of operation.

| | | |
|---|---|---|
| **UNIT-IV** | **:** | **VECTOR CONTROL OF INDUCTION MOTOR DRIVES** |

Principles of Vector control – Vector control methods – Direct methods of vector control – Indirect

methods of vector control – Adaptive control principles – Self tuning regulator Model referencing control– Direct torque control of AC motors.

| | | |
|---|---|---|
| **UNIT-V** | **:** | **CONTROL OF SYNCHRONOUS MOTOR DRIVES** |

Synchronous motor and its characteristics – Control strategies – Constant torque angle control – Unity power factor control – Constant mutual flux linkage control – closed loop operation.

**Text Books:**

1. Electric Motor Drives Pearson Modeling, Analysis and control – R. Krishnan – Publications – 1st edition – 2002.
2. Modern Power Electronics and AC Drives B K Bose – Pearson Publications 1st edition

**Reference Books:**

1. Power Electronics and Control of AC Motors – MD Murthy and FG Turn Bull Pergman Press 1st edition
2. Power Electronics and AC Drives – BK Bose – Prentice Hall Eagle wood diffs New Jersey - 1st edition
3. Power Electronic circuits Deices and Applications – M H Rashid – PHI – 1995.
4. Fundamentals of Electrical Drives – G. K. Dubey – Narosa publications – 1995

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| **SEMESTER-II** | | **L** | **T** | **P** | **C** |
|---|---|---|---|---|---|
| **19PE2E07** | **FACTS CONTROLLER (Elective-III)** | **3** | **-** | **-** | **3** |

**Course Outcomes:** ***After successful completion of this course, students should be able to***

| | | |
|---|---|---|
| CO1 | : | Understand the uncompensated lines and their behavior under heavy loading conditions. |
| CO2 | : | Understand the concept and importance controllable parameters of FACTS controllers |
| CO3 | : | Emphasize the objectives of Shunt compensation, and basic operation of SVC and STATCOM. |
| CO4 | : | Analyze the functioning of series controllers like GCSC, TSSC and TCSC |

**SYLLABUS**

| **UNIT-I** | **:** | **INTRODUCTION :** |
|---|---|---|
| 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-II** | **:** | **VOLTAGE SOURCE CONVERTERS :** |
| Single phase, three phase, full wave bridge converters, transformer connections for 12 pulse, 24 and 48 pulse operation. Three level voltage source converter, pulse width modulation converter, basic concept of current source converters, and comparison of current source converters with voltage source converters. | | |
| **UNIT-III** | **:** | **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-IV** | **:** | **SVC AND STATCOM :** |
| The regulation and slope transfer function anddynamic performance, transient stability | | |

| | | |
|---|---|---|
| enhancement and power oscillation damping, operating point control and summary of compensation control. | | |
| **UNIT-V** | **:** | **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. | | |

**Text Books:**

1. "Understanding FACTS Devices" N.G.Hingorani and L.Guygi, IEEE Press. Indian Edition is available:—Standard Publications
2. Sang.Y.H and 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

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| **SEMESTER-II** | | **L** | **T** | **P** | **C** |
|---|---|---|---|---|---|
| **19PE2E08** | **DIGITAL CONTROLLERS (Elective-III)** | **3** | **-** | **-** | **3** |

**Course Outcomes:** ***After successful completion of this course, students should be able to***

| | | |
|---|---|---|
| CO1 | : | Understand the architecture of PIC microcontrollers |
| CO2 | : | Understand the components and importance of DSP processors |
| CO3 | : | Emphasize the basic operation of registers and ADC |
| CO4 | : | Analyze the functioning of FPGA |

**SYLLABUS**

| **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. | | |

**Text 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.

**Reference Books:**

1. 3000 series datasheets ( version 3.1). Xilinx,Inc.,USA, 1998.
2. Wayne Wolf," FPGA based system design ", Prentice hall, 2004.

