Approved Syllabus for

Master of Technology

in

ELECTRICAL POWER SYSTEMS

in

BOARD OF STUDIES MEETING HELD

on

25th & 26th April, 2015

DEPARTMENT OF ELECTRICAL ENGINEERING

COLLEGE OF ENGINEERING (AUTONOMOUS), ANANTHAPURAMU

JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY ANANTAPUR

INFORMATION ON THE COURSE

1.0 Details about the Course.

1.1 Name of the Course (s)

Name of Degree/ Diploma	Name of Specialization	Intake (Full/Part time)	Year of Starting	Duration (Total)	Name of Degree & Branch eligible for admission
M. Tech.	Electrical Power Systems	25+ 7 Sponsored (Full Time) 32 (Part Time)	2009-10	2 Years	B. Tech/B. E in EEE

1.2 Course Structure and Scheme of Evaluation (Semester-wise)

Name of the Subject	Hrs/Week L	T	P	C
I-SEMESTER				
1. 15D21101 Advanced Power System Protection	4	-	-	4
2. 15D21102 Power System Stability & Control	4	-	-	4
3. 15D21103 Power System Wide Area Monitoring & Control	4	-	-	4
4. 15D21104 Power Quality Issues & Improvement	4	-	-	4
5. Elective-I	4	-	-	4
6. Elective-II	4	-	-	4
7.15D21107 Machines & Power Systems Lab	-	-	4	2
Electives:				
1.15D24101 System Reliability Concepts				
2. 15D21105 FACTS & HVDC Transmission Systems				
3.15D22101 Modern Control Theory				
4. 15D21106 Distributed Generation & Micro grid				
II-SEMESTER				
1. 15D21201 Power System Reliability	4	-	-	4
2. 15D21202 Smart Grid Design & Analysis	4	-	-	4
3. 15D21203 Restructured Power Systems	4	-	-	4
4. 15D22203 Intelligent Algorithms	4	-	-	4
5. Elective-III	4	-	-	4
6. Elective-IV	4	-	-	4
7. 15D54201 Research Methodology (Audit Course)	2	-	-	0
8. 15D21209 Power System Simulation Lab	-	-	4	2
Electives				
1. 15D21205 Reactive Power Compensation & Management				
2. 15D21206 EHVAC Transmission Systems				
3. 15D21207 Solar Energy Conversion Systems				
4. 15D21208 Wind Energy Conversion Systems				
III SEMESTER				
1. 15D21301 Seminar - I	-	-	4	2
IV SEMESTER				
1. 15D21401 Seminar – II	-	-	4	2
III & IV SEMESTER				
1. 15D21302 Project Work	-	-	-	44

15D21101 ADVANCED POWER SYSTEM PROTECTION

UNIT-I: STATIC RELAYS

Advantages of static relays - Basic construction of static relays – Level detectors – Replica impedance-mixing circuits-general equation for two input phase and amplitude comparators – Duality between amplitude and phase comparator.

UNIT-II: COMPARATORS

Amplitude: Circulating current type and opposed voltage type rectifier bridge comparators – Direct and Instantaneous comparators. Phase Comparators: Coincidence circuit type block spike phase comparator, techniques to measure the period of coincidence – Integrating type – Rectifier and vector product type phase comparators. Multi –Input Comparators: Conic section characteristics – Three input amplitude comparator – Hybrid comparator – Switched distance schemes – Polyphase distance schemes-Phase fault scheme – Three phase scheme – combined and ground fault scheme.

UNIT-III: STATIC OVER CURRENT, DIFFERENTIAL AND DISTANCE RELAYS

Introduction-Instantaneous over current relay – Time over current relays - Basic principles-Definite time and Inverse definite time over current relays. Analysis of static differential relays – static relay schemes – Dual bias transformer differential protection – Harmonic restraint relay. Static Relays: Static impedance – reactance - MHO and angle impedance relay sampling comparator – realization of reactance and MHO relay using a sampling comparator.

