Dr.M.G.R.
EDUCATIONAL AND RESEARCH INSTITUTE
UNIVERSITY
(Decl. U/S 3 of UGC Act 1956)
DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING

M.Tech –Power System (Full Time)
Curriculum and Syllabus
2013 Regulation

I SEMESTER						
S.No	**Sub.Code**	**Title of Subject**	**L**	**T**	**P**	**C**
1	MEE13P001	Power Conversion Techniques	3	0	0	3
2	MEE13P002	Power System Stability	3	2	0	4
3	MEE13P003	FACTS and HVDC Transmission	3	0	0	3
4	MEE13P004	AC Drives and Wind Turbine Technology	3	0	0	3
5	MEE13P005	Introduction to Soft Computing Techniques	3	0	0	3
6	MEE13P006	Computer Aided Power System Analysis @	2	0	2	3
7	MEE13PL01	Programming & Simulation Laboratory - I	0	0	2	1
8	MEE13PL02	Advanced Design and Implementation Practice – I	0	0	2	1
		Total	**17**	**2**	**6**	**21**

II SEMESTER						
S.No	**Sub.Code**	**Title of Subject**	**L**	**T**	**P**	**C**
1	MMA130016	Random Process and Optimization Techniques	3	1	0	4
2	MEE13P007	Modern Distribution System Design & Control	3	0	0	3
3	MEE13P008	Introduction To Photovoltaic & Thermal Energy Conversion	3	0	0	3
4	MEE13PEXX	Elective – I	3	0	0	3
5	MEE13PEXX	Elective – II	2	0	2	3
6	MEE13P009	Energy Audit Conservation and Management	2	0	2	3
7	MEE13PL03	Renewable Energy Technology Laboratory	0	0	4	2
8	MEE13PL04	Advanced Design and Implementation Practice – II	0	0	2	1
		Total	**16**	**1**	**10**	**22**

III SEMESTER						
S.No	**Sub.Code**	**Title of Subject**	**L**	**T**	**P**	**C**
1	MEE13P010	WAMPAC In Power System Stability	3	2	0	4
2	MEE13PEXX	Elective - III	3	0	0	3
3	MEE13PEXX	Elective – IV	3	0	0	3
4	MEE13P011	Power Quality and Grid Integration	3	0	0	3
5	MEE13PL05	Programming & Simulation Laboratory – II	0	0	2	1
6	MEE13PL06	Project Phase – I	0	0	12	6
		Total	**12**	**2**	**14**	**20**

IV SEMESTER						
S.No	**Sub.Code**	**Title of Subject**	**L**	**T**	**P**	**C**
1	MEE13PL07	Project Phase – II	0	0	30	12
		Total	**0**	**0**	**30**	**12**

Summary of Credits:

1st Semester Credits	**21**
2nd Semester Credits	**22**
3rd Semester Credits	**20**
4th Semester Credits	**12**
Total	**75**

The @ indicates the Final Examination will be conducted internally by the Department which includes internal examination, execution of Simulation Studies , Case study report and analysis , etc, respective to the mentioned subject.

Internal Examination Procedure: The end semester examination will be conducted in the department with both theory and practical. The theory exam will be conducted for 50 marks with the question pattern as like as to check the creativity of the brain. The practical exam will be conducted for 50 marks to check the programming or simulation skill of the student

ELECTIVE-I						
S.No	**Sub.Code**	**Title of Subject**	**L**	**T**	**P**	**C**
1	MEE13PE01	Introduction to Smart Grid Design	3	0	0	3
2	MEE13PE02	Applications of MEMS Technology	3	0	0	3
3	MEE13PE03	Power System Economics	3	0	0	3
4	MEE13PE05	Solid State Power Converters	3	0	0	3

ELECTIVE-II						
S.No	**Sub.Code**	**Title of Subject**	**L**	**T**	**P**	**C**
1	MEE13PE04	ANN and Application in Modern Electric Power System	2	0	2	3
2	MEE13PE06	Fuzzy System and Application in Modern Electric Power System	2	0	2	3
3	MEE13PE07	Digital Signal Processing	3	0	0	3
4	MEE13PE08	Power Electronics Applications in Power Systems	3	0	0	3

ELECTIVE-III						
S.No	**Sub.Code**	**Title of Subject**	**L**	**T**	**P**	**C**
1	MEE13PE09	System Theory	3	0	0	3
2	MEE13PE10	Intelligent Optimization Techniques and Application in Modern Electric Power System	2	0	2	3
3	MEE13PE11	Mathematical Modeling & Simulation Study On PV System	3	0	0	3
4	MEE13PE12	Advanced Smart Grid Design	3	0	0	3

ELECTIVE-IV						
S.No	**Sub.Code**	**Title of Subject**	**L**	**T**	**P**	**C**
1	MEE13PE13	Dynamic Modeling and Control Of Wind Turbines	3	0	0	3
2	MEE13PE14	Micro Controller Based System Design	3	0	0	3
3	MEE13PE15	Electrical Drives and Control	3	0	0	3
4	MEE13PE16	MicroGrid In Modern Power Systems	3	0	0	3

MEE13P001 **POWER CONVERSION TECHNIQUES** **3 0 0 3**

OBJECTIVES:

- Familiarity to converters level and its various control techniques.
- Capable to apply Power Electronics concepts in Renewable Energy Resources.
- Ability to solve power factor correction and reactive power compensation.

UNIT I: Converter Control Techniques **9 hours**

Review of current source and voltage source converters, basic theory, waveforms, types- Review of different types of PWM techniques, sine PWM, third harmonic injected PWM, space vector PWM, Hysteresis Control-Delta Current Regulation.

UNIT II: Cyclo converters **9 hours**

Phase Controlled Cyclo converters- Cyclo converter Circuits-Circulating & Non-Circulating Current Mode-Load & Line Harmonics-Control of Cyclo converter-Matrix Converters. High-Frequency Cyclo converters.

UNIT III: Multilevel Converters **9 hours**

Introduction to multilevel concepts and notations-Diode Clamped Multilevel Inverter-Flying Capacitor Structure- Series H-Bridge Multilevel Inverter-Multilevel Modulation.

UNIT IV: Power Electronics for Renewable Energy Resources **9 hours**

Basics of Photovoltaic's-Types of PV power Systems-Stand alone PV systems-Grid connected PV systems-Basics of wind power-Types of Wind Power Systems-Standalone Wind Power Systems-Grid Connected Wind Energy Systems-Control of Wind Turbines.

UNIT V: Reactive Power Compensation **9 hours**

Introduction- Reactive Power Phenomena & their compensation-Power Factor Correction-Voltage Regulation-Load Balancing-Modeling & Analysis of Advanced Static VAR compensator-D-STATCOM.

Total no. of Hours: 45

Text Books

1. Bimal K. Bose, (2002) *Modern Power Electronics and AC Drives*. Asia: Pearson Education.
2. Muhammad H. Rashid,(2001) *Power Electronics Handbook*.Academic Press.

References

1. Mohan, Undeland and Robbins, *Power Electronics: Converters, Applications and Design*.2nd Ed. John Wiley and Sons.
2. Bose, B.K. *Modern Power Electronics and AC Drives*. Prentice Hall PTR.
3. Hingorani L. Gyugyi, (2000) *Concepts and Technology of Flexible AC Transmission System*. New York: IEEE Press ISBN- 078033 4588.

MEE13P002 **POWER SYSTEM STABILITY** **3 2 0 4**

OBJECTIVES:

- Capable to solve Power System stability problems,
- Familiarity to different types of stability.
- Capable to apply different methods to improve the stability.

UNIT I: Introduction **12 hours**

Basic concepts & definitions - classification of stability - Rotor angle and Voltage Stability - Design and Operating Criteria for Stability - Synchronous machine representation - Classical models- Reactive Capability limits - Simplifications essential for large scale studies - Power System Stability Problems.

UNIT II: Small Signal Stability **12 hours**

Fundamental concepts of Stability of Dynamic Systems - Analysis of Stability by Lyapunov's 1st and 2nd method Eigen properties of the State Matrix - Small - Signal Stability of a Single machine Infinite bus system - Effects of Excitation System - Power System Stabilizer - Small - Signal Stability of multimachine system - Characteristics of Small Signal Stability Problems.

UNIT III: Transient Stability **12 hours**

Transient Stability - Factors influencing Transient Stability - Swing Equation - Solution of Swing Equation - Equal area Criterion - Numerical Integration methods - Euler method & Runga -Kutta method - Numerical Stability of explicit & implicit integration methods - Extended equal area criterion-transient energy function approach-Case study of transient stability of large system.

UNIT IV: Voltage stability **12 hours**

Voltage stability -Voltage collapse-Transmission system aspects-PV noise curves-VQ curves-PQ curves-Generation aspects-load aspects -Instability mechanism and counter measures- Torsional Oscillations- Turbine Generator torsional characteristics - Interaction with power system controls - Sub synchronous reactance-counter measures to SSR problems-Impact of network switching disturbances.

UNIT V: Stability Analysis **12 hours**

Methods of improving stability - Transient Stability Enhancement - High Speed Fault Clearing - Steam Turbine Fast -Valving - High Speed excitation Systems - Small Signal Stability enhancement - Power System Stabilizer - Supplementary Control of Static VAR Compensators.

Tutorials:15
Total no. of Hours: 60

Text Books

1. Kundur, (2012) *Power System Stability & Control*. McGraw-Hill International.
2. Anderson, P.M. and Fouad, A.A. (2003) *Power System Control and Stability*. New Delhi: Galgotia Publications.
3. Custem, C. Vournas, (1998) *Voltage stability of power systems*. Kluwer Academic Publishers.

