JAWAHARLALNEHRUTECHNOLOGICAL UNIVERSITY GURAJADA VIZIANAGARAM

DEPARTMENTOF ELECTRICALAND ELECTRONICS ENGINEERING

Pre-Ph.D Syllabus

COURSESTRUCTURE

S. No	Pre-Ph.DCourse-1-Subjects	Subject Code
1.	Optimal Control Theory	PH2402101
2.	Electrical Distribution system & Automation	PH2402102
3.	Power Quality & Custom power devices	PH2402103
4.	Analysis of power Electronic Converters	PH2402104
5.	Power Electronic Control of DC drives	PH2402105
6.	Advanced Electrical Machines	PH2402106
7.	SCADA & Energy Management Systems	PH2402107
8.	Artificial Intelligent Techniques	PH2402108
9.	Battery Management system for Electrical Vehicles	PH2402109
10.	Distributed Generation & Micro Grids	PH2402110

S. No	Pre-Ph.DCourse-2-Subjects	Subject Code
1.	Discrete Data Control Systems	PH2402201
2.	EHV AC Transmission Systems	PH2402202
3.	Power System Dynamic &Stability	PH2402203
4.	Advanced Power Electronics	PH2402204
5.	Power Electronic Control of AC drives	PH2402205
6.	Unified Theory of Electric Machines	PH2402206
7.	Grid Integration of Renewable Energy Systems	PH2402207
8.	Hybrid Electrical Vehicle Systems	PH2402208
9.	High Voltage DC Transmission	PH2402209
10.	Smart Grid Technologies	PH2402210

JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY GURAJADA VIZIANAGARAM
DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING

(PH2402101)OPTIMAL CONTROL THEORY

UNIT-I: Introduction

Problem formulation- State variable representation of systems – Performance measures for optimal control problems – selecting a performance measure.

UNIT-II: Dynamic programming

The optimal control law - principle of optimality and its application - optimal control system - interpolation - recurrence relation of dynamic programming-computational procedure for solving optimal control problems –characteristics of dynamic programming solution-analytical results-discrete linear regulator problems-Hamilton- Jacobi-Bellman equation-continuous linear regulator problems, Riccati Equation

UNIT-III: Calculus of variants

Fundamental concepts- linearity of functional-closeness of functions-the increment of a functional-The variation of a functional- maxima and minima of functional- the fundamental theorem of the calculus of variations - Functional of a single function- the simplest variational problem

UNIT-IV: Optimal control problems

Necessary conditions for optimal control - Linear regulator problem-Pontryagin's minimum principle and state inequality constraints.

UNIT-V: Iterative numerical techniques for finding optimal controls

Two-point boundary-value problems-The method of steepest descent-Features of the steepest descent algorithm.

Text Books:

1. Optimal control theory-An Introduction by Donald E.Kirk - Prentice Hall Networks series.
2. M. Gopal: Modern Control Systems Theory, Wiley Eastern Limited, New Delhi, 2005

Reference Books:

1. Katsuhiko Ogata: Modern control Engineering, Prentice-Hall of India, 2010
2. B.C.Kuo, Automatic control systems (5thEdition),Prentice HallofIndia,1988.

JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY GURAJADA VIZIANAGARAM
DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING

(PH2402102)ELECTRICAL DISTRIBUTION SYSTEMS & AUTOMATION

UNIT – I: General

Introduction to Distribution systems, an overview of the role of computers in distribution system planning-Load modelling 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, and 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 – III : 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; types of coordination.

UNIT – IV : 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.

UNIT – V : Distribution automation functions

Electrical system automation, EMS functional scope, DMS functional scope functionality of DMS- Steady state and dynamic performance improvement; Geographic information systems- AM/FM functions and Database management; communication options, supervisory control and data acquisition: SCADA functions and system architecture; Synchrophasors and its application in power systems.

Text Books:

1. Electric Power Distribution System Engineering by Turan Gonen, McGraw-Hill Book Company,1986.
2. Distribution System Analysis and Automation, by Juan M. Gers, The Institution of Engineering and Technology, UK 2014.

Reference Books:

1. Electric Power Distribution-by A.S.Pabla, Tata McGraw-Hill Publishing Company, 4thedition, 1997.
2. Electrical Distribution V.Kamaraju-McGraw Hill
3. Handbook of Electrical Power Distribution – Gorti Ramamurthy-Universities press

JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY GURAJADA VIZIANAGARAM
DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING

(PH2402103)POWER QUALITY AND CUSTOM POWER DEVICES

UNIT– I: Introduction to power quality

Overview of Power Quality, Concern about the Power Quality, General Classes of Power Quality Problems, Voltage Unbalance, Waveform Distortion, Voltage fluctuation, PowerFrequency Variations, Power Quality Terms, Voltage Sags, swells, flicker and Interruptions - Sources of voltage and current interruptions, Nonlinear loads.

UNIT– II: Transient and Long Duration Voltage Variations

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.

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 generation

UNIT– III: Harmonic Distortion and solutions

Voltage vs. Current Distortion, Harmonics vs. Transients - Power System Quantities under Non-sinusoidal Conditions, Harmonic Indices, Sources of harmonics, Locating Sources of Harmonics, System Response Characteristics, Effects of Harmonic Distortion, Inter harmonics,Harmonic Solutions Harmonic Distortion Evaluation, Devices for Controlling Harmonic Distortion, Harmonic Filter Design, Standards on Harmonics

UNIT– IV: Custom Power Devices

Custom power and custom power devices, voltage source inverters, reactive power and harmonic compensation devices, compensation of voltage interruptions and current interruptions, static series and shunt compensators, compensation in distribution systems, interaction with distribution equipment, installation considerations.