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| SEMESTER-II | | L | T | P | C |
|---|---|---|---|---|---|
| 19PE2E09 | CUSTOM POWER DEVICES (Elective-III) | 3 | - | - | 3 |

**Course Outcomes:** ***After successful completion of this course, students should be able to***

| | | |
|---|---|---|
| CO1 | : | Analyse the effect of various power quality issues in distribution system and their mitigation principles. |
| CO2 | : | Describe the operation of custom power devices for reactive power & harmonic compensation. |
| CO3 | : | Analyse high speed transfer switches. |
| CO4 | : | Analyse the operation and control of custom power devices in power system applications |

**SYLLABUS**

| **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. | | |

**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, Arindam Ghosh, Kluwer Academic Publishers, 2002.

**Reference Books:**

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

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| **SEMESTER-II** | | **L** | **T** | **P** | **C** |
|---|---|---|---|---|---|
| **19PE2E11** | **ARTIFICIAL INTELLIGENCE TECHNIQUES (Elective-IV)** | **3** | **-** | **-** | **3** |

**Course Outcomes:** ***After successful completion of this course, students should be able to***

| | | |
|---|---|---|
| CO1 | : | Understand the Artificial Neural Networks and its basic mathematical model |
| CO2 | : | Acquire Knowledge about data preprocessing |
| CO3 | : | Understand basic concept of Optimization algorithms and solution of typical control problems |
| CO4 | : | Analyse the fuzzy logic controllers and its applications. |

**SYLLABUS**

| **UNIT-I** | **:** | **INTRODUCTION :** |
|---|---|---|
| Introduction to artificial Intelligence systems, concept of Artificial Neural Networks and its basic mathematical model, McCulloch-Pitts neuron model, simple perceptron, Adaline and Madaline, Multilayer Perceptron. Learning and Training the neural network. | | |
| **UNIT-II** | **:** | **DATA PRE-PROCESSING :** |
| Scaling, Fourier transformation, principal component analysis and wavelet transformations. Networks: Hopfield network, Self-organizing network and Recurrent network, Back propagation neural network: Architecture, algorithm and applications. | | |
| **UNIT-III** | **:** | **GENETIC ALGORITHM :** |
| Basic concept of Genetic algorithm and detail algorithmic steps, adjustment of free parameters, solution of typical control problems using genetic algorithm, Particle swarm optimization. | | |
| **UNIT-IV** | **:** | **FUZZY LOGIC CONTROLLERS :** |
| Introduction to crisp sets and fuzzy sets, basic fuzzy set operation, Fuzzy relations, membership function, defuzzication methods, fuzzy rule base, inference system, mamdani model and Takagi – sugeno fuzzy model, construction of an fuzzy logic control, fuzzy PD controller. Fuzzy modeling and control schemes for nonlinear systems. Self-organizing fuzzy logic control. Implementation of fuzzy logic controller using Matlab fuzzy-logic toolbox. | | |

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| **UNIT-V** | **:** | **FUZZY LOGIC APPLICATIONS :** |

Design of Fuzzy PI controller for speed control of DC motor- Flux programming efficiency improvement of three phase induction motor. Neural network applications:-PWM Controller-Selected harmonic elimination PWM-Space vector PWM-Vector controlled drive-feedback signal estimation-speed estimation and flux estimation of induction motor

**Text Books:**

1. Neural Networks: A comprehensive Foundation – Simon Haykins, Pearson Edition, 2003.
2. Fuzzy logic with Fuzzy Applications – T.J.Ross – Mc Graw Hill Inc, 1997.
3. Modern Power Electronics and AC Drives –B.K.Bose-Pearson Publications
4. Artificial Intelligent based Electrical Machines and Drives- Peter Vas, Oxford University Press

**Reference Books:**

1. Neural Network Design-M.T.Hagan, H. B. Demuth and M. Beale, Indian reprint, 2008.
2. Fundamental of neural networks architectures, algorithms and applications- Laurene Fausett-pearson publications
3. Principles of Neurocomputing for science and Engineering,- Fredric M.Ham and Ivica Kostanic, McGraw Hill, 2001.

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| SEMESTER-II | | L | T | P | C |
|---|---|---|---|---|---|
| 19PE2E11 | DISTRIBUTED GENERATION (Elective-IV) | 3 | - | - | 3 |

**Course Outcomes:** ***After successful completion of this course, students should be able to***

| | | |
|---|---|---|
| CO1 | : | Understand the planning and operational issues related to Distributed Generation. |
| CO2 | : | Acquire Knowledge about Distributed Generation Learn Micro-Grids |
| CO3 | : | Understand renewable energy sources |
| CO4 | : | Understanding of the working of off-grid and grid-connected renewable energy generation schemes. |