MEE13P003 FACTS & HVDC TRANSMISSION 3 0 0 3

OBJECTIVES:

- Analyze the HVDC Converters.
- Comparison of DC & AC systems.
- Modeling the power flow system.
- Comparison of Shunt & Series FACTS Controllers.
- Study about the Combined FACTS Controllers.

UNIT I: Introduction to HVDC & FACTS **9 hours**
Comparison of AC & DC- Application, Description and planning of DC Transmission – Thyristor Valve –Pulse Number - FACTS Concepts – Basic types & description of FACTS Controllers –Benefits of FACTS Technology, Introduction to VSC & CSC.

UNIT II: Converter Control, Faults and Protection **9 hours**
DC link control – system control hierarchy– Converter Faults – Protection against over currents – Over voltages in a converter station & Protection - Smoothing Reactor - DC Line.

UNIT III: Harmonics & Filters **9 hours**
DC Breakers – Monopolar Operation – Effects of proximity of AC & DC Transmission Lines – Generation of Harmonics - Design of AC Filters – DC Filters - MTDC Systems – types, control & Protection.

UNIT IV: Static Shunt Compensators **9 hours**
OBJECTIVESs of shunt compensation - Methods of Controllable VAR Generation - Static VAR Compensators: SVC and STATCOM.

UNIT V: Static Series Compensators **9 hours**
OBJECTIVESs of Series Compensation - Variable Impedance Type Series Compensators - Switching Converter Type Series Compensators.

Total no. of Hours: 45

Text Books

1. Padiyar K.R.(2001) *HVDC power transmission system* .Wiley Eastern Pvt. Ltd.
2. Narain G. Hingorani, Laszlo Gyugyi, (2000) *Understanding FACTS Concepts & Technology of Flexible AC Transmission System*. IEEE Press.

References

1. Arrillaga J.(1983) *High voltage direct current transmission* . London: Peter Peregrinus.
2. Zhang, Rehtanz, Pal, (2006) *Flexible AC Transmission Systems: Modeling and Control*. Springer.

MEE13P004 AC DRIVES & WIND TURBINE TECHNOLOGY 3 0 0 3

OBJECTIVES:

- Familiarity to basic principles of wind turbine technology.
- Capable to solve power quality issues.
- Familiarity to Electrical Machines for constant volt/HZ operation.

UNIT I: Basics of Wind Turbines 9 hours

Basic Principle of Wind Energy Conversion System-Nature of Wind-Components of wind energy conversion systems-Fixed speed – variable sped WT-HAWT – VAWT – Types of Wind turbines- Output from an ideal WT-Output from a practical WT – thrust – efficiency –blade angle control – pitch angle control – Drop offset control – position speed estimation – field weakening.

UNIT II: Wind Turbine Technology 9 hours

Principles of aerodynamics -Grid Integration of Wind Turbines-Grid Connected systems with Battery Backup-Off-grid systems (Standalone)-Hybrid Systems-Power Quality issues and solution-Effect of wind shear and tower shadow-MPPT system-Wind site Assessment-Offshore technology.

UNIT III: Review of Induction Machines 9 hours

Steady state performance equations – Rotating magnetic field – torque production, Equivalent circuit– Variable voltage, constant frequency operation – Variable frequency operation, constant Volt/Hz operation. Drive operating regions, variable stator current operation, different braking methods.

UNIT IV: Induction Machine Drives 9 hours

Dynamic d-q model – Induction motor control with small signal model – Scalar Control- Field Oriented Control DTC control - Slip Power Recovery Drives – Doubly Fed Machine Speed Control by Rotor Rheostat.

UNIT V: Synchronous Machine Drives 9 hours

Wound Field Machine Drives (Scalar & Vector Control) – Synchronous Reluctance Machine Drives – Sinusoidal SPM Machine Drives – Sinusoidal IPM Machine Drives.

Total no. of Hours: 45

Text Books

1. Bimal K. Bose,(2002) *Modern Power Electronics and AC Drives*. Pearson Education. Asia:
2. Gopal K. Dubey, (2003) *Power Semiconductor controlled Drives*, New Jersy: Prentice Hall Inc.
3. Gary L.Johnson, (1985) *Wind Energy Systems.* Prentice Hall Inc.

References

1. Vedam Subramanyam,(1994) *Electric Drives – Concepts and Applications*. Tata McGraw Hill.
2. Tony Burton, David Shapre, Nick Jenkins, Ervin Bossanyi, (Dec 2001) *Wind Energy Hand Book*, John Wiley and sons Inc.
3. Mohammed Hasan Ali,(2012) *Wind Energy Systems – Solution for Power Quality & Stabilization*.CRC Press.

MEE13P005 INTRODUCTION TO SOFT COMPUTING TECHNIQUES 3 0 0 3

OBJECTIVES:

- Understand the terminology and learning methods related to neural networks.
- Understand the applications of neural networks in image processing, signal processing, modeling and control.
- Understand the mathematical adaptation of neuro-fuzzy systems

UNIT I: Introduction **9 hours**

Motivation for the development of neural networks - Elementary Neuro physiology – From Neuron to ANNS – Activation functions – Neuron model and Network architectures. Perceptron – fundamentals – training algorithm the Delta rule – limitations.

UNIT II: Feed Forward Networks **9 hours**

Introduction to Back propagation, Back propagation Network (BPN) – Back propagation training algorithm – BPN applications. Counter Propagation Network (CPN): CPN structure – Kohonen and Gross berg layers – training of CPN – Applications.

UNIT III: Feedback Networks **9 hours**

Memory definitions – the BAM – Hopfield nets – Binary and Continuous systems – Adaptive Resonance Theory (ART): ART1 model - architecture – Analysis of ART system dynamics – ART training – applications.

UNIT IV: Introduction to Fuzzy Logic **9 hours**

Introduction to Fuzzy Logic: Fuzzy control – Principles – a comparison with real time expert systems – nonlinear control system – Advantages of Fuzzy logic limits – when to use Fuzzy logic – Fuzzy sets – Fuzzy – Set operations – Fuzzy relations – Fuzzy functions -– Adaptive fuzzy.

UNIT V: Introduction to Genetic Algorithm **9 hours**

Introduction – Simple Genetic Algorithm – reproduction, crossover and mutation – Applications.

Total no. of Hours: 45

Text Books

1.Wassermann, P.D. (1988) *Neural computing* .Van Reinhold:
2. Jacek M. Zurada, (1999) *Introduction to Artificial Neural Systems*. Jaico Publishing House.
3. Trimothy J. Ross, (2004) *Fuzzy Logic with Engineering applications*. McGraw Hill Inc.
4. David E. Gold Berg,(1996) *Genetic Algorithms*. Addison Wesley Publishing Company.

References

1. Zimmermann, H.J. (1985) *Fuzzy set Theory and its Application*. Kluwer.
2. IEEE tutorial (1996) *Application of Neural Network to Power Systems*.
3. Driankov, D. Hellendroom, H. Reinfrank, M. (1995) *An Introduction to Fuzzy Control*.2nd Ed.Springer.

MEE13P006 COMPUTER AIDED POWER SYSTEM ANALYSIS@ 2 0 2 3

OBJECTIVES:

- Familiarity to Power System generation using commitment methods and programming methods.
- Familiarity to various load flow problems.
- Capable to apply state estimation methods for detection of bad measurements in Power System.

UNIT I: General Introduction 9 hours

Modern Power Systems Analysis, Review of AC power flow methods-Sparse Matrices-Sparsity directed optimal Ordering Schemes, Solution Algorithms - LU Factorization and Iterative Methods- Review on Analysis of Faulted Power System.

UNIT II: Economic Dispatch of Generation 9 hours

Nonlinear function optimization- equality and inequality constraints- Economic dispatch problem-Economic dispatch neglecting losses and with & without generator limits-Lamda Iteration method -Hydro –thermal co-ordination-scheduling problem using Dynamic Programming and Linear Programming-Gradient Approach.

UNIT III: Unit Commitment Solution Methods 9 hours

Introduction-Constraint- spinning reserve- UC solution methods: Priority-List Methods, Dynamic-Programming Solution, Forward DP Approach-Lagrange Relaxation solution.

UNIT IV: State Estimation Solution methods 9 hours

Introduction- Least-Squares Estimation-types, Static State Estimation ,Detection and Identification of Bad Measurements, Tracking state Estimation-Network Observability and Pseudo-measurements, Application of Power Systems State Estimation

UNIT V: Security Analysis 9 hours

Basic Concepts and Factors-Static Security Analysis at Control center- Contingency Analysis-Calculation of Linear sensitivity factors-Contingency Selection-boundary security constrained optimal power flow-Inter point Algorithm

Total no. of Hours: 45

Text Books

1. Kothari,D. P. and Nagrath, I. J. (2003) *Modern Power System Analysis*, Tata McGraw Hill Publishing Co. Ltd.

2. Allen J. Wood etl, (2013) *Power Generation, Operation and Control*.3rd Ed, John Wiley & Sons, Inc.

Reference Books

1. George L. Kusic, (2000) *Computer Aided Power System Analysis*. New Delhi: Prentice Hall of India (P) Ltd.

2. Hadi Saadat, (2002) *Power System Analysis*. New Delhi: Tata McGraw Hill Publishing Co. Ltd.

Internal Examination Procedure: The end semester examination will be conducted in the department with both theory and practical. The theory exam will be conducted for 50 marks with the question pattern as like as to check the creativity of the brain. The practical exam will be conducted for 50 marks to check the programming or simulation skill of the student.