UNIT– V: Application of custom power devices in power systems

Static and hybrid Source Transfer Switches, Solid state current limiter - Solid state breaker. P-Q theory – Control of P and Q, Dynamic Voltage Restorer (DVR): Operation and control – Interline Power Flow Controller (IPFC): Operation and controlof Unified Power Quality Conditioner (UPQC); Generalized power quality conditioner

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. Understanding Power Quality Problems: Voltage Sags and Interruptions, Bollen M H J, FirstEdition, IEEE Press; 2000.
3. Guidebook on Custom Power Devices, Technical Report, Published by EPRI, Nov 2000
4. Power Quality Enhancement Using Custom Power Devices – Power Electronics and PowerSystems, Gerard Ledwich, ArindamGhosh, Kluwer Academic Publishers, 2002.

Reference Books:

1. Power Quality Primer, Kennedy B W, First Edition, McGraw-Hill, 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 NostradReinhold, New York.
4. Power Quality c.shankaran, CRC Press, 2001
5. Harmonics and Power Systems –Franciso C.DE LA Rosa-CRC Press (Taylor & Francis).
6. Power Quality in Power systems and Electrical Machines-EwaldF.fuchs, Mohammad A.S. Masoum-Elsevier
7. Power Quality, C. Shankaran, CRC Press, 2001
8. Instantaneous Power Theory and Application to Power Conditioning, H. Akagiet.al., IEEE Press, 2007.
9. Custom Power Devices - An Introduction, ArindamGhosh and Gerard Ledwich, Springer, 2002
   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.

JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY GURAJADA VIZIANAGARAM
DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING

(PH2402104)ANALYSIS OF POWER ELECTRONICS CONVERTERS

Unit-1: Single Phase AC voltage Controllers

Single Phase AC Voltage Controllers with RL and RLE loads-ac voltage controller's with PWM control-Effects of source and load inductances –synchronous tap changers –Application- numerical problems

Three Phase AC Voltage Controllers

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: Single phase AC-DC converters

Single phase Half controlled and Fully controlled Converters with RL load– Evaluation of input power factor and harmonic factor-Continuous and Discontinuous load current-Power factor improvements-Extinction angle control-symmetrical angle control-PWM single phase sinusoidal PWM-Single phase series converters- numerical problems

Three Phase AC-DC Converters

Three Phase ac-dc Converters- Half controlled and fully controlled Converters with RL load– Evaluation of input power factor and harmonic factor-Continuous and Discontinuous load current-three phase dual converters-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 –VI: Single phase PWM Inverters

Principle of operation-Voltage control of single phase inverters - sinusoidal PWM – modified PWM – phase displacement Control – Trapezoidal, staircase, stepped, harmonic injection and delta modulation – numerical problems

Three Phase PWM Inverters

Voltage Control of 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

Introduction, Multilevel Concept, Types of Multilevel Inverters- Diode-Clamped Multilevel Inverter, Principle of Operation, Features of Diode-Clamped Inverter, Improved Diode-Clamped Inverter- Flying-Capacitors Multilevel Inverter- Principle of Operation, 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

Textbooks

1. Power Electronics-Md.H.Rashid –Pearson Education Third Edition- First Indian Reprint- 2008
2. Power Electronics- Ned Mohan, Tore M.Undelan and William P.Robbins –John Wiley& Sons -2nd Edition.

JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY GURAJADA VIZIANAGARAM
DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING

(PH2402105)POWER ELECTRONIC CONTROL OF DC DRIVES

UNIT – I: Controlled Bridge Rectifier (1-Φ) with DC Motor Load

Separately excited DC motors with rectified single –phase supply – single-phase semi converter and single phase full converter for continuous and discontinuous modes of operation – power and power factor.

UNIT – II : Controlled Bridge Rectifier (3 - Φ) with DC Motor Load

Three phase semi converter and Three phase full converter for continuous and discontinuous modes of operations – power and power factor - Addition of Freewheeling diode – Three phase double converter.

Three phase naturally commutated bridge circuit as a rectifier or as an inverter.

Three phase controlled bridge rectifier with passive load impedance , resistive load and ideal supply – Highly inductive load and ideal supply for load side and supply side quantities, shunt capacitor compensation, three phase controlled bridge rectifier inverter.

UNIT – III: Phase controlled DC Motor drives.

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.

Current and speed controlled DC Motor drives.

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

UNIT – IV: Chopper controlled DC motor drives.

Principle of operation of the chopper – Four – quadrant chopper circuit – Chopper for inversion – Chopper with other power devices – model of the chopper – input to the chopper – steady state analysis of chopper controlled DC motor drives – rating of the devices – Pulsating torque.

Closed loop operation of DC motor drives.

Speed controlled drive system – current control loop – pulse width modulated current controller –hysterisis current controller – modeling of current controller – design of current controller.

UNIT – V: Simulation of DC motor drives

Dynamic simulations of the speed controlled DC motor drives – Speed feedback speed controller – command current generator – current controller.