**SYLLABUS**

| | | |
|---|---|---|
| **UNIT-I** | **:** | **Need for Distributed Generation** |
| Need for Distributed generation, Renewable sources in distributed generation and current scenario in Distributed Generation. | | |
| **UNIT-II** | **:** | **Grid Integration of DGs** |
| Planning of DGs, Sitting and sizing of DGs optimal placement of DG sources in distribution systems, Grid integration of DGs Different types of interfaces, Inverter based DGs and rotating machine based interfaces, Aggregation of multiple DG units. | | |
| **UNIT-III** | **:** | **Technical Impact of DGs** |
| Technical impacts of DGs, Transmission systems Distribution Systems De-regulation Impact of DGs upon protective relaying, Impact of DGs upon transient and dynamic stability of existing distribution systems, Steady-state and Dynamic analysis | | |
| **UNIT-IV** | **:** | **Economic and Control Aspects** |
| Economic and control aspects of DGs - Market facts, Issues and challenges Limitations of DGs, Voltage control techniques, Reactive power control, Harmonics Power quality issues, Reliability of DG based systems. | | |
| **UNIT-V** | **:** | **Introduction to Micro-grids** |
| Introduction to micro-grids, Types of micro-grids: autonomous and non-autonomous grids, Sizing | | |

of micro-grids, Modeling & analysis of Micro-grids with multiple DGs, Micro-grids with power electronic interfacing units. Transients in micro-grids, Protection of micro-grids, Case studies, Advanced topics.

**Text Books:**

1. H. Lee Willis, Walter G. Scott, "Distributed Power Generation – Planning and Evaluation", Marcel Decker Press.
2. M. Godoy Simoes, Felix A. Farret, "Renewable Energy Systems – Design and Analysis with Induction Generators", CRC press.

**Reference Books:**

1. Stuart Borlase. "Smart Grid: Infrastructure Technology Solutions" CRC Press
2. NPTEL online course on "Power Electronics and Distributed Generation" by Dr. Vinod John,Department of Electrical Engineering,IISc Bangalore.

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| SEMESTER-II | | L | T | P | C |
|---|---|---|---|---|---|
| 19PE2E12 | HYBRID ELECTRIC VEHICLES (Elective-IV) | 3 | - | - | 3 |

**Course Outcomes:** ***After successful completion of this course, students should be able to***

| | | |
|---|---|---|
| CO1 | : | Understand the upcoming technology of hybrid system. |
| CO2 | : | Understand the different aspects of drives application |
| CO3 | : | Acquire knowledge about fundamental concepts, principles, analysis and design of hybrid and electric vehicles |
| CO4 | : | Understand the applications of electric drive in vehicles / traction. |

**SYLLABUS**

| | | |
|---|---|---|
| **UNIT-I** | **:** | **Need for Distributed Generation** |
| History of hybrid and electric vehicles, Social and environmental importance of hybrid and electric vehicles, Impact of modern drive-trains on energy supplies, Basics of vehicle performance, vehicle power source characterization Transmission characteristics, Mathematical models to describe vehicle performance | | |
| **UNIT-II** | **:** | **Grid Integration of DGs** |
| Basic concept of hybrid traction, Introduction to various hybrid drive-train topologies, Power flow control in hybrid drive-train topologies, Fuel efficiency analysis. | | |
| **UNIT-III** | **:** | **Technical Impact of DGs** |
| Introduction to electric components used in hybrid and electric Vehicles, Configuration and control of DC Motor drives, Configuration and control of Introduction Motor drives configuration and control of Permanent Magnet Motor drives Configuration and control of Switch Reluctance, Motor drives, drive system efficiency | | |
| **UNIT-IV** | **:** | **Economic and Control Aspects** |
| Matching the electric machine and the internal combustion engine (ICE), Sizing the propulsion motor, sizing the power electronics Selecting the energy storage technology, Communications, | | |

| | | |
|---|---|---|
| supporting subsystems | | |
| **UNIT-V** | **:** | **Introduction to Micro-grids** |
| Introduction to energy management and their strategies used in hybrid and electric vehicle, Classification of different energy management strategies Comparison of different energy management strategies Implementation issues of energy strategies | | |

**Text Books:**

1. Siew-Chong Tan, Yuk-Ming Lai, Chi Kong Tse, “Sliding mode control of switching Power, Converters”
2. Iqbal Hussein, Electric and Hybrid Vehicles: Design fundamentals, CRC Press, 2003.
3. Mehrdad Ehsani, Yimi Gao, Sebastian E. Gay, Ali Emadi, Modern Electric, Hybrid Electric and Fuel Cell Vehicles: Fundamentals, Theory and Design, CRC Press, 2004.

**Reference Books:**

1. James Larminie, John Lowry, Electric Vehicle Technology Explained, Wiley, 2003.
2. Design of a Hybrid Electric Vehicle (HEV), Design of a Battery Electric Vehicle (BEV).
3. Sira -Ramirez, R. Silva Ortigoza, “Control Design Techniques in Power Electronics Devices”, Springer.