MEE13PL01 PROGRAMMING AND SIMULATION LABORATORY – I 0 0 2 1

OBJECTIVES:

The lab is equipped with software packages like ETAP, PSCAD, MATLAB and LABVIEW with respective licensed version. The aims of this laboratory is to develop software coding for Power System Stability Analysis, AI Techniques and Simulation analysis for Power Conversion techniques, FACTS, HVDC Transmission System. On completion of this laboratory, the students are capable to develop their own coding for any type of OBJECTIVES functions.

- To identify minimum of two logic in power system stability and develop the suitable coding with any one programming package.
- Two conversion techniques to be selected as the minimum requirement which is to be simulated for performance analysis with the help of any one simulation packages.
- To identify minimum of two logic in soft computing techniques and develop the suitable coding with any one programming package.
- Two controllers to be selected as the minimum requirement in FACTS – HVDC, which is to be simulated for performance analysis with the help of any one simulation packages.

Total no. of Hours: 45

MEE13PL02 ADVANCED DESIGN AND IMPLEMENTATION PRACTICE - I 0 0 2 1

The Procedure for execution of Advanced Design and Implementation Practice are

- Each student has to select their own topic which is in real time operation.
- Develop the mathematical model for the suitable selected topic.
- Optimize the finalized process plan with suitable selection of equipments.
- Prepare the cost analysis with breakeven chart.
- Finalize the implementation model for action.
- Simulate the finalized model with suitable simulation package.
- Implement the developed design in real or prototype category.

The end semester examination will be conducted internally in the department with suitable presentation by the student with design and implementation report.

Total no. of Hours: 45

MMA130016 RANDOM PROCESS AND OPTIMIZATION TECHNIQUES 3 1 0 4

OBJECTIVES:

- Capable to solve the problems arises in Power System, Control System etc.
- Understand the concept of interpolation like least square method etc.
- The student will be capable of solving Eigen value problems.

UNIT I:Random Variables **12 hours**
Random variables – Distribution functions – Moments – Moment generating functions – Two dimensional Random variables – Marginal and conditional distributions.

UNIT II :Random Process **12 hours**
Classification of Random Process – Stationary Process – Ergodic Process – Markov Process – Markov Chains – Auto Correlation – Auto Covariance – Cross Correlation – Cross Covariance – Spectral Density.

UNIT III:Solution of Equations **12 hours**
Solution of Algebraic and Transcendental equations – Method of false position – Iteration method – Newton-Raphson method – Solution of Linear system of equations – Gauss Elimination method – Gauss-Jordan method Iterative methods – Gauss-Jacobi method – Gauss-Seidel method – Matrix Inversion by Gauss-Jordan method.

UNIT IV:Advanced Matrix Theory **12 hours**
Generalized Eigen vectors – Jordan canonical form – Matrix norms – QR algorithm – Pseudo inverse – Singular value decomposition – Least square solutions.

UNIT V : Linear Programming **12 hours**
Formulation of LPP – Standard form of LPP – Graphical method – Simplex method – Big M method – Two phase method.

Tutorials:15
Total no. of Hours: 60

References

1. Richard Johnson, A.(2009) *Miller & Freund's Probability and statistics for Engineers*.8th Ed. Prentice Hall of India.
2. Veerarajan, T.(2008) *Probability, Statistics and Random Processes*. Tata McGraw Hill Publishing Co.
3. Gupta,S.C. Kapoor, V.K. (2007) *Fundamentals of Mathematical Statistics*, Chand S. & Co.
4. Veerarajan, T.(2005) *Numerical Methods*. Tata McGraw Hill Publishing Co.
5. Sastry, S.S.(2003) *Introductory Methods of Numerical Analysis*. Prentice Hall of India.
6. Bronson, R.(1989) *Theory and problems of Matrix operations (Schaum's outline series)*.McGraw Hill.
7. Lewis,D.W.(1995) *Matrix theory*. Allied publishers.
8. Hamdy A. Taha, (2010) *Operations Research: An Introduction*.9th Ed. Pearson.
9. Panneerselvam, R.(2011) *Operations Research* .2nd Ed. Prentice Hall of India.

MEE13P007 MODERN DISTRIBUTION SYSTEM DESIGN AND CONTROL 3 0 0 3

OBJECTIVES:

- Understand the protection schemes for various power system equipments.
- Understand the schemes incorporated for Over voltage protection
- Understand the principle of Static Relay.

UNIT I: Introduction to Distribution System Planning 9 Hours
Introduction – Factor Affecting System Planning – Planning Techniques- Future Planning Factors – Role of Computer in Planning – Importance and Impact of Distributed Generation consideration in Planning – Load Characteristics – Load Forecasting – Load Management

UNIT II: Design of Distribution Substation and Automation 9 Hours
Introduction – Types – Planning Techniques - Substation Cost – Bus Scheme – Location – Rating – Comparison of four and six feeder pattern – Derivation of K Constant - Design consideration for Remote Terminal Units - Components for Distribution Substation Automation – Power Transformers – Substation Protection Schemes- Substation Earthing and Grounding – Distribution Automation – Substation - Feeder level and Customer level Automation – Control Center Architecture.

UNIT III: Design of Primary and Secondary Distribution System 9 Hours
Introduction – Types of Primary Feeders - Methods – Radial Feeders with Distributed Loads – Application of ABCD Constants – Overhead and Underground Design Consideration – Cost Analysis – Secondary Feeder Voltage level and Design Practice – Secondary Banking – Secondary Networks – Spot Networks – Economic Design of Secondary's - Cost Analysis

UNIT IV: Application of Capacitor in Distribution System 9 Hours
Basic Definition – Effect of Series and Shunt Capacitors – Power Factor Correction – Application of Capacitor – Economic Justification for Capacitor – Mathematical Procedure to Determine the Location of Capacitor - Practical Procedure to Determine the Location of Capacitor – Dynamic Behavior of Distribution System – Application of AI Techniques in Optimal Capacitor Location.

UNIT V: Future of Distribution System 9 Hours
Introduction – Concept of distributed generations, topologies, selection of sources, regulatory standards/ framework, Standards for interconnecting Distributed resources to electric power distribution systems: IEEE 1547. DG installation classes, security issues in DG implementations. Energy storage elements: Batteries, ultra-capacitors, flywheels.

Total no. of Hours: 45

Text Books

1. Turan Gonen, (2012) *Electrical Power Distribution System Engineering*. Taylor & Francis Group. CRC Press.

References

1. MIT Study Report (2012) *Future of grid*.http://mitei.mit.edu/system/files/Electric_Grid_Full_Report.pdf
2. IEEE Tutorial *Distribution Automation*.

MEE13P008 INTRODUCTION TO PHOTOVOLTAIC & THERMAL ENERGY CONVERSION 3 0 0 3

OBJECTIVES:

- Familiarity to Photovoltaic Principles, concepts and its characteristics.
- Capable to design concentrating collectors.
- Capable to analyze its performance parameters.

UNIT I: 9 hours

Photovoltaic Principles Solar Cell Physics: p-n junction: homo and hetero junctions, Metal-semiconductor interface; The Photovoltaic Effect, Equivalent Circuit of the Solar Cell, Analysis of PV Cells: Dark and illumination characteristics; Figure of merits of solar cell; Efficiency limits; Variation of efficiency with band-gap and temperature; Efficiency measurements; High efficiency cells, Types of Solar cells.

UNIT II: 9 hours

Photovoltaic (PV): Fundamentals of solar cells: types of solar cells, semiconducting materials, band gap theory, absorption of photons, excitons and photoemission of electrons, band Engineering; Solar cell properties and design; p-n junction photodiodes, depletion region, electrostatic field across the depletion layer, electron and holes transports, device physics, charge carrier generation, recombination and other losses, I-V characteristics, output power; Single junction and triple-junction solar panels, metal-semiconductor hetero junctions, and semiconducting materials for solar cells.

UNIT III: 9 hours

Radioactive Properties and Characteristics of Materials - Reflection from ideal specular, ideal diffuse and real surfaces, Selective Surfaces: Ideal coating characteristics; Types and applications; Anti-reflective coating; Preparation and characterization. Reflecting Surfaces and transparent materials. Production and storage- Types: Sensible storage; Latent heat storage; Thermo-chemical storage. Design of storage system,

UNIT IV: 9 hours

Flat-plate Collectors- Energy balance for Flat Plate Collectors; Thermal analysis; Heat capacity effect; Testing methods; Types of Flat Plate Collectors: Liquid Flat Plate Collectors, Air flat-plate Collectors- Thermal analysis; Evacuated tubular collectors.

UNIT V: 9 hours

Concentrating Collector Designs- Classification, design and performance parameters; Tracking systems; Compound parabolic concentrators; Parabolic trough concentrators; Concentrators with point focus; Heliostats; Comparison of various designs: Central receiver systems, parabolic trough systems; Solar power plant; Solar furnaces.