UNIT-IV: POWER SWINGS

Effect of power swings on the performance of Distance relays - Power swing analysis – Principle of out of step tripping and blocking relays – Effect of line length and source impedance on distance relays.

UNIT-V: NUMERICAL RELAYS

Over current relays – Impedance relays – Directional relay – Reactance relay (Block diagram and flow chart approach only). Generalized mathematical expression for distance relays - Measurement of resistance and reactance – MHO and offset MHO relays – Realization of MHO characteristics – Realization of Offset MHO characteristics (Block diagram and flow chart approach only) Basic principle of Digital computer relaying.

TEXT BOOKS:

1. T.S.Madhava Rao, Power system Protection static relay, Tata McGraw Hill, 2nd Edition, 1989.

REFERENCE BOOKS:

1. Badri Ram and D.N.Vishwakarma, Power system Protection and Switchgear, Tata McGraw Hill, First Edition -1995.
2. S H Horowitz and A G Phadke, Power System Relaying, 3rd edition, John Wiley & Sons, 2008.

15D21102 POWER SYSTEM STABILITY & CONTROL

UNIT-I: THE ELEMENTARY MATHEMATICAL MODEL AND SYSTEM RESPONSE TO SMALL DISTURBANCES

A Classical model of one machine connected to an infinite bus – Classical model of multimachine system – Problems – Effect of the excitation system on Transient stability. The unregulated synchronous Machine – Effect of small changes of speed – Modes of oscillation of an unregulated multimachine system – Regulated synchronous machine – Voltage regulator with one time lag – Governor with one time lag – Problems.

UNIT-II: DYNAMIC STABILITY

Concept of Dynamic stability – State space model of one machine system connected to infinite bus – Effect of excitation on Dynamic stability – Examination of dynamic stability by Routh's criterion.

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 aspect using Eigen value approach.

UNIT-IV: EXCITATION SYSTEMS

Excitation system response – Non-continuously regulated systems – 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 system: Rotating rectifier system, Type-3 system: Static with terminal potential and current supplies - Type –4 system: Non – continuous acting - Block diagram representation – State space modeling equations of these types.

UNIT-V: STABILITY ANALYSIS

Review of Lyapunov's stability theorems of non-liner systems using energy concept – Method based on first concept – Method based on first integrals – Quadratic forms – Variable gradient method – Zubov's method – Popov's method, Lyapunov function for single machine connected to infinite bus. What is voltage stability – Factors affecting voltage instability and collapse – Comparison of Angle and voltage stability – Analysis of voltage instability and collapse – Integrated analysis of voltage and Angle stability – Control of voltage instability

TEXT BOOKS:

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

REFERENCE BOOKS:

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

15D21103 POWER SYSTEM WIDE AREA MONITORING AND CONTROL

UNIT - I : COMPUTER CONTROL OF POWER SYSTEMS

Need for real - time and computer control of power systems, operating states of a power system - 3 state & 5 states operation of power system - Supervisory Control and Data Acquisition system (SCADA), implementation considerations, energy control centers. WAMS (Wide Area Measurement system): Architecture, Components of WAMS, GUI (Graphical User Interface), Applications: Voltage Stability Assessment, Frequency stability Assessment, Power Oscillation Assessment, Communication needs of WAMS, WAMPAC (Wide Area Monitoring Protection & Control), RAS (Remedial Action Scheme). Standards: IEEE 1344, IEEE C37.118 (2005), IEEE Standard C37.111-1999 (COMTRADE), IEC61850 GOOSE.

UNIT - II : STATE ESTIMATION IN POWER SYSTEMS

Introduction, Power system state estimation, Maximum likelihood, Weighted least Square estimation, Weighted least square estimation. State Estimation of AC Networks: Types of measurements, Linear weighted least square (WLS) estimation theory, DC Load flow based WLS state estimation, Linearised model of WLS state estimation of Non - Linear AC power systems, sequential and non - Sequential methods to process measurements, Typical results of state estimation on an Ac network.

