ELECTRICAL AND ELECTRONICS ENGINEERING

Course Structure and Syllabi for Pre Ph.D Programme

SUBJECT – 1

S.No	Course Code	Title of the Course
1	24CMGT01T	Research Methodology

SUBJECT - 2

S.No	Course Code	Title of the Course
1	24CMGT02T	Research and Publication Ethics

SUBJECT - 3

Choose any **one** subject from the following list

S. No.	Course Code	Title of the Course
1	24CEEE01T	Power System Stability and Control
2	24CEEE02T	Smart Grid Technologies
3	24CEEE03T	Advanced Power Electronics
4	24CEEE04T	Applications of Power Electronics to Power Systems
5	24CEEE05T	Modern Control Engineering
6	24CEEE0LT	Introduction to Machine Learning

SUBJECT - 4

Choose any **one** subject from the following list

S. No.	Course Code	Title of the Course
1	24CEEE06T	Restructured Power System
2	24CEEE07T	Distribution Automation & Control
3	24CEEE08T	Reliability Engineering and Applications to Power Systems
4	24CEEE09T	Distributed Generation and Micro-Grid Control
5	24CEEE0AT	Energy Auditing and Management
6	24CEEE0BT	Advanced Drives & Control
7	24CEEE0CT	Power Quality
8	24CEEE0DT	HVDC Transmission Systems
9	24CEEE0ET	Hybrid Electric Vehicle Systems
10	24CEEE0FT	Digital Control Systems
11	24CEEE0GT	Adaptive and Learning Control
12	24CEEE0HT	Solar Energy Conversion Systems
13	24CEEE0IT	Wind Energy Conversion Systems

14	24CEEE0JT	Optimization & Heuristic Search Techniques
15	24CEEE0KT	Intelligent Control Techniques
16	24CEEE0MT	Modern Flexible Ac Transmission Systems

POWER SYSTEM STABILITY & CONTROL (24CEEE01T)

COURSE OBJECTIVES:

To make the student learn about:

- To develop linear and nonlinear models of multi-machine power systems.
- To analyze various types of stability properties of power systems.
- To Model and simulate excitation mechanisms in synchronous machines.
- To identify power system models from dynamic data.
- To Design controllers for transient/angle stabilization and voltage regulation.

UNIT-I: THE ELEMENTARY MATHEMATICAL MODEL

Introduction to equal area criteria - Power Angle curve of a Synchronous Machine - model of single machine connected to an infinite bus – model of multimachine system – Problems –Classical Stability Study of multimachine system - Effect of the excitation system on Transient stability.

UNIT-II: SYSTEM RESPONSE TO SMALL DISTURBANCES AND DYNAMIC STABILITY

The unregulated synchronous Machine – Modes of oscillation of an unregulated multimachine system – Regulated synchronous machine – Voltage regulator with one time lag – Governor with one time lag – Problems - Concept of Dynamic stability – State-space model of single machine system connected to infinite bus – Effect of excitation on Dynamic stability – Examination of dynamic stability by Routh-Hurwitz criterions.

UNIT-III: POWER SYSTEM STABILIZERS

Introduction to supplementary stabilizing signals - Block diagram of the linear system - Approximate model of the complete exciter – Generator system – Lead compensation – Stability analysis using eigen value approach.

UNIT-IV: EXCITATION SYSTEMS

Introduction to excitation systems – Non-continuously, Continuously regulated systems – Excitation system compensation – State-space description of the excitation system - Simplified linear model – Effect of excitation on generator power limits. Type –2, Type-3 and Type –4 excitation systems and their state-space modeling equations.

UNIT-V: STABILITY ANALYSIS

Review of Lyapunov’s stability of non-liner systems using energy concept – Method based on first concept – Method based on first integrals – Zubov’s method – Popov’s method, Lyapunovfunction for single machine connected to infinite bus. Voltage stability – Factors affecting voltage instability and collapse – Comparison of Angle and voltage stability – Analysis of voltage instability and collapse – Control of voltage instability.

TEXT BOOKS:

1. P.M.Anderson, A.A.Fouad, "Power System Control and Stability", IOWA State UniversityPress, Galgotia Publications, Vol-I, 1st Edition.

REFERENCE BOOKS:

1. M.A.Pai, Power System Stability-Analysis by the direct method of Lyapunov, North HollandPublishing Company, New York, 1981.

Course Outcomes:

After the end of this course student will:

- Develop linear and nonlinear models of multi-machine power systems.
- Analyze various types of stability properties of power systems.
- Model and simulate excitation mechanisms in synchronous machines.
- Identify power system models from dynamic data.
- Design controllers for transient/angle stabilization and voltage regulation.

SMART GRID TECHNOLOGIES (24CEEE02T)

COURSE OBJECTIVES:
To make the student learn about:

- To know the importance of smart grid technology functions over the present grid.
- To get the knowledge about the measurement system and communication technology of Smart grid.
- To make the use of analysis tools to improve the performance and stability of the smart grid.
- To know the knowledge about the renewable energy storage technology associated with smart grid.

SYLLABUS:

UNIT I: SMART GRID ARCHITECTURAL DESIGNS
Introduction – Comparison of Power grid with Smart grid – power system enhancement – communication and standards - General View of the Smart Grid Market Drivers - Stakeholder Roles and Function - Measures - Representative Architecture - Functions of Smart Grid Components-Wholesale energy market in smart grid-smart vehicles in smart grid.

UNIT II: SMART GRID COMMUNICATIONS AND MEASUREMENT TECHNOLOGY
Communication and Measurement - Monitoring, Phasor Measurement Unit (PMU), Smart Meters, Wide area monitoring systems (WAMS) - Advanced metering infrastructure- GIS and Google Mapping Tools.

UNIT III: PERFORMANCE ANALYSIS TOOLS FOR SMART GRID DESIGN
Introduction to Load Flow Studies - Challenges to Load Flow in Smart Grid and Weaknesses of the Present Load Flow Methods - Load Flow State of the Art: Classical, Extended Formulations, and Algorithms –Load flow for smart grid design-Contingencies studies for smart grid.

UNIT IV: STABILITY ANALYSIS TOOLS FOR SMART GRID
Voltage Stability Analysis Tools-Voltage Stability Assessment Techniques-Voltage Stability Indexing-Application and Implementation Plan of Voltage Stability in smart grid-Angle stability assessment in smart grid-Approach of smart grid to State Estimation-Energy management in smart grid.

UNIT V: RENEWABLE ENERGY AND STORAGE
Renewable Energy Resources-Sustainable Energy Options for the Smart Grid-Penetration and Variability Issues Associated with Sustainable Energy Technology-Demand Response Issues-Electric Vehicles and Plug-in Hybrids-PHEV Technology-Environmental Implications-Storage Technologies-Grid integration issues of renewable energy sources.

TEXT BOOKS:

1. James Momoh, “Smart Grid: Fundamentals of design and analysis”, John Wiley & sons Inc, IEEE press 2012.
2. Janaka Ekanayake, Nick Jenkins, Kithsiri Liyanage, Jianzhong Wu, Akihiko Yokoyama, “Smart Grid: Technology and Applications”, John Wiley & sons inc, 2012.

REFERENCE BOOKS:

1. Fereidoon P. Sioshansi, “Smart Grid: Integrating Renewable, Distributed & Efficient Energy”, Academic Press, 2012.
2. Clark W.Gellings, “The smart grid: Enabling energy efficiency and demand response”, Fairmont Press Inc, 2009.

COURSE OUTCOMES:

After the end of this course student will:

- Know the importance of smart grid technology functions over the present grid.
- Get the knowledge about the measurement system and communication technology of Smart grid.
- Make the use of analysis tools to improve the performance and stability of the smart grid.
- Get the knowledge about the renewable energy storage technology associated with smart grid.