Total no. of Hours: 45

Text Books

1. Pietro Vincenzini, Kunihito Koumoto, Nicola Romeo, and Mark Mehos, (Mar 2011) *New Materials: Thermal-to-Electrical Energy Conversion, Photovoltaic Solar Energy Conversion and Concentrating*.
2. Jihui Yang, George S. Nolas, Kunihito Koumoto, and Yuri Grin, (Sep 9, 2009) *Materials and Devices for Thermal-to-Electric Energy Conversion*. Volume 1166 (MRS Proceedings).
3. Alireza Khaligh, and Omer C. Onar, (Dec 1, 2009) *Energy Harvesting: Solar, Wind and Ocean Energy Conversion Systems (Energy, Power Electronics, and Machines).*

MEE13P009 ENERGY AUDIT CONSERVATION AND MANAGEMENT 2 0 2 3

OBJECTIVES:

- Familiarity to Energy Audit and Energy Management.
- Ability to design and practice energy efficient motors for energy audit.
- Capable to solve energy crisis using energy audit and energy management.

UNIT I : Basic Principles Of Energy Audit 9 hours

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 9 hours

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

UNIT III: Energy Efficient Motors, PF Improvement, Lighting 9 hours

Energy efficient motors, factors affecting efficiency, loss distribution, constructional details, characteristics - variable speed , variable duty cycle systems, RMS HP- voltage variation-voltage imbalance- over motoring-motor energy audit. Power factor – methods of improvement, location of capacitor, Pf with non linear loads, effect of harmonics on Power factor, Power factor motor controllers - Good lighting system design and practice , lighting control ,lighting energy audit.

UNIT IV: Energy Instruments 9 hours

Energy Instruments wattmeter, data loggers, thermocouples, pyrometers, lux meters, tongue testers, application of PLC's

UNIT V: Economic Aspects and analysis 9 hours

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.

Unit VI: Innovative Learning Practices 9 hours

Conduct energy audit at various locations and implement energy management strategies and submit a report regarding the outcome.

Total no. of Hours: 45

Text Books

1. Tarik Al-Shemmeri, (Oct 3, 2011) *Energy Audits: A Workbook for Energy Management in Buildings*.
2 Abbi.Y.P. and Shashank Jain, (Jan 30, 2009) *Handbook on Energy Audit and Environment Management*.
3. Lal Jayamaha, (Nov 20, 2006) *Energy-Efficient Building Systems: Green Strategies for Operation and Maintenance.*
4. Steve Doty, (Nov 22, 2010) *Commercial Energy Auditing Reference Handbook*, 2nd Ed.

MEE13PL03 RENEWABLE ENERGY TECHNOLOGY LABORATORY 0 0 4 2

OBJECTIVES :

Students will develop the ability to apply software and hardware Implementation of what they have learned theoretically in the field of Renewable energy.

- In this Laboratory, students will obtain knowledge about specific wind power, calculate the wind frequency, turbine characteristics, time period and the frequency of the rotating turbine at different speeds.

- Performance characteristics of Induction generator , Double fed Induction generator ,permanent magnet generators and converters. Grid integration study to analyze power quality, fault analysis and Design of Battery storage.

- To understand the concept of semiconductors and p-n junctions energy band, to study the Effect of Light, Effect of Temperature, Effect of Parasitic Resistance, to plan, design, simulate solar photovoltaic and also to understand hardware interface for simulation, Characterization of solar cells/PVs are the component of renewable energy systems sizing/selection of PV modules, battery.

- To familiarize the students with the Efficiency of a Flat Plate Solar Collector, I-V Characteristics and Efficiency of a Solar PV cell , Analysis of Flat Plate Collector, studies on Solar thermal systems for residential water heating, industrial heating and power generation, solar collector.

Total no. of Hours: 45

MINIPROJECTS:

1. Case study report on design of power supply to Duplex home. Design an Innovative Structure of wind blade and small ratings of wind mill.
2. Design a demo model for Solar water heater, Solar cooker, Battery for solar energy storage and solar lamp

Students can choose any innovative ideas of their own interest, based on the above OBJECTIVESs.

MEE13PL04 ADVANCED DESIGN AND IMPLEMENTATION PRACTICE- II 0 0 2 1

The Procedure for execution of Advanced Design and Implementation Practice are

- Each student has to select their own topic which is in real time operation
- Develop the mathematical model for the suitable selected topic
- Optimize the finalized process plan with suitable selection of equipments
- Prepare the cost analysis with breakeven chart
- Finalize the implementation model for action
- Simulate the finalized model with suitable simulation package
- Implement the developed design in real or prototype category.

The end semester examination will be conducted internally in the department with suitable presentation by the student with design and implementation report.

Total no. of Hours: 45

MEE13P010 WAMPAC IN POWER SYSTEM STABILITY 3 2 0 4

OBJECTIVES:

- Understand the concept of PMU and its techniques.
- Capable to estimate frequency during Balanced and Unbalanced conditions.
- Able to develop communication options for PMU.

UNIT I: Introduction to Phasor Measurement Techniques 9 hours

Historical Review- Phasor Representation of Sinusoids- Fourier Series-Fourier Transformation- Sample Data & Aliasing- DFT – Leakage phenomenon – Phasor Estimation of Nominal Frequency input and Off Nominal Frequency input

UNIT II: Frequency Estimation, PMU &PDC 9 hours

Historic Overview- Frequency Estimation from Balanced and Unbalanced 3ø input- Non Linear Frequency estimation- other techniques.

Introduction to PMU – GPS- Hierarchy for Phasor measurement systems- Communication options for PMU-Functional requirement for PMU and PDC's- Transient response of Phasor Measurement units.

UNIT III: Phasor Measurement Application 9 hours

State Estimation-History- Weighted Least Square- Static State Estimation- Bad Data Detection- State Estimation with Phasor Measurements- Linear State Estimation- Calibration- Dynamic Estimation.

UNIT IV: Control & Protection with Phasor Input 9 hours

Introduction to Control- Linear Optimal Control- Linear Optimal Control Applied to Nonlinear Problem-Coordinated Control of Oscillation – Discrete event Control. Introduction to Protection – Differential Protection of Transmission line- Distance Relaying of Multiterminal transmission line- Adaptive Protection- Control of backup Relay Performance- Intelligent Islanding- Supervisory Load Shedding.

UNIT V : WAMPAC – Guardian of Power System 9 hours

Introduction & Scope- WAMPAC Background- Impact on Power System Stability- Interoperability-Experiences of using WAM system worldwide- Real-time monitoring applications-Future protection schemes based on synchronized Phasor measurements- Applications based on synchronized Phasor measurements-Improved state estimation- Phasor Measurement Unit – Testing standards- System Integrity Protection Scheme-Future growth.

Tutorials:15
Total no. of Hours: 60

Reference Books

1. Phadke, A. G. and Thorp, J. S. *Synchronized Phasor measurement and their applications*.
2. Kundur,P. *Power systems stability and control*.
3. Hector J. Altuve Ferrer, and Edmund O. Schweitzer III, (2010) *Modern Solutions for Protection, Control and Monitoring of Electric Power Systems.*
4. Fahd Hashiesh, M. M. Mansour, and Hossam E. Mostafa, (Feb 28, 2011) *Wide Area Monitoring, Protection and Control: The Gateway to Smart Grids.*
5. Zhao yang Dong, Pei Zhang, Jian Ma, and Junhua Zhao, (May 21, 2010) *Emerging Techniques in Power System Analysis.*

MEE13P011 POWER QUALITY AND GRID INTEGRATION 3 0 0 3

OBJECTIVES:

- Understand the importance and causes of transients .
- Understand the sources of transient over-voltages and its causes.
- Understand the effect of harmonics in industrial and commercial loads.

UNIT I: Introduction 9 Hours

Introduction – Characterization of Electric Power Quality: Transients, short duration and long duration voltage variations, Voltage unbalance, waveform distortion, Voltage fluctuations, Power frequency variation, Power acceptability curves – power quality problems: poor load power factor, Non linear and unbalanced loads, DC offset in loads, Notching in load voltage, Disturbance in supply voltage – Power quality standards.

UNIT II : Measurement and Analysis Methods 9 Hours

Voltage, Current, Power and Energy measurements, power factor measurements and definitions, event recorders, Measurement Error – Analysis: Analysis in the periodic steady state, Time domain methods, Frequency domain methods: Laplace, Fourier and Hartley transform – The Walsh Transform – Wavelet Transform.

UNIT III: Analysis and Conventional Mitigation Methods 9 Hours

Analysis of power outages, Analysis of unbalance: Symmetrical components of Phasor quantities, Instantaneous symmetrical components, Instantaneous real and reactive powers, Analysis of distortion: On–line extraction of fundamental sequence components from measured samples – Harmonic indices – Analysis of voltage sag: Detorit Edison sag score, Voltage sag energy, Voltage Sag Lost Energy Index (VSLEI)- Analysis of voltage flicker, Reduced duration and customer impact of outages, Classical load balancing problem: Open loop balancing, Closed loop balancing, current balancing, Harmonic reduction, Voltage sag reduction.

UNIT IV : Power Quality Improvement 9 Hours

Utility-Customer interface –Harmonic filters: passive, Active and hybrid filters –Custom power devices: Network reconfiguring Devices, Load compensation using DSTATCOM, Voltage regulation using DSTATCOM, protecting sensitive loads using DVR, UPQC –control strategies: P-Q theory, Synchronous detection method – Custom power park –Status of application of custom power devices.

UNIT V: Grid Integration and Power Quality 9 Hours

Stand alone and Grid Connected WECS system- Basics of Grid Connection; Characteristics of Wind Generator; State-of-the-art of power Electronics in Wind Energy - Soft-starter, Capacitor bank, Rectifiers and inverters, Frequency converters. Power Converters for WECS; Power Quality Standards in Wind Farms- Reactive power, flicker coefficient, Maximum number of wind turbine switching operations, flicker step factor, Voltage change factor, Harmonic currents.