UNIT - III : TYPES OF STATE ESTIMATION AND NETWORK OBSERVABILITY

State estimation by conventional WLS (normal equations), Orthogonal decomposition and its algorithm, hybrid method. Tracking of state estimation, Dynamic state estimation, Detection and identification of bad measurements, estimation of quantities not being measured. Network observability and pseudo-measurements, observability by graphical technique and triangularisation approach, Optimal meter placement, Application of power system state estimation.

UNIT - IV : POWER SYSTEM SECURITY ANALYSIS

Concept of security, Security analysis and monitoring, factors affecting power system security, detection of network problems, an overview of security analysis. Contingency analysis for generator and line outages by Interactive Linear Power Flow (ILPF) method, Fast decoupled inverse Lemma based approach, network sensitivity factors, Contingency selection, concentric relaxation and bounding.

UNIT – V: VOLTAGE STABILITY

Basic concepts, Voltage collapse – general characterization, clasiffication, Voltage stability analysis – modeling, dynamic analysis, static analysis, shortest distance to instability, continuation power flow analysis, prevention of voltage collapse – design measures, operating measures.

TEXT BOOKS:

1. Allen J. Wood and Bruce Woolenberg, Power System Generation, Operation and Control, John Wiley and Sons, 1996.
2. John J. Grainger and William D Stevenson Jr, Power System Analysis, McGraw Hill ISE, 1994.
3. P. Kundur, Power System Stability and Control, McGraw Hill.
4. Fahd Hashiesh, M. M. Mansour , Hossam E. Mostafa Fahd Hashiesh , M. M. Mansour , Hossam E. Mostafa, Wide Area Monitoring, Protection and Control: The Gateway to Smart Grids, Lambert Academic Publishing.

REFERENCE BOOKS:

1. E. Handschin, Real-time Control of Electrical Power Systems, Elsevier Publications & Co, 1988.
2. Special Issue on Computer Control of Power Systems, IEEE Proc, July 1974.

15D21104 POWER QUALITY ISSUES & IMPROVEMENT

UNIT I: INTRODUCTION TO POWER QUALITY

Definition of Power Quality - Power Quality Progression - Power Quality Terminology - Power Quality Issues - Susceptibility Criteria - Responsibilities of Power Suppliers and Users - Power Quality Standards.

UNIT II: POWER FREQUENCY DISTURBANCE & TRANSIENTS

Introduction to Power Frequency Disturbance - Common Power Frequency Disturbances - Cures for Low Frequency Disturbances - Voltage Tolerance Criteria - ITIC Graph - Introduction to Transients - Transient System Model - Examples of Transient Models and Their Response - Power System Transient Modeling - 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 & ELECTROMAGNETIC INTERFERENCE (EMI)

Definition of Harmonics - Harmonic Number (h) - Odd and Even Order Harmonics - Harmonic Phase Rotation and Phase Angle - 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 - Introduction to EMI - Frequency Classification - Electrical Fields - Magnetic Fields - EMI Terminology - Power Frequency Fields - High Frequency Interference - EMI Susceptibility - EMI Mitigation - Cable Shielding - Health Concerns of EMI.

UNIT IV: GROUNDING AND BONDING

Introduction to Grounding and Bonding - Shock and Fire Hazards - NEC Grounding Requirements - Essentials of a Grounded System - Ground Electrodes - Earth Resistance Tests - Earth Ground Grid Systems - Power Ground System - Signal Reference Ground (SRG) - SRG Methods - Single and Multipoint Grounding - Ground Loops - Electrochemical Reaction - Examples of Grounding Anomalies.