ADVANCED POWER ELECTRONICS (24CEEE03T)

COURSE OBJECTIVES:

- To understand the static and dynamic characteristics of Advanced power semiconductor devices.
- To enable the students for the selection of devices for different power electronics applications.
- To understand Principle of Operation of Advanced Power Converters.
- To describe the operation of multi- level inverters with switching strategies for high powerapplications.

UNIT-I: Advanced Solid State Devices: Power MOSFETs and IGBTs – Principle of voltage controlled devices, construction, types, static and switching characteristics, steady-state and dynamic models of MOSFET and IGBTs - Basics of GTO, MCT(Mos Controlled Thyristor), FCT(Field Controlled Thyristor), RCT(Reverse Conducting Thyristor)

UNIT-II: Resonant Converters: Zero Current Switching Resonant Converters – L Type– M Type – Zero Voltage Switching Resonant Converters – Comparison Between ZCS And ZVS – Resonant Converters – Two Quadrant ZVS Resonant Converters – Resonant DC-Link Inverters – Numerical Problems.

UNIT-III: Multilevel Inverters

Multilevel Concept – Types of Multilevel Inverters – Diode Clamped Multilevel Inverter – Improved Diode Clamped Inverter – Flying Capacitors Multilevel Inverter – Cascaded Multilevel Inverter– Principle Of Operation – Main Features– Applications – Reactive Power Compensation, Back to Back Intertie System, Adjustable Drives– Switching Device Currents – DC Link Capacitor Voltage Balancing – Features of Multilevel Inverters –Comparisons of Multilevel Converters – Numerical Problems.

UNIT-IV: DC Power Supplies :DC Power Supplies – Types – Switched Mode DC Power Supplies – Fly Back Converter –Forward Converter – Push-Pull Converter – Half Bridge Converter – Full Bridge Converter –Resonant DC Power Supplies – Bidirectional Power Supplies – Applications – Numerical Problems.

UNIT-V: AC Power Supplies: AC Power Supplies – Types – Switched Mode Ac Power Supplies – Resonant AC Power Supplies – Bidirectional Ac Power Supplies – Multistage Conversions – Control Circuits – Power Line Disturbances – Power Conditioners – Uninterruptible Power Supplies – Applications – Numerical Problems.

TEXT BOOKS:

1. M. H. Rashid,“Power Electronics, circuits, Devices and Applications”,Pearson, 2002, India.
2. Fundamentals of Power Electronics by Robert Warren Erickson and Dragan Maksimovic, Springer US, 2nd Edition, 2001.
3. N. Mohan, T. M. Undeland and W.P. Robbins,“Power Electronics, Converter, Application and Design”, Third Edition, John Willey & Sons, 2004.
4. R.S. Ramshaw,“Power Electronics Semiconductor Switches”, Champman & Hall, 1993.

5. Advanced power electronics converters by Euzeli dos santos, Edison R. da silva.

Course Outcomes:

After taking this course, student will be able to:

- Understand the static and dynamic characteristics of advanced power semiconductor devices.
- Understand Principle of Operation of Advanced Power Converters.
- Describe the operation of multi level inverters with switching strategies for high power applications.

APPLICATIONS OF POWER ELECTRONICS TO POWER SYSTEMS (24CEEE04T)

COURSE OBJECTIVES:
Student will be able:

- To develop the understanding of uncompensated lines and their behavior under heavy loading conditions.
- To understand the concept and importance controllable parameters of FACTS controllers.
- To emphasize the objectives of Shunt compensation, and basic operation of SVC and STATCOM.

SYLLABUS:

UNIT I: General System considerations and FACTS: Transmission Interconnections, Flow of Power in an AC System, Power Flow and Dynamic Stability Considerations of a Transmission Interconnection, principles of series and shunt compensation, Basic Types of FACTS Controllers, Benefits from FACTS, Application of FACTS.

UNIT II: Shunt Compensators: Objectives of Shunt Compensation, Midpoint Voltage Regulation for Line Segmentation, End of Line Voltage Support to Prevent Voltage Instability, improvement of Transient Stability, Power Oscillation Damping, Static Var Compensators, SVC and STATCOM, The Regulation Slope, Transfer Function and dynamic Performance, Transient Stability, Enhancement and Power Oscillation Damping

UNIT III: Series Compensators: Objectives of Series Compensation, concept of series capacitive compensation, voltage stability, improvement of transient stability, power oscillation damping, GTO thyristor controlled series capacitor, Thyristor controlled series capacitor, SSSC.

UNIT IV: Combined Compensators: Introduction, Unified power flow controller, basic operating principles, independent real and reactive power flow control, and control structure, basiccontrol system for P and Q control.

UNIT V: Mitigation of Harmonics: Power quality problems, harmonics, harmonic creating loads, harmonic power flow, and mitigation of harmonics, filters, passive filters, active filters, shunt, series and hybrid filters.

Text books:
1. Narain G. Hingorani, Laszlo Gyugyi, Understanding FACTS, IEEE press
2. Roger. C. Dugan, Mark. F. McGranagham, Surya Santoso, H.Wayne Beaty, Electrical Power Systems Quality, McGraw Hill,2003

Suggested Reading:
1. Y.H.Song, A.T.Johns, Flexible A.C.Transmission System, IEE, London, 1999

COURSE OUTCOMES:

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

- Choose proper controller for the specific application based on system requirements
- Understand various systems thoroughly and their requirements
- Interpret the control circuits of Shunt Controllers SVC & STATCOM for various functions viz. Transient stability Enhancement, voltage instability prevention and power oscillation damping

MODERN CONTROL THEORY (24CEEE05T)

COURSE OBJECTIVES:

Student will be able to:

- Learn about basics of state space analysis, state transition matrix and Linearization process
- Understand the concepts of controllability, observability and state feedback design
- Understand full order and reduced order observer designs
- Learn about model decomposition and disturbance rejection
- Understand the concepts of linear state regulator and Riccati equation

Unit I

Fields, Vectors, and vector spaces; State space representation, state equations for dynamic systems, solution of state equations; State transition matrix – Properties of state transition matrix; evaluation. Fadeeva algorithm for conversion from state space to transfer function, Linearization of non-linear models

Unit II

Non uniqueness of state model, Similarity transformation, Invariance of system properties. Controllability – necessary and sufficient condition - Pole assignment using State feedback – Ackerman's formula for feedback gain determination; Observability. Duality. Effect of state feedback on controllability and observability. Controllable subspace – decomposition of state into controllable and uncontrollable components.

Unit III

Design of full order observer – Bass Gura algorithm. The separation principle - Combined observer – controller compensator. Design of reduced order observer. Unobservable subspace – decomposition of state into observable and unobservable components – Canonical decomposition theorem.

Unit IV

Reducibility – realization of transfer function matrices. Model decomposition and decoupling by state feedback. Design of robust control system for asymptotic tracking and disturbance rejection using State variable equations. Transfer function interpretations – transfer function form of observer and state estimate feedback. State space interpretation of internal model principle.

Unit V

Discrete time linear state regulator – Algorithm for the solution, Use of observer in implementing the control law. Continuous time linear state regulator – Matrix Riccati equation. Time invariant linear state regulator – the reduced matrix Riccati equation - An iterative method to solve the reduced matrix Riccati equation. Suboptimal linear regulator.

Text Books:

1. Modern Control Engineering, Katsuhiko Ogata, 5th Edition, Prentice Hall India, 1997
2. Modern Control System Theory, M. Gopal, Revised 2nd Edition, New Age International Publishers, 2005.

References:

1. Linear Systems, Thomas Kailath, Perntice Hall, 1980.
2. Control System Design, Graham C. Goodwin, StefanF. Graebe and Mario E. Salgado, Pearson Education, 2000.
3. Linear System Theory and Design, Chi-Tsong Chen, OXFORD University Press.