UNIT VI: Innovative Learning Practices 9 Hours

Case study on power quality issues on grid integration and find solutions for the same.

Total no. of Hours: 45

Text Books

1. Dranetz--BMI; NJATC (2010) *Power Quality Analysis*. 2010 Ed. (Dranetz-BMI and NJATC).
2. Luisa Martinez Muneta, Gregorio Romero Rey, and Teodora Smiljanic, (Nov 23, 2011) *Power Quality Harmonics Analysis and Real Measurements Data*.
3. Antonio Moreno-Muñoz, (Dec 10, 2010) *Power Quality: Mitigation Technologies in a Distributed Environment (Power Systems).*
4. Mohammed Hasan Ali, (Feb 16, 2012) *Wind Energy Systems: Solutions for Power Quality and Stabilization.*

MEE13PL05 PROGRAMMING & SIMULATION LABORATORY – II 0 0 2 1

OBJECTIVES:

- To encourage the student to learn various programming languages like C, C++, FORTRAN, MATLAB etc and apply the same to the Power and Energy sector.
- To have hands on experience on various simulation packages like ETAP, PSCAD, and MATLAB Simulink etc. and apply it to learn the operation of various test cases and gain extensive knowledge.
- The various test cases are chosen from the following subjects:
  - Modern Distribution System Design & Control
  - Application of Optimization Techniques to Power & Energy Systems*
  - Power System Operation & Control
  - Sustainable Power Generation & Utilization
  - Electrical Energy Audit & Conservation *
  - Advanced Smart Grid Design
  - Mechanical Design & Economics of Wind Turbines
  - Mathematical Modeling & Simulation Study on PV System
  - Energy & Climate Change
  - Modeling & Simulation of Solar Energy Conversion System

Total no. of Hours: 45

MEE13PE01 INTRODUCTION TO SMART GRID DESIGN 3 0 0 3

OBJECTIVES:

- Understand smart grid need and communication standards.
- Capable to solve Power System problems using stability analysis tools.
- Familiarity to Microgrid, Communication and Measurement technology.

UNIT I: Smart Grid Architectural Design 9 hours

Introduction-Today's grid Vs smart grid-Computational Intelligence – Power system enhancement-Communication & Standards- Environment & Economy- Stake holder Roles & Function- Performance Measure-Architecture- Functions of Smart grid components

UNIT II:Smart Grid Communication and Measurement Technology 9 hours

Communication & Measurement- Monitoring –PMU – Smart Meter- Measurement Technology- GIS & Google Mapping Tools – MAS Technology – Comparison of Smart Grid & Micro grid.

UNIT III : Performance Analysis Tools for Smart Grid Design 9 hours

Introduction to Load Flow Studies- Challenges to Load Flow In Smart Grid and Weakness of Present Load Flow Method- Load Flow State of the Art: Classical- Extended Formulation and Algorithm for GS, NR, FD DLF Methods - Congestion Management Effect- Load Flow for Smart Grid Design (DSOPF)- Application of DSOPF in Smart Grid- Static Security Assessment & Contingencies- Contingencies and their Classification-Contingencies Study for Smart Grid.

UNIT IV: Stability Analysis Tools for Smart Grid 9 hours

Introduction- Strength and Weakness of existing Voltage Stability Analysis Tools- Voltage Stability Assessments- Techniques- Voltage Stability Indexing- Analysis Techniques for Steady state Voltage Stability Studies- Application and Implementation, planning of Voltage Stability- Optimizing Stability Constraint through Preventive control of Voltage stability- Angle Stability Assessment – State Estimation.

UNIT V: Computational Tools for Smart Grid Design 9 hours

Introduction to Computational Techniques- Decision tools- Optimization Techniques- Classical Optimization methods- Heuristic Optimization-Evolutionary Computational Techniques- Adaptive Dynamic Programming Techniques - Pareto Methods – Hybridizing Optimizing Techniques and Application to Smart Grid-Computational Challenges.

Total no. of Hours: 45

Text Books

1**.** JAMES MOMOH *SMART GRID-Fundamentals of Design and Analysis*.published in John Wiley.IEEE Press.
2. Chowdhury,S.P. Crossley, P. and Chowdhury, S. (Jul 15, 2009) *Micro grids and Active Distribution Networks.*
3. Shin'ya Obara, (Dec 10, 2010) *Fuel Cell Micro-grids (Power Systems)***.**
4. Gloria Phillips-Wren, (Dec 1, 2010) *Advances in Intelligent Decision Technologies.* Proceedings of the Second KES International Symposium IDT 2010.
5. RITWIK MAJUMDER,(Mar 30, 2010) *Micro grid: Stability Analysis and Control: Modeling, Stability Analysis and Control of Micro grid for Improved***.**

MEE13PE02 APPLICATIONS OF MEMS TECHNOLOGY 3 0 0 3

OBJECTIVES:

- Implementing Sensors & Actuators.
- Knowledge to Micromachining.
- Familiar with Polymer & Optical MEMS.

UNIT I: MEMS: Micro-Fabrication, Materials And Electro-Mechanical concept 9 Hours

Overview of micro fabrication – Silicon and other material based fabrication processes –Concepts: Conductivity of semiconductors-Crystal planes and orientation-stress and strain-flexural beam bending analysis-torsional deflections-Intrinsic stress- resonant frequency and quality factor.

UNIT II: Electrostatic Sensors And Actuation 9 Hours

Principle, material, design and fabrication of parallel plate capacitors as electrostatic sensors and actuators-Applications

UNIT III: Thermal Sensing And Actuation 9 Hours

Principle, material, design and fabrication of thermal couples, thermal bimorph sensors, thermal resistor sensors-Applications.

UNIT IV: Piezoelectric Sensing And Actuation 9 Hours

Piezoelectric effect-cantilever piezo electric actuator model-properties of piezoelectric materials-Applications.

UNIT V:Case Studies 9 Hours

Piezoresistive sensors, Magnetic actuation, Micro fluidics applications, Medical applications, Optical MEMS.

Total no. of Hours: 45

Text Books

1. Chang Liu, (2006) *Foundations of MEMS*. Pearson International Edition.
2. Marc Madou, (1997) *Fundamentals of micro fabrication*.CRC Press.
3. Boston, (1998) *Micro machined Transducers Source book*.WCB McGraw Hill.
4. Bao, M.H. *Micromechanical transducers: Pressure sensors, accelerometers and gyroscopes*. Newyork: Elsevier.

MEE13PE03 POWER SYSTEM ECONOMICS 3 0 0 3

OBJECTIVES:

- Familiarity to Power Plant chemistry and treatment of boilers.
- Capable to manage the grid using SCADA.
- Capable to create awareness through energy audit and DSM technology.

UNIT I : POWER PLANT CHEMISTRY & ENVIRONMENTAL 9 Hours

Chemical control and treatment of Boiler feed water, Cooling water treatment, Classification of coal and coal analysis, effect of energy on ecology and concept of green house effect, standards for noise and air pollution , Air pollution due to thermal power station, zero discharge concept, Air Pollution caused by coal and combustion of coal , stack emission, ESP etc.

UNIT II: POWER SYSTEM MANAGEMENT 9 Hours

Load management in power sector, Introduction to power System Planning, Power scenario in India, Load Forecasting, Generation Scheduling and Economic Load dispatch, Grid Management, SCADA and energy Management System, VAR management, Tariff, Introduction to Availability Based Tariff.

UNIT III : ENERGY AUDIT AND DSM 9 Hours

Energy Scenario, Conservation, strategy for reduction of Transmission & Distribution Losses, Capacitors, power factor improvement, Energy Management - Role of Energy Managers, Energy Auditing, Demand Side Management (DSM).

UNIT IV: COMPUTER APPRECIATION 9 Hours

Introduction to personal computers with reference to its operating systems and devices, emerging trends in information technology, Introduction to MS-DOS and Hands on Practice on DOS, Introduction to Microsoft word, excel, power point and Hands on practice on M.S. Office Introduction to AUTOCAD Introduction to internet service, Introduction to Hardware & Networking

UNIT V 9 Hours

I.T initiatives in Electricity Distribution System IT in Distribution Sector. Principles of SCADA & TCMS, Micro Controllers, Intelligent DTRs, Distribution Automation, MBC, CAT, PMRS, TIMS & MIMS, GIS & GPS, Web Enabled Services. Role of computers in Management Information System,**ONSITE VISITS: Depending on the need, there shall be regular onsite visits to the Power Plant throughout the Semester on various topics taught.

Total no. of Hours: 45

References

1. *Power systems reliability.* IEEE gold book.
2. Hessler Peter, G. *Power Plant Construction Management* .
3. Hitt Michael, *Management Of Strategy*.
4. David, I. *Project management Cleland,*
5. Clarke, *Environmental Management: A Guide For Facility Managers (Upword Publishing).*

MEE13PE05 SOLID STATE POWER CONVERTERS 3 0 0 3

OBJECTIVES:

- Familiarity to Power Electronic Devices and its characteristics.
- Capable of designing converters.
- Familiarization to inverters, choppers and Industrial drives.

UNIT I: Characteristics of Thyristors **9 Hours**

Characteristics of Thyristors – Power transistors, GTO's, IGBTs and Power MOSFETs, its ratings and triggering circuits, Protection against over voltage and over currents, cooling of semiconductor devices.

UNIT II: AC to DC Conversion **9 Hours**

Line commutated converters and AC Chopper – Single and three phase converters – Dual converters – Application of Dual converters.