Textbooks:

1. Power Electronics circuits, Devices and Applications – MH Rashid – PHI – 1 Edition 1995.
2. Fundamentals of Electric Drives – GK Dubey Narosa Publishers 1995

REFERENCES:

1 Power Electronics and motor control – Shepherd , Hulley, Liang – II Edition Cambridge Univeristy Press.

2. Electronic motor drives modeling Analysis and control – R. Krishnan – I Edition PrenticeHall India.

3. Power Semiconductor drives – SB Dewan and A Straughen -1975.

JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY GURAJADA VIZIANAGARAM
DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING

(PH2402106)ADVANCED ELECTRICAL MACHINES

UNIT - I: Permanent Magnet Materials

Types, properties and characteristics of permanent magnets, features of permanent magnet excitation, magnetic circuit model, sintered permanent magnet and bonded permanent magnet materials , effect of temperature, handling of permanent magnets

UNIT - II: Permanent Magnet Brushless Motors

Construction, operating principle & features of permanent magnet brushless(PMBL)motors, various types of PMBL motors, magnetic circuit model, armature reaction ,derivation of emf and torque equation, types of emf generated, performance characteristics ,closed loop control of PMBL motors, sensor less control of PMBL motors, case studies considering applications viz. electric vehicle, marine propulsion & PV fed water ping, advancements in topologies and reviews, applications of PMSG in various energy conversion systems.

UNIT - III: Stepper Motors

Concept of Stepper Motors, types and operating principle of stepper motors, static and dynamic characteristics of stepper motors, stepper motor converters

UNIT - IV: Switched Reluctance Motors:

Construction and operating principle and features of switched reluctance motors(SRM), equivalent circuit, inductance profile, derivation of torque equation and factors affecting torque, performance characteristics, control of SRM, various types of converters, closed loop control of SRM, sensor less control of SRM, case studies considering applications viz. electric vehicle, washing machine

UNIT-V: Synchronous Reluctance Motors

Construction, operating, principle, features, equivalent circuit, vector diagram, control and topological advancements of synchronous reluctance motors, case studies considering Applications viz. electric vehicle, water pumping and etc

Text books:

1. MillerT.J.E., BrushlessPermanentMagnetandReluctanceMotorDrives,ClarendonPress
2. V.V.Athani,“StepperMotors:Fundamentals,ApplicationsandDesign”,NewAgeInternationalPvt.Ltd.

Reference Books:

1. R.Krishnan,Permanent Magnet Synchronou sand Brushless DC Motor Drives ,CRC Press
2. VenkatratnamK.,Special Electric Machines, CRC Press.
3. Recent papers from IEEE transactions and reputed journals

JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY GURAJADA VIZIANAGARAM
DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING

(PH2402107)SCADA AND ENERGY MANAGEMENT SYSTEMS

UNIT-I: General Theory

Purpose and necessity, general structure, data acquisition, transmission and monitoring, general power system hierarchical structure, overview of the methods of data acquisition systems, commonly acquired data, transducers, RTUs, data concentrators, various communication channels, cables, telephone lines, power line carrier, microwaves, fiber- optical channels and satellites.

UNIT-II: Supervisory and Control Functions

Data acquisitions, status indications, measured values, energy values, monitoring alarm and event application processing. Control function: ON/OFF control of lines, transformers, capacitors and applications in process industry, valve, opening, closing etc. Regulatory functions: set points and feed-back loops, time tagged data, disturbance data collection and analysis, calculation and report preparation.

UNIT- III: Man- Machine Communication

Operator consoles and VDUs, displays, operator dialogues, alarm and event loggers, mimic diagrams, report and printing facilities.

UNIT-IV: Data Bases - SCADA, EMS And Network Data Bases

SCADA system structure - local system, communication system and central system, Configuration- non-redundant single processor, redundant dual processor, multi control centers, system configuration. Performance considerations, real time operation system requirements, modularization of software programming languages.

UNIT- V: Energy Management Center

Functions performed at a centralized management center, production control and load management, economic dispatch, distributed centers and power pool management.

Text Books:

1. TorstenCegrell, Power System Control Technology, Prentice Hall International, 1986
2. Stuart A. Boyer, SCADA: Supervisory Control And Data Acquisition, The Instrumentation, Systems and Automation Society, 4th edition, 2009.
3. Krishna Kant, Computer-Based Industrial Control, PHI Learning,2nd edition, 2013

JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY GURAJADA VIZIANAGARAM
DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING

(PH2402108)ARTIFICIAL INTELLIGENCE TECHNIQUES

Unit – I: 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- II: 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 III: Genetic algorithms & Modelling-introduction-encoding-fitness function-reproduction operators-genetic operators-cross over and mutation-generational cycle-convergence of genetic algorithm

Unit – VI: 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 V: APPLICATION OF AI TECHNIQUES-load forecasting-load flow studies-economic load dispatch-load frequency control-reactive power control-speed control of dc and ac motors

TEXT BOOK:

1. Neural Networks, Fuzzy logic, Genetic algorithms: synthesis and applications by Rajasekharan and Rai – PHI Publication.