4. Richard C. Dorf and Robert H. Bishop, Modern Control Systems, 11th Edition, Pearson Edu India, 2009.

COURSE OUTCOMES:

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

- Learn about basics of state space analysis, state transition matrix and Linearization process
- Understand the concepts of controllability, observability and state feedback design
- Understand full order and reduced order observer designs
- Learn about model decomposition and disturbance rejection
    - Understand the concepts of linear state regulator and Riccati equation

Introduction to Machine Learning (24CEEE0LT)

UNIT-1

Introduction: Statistical Decision Theory - Regression, Classification, Bias Variance, Linear Regression, Multivariate Regression, Subset Selection, Shrinkage Methods, Principal Component Regression, Partial Least squares, Linear Classification, Logistic Regression, Linear Discriminant Analysis.

UNIT-2

Perceptron, Support Vector Machines, Neural Networks - Introduction, Early Models, Perceptron Learning, Backpropagation, Initialization, Training & Validation, Parameter Estimation - MLE, MAP, Bayesian, Estimation Decision Trees, Regression Trees, Stopping Criterion & Pruning loss functions, Categorical Attributes, Multiway Splits, Missing Values, Decision Trees - Instability Evaluation Measures.

UNIT-3

Bootstrapping & Cross Validation, Class Evaluation Measures, ROC curve, MDL, Ensemble Methods - Bagging, Committee Machines and Stacking, Boosting, Gradient Boosting, Random Forests, Multi-class Classification, Naive Bayes, Bayesian Networks.

UNIT-4

Undirected Graphical Models, HMM, Variable Elimination, Belief Propagation, Partitional Clustering, Hierarchical Clustering, Birch Algorithm, CURE Algorithm, Density- based Clustering, Gaussian Mixture Models, Expectation Maximization.

UNIT-5

Learning Theory, Introduction to Reinforcement Learning, Optional videos (RL framework, TD learning, Solution Methods, Applications).

Books and references

1. The Elements of Statistical Learning, by Trevor Hastie, Robert Tibshirani, Jerome H. Friedman (freely available online)
2. Pattern Recognition and Machine Learning, by Christopher Bishop (optional)

RESTRUCTURED POWER SYSTEM (24CEEE06T)

COURSE OBJECTIVES:

- To introduce the restructuring of power industry and market models.
- To impart knowledge on fundamental concepts of congestion management.
- To analyze the concepts of locational marginal pricing and financial transmission rights.
- To Illustrate about various power sectors in India.

SYLLABUS:

UNIT I: KEY ISSUES IN ELECTRIC UTILITIES

Introduction – Restructuring models – Independent System Operator (ISO) – Power Exchange - Market operations – Market Power – Standard cost – Transmission Pricing – Congestion Pricing – Management of Inter zonal/Intra zonal Congestion.

UNIT II: OPEN ACCESS SAME-TIME INFORMATION SYSTEM (OASIS) &MARKET POWER

Structure of OASIS - Posting of Information – Transfer capability on OASIS. Market Power: Introduction - Different types of market Power – Mitigation of Market Power - Examples.

UNIT III: AVAILABLE TRANSFER CAPABILITY (ATC) &ELECTRICITY PRICING

Transfer Capability Issues – ATC – TTC – TRM – CBM Calculations – Calculation of ATC based on power flow. Electricity Pricing: Introduction – Electricity Price Volatility Electricity Price Indexes – Challenges to Electricity Pricing – Construction of Forward Price Curves – Short-time Price Forecasting.

UNIT IV: POWER SYSTEM OPERATION IN COMPETITIVE ENVIRONMENT

Introduction – Operational Planning Activities of ISO- The ISO in Pool Markets – The ISO in Bilateral Markets – Operational Planning Activities of a GENCO.

UNIT V: TRANSMISSION COST ALLOCATION METHODS&ANCILLARY SERVICES MANAGEMENT

Introduction - Transmission Cost Allocation Methods : Postage Stamp Rate Method - Contract Path Method - MW-Mile Method – Unused Transmission Capacity Method - MVA-Mile method – Comparison of cost allocation methods. Ancillary Services Management: Introduction – Reactive Power as an Ancillary Service – a Review – Synchronous Generators as Ancillary Service Providers.

TEXT BOOKS:

1. Kankar Bhattacharya, Math H.J. Boller and JaapE.Daalder, Operation of Restructured Power System, Kulwer Academic Publishers, 2001.
2. Mohammad Shahidehpour and Muwaffaqalomoush, Restructured Electrical Power Systems, Marcel Dekker, Inc., 2001.

REFERENCE BOOKS:

1. Loi Lei Lai, Power System Restructuring and Deregulation, John Wiley & Sons Ltd., England.

COURSE OUTCOMES:

After completion of the course, Students are able to:

- Bring out the differences between the conventional power system operation and the restructured one.
- Design power markets and market architectural aspects.
- Analyze the concepts of locational marginal pricing and financial transmission rights
- Prepare a background with fundamentals of microeconomics.

DISTRIBUTION AUTOMATION & CONTROL (24CEEE07T)

Course Objectives:
The student will be able to understand:

- The basic concepts of distribution system planning, design considerations and various characteristics
- Applications and effects of capacitors and distribution system voltage regulation
- Distribution system protection
- Automation and control functions
- Intelligent systems in distribution automation

UNIT-I:
Introduction, Distribution System Planning, Factors Affecting System Planning, Present Distribution System Planning Techniques, Distribution System Planning Models, Distribution System Planning in the Future, Future Nature of Distribution Planning, The Central Role of the Computer in Distribution Planning, Impact of Dispersed Storage and Generation - Load Characteristics: Basic Definitions, The Relationship Between the Load and Loss Factors, Maximum Diversified Demand - Design Considerations: Introduction , Radial-Type Primary Feeder, Loop-Type Primary Feeder, Primary Network, Primary-Feeder Voltage Levels, Primary- Feeder Loading, Tie Lines, Distribution Feeder Exit: Rectangular-Type Development, Radial- Type Development, Radial Feeders with Uniformly Distributed Load, Radial Feeders with No uniformly Distributed Load, Application of the A,B,C,D, General Circuit Constants to Radial Feeders, The Design of Radial Primary Distribution Systems, Primary System Costs - Design Considerations of Secondary Systems: Introduction, Secondary Voltage Levels, The Present Design Practice, Secondary Banking, The Secondary, Networks, Spot Networks, Economic Design of Secondaries, Unbalanced Load and VoltagesSecondary System Costs, Problems.

UNIT- II:

Application of Capacitors to Distribution Systems, Power Capacitors, Effects of Series and Shunt Capacitors, Power Factor Correction, Application of Capacitors, Economic Justification for Capacitors, A Practical Procedure to Determine the Best Capacitor LocationA Mathematical Procedure to Determine the Optimum Capacitor Allocation, Capacitor TankRupture Considerations, Dynamic Behaviour of Distribution Systems Distribution System Voltage Regulation: Basic Definitions, Quality of Service and Voltage Standards, Voltage Control, Feeder Voltage Regulators, Line-Drop Compensation Distribution Capacitor Automation, Voltage Fluctuations, Problems

UNIT-III:

Distribution System Protection: Basic Definitions, Over current Protection Devices, Objective of Distribution System Protection, Coordination of Protective Devices, Fuse-to-Fuse Coordination, Recloser-to-Recloser Coordination, Recloser-to-Fuse Coordination Recloser-to-Substation Transformer High-Side Fuse Coordination, Fuse-to-Circuit-Breaker Coordination, Recloser-to-Circuit-Breaker Coordination, Fault Current Calculations, Fault CurrentCalculations in Per Units, Secondary System Fault Current Calculations, High-Impedance Faults, Lightning Protection, Insulators, Problems.