UNIT III: DC To DC Conversion **9 Hours**

Choppers – different types and its analysis.

UNIT IV: AC to AC CONVERSION **9 Hours**

Basic principles of cycloconverter operation - single phase and three phase cycloconverter.

UNIT V: DC to AC CONVERSION **9 Hours**

Introduction to force commutated schemes for Thyristors – Series parallel capacitor commutated Thyristor inverter – Single phase and polyphase inverters using solid state devices.

Total no. of Hours: 45

Text Books

1. Vedam Subrahmanyam, (1996) *Power Electronics*. New Delhi: New Age International Pvt. Ltd.
2. Rashid, M.H. (1995) *Power Electronics Circuits, Devices and Applications*. 2nd Ed. New Delhi: New Age International Pvt. Ltd.
3. Sen, P.C.(1998) *Modern Power Electronics*.1st Ed. New Delhi: Wheeler Publishing Co.

References

1. Ned Mohan, Udeland & Robbins,(1995) *Power Electronics: Converter, Application & Design*. John Wiley & Sons Inc. New York:
2. Dubey, G.K. Doradla, S.R. Joshi, A. R. Shinha, M.K.(1996) *Thyristorised Power Controllers*. New Delhi: New Age International Pvt. Ltd.

MEE13PE04 ANN AND APPLICATION IN MODERN ELECTRIC POWER SYSTEM 2 0 2 3

OBJECTIVES:

- Capable to forecast Electricity pricing with propagation network.
- Ability to apply applications of ANN.
- Capable to detect fault and diagnose in rotating machines.

UNIT I: Power System Stabilizer 9 hours
Introduction-Conventional PSS- Tuning of parameter -back-propagation –Application of ANN with PSS for DFIG.

UNIT II: State Estimation 9 hours
Introduction-different modules of state estimator ANN models- Observability analysis using back propagation network, counter propagation network models. Application of ANN to WLSE method

UNIT III: Forecasting 9 hours
Introduction- Load forecasting-types using ANN. Electricity price forecasting with back propagation-wind speed, direction, power forecasting using multi layer approach. Application of ANN to Electric Load Forecasting**.**

UNIT IV: Fault Deduction and Diagnosis 9 hours
Introduction –Rotating machines fault-transformer fault-transmission fault-Relay coordination-speed control of AC and DC machines using ANN. Application of ANN to identify different types of Machines Faults.

UNIT V: ANN for security Assessment 9 hours
Introduction -static security problems-challenges-characteristics of supervised and unsupervised learning-Architecture-training set selection –Interpretation of the weight. Application of ANN to predetermine the Contingency Status of Power system.

Total no. of Hours: 45

Reference books

1. Kothari, D.P. Dhillon, J. S.(2012) *Power System Optimization.*
2. Rajasekaran, S.and Pai, G.A.V.(2003) *Neural Networks, Fuzzy Logic & Genetic Algorithms*. New Delhi: PHI.
3. Warwick, K. Arthur Ekwue, Raj Aggarwal, (1999) *Artificial Intelligence Techniques in Power System*. IEEE.

MEE13PE06 FUZZY SYSTEM AND APPLICATION IN MODERN ELECTRIC POWER SYSTEM 2 0 2 3

OBJECTIVES:

- Understand the mathematical adaptation of fuzzy systems.
- Capable to forecast load forecasting in Power System .
- Capable to detect and diagnose in rotating machines.

UNIT I: Fuzzy Logic and Its Controllers 9 hours
Fuzzy set - Crisp set – vagueness – uncertainty and imprecision – fuzzy set –fuzzy operation- properties – crisp versus fuzzy relations – fuzzy relations –fuzzy Cartesian product and composition – composition of fuzzy relations-Fuzzy to crisp conversion –structure of fuzzy logic controller – database – rule base – Inference engine.

UNIT II: Fuzzy Application to power system Operation 9 hours
Overview-Load Forecasting-Economic Dispatch-Unit commitment using Fuzzy concepts

UNIT III: Control of Electrical Energy Systems 9 hours
Automatic Generation Control (AGC) and Reactive Power control using: classical, optimal-Fuzzy control techniques. Energy Storage Devices to Power System Control using Fuzzy concepts

UNIT IV: Power system Stability Control 9 hours
Introduction-Types-Voltage Stability Control-Angle Stability Control-stability assessment using Fuzzy concepts.

UNIT V: Fault Deduction and Diagnosis 9 hours
Introduction –Transmission line fault Diagnosis-Rotating machines fault-transformer fault-transmission fault-using Fuzzy concept. Application of fuzzy logic to identify different types of Machines Faults.

Total no of hours: 45

Reference books

1. Timothy J. Ross,(1997) *Fuzzy Logic with Engineering Applications*. McGraw Hill International Edition.
2. Hawary, *E.L.(1998)Electric Power Applications of Fuzzy Systems*. IEEE Press.
3. Klir, G. J. and Yuan, B. *Fuzzy Sets and Fuzzy Logic*.
4. Loi Lei Lai, *Intelligent System Application in Power Engineering* .

MEE13PE07 **DIGITAL SIGNAL PROCESSING** **3 0 0 3**

OBJECTIVES:

- Understand the fundamentals of signals & systems.
- Capable to solve problems using Z- transform.
- Capable to Design filters using transformation techniques.

UNIT I **9 Hours**

Review of Discrete – Time Signal & System representation in Z – Transform domain – Inverse Z – Transform – Properties – System characterization in Z – domain -- Equivalence between Fourier Transform and the Z-Transform of a Discrete signal.

UNIT II **9 Hours**

Sampling in Fourier domain - Discrete Fourier Transform and its properties – Linear filtering using DFT – Resolution of DFT - FFT Algorithm – Radix-2 FFT Algorithm - DIT & DIF Structures - Higher Radix schemes.

UNIT III **9 Hours**

Classification of filter design - Design of IIR filters – Bilinear transformation technique – Impulse invariance method – Step invariance method.

UNIT IV **9 Hours**

FIR filter design – Fourier series method - Window function technique - Finite Word Length Effects.

UNIT V **9 Hours**

Introduction to Multirate Signal Processing - Decimation - Interpolation - Case Studies on Speech Coding, Transform Coding – DSP based measurement system.

Total no. of Hours: 45

Text Books

1. Ludemann, L. C.(1997) *Fundamentals of Digital Signal Processing*.Harper and Row publications.
2. Antoniou, A.(1999) *Digital Filters – Analysis and Design*. Tata Mc-Graw Hill.
3. Oppenheim, and Schaffer,(1999) *Discrete time Signal processing*.PHI.
4. Vaidhyanathan, P.P. (1995) *Multi rate systems and filter banks.*PHI.

MEE13PE08 POWER ELECTRONICS APPLICATIONS IN POWER SYSTEMS 3 0 0 3

OBJECTIVES:

- Capable to regulate and control voltage using Thyristors.
- Familiarity to converters, UPS and frequency devices.
- Capable to improve power factor of converters

UNIT – I STATIC VAR CONTROL 9 Hours

Principles of load compensation – voltage regulation and power factor correction – unsymmetrical loads – phase balancing and power factor Corrections – static compensation properties – Thyristors controlled Reactor (TCR), Thyristors switched capacitor (TSC), saturable core reactor (control strategies)

UNIT – II POWER FACTOR IMPROVEMENT AND HARMONIC CONTROL CONVERTERS 9 Hours

Poor power factor – forced commutation techniques for power factor improvement – methods of improving the power factor of the line commutated converters – use of high frequency devices.

UNIT – III VOLTAGE CONTROL 9 Hours

Static Tap changer for voltage control – Static Tap changing using Thyristors -comparison of different schemes Generator excitation – schemes, comparison.

UNIT – IV UNINTERRUPTED POWER SUPPLY 9 Hours

Parallel redundant & non-redundant UPS, UPS using frequency devices, resonant converters and switched mode power supplies

UNIT – V UNIFIED POWER FLOW CONTROL 9 Hours

Implementation of power flow control using conventional Thyristors, implementation of Unified power flow controller.

Total no. of Hours: 45

Text Books

1. Miller, T.J.E. (1982) *Reactive Power control in Electric Systems*. New York: Wiley Interscience.

References

1. Gyugyi, L.(July 1994) *Unified Power Flow Control Concept for Flexible AC Transmission*. Vol. 139. IEEE proceedings.

MEE13PE09 **SYSTEM THEORY** **3 0 0 3**

OBJECTIVES:

- Capable to solve the problems related to linear and non-linear system.
- Understand the concept of Z domain transformation in digital control system.
- Capable to solve LTI system.

UNIT I **9 Hours**

State space modeling of physical systems –determining of STM – controllability and Observability of time invariant linear system

UNIT II **9 Hours**

Different techniques of line arising in non-linear systems – Describing functions for various types of non-linearity's – describing function analysis of non linear control systems

UNIT III **9 Hours**

Method of constructing phase – trajectories- phase plane analysis of linear and non-linear systems – Bang-bang system

UNIT IV **9 Hours**

Different methods of constructing Lyapunov's functions for linear and non-linear continuous systems – stability analysis

UNIT V **9 Hours**

Pole placement technique by state feedback for linear SISO time, invariant system – Theory of high-gain feedback-advantages – Pole placement technique along with high-gain feedback control.

Total no. of Hours: 45

Text Books

1. Gopal, M. (1995) *Modern Control Systems Theory*. Wiley Eastern Ltd.
2. Ogata, K. (2003) *Modern Control Engineering*.4th Ed. Prentice Hall of India.
3. Kuo, B.C. (1999) *Automatic Control Systems*. Prentice Hall of India.