UNIT V: MEASURING AND SOLVING POWER QUALITY PROBLEMS

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.Wayne Beaty, 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,Kluwer academic publishers

15D21107 MACHINES & POWER SYSTEMS LAB

1. Determination of Subtransient Reactance of a Salient Pole Machine
2. Determination of Sequence Impedances of a Cylindrical Rotor Synchronous Machine
3. Fault Analysis
   i) LG Fault
   ii) LL Fault
   iii) LLG Fault
   iv) LLLG Fault
4. Equivalent Circuit of a Three Winding Transformer
5. Separation of No Load losses of a Three Phase Squirrel Cage Induction Motor
6. Power Angle Characteristics of a Salient Pole Synchronous Machine
7. Scott Connection
8. Characteristics of IDMT Over Current Relay (Electro Magnetic Type)
9. Characteristics of Static Negative Sequence Relay
10. Characteristics of Over Voltage Relay
    i) Electromagnetic Type
    ii) Microprocessor Type
11. Characteristics of Percentage Biased Differential Relay
    i) Electromagnetic Type
    ii) Static Type

15D24101 SYSTEM RELIABILITY CONCEPTS

UNIT-I: Basic Probability Theory

Basic concepts – Rules for combining Probabilities of events – Failure Density and Distribution functions – Bernoulli's trials – Binomial distribution – Expected value and standard deviation for binomial distribution – Examples.

UNIT-II: Network Modeling and Reliability Evaluation

Basic concepts – Evaluation of network Reliability / Unreliability – Series systems, Parallel systems, Series - Parallel systems, partially redundant systems – Types of redundancies - Evaluation of network Reliability / Unreliability using conditional probability method – Paths based and Cutset based approach – complete event tree and reduced event tree methods - Examples.

UNIT-III: Time Dependent Probability

Basic concepts – Reliability functions f(t), F(t), R(t), h(t) – Relationship between these functions – Baths tubs curve – Exponential failure density and distribution functions - Expected value and standard deviation of Exponential distribution – Measures of reliability – MTTF, MTTR, MTBF – Evaluation of network reliability / Unreliability of simple Series, Parallel, Series-Parallel systems - Partially redundant systems - Evaluation of reliability measure – MTTF for series and parallel systems – Examples.

UNIT-IV: Discrete Markov Chains & Continuous Markov Processes

Basic concepts – Stochastic transitional Probability matrix – time dependent probability evaluation – Limiting State Probability evaluation – Absorbing states – Markov Processes- Modelling concepts – State space diagrams – time dependent reliability evaluation of single component repairable model – Evaluation of Limiting State Probabilities of one, two component repairable models – Frequency and duration concepts – Frequency balance approach - Examples.

UNIT-V: Multi Component & Approximate System Reliability Evaluation

Recursive relation for evaluation of equivalent transitional rates, cumulative probability and cumulative frequency and 'n' component repairable model - Series systems, Parallel systems, Basic reliability indices – Cutset approach – Examples.

Text Book:

1. System Reliability Concepts by V. Sankar, Himalaya Publishing House, 2015.

Reference Books:

1. Reliability Evaluation of Engineering Systems by Roy Billinton and Ronald N. Allan, Reprinted in India B. S. Publications, 2007.
2. Reliability Engineering by E. Balagurusamy, Tata McGraw Hill, 2003.
3. Reliability and Maintainability Engineering by Charles E. Ebeling, Tata McGraw Hill, 2000.
4. Probability concepts in Electric Power system – G.J.Anders- 1st edition –1990 – John wiley & sons.

15D21105 FACTS & HVDC TRANSMISSION SYSTEMS

UNIT – I: SHUNT COMPENSATION

Objectives of shunt compensation - Methods of controllable var generation - variable impedance type static var generators - switching converter type var generators - hybrid var generators – Comparison of SVC and STATCOM.

UNIT – II: SERIES COMPENSATION

Objectives of series compensation – GTO Thyristor Controlled Series Capacitor (GCSC) - Thyristor Switched Series Capacitor (TSSC) - Thyristor Controlled Series Capacitor (TCSC) - Control schemes for TCSC, TSSC and TCSC.

UNIT- III: UNIFIED POWER FLOW CONTROLLER (UPFC)

Introduction - 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 - Hybrid Arrangements: UPFC With a Phase Shifting Transformer.