UNIT – IV:

Distribution Automation and Control Functions, Demand-Side Management, Voltage/VArControl, Fault Detection (Distribution Automation Function), Trouble Calls Restoration Functions, Reconfiguration of Distribution Systems, Power Quality, OptimizationTechniques

UNIT – V:

Intelligent Systems in Distribution Automation, Distribution Automation Function , Artificial Intelligence Methods, Intelligent Systems in Distribution Automation, Voltage/VAr Control, Network Reconfiguration via AI, Fault Detection, Classification, and Location in Distribution Systems

TEXT BOOKS:

1. Electric Power Distribution System Engineering by Turen Gonen, 2nd Edition, CRC Press, 2007.
2. Electric Power Distribution, Automation, Protection and Control by James A. Momoh, CRC Press, 2007.

REFERENCES:

1. Electric Power Distribution by A.S.Pabla, Tata Mc. Grawhill, 6th Edition, 2012.

Course Outcomes:

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

- The basic concepts of distribution system planning, design considerations and various characteristics
- Applications and effects of capacitors and distribution system voltage regulation
- Distribution system protection
- Automation and control functions
- Intelligent systems in distribution automation

RELIABILITY ENGINEERING AND APPLICATIONS TO POWERSYSTEMS (24CEEE08T)

COURSE OBJECTIVES:

This course enables the students to:

- The Probability Density and Distribution Functions
- Analyse the Decomposition Method.
- Identify the Expected Value and Standard Deviation of Exponential Distribution
- Analyse the Concept of Stochastic Transitional Probability Matrix
- Evaluate the Transition Rates for Merged State Model

UNIT–I BASICS OF PROBABILITY THEORY, DISTRIBUTION & NETWORK MODELLING

Basic Probability Theory – Rules for Combining Probabilities of Events – Bernoulli's Trials – Probability Density and Distribution Functions – Binomial Distribution – Expected Value and Standard Deviation of Binomial Distribution. Analysis of Series, Parallel, Series-ParallelNetworks – Complex Networks – Decomposition Method.

UNIT–II RELIABILITY FUNCTIONS

Reliability Functions F(T), F(T), R(T), H(T) and Their Relationships – Exponential Distribution – Expected Value and Standard Deviation of Exponential Distribution – Bath Tub Curve – Reliability Analysis of Series Parallel Networks Using Exponential Distribution – ReliabilityMeasures MTTF, MTTR, MTBF

UNIT–III MARKOV MODELLING AND FREQUENCY & DURATION TECHNIQUES

Markov Chains – Concept of Stochastic Transitional Probability Matrix, Evaluation of Limiting State Probabilities – Markov Processes One Component Repairable System – Time Dependent Probability Evaluation Using Laplace Transform Approach – Evaluation of Limiting State Probabilities Using Stpm – Two Component Repairable Models. Frequency and Duration Concept – Evaluation of Frequency of Encountering State, Mean Cycle time, For One, Two Component Repairable Models – Evaluation of Cumulative Probability and Cumulative Frequency of Encountering of Merged States – Approximate System Reliability analysis – series parallel configuration – Basic probability indices – cutest approach

UNIT–IV APPLICATIONS TO POWER SYSTEMS -I

Generation System Reliability Analysis: Reliability Model of a Generation System– Recursive Relation for Unit Addition and Removal – Load Modeling - Merging of Generation Load Model – Evaluation of Transition Rates for Merged State Model – Cumulative Probability, Cumulative Frequency of Failure Evaluation – LOLP, LOLE, LOEE.

UNIT–V APPLICATIONS TO POWER SYSTEMS - II

Basic Techniques - Radial Networks – Evaluation of Basic Reliability Indices, Performance Indices – Load Point and System Reliability Indices – Customer Oriented, Loss and Energy Oriented Indices

-Examples single feeder - parallel configuration RDS – Network reductiontechnique – cut set approaches – weather effects – repairable and non – repairable effects modeling and evaluation of basic probability indices.

TEXT BOOKS:

1. Reliability Evaluation of Engg. System – R. Billinton, R.N.Allan, Plenum Press, New York, reprinted in India by B.S.Publications, 2007.
2. Reliability Evaluation of Power systems – R. Billinton, R.N.Allan, Pitman Advance Publishing Program, New York, reprinted in India by B.S.Publications, 2007.

REFERENCE BOOKS:

1. System Reliability Concepts by Dr.V.Sankar, Himalaya Publishing House Pvt.Ltd,, Mumbai

COURSE OUTCOMES:

The students will have knowledge on the following concepts:

- *The concept of probability theory, distribution, network modeling and reliability analysis.*
- Describing the reliability functions with their relationships and Markov-modelling.
- Evaluate reliability models using frequency and duration techniques and generate various reliability models.
- The reliability composite systems and distribution systems.

DISTRIBUTED GENERATION AND MICROGRID CONTROL (24CEEE09T)

COURSE OBJECTIVES: The student able to learn about:

- Able to know about the concept of distributed generation, distribution network & the concept ofMicrogrid, its configuration, advantages & limitations.
- Able to understand the basic concepts in combined heat and power, Wind energy conversionsystems, solar photovoltaic systems & other renewable energy sources.
- Able to analyze the impact of Microgrid & Active distribution network management system onvarious factors.
- Able to know the effect of SCADA & understand the concept of Power quality disturbances,improvement technologies & issues of premium power in DC integration.

UNIT I: INTRODUCTION TO DISTRIBUTED GENERATION AND MICROGRID CONCEPT

Introduction to distributed generation - Active distribution network - Concept of Microgrid - Microgrid configuration - Interconnection of Microgrids - Technical and economical advantages of Microgrid - Challenges and limitations of Microgrid development - Management and operational issues of a Microgrid - Dynamic interactions of Microgrid with main grid – low voltage DC grid.

UNIT II: DISTRIBUTED ENERGY RESOURCES

Introduction - Combined heat and power (CHP) systems: Micro-CHP systems - Wind energy conversion systems (WECS): Wind turbine operating systems - Solar photovoltaic (PV) systems: Classification of PV cell - Small-scale hydroelectric power generation - Other renewable energy sources - Storage devices.

UNIT III: MICROGRID AND ACTIVE DISTRIBUTION NETWORK MANAGEMENT SYSTEM

Introduction - Impact on heat utilisation - Impact on process optimisation - Impact on market - Impact on environment - Impact on distribution system - Impact on communication standards and protocols - Network management needs of Microgrid - Microsource controller - Central controller.

UNIT IV: SCADA AND ACTIVE DISTRIBUTION NETWORKS

Introduction - Existing DNO SCADA systems - Control of DNO SCADA systems - SCADA in Microgrids - Human–machine interface (HMI) - Hardware components - Communication trends in SCADA - Distributed control system (DCS) - Sub-station communication standardization - SCADA communication and control architectures - Communication devices.

UNIT V: IMPACT OF DG INTEGRATION ON POWER QUALITY AND RELIABILITY

Introduction - Power quality disturbances - Power quality sensitive customers - Power quality improvement technologies - Impact of DG integration - Issues of premium power in DG integration.

TEXT BOOK:

1. S. Chowdhury, S.P. Chowdhury and P. Crossley, "Microgrids and Active Distribution Networks", The Institution of Engineering and Technology, 2009.

COURSE OUTCOMES: Student acquire knowledge about:

- Understand the concept of distributed generation, distribution network & the concept of Microgrid,its configuration, advantages & limitations.
- Understand the basic concepts in combined heat and power, Wind energy conversion systems,Solar photovoltaic systems & other renewable energy sources.
- The impact of Microgrid & Active distribution network management system on various factors isknown.
- Understand the effect of SCADA & understand the concept of Power quality disturbances,improvement technologies & issues of premium power in DC integration.