2. Introduction to Artificial Neural Systems - Jacek M. Zuarda, Jaico Publishing House, 1997.

JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY GURAJADA VIZIANAGARAM
DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING

(PH2402109)BATTERY MANAGEMENT SYSTEM FOR ELECTRIC VEHICLES

UNIT-I: Batteries - Specifications and components:
Batteries: Lead Acid Battery, Nickel based batteries, Sodium based batteries, Lithium based batteries – Li-ion & Li-poly, Metal Air Battery, Zine Chloride battery; Ultra capacitors; Flywheel Energy Storage System; Hydraulic Energy Storage System; Comparison of different Energy Storage System. Battery Specifications: Variables to characterize battery operating conditions and Specifications to characterize battery nominal and maximum characteristics; Efficiency of batteries; Electrical parameters Heat generation- Battery design-Performance criteria for Electric vehicles batteries

UNIT-II: Design features of batteries for Electric vehicles:
Selection of battery for EVs & HEVs, Traction Battery Pack design, Requirement of Battery Monitoring, Battery State of Charge Estimation methods, Battery Cell equalization problem, thermal control, protection interface, SOC Estimation, Energy & Power estimation, properties for cell safety and battery design, battery testing, limitations for transport and storage of cells and batteries, Recycling, disposal and second use of batteries. Battery Leakage: gas generation in batteries, leakage path, leakage rates. Ruptures: Mechanical stress and pressure tolerance of cells, safety vents, Explosions: Causes of battery explosions, explosive process, Thermal Runway: High discharge rates, short circuits, charging and discharging. Environment and Human Health impact assessments of batteries,

UNIT-III: Static Modelling of Battery: Static modelling of battery: static model parameters of the battery, lab test to determine the parameters of battery model, static equivalent circuit determination.
Dynamic Modelling of Battery: Dynamic modelling of battery, parameters affecting the dynamic model, lab test to determine the dynamic model parameters, dynamic equivalent circuit determination

UNIT-IV: Battery Management Systems:
Identify electronic components that can provide protection and specify a minimum set of protections needed - Compute stored energy in a battery pack - List the manufacturing steps of different types of lithium-ion cells and possible failure modes. major functions provided by a battery-management system and their purpose - Understand how a battery-management system “measures” current, temperature, and isolation. Battery thermal management system.

UNIT-V: Functions of Battery Management System: Definition, Parts: Power Module, Battery, DC/DC Converter, load, communication channel, Battery Pack Safety, Battery Standards & Tests. Vehicle propulsion factors- Power and energy requirements of batteries- Meeting battery performance criteria-setting new targets for battery performance.

Text books:

1. AK Bandyopadhyay, Nanomaterials, New Age International (P) Ltd., 2 nd Edition, 2010
2. N. Kumar, Concise concepts of nanoscience and nanomaterials, Scientific publishers, 2018
3. L.Plett , Gregory, Battery management systems: Battery Modeling, Artech house, 2015.
4. Gregory L.Plett, Battery management systems: Equivalent circuit methods, Artech house, 2015.

Reference books:

1. Chris Mi, M. AbdulMasrur and David Wenzhong Gao, Hybrid Electric Vehicles-Principles and Applications with practical perspectives, Wiley Publications,1 edition 2011
2. Gianfranco Pistoia, Electric and Hybrid Vehicles power sources, models, sustainability, infrastructure and the market, Elsevier 1 edition 2010.
3. Iqbal Hussain, Electric and Hybrid Vehicles Design Fundamentals, CRC Press2nd edition, 2010.

4. Ibrahim Dinçer, Halil S. Hamut and Nader Javani, Thermal Management of Electric Vehicle Battery Systems, JohnWiley& Sons Ltd., 2016

JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY GURAJADA VIZIANAGARAM
DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING

(PH2402110)DISTRIBUTED GENERATION & MICRO GRIDS

UNIT – I: Need for Distributed Generation

Renewable sources in distributed generation – Current scenario in distributed generation – Planning of DGs – Siting and sizing of DGs – Optimal placement of DG sources in distribution systems.

UNIT – II: Grid integration of DGs

Different types of interfaces – Inverter based DGs and rotating machine-based interfaces – Aggregation of multiple DG units – Energy storage elements – Batteries, ultracapacitors, flywheels.

UNIT – III: 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.

UNIT-IV: 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 – Steady state and Dynamic analysis.

UNIT – V: Introduction to micro-grids

Types of micro-grids – Autonomous and non-autonomous grids – Sizing of micro-grids – Modeling& analysis – Micro-grids with multiple DGs – Micro-grids with power electronic interfacing units – Transients in micro-grids – Protection of micro-grids – Case studies.

Text Books:

1. H. Lee Willis, Walter G. Scott , 'Distributed Power Generation – Planning and Evaluation', Marcel Decker Press, 2000.
2. M.GodoySimoes, Felix A.Farret, 'Renewable Energy Systems – Design and Analysis with Induction Generators', CRC press.
3. Nikos Hatziargyriou ,Microgrids: Architectures and Control (Wiley - IEEE),2014.

Reference Books:

1. Z. Ye, R. Walling, N. Miller, P. Du, K. Nelson, 'Facility Microgrids', General Electric Global Research Center, Niskayuna, New York, Subcontract report, May 2005.
2. K.Venkatanagaraju,M. Biswal ,'Microgrid: Operation, Control, Monitoring and Protection' , Monalisa (Eds.),2020

JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY GURAJADA VIZIANAGARAM

DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING

Pre-Ph.D Syllabus

S. No	Pre-Ph.D Course-2-Subjects
1.	Discrete Control Systems
2.	EHVAC Transmission Systems
3.	Power System Dynamic & Stability
4.	Advanced Power Electronics
5.	Power Electronic Control of AC drives
6.	Unified Theory of Electric Machines
7.	Grid Integration of Renewable Energy Systems
8.	Hybrid Electrical Vehicle Systems
9.	High Voltage DC Transmission
10.	Smart Grid Technologies

JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY GURAJADA VIZIANAGARAM
DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING

(PH2402201)DISCRETE DATA CONTROL SYSTEMS

UNIT – I: Modelling and parameter estimation

Introduction to probability theory, elements of estimation theory, application to parameter estimation for a dynamical model, some methods for the determination of transfer functions.