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| SEMESTER-II | | L | T | P | C |
|---|---|---|---|---|---|
| 19GEXM04 | ENGLISH FOR RESEARCH PAPER WRITING (Audit Course-II) | 2 | - | - | 0 |

**Course Outcomes:** ***After successful completion of this course, students should be able to***

| | | |
|---|---|---|
| CO1 | : | Understand that how to improve your writing skills and level of readability |
| CO2 | : | Learn about what to write in each section |
| CO3 | : | Understand the skills needed when writing a Title Ensure the good quality of paper at very first-time submission |

**SYLLABUS**

| | | |
|---|---|---|
| **UNIT-I** | **:** | **PLANNING AND PREPARATION** |
| Planning and Preparation, Word Order, Breaking up long sentences, Structuring Paragraphs and Sentences, Being Concise and Removing Redundancy, Avoiding Ambiguity and Vagueness | | |
| **UNIT-II** | **:** | **ABSTRACT** |
| Clarifying Who Did What, Highlighting Your Findings, Hedging and Criticizing, Paraphrasing and Plagiarism, Sections of a Paper, Abstracts. Introduction | | |
| **UNIT-III** | **:** | **DISCUSSION AND CONCLUSIONS** |
| Review of the Literature, Methods, Results, Discussion, Conclusions, The Final Check. Key skills are needed when writing a Title, key skills are needed when writing an Abstract, key skills are needed when writing an Introduction, skills needed when writing a Review of the Literature. | | |
| **UNIT-IV** | **:** | **WRITING SKILLS** |
| Skills are needed when writing the Methods, skills needed when writing the Results, skills are needed when writing the Discussion, skills are needed when writing the Conclusions | | |
| **UNIT-V** | **:** | **QUALITY AND TIME MAINTENANCE** |
| Useful phrases, how to ensure paper is as good as it could possibly be the first- time submission | | |

**Text Books:**

1. Goldbort R, “Writing for Science”, Yale University Press. 2011.
2. Adrian Wallwork, “English for Writing Research Papers”, Springer New York Dordrecht Heidelberg London, 2011.

**Reference Books:**

1. Highman N, “Handbook of Writing for the Mathematical Sciences”, SIAM Highman‟s book.

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| **Semester-II** | | L | T | P | C |
|---|---|---|---|---|---|
| **19PE2L01** | **RENEWABLE ENERGY SYSTEMS LAB** | **0** | **-** | **4** | **2** |

**Course Outcomes:** At the end of the course, the student is able to

1. Ability to understand and analyze Renewable energy systems.
2. Ability to provide adequate inputs on a variety of issues in harnessing Renewable Energy.
3. Ability to simulate the various Renewable energy sources.
4. Ability to recognize current and possible future role of Renewable energy sources.

**List of Experiments**

1. Simulation study on Solar PV Energy System.
2. Experiment on VI-Characteristics and Efficiency of Solar PV System.
3. Experiment on Shadowing effect and diode based solution of Solar PV System.
4. Experiment on Performance assessment of Grid connected and Standalone of Solar Power System.
5. Simulation study on Wind Energy Generator.
6. Experiment on Performance assessment of micro Wind Energy Generator.
7. Simulation study on Hybrid (Solar-Wind) Power System.
8. Experiment on Performance Assessment of Hybrid (Solar-Wind) Power System.
9. Simulation study on Hydel Power.
10. Experiment on Performance Assessment of Fuel Cell.
11. Simulation study on Intelligent Controllers for Hybrid Systems.

**Note:** Conduct any 10 experiments from the above using any simulation tool

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| **Semester-II** | | L | T | P | C |
|---|---|---|---|---|---|
| **19PE2L02** | **ADVANCED POWER CONVERTERS AND DRIVES LAB** | **0** | **-** | **4** | **2** |

**Course Outcomes:** At the end of the course, the student is able to

8. Design the gate driver circuits for converter topologies
9. Know the complete study of advanced converter technologies
10. Know the speed control strategies of AC and DC drives
11. Design speed, current controllers for AC and DC drives

**List of Experiments**

**Part-A**

1. Single phase diode clamped multilevel inverter.
2. Single phase cascaded multilevel inverter
3. Push pull converter
4. Fly back converter
5. Forward converter
6. Series resonant converter
7. Parallel resonant converter
8. ZVS

***Note:*** *Conduct any 5 experiments from the above Part-A*

**Part-B**

1. Speed control of BLDC Motor Drive
2. Breaking of Three Phase Induction Motor
3. Performance & Operation of a four quadrant Chopper on D.C. Drive
4. Performance & speed control of D.C. drive using 3-phase full Converter.
5. Three phase PWM Pulse generation using PIC Micro controller
6. PIC Microcontroller based speed control of three phase Induction Motor
7. DSP based V/F Control of 3 phase Induction motor.
8. Speed control of 3 phase slip ring Induction motor by Static Rotor Resistance controller.