UNIT- IV: CONVERTER AND HVDC SYSTEM CONTROL

Basic means of control-power reversal-constant current versus constant voltage control-desired features of control- actual control characteristics.- constant minimum ignition angle control-constant current control-constant extinction angle control-stability of control-tap changer control-frequency control.

UNIT - V: HARMONICS AND FILTERS & INTERACTION BETWEEN AC AND DC SYSTEMS

Characteristic Harmonics-troubles caused by harmonics-definitions of wave distortion or ripples –means of reducing harmonics-design of AC filters –Dc side filters- Voltage interaction –DC power modulation –power frequency control-Large signal modulation –active and reactive power coordination.

REFERENCE BOOKS:

1. Understanding FACTS: Concepts and Technology of Flexible AC Transmission Systems by Narain G. Hingorani, Laszlo Gyugyi - Standard Publishers Distributors - IEEE Press – First Edition – 2001.
2. HVDC power Transmission systems by K.R.Padiyar 2nd edition, Wiley Eastern limited.
3. High voltage direct current transmission by J.Arrilaga, IEE power engineering series.
4. Direct current transmission by E.W.Kimbark, Vol-1, Wiley inter science-Newyork.

15D22101 MODERN CONTROL THEORY

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.

15D21106 DISTRIBUTED GENERATION & MICROGRID

UNIT I: DISTRIBUTED GENERATION AND MICROGRID CONCEPT

Distributed generation - Why integration of distributed generation? - Active distribution network - Concept of Microgrid - A typical Microgrid configuration - Interconnection of Microgrids - Technical and economical advantages of Microgrid - Challenges and disadvantages 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: Types 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 standardisation - SCADA communication and control architecture - Communication devices - Observations on SCADA and communication.

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

Introduction - Power quality disturbances - Power quality sensitive customers - Existing 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.

15D21201 POWER SYSTEM RELIABILITY

UNIT-I : Generating System Reliability Analysis

Generation system model – Capacity outage probability tables – Recursive relation for capacitive model building – Sequential addition method – Unit removal – Evaluation of loss of load and energy indices – Examples.

UNIT-II : Combined Generation and Load System Reliability Analysis

Frequency and Duration methods – Evaluation of equivalent transitional rates of identical and non-identical units – Evaluation of cumulative probability and cumulative frequency of non-identical generating units – 2-level daily load representation - Merging generation and load models – Examples.

UNIT-III : Bulk Power System Reliability Evaluation

Basic configuration – Conditional probability approach – System and load point reliability indices – Weather effects on transmission lines – Weighted average rate and Markov model – Common mode failures.

UNIT-IV : Radial Distribution System Configuration Reliability Analysis

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.

UNIT-V : Meshed System Reliability Analysis

Basic techniques – Inclusion of bus bar failures, scheduled maintenance – Temporary and transient failures – Weather effects – Common mode failures – Evaluation of various indices – Examples.

Text Books:

1. Roy Billinton and Ronald N. Allan, Reliability Evaluation of Power Systems, Plenum Press, New York and London, 2nd Edition, 1996.
2. J. Endrenyi , Reliability Modeling in Electric Power Systems, John Wiley & Sons, 1st Edition, 1978.

15D21202 SMART GRID DESIGN AND ANALYSIS

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.

15D21203 RESTRUCTURED POWER SYSTEMS

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 Jaap E.Daalder, Operation of Restructured Power System, Kulwer Academic Publishers, 2001.
2. Mohammad Shahidehpour and Muwaffaq alomoush, Restructured Electrical Power Systems, Marcel Dekker, Inc., 2001.

REFERENCE BOOKS:

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

15D22203 INTELLIGENT ALGORITHMS

UNIT I: Introduction and motivation. Approaches to 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.

Witold Pedrycz, Fuzzy Control and Fuzzy Systms, Overseas Press, Indian Edition, 2008.

15D54201 RESEARCH METHODOLOGY

(Audit Course)

UNIT I

Meaning of Research – Objectives of Research – Types of Research – Research Approaches – Guidelines for Selecting and Defining a Research Problem – research Design – Concepts related to Research Design – Basic Principles of Experimental Design.