UNIT – II: Parameter estimation for large scale systems

Hierarchical parameter estimation, the multiple projection approach, recursive algorithm for the minimum variance estimator Aggregation of control systems, problem statement, properties of the aggregated system matrix, determination of the Aggregation matrix; Generation of feedback controls: linear dynamic optimization, bounds on sub optimality, eigen value assignment.

UNIT – III: Model reduction techniques

Model analysis approach, mathematical development, three basic methods, and a general approach. Subspace projection methods, projection error minimization, and derivation of reduced model. Optimal order reduction, problem formulation, conditions of optimality, numerical algorithm, polynomial input functions. A comparative study. Extension to discrete systems, preliminary analysis, two model reduction techniques, output error minimization. Examples.

UNIT-IV: Model simplification using frequency domain techniques

Simplification by continued function expansions: three Cauer forms, a generalized Routh algorithm, simplified models, relationship to aggregation, and extension to discrete models; Approximation methods for simplification: time moment matching, Padetype approximations, Routh-Hurwitz method. Minimal realization algorithms: conditions of reliability, Pade - type realizable models, aggregated model of Routh approximants

UNIT–V: Scale Analysis Block-Diagonalization of Continuous Systems

Problem statement, numerical algorithms, basic properties, relation to model aggregation. Feedback control design: two stage eigen value placements. Decoupling of discrete systems:, state feedback design.

Text Books:

1. Magdi S. Mahmoud and Madan G. Singh – “Large scale systems modeling”, Pergamon press, Oxford.
2. LanLunze – “Feedback control of Large scale systems”, Prentice Hall International, New York.

Reference Books:

1. Magdi S. Mahmoud, Mohamed F. Hassan, Mohamed G. Darwish- “Large scale control systems - Theories and Techniques”, Marcel Dekkar, Inc, New York and Basel.
2. Andrew P. Sage, “Methodology for large-scale systems”, McGraw-Hill, 1977
3. Efficient Modeling and Control of Large-Scale Systems, edited by Javad Mohammad pour, and Karolos M., Springer, 2010.

JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY GURAJADA VIZIANAGARAM
DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING

(PH2402202)EHVAC TRANSMISSION SYSTEMS

Unit I: E.H.V. A.C. Transmission

E.H.V. A.C. Transmission line trends and preliminary aspects standard transmission voltages – power handling capacities and line losses – mechanical aspects.

Unit II: Calculation of Line Resistance and Inductances

Resistance of conductors, temperature rise of conductor and current carrying capacity. Properties of bundled conductors and geometric mean radims of bundle, inductance of two conductor lines and multi – conductor lines, Maxwell's coefficient matrix.

Line capacitance calculation: capacitance of two conductor line, and capacitance of multiconductor lines, potential coefficients for bundled conductor lines, sequence inductances and capacitances and diagonalization.

Unit III: Calculation of Electro Static Field

Calculation of electro static field traveling waves due to corona – Audio noise die to corona, its generation, characteristics and limits measurement of audio noise.

Surface voltage Gradient on conductors, surface gradient on 2 conductor bundle and consine law, Maximum surface voltage gradient of bundle with more than 3 sub conductors, Mangolt formula.

Unit IV: Corona

Corona in EHV lines – corona loss formulate – attenuation of traveling waves due to corona – Audio noise due to corona, its generation, characteristics and limits measurement of audio noise.

Power Frequency voltage control : Problems at power frequency, generalized constants, No load voltage conditions and charging currents, voltage control using synchronous conductor, cascade connection of components : Shunt and series compensation, sub synchronous resonance in series – capacitor compensated lines

Unit V: Static Reactive Compensation Systems

Introduction, SVC schemes, Harmonics injected in to network by TCR, design of filters for suppressing harmonics injected in to the system.

Text Books:

1. Extra High Voltage AC Transmission Engineering – Rakosh Das Begamudre, WileyEastem ltd.,New Delhi – 1987.
2. EHV Transmission line reference book – Edision Electric Institute (GEC) 1986.

REFERENCE BOOKS:

1. HVAC and DC Transmission by S. Rao

JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY GURAJADA VIZIANAGARAM
DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING

(PH2402203)POWER SYSTEMS DYNAMICS AND STABILTY

UNIT – I: System Dynamics
Synchronous machine model in state space from computer representation for excitation and governor system – modelling of loads and induction machines.

UNIT – II: Steady state stability
Steady state stability limit – Dynamics Stability limit – Dynamic stability analysis – State space representation of synchronous machine connected to infinite bus-time response – Stability by eigen value approach.

UNIT – III: Digital Simulation of Transient Stability
Swing equation machine equations – Representation of loads – Alternate cycle solution method – Direct method of solution – Solution Techniques: Modified Euler method – Runge Kutta method – Concept of multi machine stability.

UNIT – IV: Effects on Stability
Effect of governor action and excite on power system stability effect of saturation, saliency & automatic voltage regulators on stability.

UNIT – V: Excitation Systems
Rotating Self-excited Exciter with direct acting Rheostatic type voltage regulator – Rotating main and Pilot Exciters with Indirect Acting Rheostatic Type Voltage Regulator – Rotating Main Exciter, Rotating Amplifier and Static Voltage Regulator – Static excitation scheme – Brushless excitation system.