***Note:*** *Conduct any 5 experiments from the above Part-B*

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**SEMESTER-III**

| **SEMESTER-III** | | **L** | **T** | **P** | **C** |
|---|---|---|---|---|---|
| **19PE3E13** | **ELECTRICAL DISTRIBUTION SYSTEMS (Elective-V)** | **3** | **-** | **-** | **3** |

**Course Outcomes:** ***After successful completion of this course, students should be able to***

| | | |
|---|---|---|
| CO1 | : | Understanding the overview of distribution systems |
| CO2 | : | Understand the design consideration of feeders, substations and system analysis |
| CO3 | : | Understand the uses of protective devices and coordination |
| CO4 | : | Analyze the power factor control using capacitive compensation |

**SYLLABUS**

| **UNIT-I** | **:** | **GENERAL** |
|---|---|---|
| Introduction to Distribution systems, an overview of the role of computers in distribution system planning-Load modeling and characteristics: definition of basic terms like demand factor, utilization factor, load factor, plant factor, diversity factor, coincidence factor, contribution factor and loss factor-Relationship between the load factor and loss factor - Classification of loads (Residential, Commercial, Agricultural and Industrial) and their characteristics. | | |
| **UNIT-II** | **:** | **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 primary feeders. Benefits derived through optimal location of substations. | | |
| **UNIT-III** | **:** | **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-IV** | **:** | **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-V** | **:** | **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 | | |

**Text Books:**

1. AS Pabla, "Electric Power Distribution", Tata McGraw Hill Publishing Co. Ltd., 4th Edition, 2012.
2. MK Khedkar, GM Dhole, "A Text Book of Electrical power Distribution Automation", University Science Press, New Delhi, 2nd Edition,2010.
3. "Electric Power Distribution System Engineering " by Turan Gonen, Mc.Graw-Hill Book Company,1986.

**Reference Books:**

1. Anthony J Panseni, "Electrical Distribution Engineering", CRC Press, 2nd Edition,2010.
2. James Momoh, "Electric Power Distribution, automation, protection & control", CRC Press 2ndEdition, 2006.
3. Electric Power Distribution-by A.S.Pabla, Tata Mc Graw-Hill Publishing Company, 4th edition, 1997.

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| SEMESTER-III | | L | T | P | C |
|---|---|---|---|---|---|
| 19PE3E14 | REACTIVE POWER COMPENSATION AND MANAGEMENT (Elective-V) | 3 | - | - | 3 |

**Course Outcomes:** ***After successful completion of this course, students should be able to***

| | | |
|---|---|---|
| CO1 | : | Identify the necessity of reactive power compensation |
| CO2 | : | Select various types of reactive power compensation in transmission systems |
| CO3 | : | Illustrate reactive power coordination system |
| CO4 | : | Characterize distribution side and utility side reactive power management |

**SYLLABUS**

| **UNIT-I** | **:** | **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-II** | **:** | **REACTIVE POWER COMPENSATION** |
| **STEADY–STATE REACTIVE POWER COMPENSATION IN TRANSMISSION SYSTEM**<br>Uncompensated line – types of compensation – Passive shunt and series and dynamic shunt compensation – examples<br>**TRANSIENT STATE REACTIVE POWER COMPENSATION IN TRANSMISSION SYSTEMS:**<br>Characteristic time periods – passive shunt compensation – static compensations - series capacitor compensation – compensation using synchronous condensers – examples | | |
| **UNIT-III** | **:** | **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-IV** | **:** | **DEMAND AND DISTRIBUTION SIDE MANAGEMENT** |

**DEMAND SIDE MANAGEMENT**

Load patterns – basic methods load shaping – power tariffs- KVAR based tariffs penalties for voltage flickers and Harmonic voltage levels

**DISTRIBUTION SIDE REACTIVE POWER MANAGEMENT**:

System losses –loss reduction methods – examples – Reactive power planning – objectives – Economics Planning capacitor placement – retrofitting of capacitor banks

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|---|---|---|
| **UNIT-V** | **:** | **REACTIVE POWER MANAGEMENT** |

**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

**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

**Text 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

**Reference Books:**

1. Wolfgang Hofmann, Jurgen Schlabbach, Wolfgang Just “Reactive Power Compensation: A Practical Guide, April, 2012, Wiely publication.