MEE13PE10 INTELLIGENT OPTIMIZATION TECHNIQUES AND APPLICATION IN MODERN ELECTRIC POWER SYSTEM 2 0 2 3

OBJECTIVES:

- Familiarity to evolutionary algorithm.
- Capable to solve Power System problem using optimization techniques.
- Capable to develop programming with suitable software.

UNIT I Evolutionary Algorithm 12 hours

Introduction to Computational Intelligence – Genetic Algorithms – Initiation – Selection - Crossover - Mutation – Control Parameters – Genetic Algorithm Variants – Differential Evolution - Basic Differential Evolution – Basics of Cultural Algorithm.

UNIT-II: Computational Swarm Intelligence 12 Hours

Particle Swarm Optimization: Basic Particle Swarm Optimization -Global Best PSO-Local Best PSO - Ant colony Algorithms: Ant Colony Optimization -Foraging Behavior of Ants-Simple Ant Colony Optimization.

UNIT III: Application to Modern Power System 21 Hours

Study of Power System Optimization Techniques like Optimal Capacitor Placement, Optimal Meter Placement, Optimal Location of DG, Power System Stabilizers etc.

The students has to develop the suitable code with suitable software to apply the Intelligent Optimization Techniques in Unit I and II to the Application of Power System in Unit III.

Total no. of Hours: 45

Text Books

1. Andries P. Engel brecht, *Computational intelligence*, university of Pretoria-South Africa:

References

1. Singiresu s. Rao, *Engineering optimization*. West Lafayette Indiana:

MEE13PE11 MATHEMATICAL MODELING AND SIMULATION STUDY ON PV SYSTEM 3 0 0 3

OBJECTIVES:

- Familiarity to Photovoltaic system design and optimization.
- Capable to analyze performance parameters.
- Capable to do simulation of PV system.

UNIT-I 9 Hours

Solar Photovoltaic System Design- Solar cell array system analysis and performance prediction; Shadow analysis: Reliability; Solar cell array design concepts; PV system design; Design process and optimization; Detailed array design; Storage autonomy; Voltage regulation; Maximum tracking; Use of computers in array design; Quick sizing method; Array protection and trouble shooting.

UNIT-II 9 Hours

Concentrating Collector Designs -Classification, design and performance parameters; Tracking systems; Compound parabolic concentrators; Parabolic trough concentrators; Concentrators with point focus; Heliostats; Comparison of various designs: Central receiver systems, parabolic trough systems; Solar power plant; Solar furnaces

UNIT- III 9 Hours

Performances of solar collectors -ASHRAE code; Modeling of solar thermal system components and simulation; Design and sizing of solar heating systems: f – chart method and utilizability methods of solar thermal system evaluation; Development of computer package for solar heating and cooling applications.

UNIT –IV 9 Hours

Simulation of PV system- analysis using equation and truth table, steady state analysis and state space analysis for the PV system**, solar passive architecture -** Thermal comfort - heat transmission in buildings- bioclimatic classification – passive heating concepts: direct heat gain - indirect heat gain - isolated gain and sunspaces - passive cooling concepts: evaporative cooling - radioactive cooling - application of wind, water and earth for cooling; shading - paints and cavity walls for cooling - roof radiation traps - earth air-tunnel. – Energy efficient landscape design - thermal comfort – concept of solar temperature and its significance - calculation of instantaneous heat gain through building envelope.

UNIT – V 9 Hours

Applications of solar thermal technology- Principle of working, types - design and operation of solar heating and cooling systems - solar water heaters – thermal storage systems – solar still – solar cooker – domestic, community – solar pond – solar drying

Total no. of Hours:45

Text Books

1. Luis Chastener, and Santiago Silvestre, (Dec 30, 2002) *Modeling Photovoltaic Systems Using P Spice.*
2. Maria Carmela Di Piazza, and Gianpaolo Vitale, (Oct 16, 2012) *Photovoltaic Sources: Modeling and Emulation (Green Energy and Technology).*
3. Augustin McEvoy, Tom Markvart, Luis Chastener, and Markvart, T. (Nov 13, 2003) *Practical Handbook of Photo voltaic: Fundamentals and Applications*.
4. Winter,C.J. Rudolf L. Sizmann, and Lorin L. Vant-Hull, (Oct 1, 2011) *Solar Power Plants: Fundamentals, Technology, Systems, Economics.*

MEE13PE12 ADVANCED SMART GRID DESIGN 3 0 0 3

OBJECTIVES:

- Capable to design various levels of smart grid.
- Capable to develop cyber security standards in smart grid.
- Capable to integrate renewable energy resources to smart grid**.**

UNIT I: Pathway For Designing Smart Grid 9 hours

Introduction- Barrier & Solution to Smart Grid Development- Solution pathway for Design of Smart Grid using Advanced Optimization and control Techniques for selection Functions- General level Automation- Bulk Power System Automation of Smart Grid- Distribution System Automation Requirement of Power Grid- End User-Appliance level of the Smart Grid- Application for Adaptive Control & Optimization.

UNIT II: Renewable Energy & Storage 9 hours

Renewable Energy resources- Sustainable Energy options for Smart Grid- Penetration & Variability Issues Associated with Sustainable Energy Technology- Demand Response Issues- Electric Vehicle and Plug In Hybrids- PHEV Technology- Environmental Implication- Storage Technology- Tax Credit.

UNIT III: Interoperability, Standards & Cyber Security 9 hours

Introduction- Interoperability-Standards- Smart Grid Cyber Security- Cyber Security & Possible Operation for Improving Methodology for other user.

UNIT IV: Fast Forward To Smart Grid 9 hours

Smart Grid Emergence- Rationale for an Advanced Smart Grid- Smart Convergence- Smart Grid Enterprise Architecture- Envisioning & Designing the Energy Internet-Today's Smart Grid- Advanced Smart Grid Complexities-Grid Operation- Market Operation- Revolutionary Smart Grid Tools- Smart Grid Architecture Frame (SGAF)- Smart Grid Optimization Engine(SGOE)- From Static to Dynamic Grid Operations – Grid Journey- NFTE & FE.

UNIT V:Research, Education & Training For The Smart Grid 9 hours

Introduction- Research Areas for Smart Grid Development- Research Activities in Smart Grid

Total no. of hours: 45

Text Books

1. JAMES MOMOH, *SMART GRID-Fundamentals of Design and Analysis.* published in John Wiley. IEEE Press.
2. Andres Carallo, and John Cooper, *The Advanced Smart Grid –Edge Power Driving Sustainability*. ISBN_13:978-1-60802- 127-2.

References

1. Stuart Borlase, (Jan 1, 2012) *Smart Grids: Infrastructure, Technology and Solutions (Electric Power and Energy Engineering).*
2. Tony Flick, and Justin Morehouse, (Oct 7, 2010) *Securing the Smart Grid: Next Generation Power Grid Security.*

MEE13PE13 DYNAMIC MODELING AND CONTROL OF WIND TURBINES 3 0 0 3

OBJECTIVES:

- Understand the concepts of Power Electronic Devices for wind turbine.
- Capable to design modeling of wind turbines.
- Capable to design the mechanical equations for Induction Machines.

UNIT I: GENERATORS & POWER ELECTRONICS FOR WIND TURBINES 9 Hours

Introduction – State of the art technologies – Overview of Wind Turbine Topologies – Power Control Concepts – State of the art Generators – State of the art Power Electronics – Generator Concepts – Power Electronic Concepts – Power Electronic Solutions in Wind Farms.

UNIT II: INTRODUCTION TO THE MODELING OF WIND TURBINES 9Hours

Introduction - Basic Considerations regarding Modeling and Simulations - Overview of Aerodynamic Modeling - Basic description of the turbine rotor - Different representations of the turbine rotor - Basic Modeling Block - Description of Wind Turbines - Aerodynamic system - Mechanical system - Generator drive concepts - Pitch servo Main control system - Protection systems and relays - Per Unit Systems and Data for the Mechanical System - Different Types of Simulation and Requirements for Accuracy - Simulation work and required modeling accuracy Different types of simulation

UNIT III: REDUCED-ORDER MODELING OF WIND TURBINES 9 Hours

Introduction - Power System Dynamics Simulation - Current Wind Turbine Types - Modeling Assumptions - Model of a Constant-speed Wind Turbine - Model structure - Wind speed model - Rotor model - Shaft model - Generator model - Model of a Wind Turbine with a Doubly fed Induction Generator - Model structure - Rotor model - Generator model - Converter model - Protection system model - Rotor speed controller model - Pitch angle controller model - Terminal voltage controller model - Model of a Direct drive Wind Turbine - Generator model - Voltage controller model - Model Validation - Measured and simulated model response - Comparison of measurements and simulations.

UNIT IV: HIGH-ORDER MODELS OF DOUBLY-FED INDUCTION GENERATORS 9 Hours

Introduction - Advantages of Using a Doubly-fed Induction Generator - The Components of a Doubly-fed Induction Generator - Machine Equations - The vector method - Notation of quantities - Voltage equations of the machine - Flux equations of the machine - Mechanical equations of the machine - Mechanical equations of the wind turbine - Voltage Source Converter - Sequencer - Simulation of the Doubly-fed Induction Generator - Reducing the Order of the Doubly-fed Induction Generator.