Text Books:

1. Power System Stability by Kimbark Vol. I & II, III, Willey.
2. Power System control and stability by Anderson and Fund, IEEE Press.

Reference Books:
1. Power systems stability and control by PRABHA KUNDUR, TMH.
2. Computer Applications to Power Systems–Glenn.W.Stagg& Ahmed. H.El.Abiad, TMH.
3. Computer Applications to Power Systems – M.A.Pai, TMH.
4. Power Systems Analysis & Stability – S.S.Vadhera Khanna Publishers

JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY GURAJADA VIZIANAGARAM
DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING

(PH2402204)ADVANCED POWER ELECTRONICS

UNIT-I: Resonant Converters

Introduction, Basic resonant circuit concepts, Classification -Load resonant converters, Resonant switch converters, zero voltage switching clamped voltage converters, Resonant DC link inverters High frequency link integral half cycle converters, Phase modulated resonant converters, Dual active bridge converters, High gain converters.

UNIT-II: Modeling of DC-DC Converters

Basic ac modeling approach, State space averaging, Circuit averaging and averaged switch modeling, Canonical circuit modeling, Converter transfer functions for buck, boost and buck-boost topologies.

UNIT-III: Current Mode Control

Introduction, types, advantages and disadvantages, Slope compensation, Determination of duty cycle and transfer functions for buck, boost and buck-boost converters.

UNIT-IV: Design of Closed Loop Control

Controller Design: Introduction, mechanism of loop stabilization, Shaping E/A gains vs frequency characteristics, Conditional stability in feed-back loop, Stabilizing a continuous mode forward and fly-back converter, Feedback loop stabilization with current mode control, right plane zero.

UNIT-V: Design of Power Converters Components:

Design of magnetic components - design of transformer, design of inductor and current transformer - Selection of filter capacitors, Selection of ratings for devices, input filter design, Thermal design

Text books:

1. M.H. Rashid: Power Electronics-Circuits, Devices & Applications, Pearson, 4th edition, 2013.
2. N. Mohan, T.M. Undeland, W.P. Robbins: Power Electronics: Converters, Applications & Design, J.Wiley & Sons, 3rd edition, 2003.

References:

1. Abraham I. Pressman, Keith Billings &Taylor Morey: Switching Power Supply Design, McGraw Hill International, 3rd Edition, 2009.
2. R.W. Erickson and Dragan Maksimonic: Fundamentals of Power Electronics, Springer, 2nd Edition, 2001.
3. Umanand, L., Power Electronics: Essentials and Applications, John Wiley India, 1st Edition, 2009.

JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY GURAJADA VIZIANAGARAM
DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING

(PH2402205)POWER ELECTRONIC CONTROL OF A.C. DRIVES

UNIT – I: Introduction to AC Drives.

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.

UNIT - II : Control of Induction Motor Drives at Stator Side

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 – current – fed inverter control – Independent current and frequency control – Speed and flux control in Current –Fed inverter drive – Volts/Hz control of Current –fed inverter drive – Efficiency optimization control by flux program.

UNIT – III: Control of Induction Motor Drive at Rotor Side.

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

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.

UNIT – IV: 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.

Controllers

Flux weakening operation – Maximum speed – Direct flux weakening algorithm – Constant Torque mode controller – Flux Weakening controller – indirect flux weakening – Maximum permissible torque – speed control scheme – Implementation strategy speed controller design.

UNIT – V: Variable Reluctance Motor Drive

Variable Reluctance motor drive – Torque production in the variable reluctance motor Drive characteristics and control principles – Current control variable reluctance motor service drive.

Brushless DC Motor Drives

Three phase full wave Brushless dc motor – Sinusoidal type of Brushless dc motor- currentcontrolled Brushless dc motor Servo drive

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
3. Power Electronics and Control of AC Motors – MD Murthy and FG Turn Bull pergman Press(For Chapters II, III, V) 1st edition

REFERENCES:

1. Power Electronics and AC Drives – BK Bose – Prentice Hall Eagle wood diffs New Jersey(for chapters I, II, IV) - 1st edition
2. Power Electronic circuits Deices and Applications – M H Rashid – PHI – 1995.
3. Fundamentals of Electrical Drives – G. K. Dubey – Narora publications–1995 (for chapter II)
4. Power Electronics and Variable frequency drives – BK Bose – IEEE Press – Standardpublications - 1st edition – 2002.

JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY GURAJADA VIZIANAGARAM
DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING

(PH2402206)UNIFIED THEORY OF ELECTRICAL MACHINES

UNIT - I: Introduction
Introduction to the theory of basic two pole machine applicable to DC machines, 3-ph induction machines and synchronous machine. Kron'sprimitive Machine. Need of modeling, Introduction to modeling of electrical machines, voltage and torque equations

UNIT - II: Concept of Transformation
Change of variables & Machine variables and transform variables for arbitrary reference frames. Application to D.C. machine for steady state and transient analysis, and equation of cross field commutator machine, linear transformation from 3-phase to 2-phase - transformation from rotating axes to stationary axes - power invariance - park's transformation for 3-phase synchronous and induction machines...

UNIT - III: Poly phase Induction Machines& Synchronous Machines

Voltage, torque equations, Equivalent circuit, Steady state analysis, Dynamic performance during sudden changes in load torque and three phase faults at the machine terminals.