ENERGY AUDITING AND MANAGEMENT (24CEEE0AT)

COURSE OBJECTIVES:

To make the student learn about:

- Basic Principles of Energy Audit and Management.
- How these principles are applicable to various day to day equipment.
- Various measuring devices by which the energy is measured.
- How energy management and auditing has impacts on the economic aspects.

SYLLABUS:

UNIT I: BASIC PRINCIPLES OF ENERGY AUDIT

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

UNIT II: ENERGY MANAGEMENT

Principles of energy management, organizing energy management program, initiating, planning, controlling, promoting, monitoring, reporting. Energy manger, qualities and functions, language, Questionnaire - Check list for top management.

UNIT III: ENERGY EFFICIENT MOTORS, POWER FACTOR IMPROVEMENT

Energy efficient motors, factors affecting efficiency, loss distribution, constructional details, characteristics - Variable speed, variable duty cycle systems, RMS hp - Voltage variation - Voltage unbalance - Over motoring - Motor energy audit. Power factor – Methods of improvement, location of capacitors, p.f. with non linear loads, effect of harmonics on p.f.,
p.f motor controllers - Good lighting system design and practice, lighting control, lighting energy audit

UNIT IV: ENERGY INSTRUMENTS

Energy Instruments - Wattmeter, Data loggers, Thermocouples, Pyrometers, Lux meters, Tongue testers, Application of PLC's**.**

UNIT V: ECONOMIC ASPECTS AND ANALYSIS

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

TEXT BOOKS:

1. W.R. Murphy & G. Mckay Butter worth, Energy management, Heinemann publications.
2. John, C. Andreas, Energy efficient electric motors, Marcel Dekker Inc. Ltd, 2nd edition, 1995.

REFERENCE BOOKS:

1. Paul O' Callaghan, Energy management, Mc-graw Hill Book company, 1st edition, 1998
2. W.C.Turner, Energy management hand book, John wiley and sons.
3. Energy management and good lighting practice : fuel efficiency- booklet12-EEO

COURSE OUTCOMES:

After completing the course, the student should be able to do the following:

- Understand the basic principles of Energy Management and Auditing.
- Implement Energy Efficient methods and power factor improvement techniques.
- Use of Various Energy Instruments for measuring the energy consumption.
- Analyze the economic impacts of the energy management and auditing.

ADVANCED DRIVES & CONTROL(24CEEE0BT)

COURSE OBJECTIVES:

The student will be able:

- To understand principle operation of scalar control of ac motor and corresponding speed-torque characteristics
- To understand the vector control for ac motor drive (IM and SM)
- To explain the static resistance control and Slip power recovery drive
- To explain synchronous motor drive characteristics and its control strategies
- To understand the brushless dc motor principle of operation.

UNIT-I: Induction Motor- An Overview
Review of Steady-State Operation of Induction Motor, Equivalent Circuit Analysis, Torque-Speed Characteristics. Phase Controlled Induction Motor Drive, Stator Voltage Control of Induction Motor, Phase-Controlled Converter Fed Induction Motor, Power Circuit and Gating, Reversible Phase-Controlled Induction Motor Drive, Torque-Speed Characteristics.

UNIT-II: Voltage Source Inverter Fed Induction Motor Drive
Stator Voltage and Frequency Control of Induction Motor, Torque-Speed Characteristic Static Frequency Changers, PWM Inverter Fed Induction Motor Drive, Variable-Voltage Variable-Frequency Operation of Induction Motor, Constant E/f And V/f Control Schemes, Slip Regulation. Current Source Inverter Fed Induction Motor Drive, Stator Current and Frequency Control of Induction Motor, Auto Sequentially Commutated Inverter (ASCI), Power Circuit, Commutation, Phase Sequence Reversal, Regeneration, Steady-State Performance.

UNIT-III: Rotor Side Control of Slip-Ring Induction Motor
Slip-Power Recovery Schemes, Steady-State Analysis- Range of Slip, Equivalent Circuit, Performance Characteristics; Rating of Converters. Vector Control of Induction Motor, Principles of Vector Control, Direct Vector Control, Derivation of Indirect Vector Control, Implementation – Block Diagram, Estimation of Flux, Flux Weakening Operation.

UNIT-IV: Control of Synchronous Motor Drives
Synchronous Motor and Its Characteristics- Control Strategies-Constant Torque Angle Control-Power Factor Control, Constant Flux Control, Flux Weakening Operation, Load Commutated Inverter Fed Synchronous Motor Drive, Motoring and Regeneration, Phasor Diagrams.

Unit-V: PMSM and BLDC Drives
Characteristics of Permanent Magnet, Synchronous Machines With Permanent Magnet, Vector Control of PMSM- Motor Model and Control Scheme, Constant Torque Angle Control, Constant Mutual Flux Linkages, Unity PF Control. Modeling of PM Brushless Dc Motor, Drive Scheme, Commutation Torque Ripple, Phase Advancing.

TEXT BOOK:

1.R. Krishnan, **Electric Motor Drives Modeling, Analysis & control**, Pearson Education, 2001

REFERENCE BOOKS:

1. B. K. Bose **Modern Power Electronics and AC Drives**, Pearson Publications-2001.
2. MD Murphy & FG Turn Bull, Pergaman press, **Power Electronics control of AC motors** 1stedition-1998.
3. G.K. Dubey **Fundamentals of Electrical Drives,** Narosa Publications -1995.

COURSE OUTCOMES:

After taking this course, student will be able to:

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

POWER QUALITY (24CEEE0CT)

COURSE OBJECTIVES:

To make the student learn about:

- Understand the different power quality and power frequency problems in the power system.
- Analyzing the types and causes of Electrical transients.
- Various types of Harmonics their causes and effects on Power System.
- The Concept of Electromagnetic Interference and its impacts Power Quality and Power System.

SYLLABUS:

UNIT I: INTRODUCTION TO POWER QUALITY AND POWER FREQUENCY DISTURBANCE

Introduction to Power Quality - Power Quality Issues - Susceptibility Criteria - Role of Power Suppliers and Users - Power Quality Standards. Introduction to Power Frequency Disturbances - Common Power Frequency Disturbances - Cures for Low Frequency Disturbances - Voltage Tolerance Criteria.

UNIT II: ELECTRICAL TRANSIENTS

Introduction to Transients - Transient System Model - Examples of Transient Models and Their Response - Types and Causes of Transients - Examples of Transient Waveforms – Three Phase unbalance – single phase faults – phase to phase faults – two phase to ground faults – seven tips of three phase unbalanced sag.

UNIT III: HARMONICS

Definition of Harmonics - Odd and Even Order Harmonics - Harmonic Phase Rotation and Phase Angle – Causes of Voltage and Current Harmonics – Individual and Total Harmonic Distortion - Harmonic Signatures - Effect of Harmonics on Power System Devices - Guidelines for Harmonic Voltage and Current Limitation - Harmonic Current Mitigation.

UNIT IV: ELECTROMAGNETIC INTERFERENCE

Introduction to EMI - Frequency Classification - Electrical Fields - Magnetic Fields - EMI Terminology - Power Frequency Fields - High Frequency Interference - EMI Susceptibility - EMI Mitigation - Health Concerns of EMI.

UNIT V: POWER QUALITY PROBLEMS – EMI IMPACT

Introduction to Power Quality Measurements - Power Quality Measurement Devices - Power Quality Measurements - Test Locations - Test Duration - Instrument Setup - Instrument Guidelines

TEXT BOOKS:

1. Power quality by C. Sankaran, CRC Press
2. Electrical Power Systems Quality, Roger C. Dugan, Mark F. McGranaghan, Surya Santoso, H.WayneBeaty, 2nd Edition, TMH Education Pvt. Ptd.