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| SEMESTER-III | | L | T | P | C |
|---|---|---|---|---|---|
| 19PE3E15 | POWER QUALITY (Elective-V) | 3 | - | - | 3 |

**Course Outcomes:** ***After successful completion of this course, students should be able to***

| | | |
|---|---|---|
| CO1 | : | Understand different terms of power quality. |
| CO2 | : | Illustrate power quality issues for short and long interruptions. |
| CO3 | : | Construct study of characterization of voltage sag magnitude and three phase unbalanced voltage sag. |
| CO4 | : | Learn the behavior of power electronics loads, induction motors, synchronous motor etc. by the power quality issues. |

**SYLLABUS**

| | | |
|---|---|---|
| **UNIT-I** | **:** | **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-II** | **:** | **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-III** | **:** | **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-IV** | **:** | **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-V** | **:** | **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 | | |

**Text 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.

**Reference Books:**

1. Understanding Power Quality Problems: Voltage Sags and Interruptions, Bollen M H J, First Edition, IEEE Press; 2000.
2. Power System Harmonics, Arrillaga J and Watson N R, Second Edition, John Wiley & Sons, 2003.
3. Electric Power Quality control Techniques, W. E. Kazibwe and M. H.Sendaula, Van Nostrad Reinhold, New York.
4. Power Quality by C.Shankaran, CRC Press,2001

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| SEMESTER-III | | L | T | P | C |
|---|---|---|---|---|---|
| 19GM3O06 | WASTE TO ENERGY | 3 | - | - | 3 |

**Course Outcomes:** ***After successful completion of this course, students should be able to***

| | | |
|---|---|---|
| CO1 | : | Understand the principles associated with effective energy management and to apply these principles in the day to day life. |
| CO2 | : | Develop insight into the collection, transfer and transport of municipal solid waste. |
| CO3 | : | Analyse the design and operation of a municipal solid wasteland fill |
| CO4 | : | Analyse the main operational challenges in operating thermal and biochemical energy from waste facilities. |

**SYLLABUS**

| | | |
|---|---|---|
| **UNIT-I** | **:** | **Introduction to Energy from Waste** |
| Introduction to Energy from Waste: Classification of waste as fuel - Agro based - Forest residue - Industrial waste – MSW - Conversion devices – Incinerators – Gasifiers - Digestors | | |
| **UNIT-II** | **:** | **Biomass Pyrolysis** |
| Biomass Pyrolysis: Pyrolysis – Types - Manufacture of charcoal - Methods, Yields and application - Manufacture of pyrolytic oils and gases - yields and applications. | | |
| **UNIT-III** | **:** | **Biomass Gasification** |
| Gasifiers - Fixed bed system - Downdraft and updraft gasifiers - Fluidized bed gasifiers - Design, construction and operation - Gasifier burner arrangement for thermal heating - Gasifier engine arrangement and electrical power - Equilibrium and kinetic consideration in gasifier operation. | | |
| **UNIT-IV** | **:** | **Biomass Combustion** |
| Biomass stoves - Improved chullahs – types - some exotic designs - Fixed bed combustors – Types - Inclined grate combustors - Fluidized bed combustors - Design, construction and operation - Operation of all the above biomass combustors. | | |
| **UNIT-V** | **:** | **Biogas** |
| Properties of biogas (Calorific value and composition) - Biogas plant technology and status - Bio energy system - Design and constructional features - Biomass resources and their classification - | | |

Biomass conversion processes - Thermo chemical conversion - Direct combustion - biomass gasification - pyrolysis and liquefaction = biochemical conversion - anaerobic digestion -Bio diesel production = Biomass energy programme in India.

**Text Books:**

1. Desai, Ashok V, “Non Conventional Energy”, Wiley Eastern Ltd., 1990.

**Reference Books:**

1. Khandelwal, K. C. and Mahdi, S. S, “Biogas Technology - A Practical Hand Book”, Vol. I & II Tata McGraw Hill Publishing Co. Ltd., 1983.
2. Challal, D. S, “Food, Feed and Fuel from Biomass”, IBH Publishing Co. Pvt. Ltd., 1991.