Poly phase Synchronous Machine: Voltage and Torque Equations in stator, rotor and air-gap field reference frames. Transformation and Transformed Equations. Parks Transformation Voltage and power equation for salient and non-salient machines, their phasor diagrams, simplified equations of a synchronous machine with two damper coils

UNIT - IV: Dynamic Analysis of Interconnected Machines
Machine Interconnection Matrices. Transformation of Voltage and Torque Equations using Interconnection Matrix. Large Signal Transient Analysis using Transformed Equations.

UNIT-V: Linearized Machine Equations:

Linearization of machine equations. Small displacement stability: Eigen values, Eigen values of typical induction machine and synchronous machine, Transfer Function Formulation.

Text books:

1. P.C. Krause, Analysis of Electric Machinery, Wiley publication.
2. B. Adkins, The General theory of Electrical Machines, Chapman & Hall publication.
3. P.S. Bhimbra, Generalized theory of Electrical machines, Khanna publisher.

Reference Books:

1. B. Adkins & R.G. Harley, The General theory of AC Machines, Springer Natherland
2. Boldia& S.A. Nasar, Electrical Machine Dynamics, The Macmillan Press Ltd.

JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY GURAJADA VIZIANAGARAM
DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING

(PH2402207)GRID INTEGRATION OF RENEWABLE ENERGY SYSTEMS

UNIT-I: Introduction

Various techniques of utilizing power from renewable energy sources, concept of nano / micro / mini grid. Need of integrating large renewable energy sources, issues related to integration of large renewable energy sources, rooftop plants. Concept of VPP.

UNIT-II: Power system equipments for grid integration Synchronous generator synchronization/integration to existing grid, load sharing during parallel operation, stability (swing equation and solution) Induction Generator: working principle, classification, stability due to variable speed and counter measures Power Electronics: need of power electronic equipments in grid integration, converter, inverter, chopper, ac regulator and cyclo converters for AC/DC conversion.

UNIT-III: Power quality and management

THD, voltage sag, voltage swell, frequency change and its effects, network voltage management, frequency management, system protection, grid codes.

UNIT-IV: Grid stabilization

Scheduling and dispatch, Forecasting, reactive power and voltage control, frequency control, operating reserve, storage systems, electric vehicles Ancillary services in Indian Electricity Market (regulatory aspect), CERC and CEA orders (technical and safety standards)

UNIT – V: Integration of alternate sources of energy

Introduction, principles of power injection: converting technologies, power flow; instantaneous active and reactive power control approach; integrating multiple renewable energy sources; DC link integration; AC link integration; HFAC link integration; islanding and interconnection

Text Book:

1. Integration of Alternative sources of Energy, Felix A. Farret and M. Godoy Simoes, IEEE Press – Wiley-Interscience publication, 2006.
2. Grid integration of solar photovoltaic systems, Majid Jamil, M. Rizwan, D.P.Kothari, CRC Press (Taylor & Francis group), 2017
3. Renewable Energy Grid Integration, Marco H. Balderas, Nova Science Publishers, New York, 2009.
4. Wind Power Integration connection and system operational aspects, B. Fox, D. Flynn L. Bryans, N. Jenkins, M. O' Malley, R. Watson and D. Milborrow, IET Power and Energy Series 50 (IET digital library), 2007

Reference Books:

1. Power Generation, Operation, and Control, Allen J. Wood, Bruce F. Wollenberg, Gerald B. Sheblé, John Wiley & Sons, New York, 2013 (3rd edition)
2. Power Electronics: Circuits, Devices, and Applications. M.H.Rashid, Pearson Education India, 2013
3. Advanced power system analysis and dynamics, L.P.Singh, New age international publishers, 2017

JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY GURAJADA VIZIANAGARAM
DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING

(PH2402208)HYBRID ELECTRIC VEHICLE SYSTEMS

UNIT-I: Introduction to Hybrid Electric Vehicles

Conventional Vehicles: Basics of vehicle performance, vehicle power source characterization, transmission characteristics, and mathematical models to describe vehicle performance. History of hybrid and electric vehicles, social and environmental importance of hybrid and electric vehicles, impact of modern drive-trains on energy supplies.

UNIT-II: Hybrid Electric Drive-trains

Basic concept of electric traction, introduction tovarious electric drive-train topologies, power flow control in electric drive-train topologies, fuel efficiency analysis. 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: Electric Propulsion unit

Introduction to electric components used in hybrid and electric vehicles, Configuration and control of DC Motor drives, Configuration and control of Induction Motor drives, configuration and control of Permanent Magnet Motor drives,Configuration and control of Switch Reluctance Motor drives, drive system efficiency.

UNIT-IV: Energy Storage

Introduction to Energy Storage Requirements in Hybrid and Electric Vehicles, Battery based energy storage and its analysis, Fuel Cell based energy storage and its analysis, Super Capacitor based energy storage and its analysis, Flywheel based energy storageand its analysis, Hybridization of different energy storage devices.

UNIT-V: Energy Management Strategies

Introduction to energy management strategies used inhybrid and electric vehicles, classification of different energy management strategies, comparison of different energy management strategies, implementation issues of energy management strategies. Case Studies: Design of a Hybrid Electric Vehicle (HEV), Design of a Battery Electric Vehicle (BEV).