REFERENCE BOOKS:

1. Understanding Power quality problems by Math H. J. Bollen IEEE Press
2. Power quality enhancement using custom power devices by Arindam Ghosh, Gerard Ledwich, Kluweracademic publishers

COURSE OUTCOMES:

After completing the course, the student should be able to do the following:

- Understand the concepts of power quality and power frequency problems in the power system.
- Analyze different types of Electrical Transients and Harmonics along with their causes and effects.
- Understand the concept of Electromagnetic interference**.**
- Analyze the various effects of Electromagnetic Interference on Power Quality.

HVDC TRANSMISSION SYSTEMS (24CEEE0DT)

COURSE OBJECTIVES:
The student will be able to:
- Understand the basic concepts of HVDC Transmission
- Analyze various HVDC converters
- Learn about control concepts of HVDC converters
- Understand Power flow analysis in AC/DC systems
- Learn about converter faults, harmonics and protection

UNIT-I: Basic Concepts
Introduction of DC Power transmission technology – Comparison of AC and DC transmission – Application of DC transmission – Description of DC transmission system – Power Handling Capabilities of HVDC Lines - Basic Conversion principles- Modern trends in DC transmission.

UNIT-II: Analysis of HVDC Converters
Converter station and Terminal equipment- Commutation process- Rectifier and inverter operation- Choice of Converter configuration – Analysis of Graetz – characteristics of 6 Pulse & 12 Pulse converters- Analysis of converter with grid control – with and without overlap angle - Equivalent circuit for converter – Special features of converter transformers.

UNIT-III: Control of HVDC Converters
Principle of DC Link Control – Converters Control Characteristics – Firing angle control – Current and extinction angle control – Effect of source inductance on the system; Starting and stopping of DC link; Power Control. Reactive Power Req1uirements in steady state-Conventional control strategies-Alternate control strategies-sources of reactive power-AC Filters – shunt capacitors-synchronous condensers.

UNIT-IV: Power Flow Analysis in AC/DC Systems & MTDC Systems
Modelling of DC Links-DC Network-DC Converter-Controller Equations-Solution of DC load flow – P.U. System for DC quantities-solution of AC-DC Power flow-Simultaneous method- Sequential method. Series parallel and series parallel systems their operation and control.

UNIT-V Converter Faults, Harmonics & Protection
Converter faults – protection against over current and over voltage in converter station – surge arresters – smoothing reactors – DC breakers –Generation of Harmonics –Characteristics harmonics, calculation of AC Harmonics, Non- Characteristics harmonics, adverse effects of harmonics – Calculation of voltage & Current harmonics – Effect of Pulse number on harmonics- Types of AC filters, Design of Single tuned filters –Design of High pass filters.

TEXT BOOKS:

1. E.W. Kimbark: Direct current Transmission, Wiely Inter Science – New York.
2. J. Arillaga HVDC Transmission Peter Peregrinus ltd. London UK 1983
3. K R Padiyar: High Voltage Direct current Transmission Wiely Eastern Ltd New Delhi – 1992

REFERENCE BOOKS:

1. E. Uhlman: Power Transmission by Direct Current , Springer Verlag, Berlin Helberg 1985

COURSE OUTCOMES:

After completing the course, the student should be able to:

- Understand the basic concepts of HVDC Transmission
- Analyze various HVDC converters
- Learn about control concepts of HVDC converters
- Understand Power flow analysis in AC/DC systems
- Learn about converter faults, harmonics and protection

HYBRID ELECTRIC VEHICLE SYSTEMS (24CEEE0ET)

COURSE OBJECTIVES:

Objectives of this course are to:

- Introduce the fundamental concepts, principles, analysis and design of hybrid and electric vehicles
- Introduce the various aspects of hybrid and electric drive train such as their configuration, types of electric machines that can be used, energy storage devices, etc.

SYLLABUS:

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-trainson 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 storage and its analysis, Hybridization of different energy storage devices.

UNIT-V: Energy Management Strategies: Introduction to energy management strategies used in hybrid 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 and

3. Fuel Cell Vehicles: Fundamentals, Theory and Design, CRC Press, 2004.
4. 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 Electric Vehicles, Springer, 2013.
3. http://nptel.ac.in/syllabus/108103009

COURSE OUTCOMES:

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

- Get knowledge on hybrid electric vehicles
- Compare the advantages and disadvantages of hybrid electric vehicles over conventional vehicles
- Compare the merits and demerits of hybrid electric trains over electrical trains
- Know the different energy storage techniques
- Discuss the electric population, motor drive technologies
- Analyze the different types of energy management strategies

DIGITAL CONTROL SYSTEMS (24CEEE0FT)

COURSE OBJECTIVES:

The student will be able to:

- Understand the basic concepts of Digital Control Systems
- Learn about Z-transforms, Transformations and Stability analysis
- Understand the concepts of state equations and controllability, observability
- Learn about pole placement design, Observer design concepts
- Learn about digital control system design

UNIT – I

Digital Control Systems – Block Schematic, Examples, Signal Forms, Advantages and Disadvantages of Digital Control, Data Conversion and Quantization, Sampling Process. Reconstruction of Original Signals from Sampled Signals - Sampling Theorem, Ideal Low – Pass Filter. Impulse Sampling and Data Hold-Transfer Function of Zero - Order Hold and First-Order Hold, Frequency Response Characteristics.

UNIT – II

The Z-Transform and Inverse Z Transform, Z - Transform Method for Solving Difference Equations. The Pulse Transfer Function (PTF) – PTFs of Closed - Loop Systems, Digital Controllers, Digital PID Controller and Digital Control Systems. Mapping Between The S – Plane and Z – Plane - Primary and Complementary Strips. Stability Analysis – Jury Test, Bilinear Transformation and Routh Criterion, Lyapunov Method for LTI Discrete time systems. Design based on the Frequency Response Method and Bilinear Transformation.

UNIT – III

State Space Representations of Discrete - Time Systems, Solution of The Time - Invariant Discrete-Time State Equation, State Transition Matrix , Z-Transform Approach to The Solution ofState Equation , Discritization of Continuous- Time State- Space Equations , Controllability and Observability of Discrete- Time Systems, Conditions, Principle of Duality.

UNIT – IV

Design via Pole Placement – Necessary and Sufficient Condition for Pole Placement, Ackerman’s Formula, Dead Beat Response, Design of Dead Beat Controllers. State Observers – Necessary and Sufficient Condition for State Observation. Full Order State Observer, Error Dynamics of The Full Order State Observer, Design of Prediction Observers –Ackerman’s Formula.

UNIT – V

Design of Minimum-Order Observer, Observed- State Feedback Control System with Minimum-Order Observer. Diophantine Equation, Polynomial Equation approach to Control System Design. Design of Model Matching Control Systems.

Text books:

1. K. Ogata, Discrete Time Control Systems, PHI/Addison - Wesley Longman Pte. Ltd., India, Delhi, 1995.
2. B.C Kuo, Digital Control Systems, 2nd Edition, Oxford Univ Press, Inc., 1992.

Reference Books:

1. .F. Franklin, J.D. Powell, and M.L. Workman, Digital control of Dynamic Systems, Addison - Wesley Longman, Inc., Menlo Park, CA , 1998.
2. Gopal, Digital Control and State Variable Methods, Tata McGraw Hill, India, 1997.
3. C. H. Houpis and G.B. Lamont, Digital Control Systems, McGraw Hill, 1985.
4. John S. Baey, Fundamentals of Linear State Space Systems, Mc. Graw – Hill, 1st edition
5. Bernard Fried Land, Control System Design, Mc. Graw – Hill, 1st edition
6. Dorsay, Continuous and Discrete Control Systems, McGraw - Hill.