UNIT V: FULL-SCALE VERIFICATION OF DYNAMIC WIND TURBINE MODELS 9 Hours

Introduction - Background - Process of validation - Partial Validation - Induction generator model - Shaft system model - Aerodynamic rotor model - Summary of partial validation - Full-scale Validation - Experiment outline - Measured behavior - Modeling case - Model validation - Discrepancies between model and measurements.

Total no. of hours: 45

Text Books

1. Thomas Ackerman ,*Wind Power in Power Systems*.John Wiley & Sons Ltd.

References

1. Olimpo Anaya-Lara, Nick Jenkins, Janaka Ekanayake, and Pill Cartwright, (Aug 31, 2009) *Wind Energy Generation: Modeling and Control*.
2. (Jul 21, 2012) *Dynamics Modeling and Loads Analysis of an Offshore Floating Wind Turbine*. National Renewable Energy Laboratory (NR).
3. Loi Lei Lai, and Tze Fun Chan, (Nov 28, 2007) *Distributed Generation: Induction and Permanent Magnet Generators.*
4. Thomas Ackermann, (Mar 28, 2005) *Wind Power in Power Systems.*

MEE13PE14 MICRO CONTROLLER BASED SYSTEM DESIGN 3 0 0 3

OBJECTIVES:

- Capable to program the Assembly language in Microcontroller.
- Interfacing of peripheral devices using PIC Microcontroller.
- Capable to develop the programs using MP-LAB.

UNIT I : **9 Hours**

8051 ARCHITECTURE Basic organization – 8051 CPU structure – Register file – Interrupts – Timers – Port circuits –Instruction set – Timing diagram – Addressing modes – Simple Program and Applications.

UNIT II: **9 Hours**

8051 PROGRAMMING Assembly language programming – Arithmetic Instructions – Logical Instructions – Single bit Instructions – Timer Counter Programming – Serial Communication Programming Interrupt Programming – RTOS for 8051 – RTOS Lite – Fullerton –Task creation and run – LCD digital clock/thermometer using Fullerton

UNIT III: **9 Hours**

PIC MICROCONTROLLER Architecture – memory organization – addressing modes – instruction set – PIC programming in Assembly & C –I/O port, Data Conversion, RAM & ROM Allocation, Timer programming, MP-LAB.

UNIT IV: **9 Hours**

PERIPHERAL OF PIC MICROCONTROLLER Timers – Interrupts I/O ports- I2C bus-A/D converter-UART-CCP modules -ADC, DAC and Sensor Interfacing –Flash and EEPROM memories.

UNIT V : **9 Hours**

SYSTEM DESIGN – CASE STUDY Interfacing LCD Display – Keypad Interfacing - Generation of Gate signals for converters and Inverters - Motor Control – Controlling AC appliances –Measurement of frequency – Stand alone Data Acquisition System.

Total no. of hours: 45

Text Books

1. John B.Peatman, (1999) *Design with Micro controllers*. Singapore: McGraw Hill international Limited.
2. Michael Slater,(1995) *Microprocessor based designs A comprehensive guide to effective Hardware design*. New Jersey: Prentice Hall.
3. Ayala Kenneth,(2000) *The 8051 Microcontroller*.Upper Saddle River.New Jersey: Prentice Hall.
4. Muhammad Ali Mazidi, Janice Gillispie Mazidi,(2004) *The 8051 Microcontroller and Embedded systems.*Person Education.
5. Muhammad Ali Mazidi, Rolin D. Mckinlay, Danny Causey,(2008) *PIC Microcontroller and Embedded Systems using Assembly and C for PIC18*.Pearson Education.
6. John Iovine, (2000) *PIC Microcontroller Project Book*. McGraw Hill.
7. Myke Predko, *Programming and customizing the 8051 microcontroller*. Tata McGraw Hill.

MEE13PE15 **ELECTRICAL DRIVES AND CONTROL** **3 0 0 3**

OBJECTIVES:

- Different types of Drives.
- Various control Schemes for the Drives.
- Knowledge to the Electrical Machines.

UNIT – I CONVERTER FED DC DRIVES **9 Hours**

Single phase drives – Three phase drives – half controlled and fully controlled drives – continuous and discontinuous operation – features of DC motor operations on phase controlled converters – evaluations of DC drive performance – commutation of the motors – Torque speed curve, power factor, optional free wheeling – CLC and TRC of DC motors on converter sources.

UNIT – II CHOPPER FED DRIVES **9 Hours**

CLC and TRC strategies for controlling DC motor Speed – closed loop control – two quadrant and four quadrant operation – a comparison of chopper fed and converter fed drives.

UNIT – III INDUCTION MOTOR DRIVES **9 Hours**

Speed control by stator frequency variation –operation of induction motor on variable frequency sources – operation of IM on non sinusoidal waveforms – constant flux operation current fed operation – Introduction to vector control – cycloconverter drives –features.

UNIT – IV ROTOR RESISTANCE CONTROL & SLIP RECOVERY SCHEME **9 Hours**

Speed control by additional resistance in the rotor circuit – speed torque characteristics – chopper controlled resistance in the rotor circuit – speed torque characteristics with time ratio of chopper as a parameter – CLC, TRC strategies – braking – combined stator voltage control and rotor resistance control – closed loop control. Slip energy recovery schemes: Sub-synchronous converter cascade in the rotor circuit – Principle of operation – Torque speed curves with firing angle of the inverter as a parameter – Slip and torque equations – Emulating DC motor characteristics – Specific features and criteria favoring the slip energy recovery scheme.

UNIT – V SYNCHRONOUS MOTOR DRIVES **9 Hours**

Variable frequency operation of synchronous motors operation of synchronous motor on non-sinusoidal voltages – methods of providing variable – separate and self control concept of S.V control. Load commutation – Advantage and disadvantage – VSI and CSI drives - CLM operation – DC motor like control – torque angle control - Principle of vector control.

Total no. of hours: 45

Text Books

1. Subrahmanyam Vedam,(1994) *Electric Drives, Concepts and Applications*. New Delhi: TMH.
2. Subrahmanyam Vedam, (1988) *Thyristors Control of Electrical Drives*.Tata McGraw Hill.
3. Dubey, G.K.(1989) *Power Semiconductor Controlled Drives*.PH International.NJ.

References

1. Sen P.C.(1981) *Thyristor Controlled DC drives*.John Wiley. NY.
2. Bose, B.K. *Power Electronics and AC Drives*. Prentice Hall Enlewood Cliffs.NJ 07632.
3. Murphy, J.M.D. Turnbull, (1988) *Thyristors Control of AC Motors*. Pergamon Press Oxford.

MEE13PE16 MICROGRID IN MODERN POWER SYSTEMS 3 0 0 3

OBJECTIVES:

- Familiarity to Micro grid concepts
- Development of Micro grid.

UNIT I- Distributed Generation And Micro grid Concept 9 hours

Distributed Generation-Active Distribution Network-Concept of Microgrid- Configuration-Interconnection of Microgrid-Technical and economical Advantage of Microgrid-Challenges and disadvantages of Microgrid Development- Management and Operational Issues of a Microgrid- Dynamic Interactions of Microgrid with main grid- Basics of Distributed Energy Resources.

UNIT II: Impacts Of Micro grid and Active Distribution Management System 9 hours

Introduction- Impact of Heat Utilization- Impact on process Optimization-Impact on market-Impact on environment-Impact on Distribution System-Impact on communication standards and protocols-Network Management needs of Microgrid—Micro source Controller- Central Controller.

UNIT III- Protection Issues On Microgrid And Power Electronic Interface 9 hours

An Introduction-Islanding: Separation from Utility-Major Protection issues of standalone Microgrid-Power Electronic Interface Introduction- Background- Power converter trends- Bricks-Buses-Software (BBS) framework- BBS Issues.

UNIT IV: SCADA and Active Distribution Networks And Impact Of DG Integration On Power Quality & Reliability 9 hours

Introduction- Existing DNO SCADA systems-Control of DNO SCADA systems- SCADA in Microgrid - Human–machine interface (HMI)- Hardware components -Communication trends in SCADA-Distributed control system (DCS)- Sub-station communication standardization - SCADA communication and control architecture - Communication devices- Observations on SCADA and communication - Introduction to Power quality Disturbances-Power quality sensitive customers- Existing power quality improvement technologies- Impact of DG integration - Issues of premium power in DG integration.

UNIT V- Micro grid Economics and Market Participation 9 hours

Introduction-Main issues of Microgrid economics-Micro grids and traditional power system economics- Joint optimization of heat and electric power supply- Emerging economic issues in Micro grids-Economic issues between Microgrid and bulk power systems-Microgrid economics-Micro generation-Future developments of Microgrid economics.Restructuring models - Independent System Operator (ISO) - Power exchange (PX) - Market clearing price (MCP) -Day-ahead and hour-ahead markets - Elastic and inelastic markets- Market power Stranded costs - Transmission pricing - Congestion management -Role of Microgrid in power market competition.

UNITVI: Innovative Learning Practices: 9 hours

Case study on Microgrid economics, economic issues between micro grids and bulk power.

Total no. of hours:45

Text Books

1. Hector J. Altuve Ferrer, and Edmund O. Schweitzer III, (2010) *Modern Solutions for Protection, Control and Monitoring of Electric Power Systems.*
2. Fahd Hashiesh, M. M. Mansour, and Hossam E. Mostafa, (Feb 28, 2011) Wide Area Monitoring, Protection and Control: The Gateway to Smart Grids.
3. Zhaoyang Dong, Pei Zhang, Jian Ma, and Junhua Zhao, (May 21, 2010) *Emerging Techniques in Power System Analysis.*