TEXT BOOKS:

1. Iqbal Hussein, Electric and Hybrid Vehicles: Design Fundamentals, CRC Press, 2003.
2. Mehrdad Ehsani, Yimi Gao, Sebastian E. Gay, Ali Emadi, Modern Electric, Hybrid Electric andFuel Cell Vehicles: Fundamentals, Theory and Design,CRC Press, 2004.
3. Ali Emadi,Advanced Electric Drive Vehicles, ,CRC Press, 2017

REFERENCE BOOKS:

1. James Larminie, John Lowry, Electric Vehicle Technology Explained, Wiley, 2003.
2. Sheldon S. Williamson, Energy Management Strategies for Electric and Plug-in Hybrid ElectricVehicles, Springer, 2013.
3. http://nptel.ac.in/syllabus/108103009

JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY GURAJADA VIZIANAGARAM
DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING

(PH2402209)HIGH VOLTAGE DC TRANSMISSION

Unit I:

Comparison of DC transmission and AC Transmission. Application of DC transmission, Description of DC transmission systems, planning for HVDC transmission, Modern trends in DC transmission.

Unit II:

Static Power Conversion Basic conversion principle, pulse number, analysis of GRAETZ circuit with and without overlap, equivalent circuit, inverter equations, PowerFactor and reactive power, 12 pulse converter unit.

Unit III:

Basic philosophy, constant current Vs constant voltage, desired features of control, actual control characteristics, individual characteristics of rectifier and inverter, combined characteristics of rectifier and inverter, constant-minimum-ignition-angle control, constant current control, constant-extinction-angle control, individual phase-control, equidistant firing control, voltage dependent current order limit (VDCOL), basic philosophy of system control, direction of DC power flow, reversal of power flow, starting and stopping of DC link.

Unit IV:

DC system model for load flow studies. Load flow study of Ac Dc system sequentialmethod, simultaneous method.

Reactive power requirements in steady state, conventional control strategies, alternatecontrol strategies equipment for reactive power.

short circuit ratio, Effective short circuit ratio, dynamic over voltages, DC power modulation, commutation failure, disturbances on AC side, disturbances on DC side.

Unit V

Characteristic harmonics, derivation of relevant equations for 12 pulse converter. AC filters, single tuned, doubled tuned filters. Brief introduction to DC circuit breakers,multi terminal DC transmission.

Text books:

1. Direct current transmission by E.W. Kimbark. Wiley Interscience 1971.
2. HVDC Transmission by K.R. Padiyar.
3. High voltage Direct current transmission by J. Arrillaga IEE controlengineering series 2000

REFERENCE BOOKS:

1. HVAC and DC Transmission by S. Rao

JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY GURAJADA VIZIANAGARAM
DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING

(PH2402210)SMART GRID TECHNOLOGIES

UNIT - I: Introduction to Smart Grid & Evolving it to a Perfect Power System:

Introduction: Introduction to smart grid- Electricity network-Local energy networks- Electric transportation-Low carbon central generation-Attributes of the smart grid- Alternate views of a smart grid.

Smart Grid to Evolve a Perfect Power System: Introduction- Overview of the perfect power system configurations- Device level power system- Building integrated power systems- Distributed power systems-Fully integrated power system-Nodes of innovation.

UNIT - II: DC Distribution and Smart Grid

AC vs DC sources-Benefits of and drives of DC power delivery systems-Powering equipment and appliances with DC-Data centers and information technology loads-Future neighborhood-Potential future work and research.

Intelligrid Architecture for the Smart grid: Introduction-Launching intelligrid - Intelligrid today- Smart grid vision based on the intelligrid architecture-Barriers and enabling technologies. SCADA, synchrophasors (WAMS)

UNIT – III: Dynamic Energy Systems Concept

Smart energy efficient end use devices-Smart distributed energy resources-Advanced whole building control systems- Integrated communications architecture-Energy management-Role of technology in demand response-Current limitations to dynamic energy management-

Distributed energy resources-Overview of a dynamic energy management-Key characteristics of smart devices-Key characteristics of advanced whole building control systems-Key characteristics of dynamic energy management system.

UNIT - IV: Energy Port as a Part of The Smart Grid & Market Implementation

Energy Port As Part Of The Smart Grid: Concept of energy -Port, generic features of the energy port. Policies and Programs to Encourage End – Use Energy Efficiency: Policies and programs in action -multinational - national-state-city and corporate levels.

Market Implementation: Framework-factors influencing customer acceptance and response - program planning-monitoring and evaluation.

UNIT - V: Efficient Electric End – Use Technology Alternatives

Existing technologies – lighting - Space conditioning - Indoor air quality - Domestic water heating - hyper efficient appliances - Ductless residential heat pumps and air conditioners - Variable refrigerant flow air conditioning-Heat pump water heating - Hyper efficient residential appliances - Data center energy efficiency-LED street and area lighting - Industrial motors and drives - Equipment retrofit and replacement - Process heating - Cogeneration, Thermal energy storage - Industrial energy management programs - Manufacturing process-Electro-technologies, Residential, Commercial and industrial sectors.

Text Books:

1. The Smart Grid, Enabling Energy Efficiency and Demand Side Response, Clark W Gellings, CRC Press,2009
2. Smart Grids, Jean Claude Sabonnadiere, Nouredine Hadjsaid, Wiley-ISTE, IEEE Press, May 2012.
3. SMART GRID Fundamentals of Design and Analysis, James Momoh, IEEE press, A John Wiley & Sons, Inc.,Publication.

Reference Books:

1. Smart Grid: Technology and Applications, Janaka Ekanayake, Kithsiri Liyanage, Jianzhong. Wu, Akihiko Yokoyama, Nick Jenkins, Wiley,2012.
2. Smart Grid: Fundamentals of Design and Analysis, James Momoh, Wiley, IEEE Press, 2012.