COURSE OUTCOMES:

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

- Understand the basic concepts of Digital Control Systems
- Learn about Z-transforms, Transformations and Stability analysis
- Understand the concepts of state equations and controllability, observability
- Learn about pole placement design, Observer design concepts
- Learn about digital control system design

ADAPTIVE AND LEARNING CONTROL (24CEEE0GT)

COURSE OBJECTIVES:

The student will be able to:

- Understand the Adaptive control concept and types of adaptive control
- Learn about self-tuning regulator and adaptive control algorithms
- Understand the algorithms on LQG control
- Learn about MRAS design using different methods
- Understand the concept of gain scheduling and various applications of adaptive control

Unit – I

Introduction, Block Diagram of an Adaptive System, Effects of Process Variations on System Performance, Types of Adaptive Schemes, Formulation of the Adaptive Control Problem, Least Squares Method and Regression Models for Parameter Estimation, Estimating Parameters inModels of Dynamic Systems, the Finite Impulse Response Model, The Transfer Function and Stochastic Model.

Unit – II

Block Diagram of Deterministic Self Tuning Regulator (STR), Pole Placement Design – Process Model, Causality Conditions. Indirect STRs – Estimation, Continuous - Time STRs, Direct STRs – Minimum Phase Systems, Adaptive Control Algorithm, Feed Forward Control, Non Minimum Phase Systems – Adaptive Control Algorithm, Algorithm For Hybrid STR.

Unit – III

Design of Minimum Variance and Moving - Average Controllers, Stochastic STR – Indirect STR, Algorithm for Basic STR, Theorems on Asymptotic Properties. Unification of Direct STRs, Generalized Direct Self Tuning Algorithm, Self Tuning Feed Forward Control. Linear Quadratic STR – Theorems on LQG Control, Algorithms for Indirect LQG – STRs Based on Spectral Factorization and Riccati Equation.

Unit –IV

Model Reference Adaptive System (MRAS), The MIT Rule, Block Diagram of an MRAS for adjustment of Feed Forward Gain based on MIT Rule. Adaptation Gain – Methods for determination. Design of MRAS using Lyapunov Theory – Block Diagram of an MRAS based on Lyapunov Theory for a First Order System. Proof of The Kalman – Yakubovich Lemma, Adjustment Rules for Adaptive Systems, Relation between MRAS and STR.

Unit – V

Gain Scheduling – Principle, Block Diagram, Design of Gain Scheduling Controllers, Nonlinear Transformations, Block Schematic of a Controller based on Nonlinear Transformations.Application of Gain Scheduling for Ship Steering, Flight Control. Self Oscillating Adaptive System (SOAS) – Principle, Block Diagram, Properties of The Basic SOAS, Procedure for Design of SOAS. Industrial Adaptive Controllers and applications.

Text books

1. K.J.Astrom and Bjorn Wittenmark, Adaptive control, Pearson Edu., 2nd Edn.
2. Sankar Sastry, Adaptive control.

References

1. V.V.Chalam, Adaptive Control System - Techniques & Applications, Marcel Dekker Inc.
2. Miskhin and Braun, Adaptive control systems, MC Graw Hill
3. Karl Johan Åström, Graham Clifford Goodwin, P. R. Kumar, Adaptive Control, Filtering and SignalProcessing
4. G.C. Goodwin, Adaptive control.
5. Narendra and Anna Swamy, Stable Adaptive Systems.

COURSE OUTCOMES:

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

- Understand the Adaptive control concept and types of adaptive control
- Learn about self tuning regulator and adaptive control algorithms
- Understand the algorithms on LQG control
- Learn about MRAS design using different methods
- Understand the concept of gain scheduling and various applications of adaptive control

SOLAR ENERGY CONVERSION SYSTEMS (24CEEE0HT)

COURSE OBJECTIVES:
The student will be able:

- To introduce photovoltaic systems
- To deal with various technologies of solar PV cells
- To understand details about manufacture, sizing and operating techniques
- To have knowledge of design considerations.

SYLLABUS:

UNIT-I: SOLAR CELL FUNDAMENTALS
Introduction to PV, world energy scenario – need for sustainable energy sources – current status of Renewable energy sources – place of photovoltaic in Energy supply – solar radiation – the sun and earth movement – angle of sunrays on solar collectors – sun tracking – estimating solar radiation empirically – measurement of solar radiation.

UNIT-II: DESIGN OF SOLAR CELLS
Introduction to Solar cells, Solar cell design- design for high I_{SC} – design for high V_{OC} – design for high F,F upper limits of cell parameters – short circuit current, open circuit voltage, fill factor, efficiency, losses in solar cells – model of a solar cell, effect of series and shunt resistance on efficiency , effect of solar radiation on efficiency, Analytical techniques.

UNIT-III: SOLAR PHOTOVOLTAIC MODULES
Solar PV Modules from solar cells – series and parallel connection of cells – mismatch in module – mismatch in series connection – hot spots in the module , bypass diode – mismatching in parallel diode – design and structure of PV modules – number of solar cells in a module, wattage of modules, fabrication of PV module – PV module power output.

UNIT-V: BALANCE OF SOLAR PV SYSTEMS
Basics of Electromechanical cell – factors affecting performance – batteries for PV systems – DC to DC converters – charge controllers – DC to AC converters(Inverters) – Maximum Power Point tracking (MPPT) – Algorithms for MPPT.

UNIT V: PV SYSTEM DESIGN AND APPLICATIONS
Introduction to solar PV systems – standalone PV system configuration – design methodology of PV systems – design of PV powered DC fan without battery, standalone system with DC load using MPPT, design of PV powered DC pump, design of standalone system with battery and AC/DC load – wire sizing in PV system – precise sizing of PV systems – Hybrid PV systems – grid connected PV systems.

TEXT BOOKS:

1. “Solar Photovoltaics Fundamentals, Technologies and Applications” by Chetan singh solanki, PHIpublications.

REFERENCES:

1. Solar Energy Fundamentals and applications by H.P. Garg, J. Prakash "Tata McGraw- Hill publishers Ist edition"
2. S.Rao & B.B.Parulekar, "Energy Technology", 4th edition, Khanna publishers, 2005.

COURSE OUTCOMES:

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

- Identify photovoltaic system components and system types
- Calculate electrical energy and power
- Correctly size system components, design considerations of solar equipment
- Design a basic grid-tie PV system.

WIND ENERGY CONVERSION SYSTEMS (24CEEE0IT)

COURSE OBJECTIVES:

The student will be able:

- To learn the design and control principles of Wind turbine.
- To understand the concepts of fixed speed and variable speed, wind energy conversion systems.
- To analyze the grid integration issues.

UNIT-I: FUNDAMENTALS OF WIND TURBINES

Historical background - basics of mechanical to electrical energy conversion in wind energy - types of wind energy conversion devices – definition - solidity, tip speed ratio, power coefficient, wind turbine ratings and specifications - aerodynamics of wind rotors - design of the wind turbine rotor.

UNIT-II: WIND TURBINE CONTROL SYSTEMS & SITE ANALYSIS

Wind Turbine - Torque speed characteristics - Pitch angle control – stall control – power electronic control – Yaw control – Control strategy – Wind speed measurements – Wind speed statistics – Site and turbine selection.

UNIT-III: BASICS OF INDUCTION AND SYNCHRONOUS MACHINES

The Induction Machine – constructional features - equivalent circuit model - performance characteristics - saturation characteristics – dynamic d-q model – the wound – field synchronous machine – the permanent magnet synchronous machine – power flow between two synchronous sources – induction generator versus synchronous generator

UNIT-IV: GRID CONNECTED AND SELF-EXCITED INDUCTION GENERATOR OPEARTION

Constant – voltage, constant – frequency- single output system –double output system with current converter & voltage source inverter – equivalent circuits – reactive power and harmonics – reactive power compensation – variable voltage, variable frequency – the self-excitation process – circuit model for the self-excited induction generator – analysis of steady state operation – the excitation requirement – effect of a wind generator on the network .

UNIT-V: WIND GENERATION WITH VARIABLE-SPEED TURBINES AND APPLICATION

Classification of schemes – operating area – induction generators – doubly fed induction generator – wound field synchronous generator – the permanent magnet generator – Merits and limitations of wind energy conversion systems – application in hybrid energy systems – diesel generator and photovoltaic systems – wind photovoltaic systems.

TEXT BOOKS:

1. S.N.Bhadra,D.Kastha, S.Banerjee, " wind electrical systems" Oxford University Press.

REFERENCES:

1. S.Rao & B.B.Parulekar, “Energy Technology”, 4th edition, Khanna publishers, 2005.

2. “Renewable Energy sources & Conversion Technology” by N.K.Bansal, Manfred Kleemann, Michael Meliss. Tata Mcgraw Hill Publishers.

COURSE OUTCOMS:

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

- Design and control principles of Wind turbine.
- Understand the concepts of fixed speed and variable speed, wind energy conversion systems.
- Analyze the grid integration issues.

OPTIMIZATION & HEURISTIC SEARCH TECHNIQUES (24CEEE0JT)

COURSE OBJECTIVES:

The student will be able to:

- Learn about optimization problem and basic optimization issues
- Understand the concept of linear programming
- Learn about transportation problem and solution
- Understand unconstrained optimization techniques
- Acquire knowledge about various heuristic optimization techniques

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 : TRANSPORTATION PROBLEM

Finding initial basic feasible solution by north – west corner rule, least cost method and Vogel's approximation method – testing for optimality of balanced transportation problems. One – dimensional minimization methods: Classification, Fibonacci method and Quadratic interpolation method. 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.

UNIT – IV: UNCONSTRAINED OPTIMIZATION TECHNIQUES

Univariate method, Random Search methods, Grid Search method, Pattern Directions, Powell's method, Simplex method, Gradient of a function, Steepest Descent (Cauchy) method, Conjugate Gradient (Fletcher-Reeves) method, Newton's method.

UNIT – V: HEURISTIC OPTIMIZATION TECHNIQUES

Meta heuristic search methods: Genetic Algorithm based optimization, Simulated Annealing Techniques, Swarm Intelligent Algorithms, PSO, etc.

TEXT BOOKS:

1. "Modern Heuristic Optimization Techniques" by Kwang Y. Lee, Mohamed A. El-Sharkawi
2. "Engineering optimization: Theory and practice"-by S. S.Rao, New Age International (P) Limited, 3rdedition, 1998.
3. "Introductory Operations Research" by H.S. Kasene & K.D. Kumar, Springer(India), Pvt.LTd.

REFERENCES:

1. "Optimization Methods in Operations Research and systems Analysis" – by K.V. Mital and C. Mohan, New Age International (P) Limited, Publishers, 3 rd edition, 1996.
2. Operations Research – by Dr. S.D.Sharma.
3. "Operations Research: An Introduction" by H.A. Taha, PHI Pvt. Ltd., 6thedition
4. Linear Programming by G. Hadley

COURSE OUTCOMES:

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

- Learn about optimization problem and basic optimization issues
- Understand the concept of linear programming
- Learn about transportation problem and solution
- Understand unconstrained optimization techniques
- Acquire knowledge about various heuristic optimization techniques

INTELLIGENT CONTROL TECHNIQUES (24CEEE0KT)

COURSE OBJECTIVES:
The student will be able to:

- Learn about basic concepts of AI
- Understand concepts of ANN and various learning algorithms
- Learn about Genetic Algorithm, ACO and Tabu search concepts
- Understand the concepts of Fuzzy
- Learn about Fuzzy logic controller and design using MATLAB

UNIT I: Introduction to control techniques, need of intelligent control. Architecture for intelligent control. Symbolic reasoning system, rule - based systems, the AI approach. Knowledge representation. Expert systems. Data Pre - Processing: Scaling, Fourier transformation, principal - component analysis and wavelet transformations.

UNIT II
Concept of Artificial Neural Networks and its basic mathematical model, McCulloch - Pitts neuron model, simple perceptron, Adaline and Madaline, Feed - forward Multilayer Perceptron. Learning and Training the neural network. Networks: Hopfield network, Self - organizing network and Recurrent network. Neural Network based controller, Case studies: Identification and control of linear and nonlinear dynamic systems using Matlab / Neural Network toolbox.

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. Concept on some other than GA search techniques like tabu search and ant - colony search techniques for solving optimization problems.

UNIT IV
Introduction to crisp sets and fuzzy sets, basic fuzzy set operation and approximate reasoning. Introduction to Fuzzy logic modeling and control of a system. Fuzzification, inference and defuzzification. Fuzzy knowledge and rule bases.

UNIT V
Fuzzy modeling and control schemes for nonlinear systems. Self - organizing fuzzy logic control. Implementation of fuzzy logic controller using Matlab fuzzy - logic toolbox. Stability analysis of fuzzy control systems. Intelligent Control for SISO/MIMO Nonlinear Systems. Model Based Multivariable Fuzzy Controller.

Text Books:

1. Simon Haykins, Neural Networks: A comprehensive Foundation, Pearson Edition, 2003.
2. T.J.Ross, Fuzzy logic with Fuzzy Applications, Mc Graw Hill Inc, 1997.
3. David E Goldberg, Genetic Algorithms.

References:

1. M.T.Hagan, H. B. Demuth and M. Beale, Neural Network Design, Indian reprint, 2008.
2. Fredric M.Ham and Ivica Kostanic, Principles of Neurocomputing for science and Engineering, McGraw Hill, 2001.
3. N.K. Bose and P.Liang, Neural Network Fundamentals with Graphs, Algorithms and Applications, Mc - Graw Hill, Inc. 1996.
4. Yung C. Shin and Chengying Xu, Intelligent System - Modeling, Optimization and Control, CRC Press, 2009.
5. N.K.Sinha and Madan M Gupta, Soft computing & Intelligent Systems - Theory & Applications, Indian Edition, Elsevier, 2007.
6. John Yen and Reza Langari, Fuzzy logic Intelligence, Control, and Information, Pearson Education, Indian Edition, 2003.
7. Witold Pedrycz, Fuzzy Control and Fuzzy Systms, Overseas Press, Indian Edition, 2008.

COURSE OUTCOMES:

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

- Learn about basic concepts of AI
- Understand concepts of ANN and various learning algorithms
- Learn about Genetic Algorithm, ACO and Tabu search concepts
- Understand the concepts of Fuzzy
- Learn about Fuzzy logic controller and design using MATLAB

Modern Flexible AC Transmission Systems (24CEEE0MT)

UNIT1: FACTS CONCEPTS AND GENERAL SYSTEM CONFIGURATION
Transmission interconnections power flow in an AC system, loading capability limits, Dynamic stability considerations, importance of controllable parameters basic types of FACTS controllers, benefits from FACTS controllers

UNIT 2: 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

UNIT3: STATIC SHUNT COMPENSATORS SVC AND STATCOM
Objective of shunt compensation, methods of controllable Var generation, static Var compensator, SVC and STA TCOM, comparison between, SVC and STA TCOM.

UNIT4: STATIC SERIES COMPENSATORS
GCSC, TSSC, TCSC and SSSC, objectives of series compensation, variables impedance type of series compensation, switching converter type series compensation, external control for series reactive compensators.

UNIT5: UNIFIED POWER FLOW CONTROLLER AND INTERLINE POWER FLOW CONTROLLER:
The Unified Power Flow Controller-Basic Operating Principles, Conventional Transmission Control Capabilities, Independent Real and Reactive Power Flow Control. Control Structure, Basic Control System for P and Q Control, Dynamic Performance, The Interline Power Flow Controller (IPFC), Basic Operating Principles and Characteristics, Generalized and Multifunctional FACTS Controllers.

TEXT BOOKS:
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