UNIT II

Sampling Design – steps in Sampling Design –Characteristics of a Good Sample Design – Random Sampling Design.

Measurement and Scaling Techniques-Errors in Measurement – Tests of Sound Measurement – Scaling and Scale Construction Techniques – Time Series Analysis – Interpolation and Extrapolation.

Data Collection Methods – Primary Data – Secondary data – Questionnaire Survey and Interviews.

UNIT III

Correlation and Regression Analysis – Method of Least Squares – Regression vs Correlation – Correlation vs Determination – Types of Correlations and Their Applications

UNIT IV

Statistical Inference: Tests of Hypothesis – Parametric vs Non-parametric Tests – Hypothesis Testing Procedure – Sampling Theory – Sampling Distribution – Chi-square Test – Analysis of variance and Co-variance – Multi-variate Analysis.

UNIT V

Report Writing and Professional Ethics: Interpretation of Data – Report Writing – Layout of a Research Paper – Techniques of Interpretation- Making Scientific Presentations in Conferences and Seminars – Professional Ethics in Research.

Text books:

1. **Research Methodology:Methods and Techniques – C.R.Kothari, 2nd Edition,New Age International Publishers.**
2. **Research Methodology: A Step by Step Guide for Beginners- Ranjit Kumar, Sage Publications (Available as pdf on internet)**
3. **Research Methodology and Statistical Tools – P.Narayana Reddy and G.V.R.K.Acharyulu, 1st Edition,Excel Books,New Delhi.**

REFERENCES:

1. **Scientists must Write - Robert Barrass (Available as pdf on internet)**
2. **Crafting Your Research Future –Charles X. Ling and Quiang Yang (Available as pdf on internet)**

15D21209 POWER SYSTEM SIMULATION LAB

MATLAB

1. Y - Bus Formation Using MATLAB
2. Gauss – Seidel Load Flow Analysis using MATLAB
3. Fast Decoupled Load Flow Analysis using MATLAB
4. Fast Decoupled Load Flow Analysis for Distribution Systems using MATLAB
5. Point by Point Method using MATLAB
6. Step Response of Two Area System with Integral Control and Estimation of Tie Line Power Deviation using SIMULINK
7. Step Response of Two Area System with Integral Control and Estimation of Tie Line Frequency Deviation using SIMULINK

MiPower

8. Load Flow Analysis using MiPower
   i) Gauss Seidel Method
   ii) Newton Raphson Method
9. Short Circuit Analysis using MiPower
10. Transient Stability Analysis using MiPower
11. Economic Load Dispatch Analysis using MiPower

15D21205 REACTIVE POWER COMPENSATION & MANAGEMENT

UNIT I : LOAD COMPENSATION

Objectives and specifications – Reactive power characteristics – Inductive and capacitive approximate biasing – Load compensator as a voltage regulator – Phase balancing and power factor correction of unsymmetrical loads - Examples.

UNIT II : STEADY – STATE & TRANSIENT STATE REACTIVE POWER COMPENSATION IN TRANSMISSION SYSTEM

Uncompensated line – Types of compensation – Passive shunt and series and dynamic shunt compensation – Characteristic time periods – Passive shunt compensation – Static compensations - Series capacitor compensation – Compensation using synchronous condensers – Examples.

UNIT-III : REACTIVE POWER COORDINATION & DEMAND SIDE MANAGEMENT

Objective – Mathematical modeling – Operation planning – Transmission benefits – Basic concepts of quality of power supply – Disturbances - Steady – state variations – Effects of under Voltages – Frequency – Harmonics, radio frequency and electromagnetic interferences.Load patterns – Basic methods load shaping – Power tariffs - KVAR based tariffs penalties for voltage flickers and Harmonic voltage levels.

UNIT-IV : DISTRIBUTION & USER SIDE REACTIVE POWER MANAGEMENT

System losses – Loss reduction methods – Examples – Reactive power planning – Objectives – Economics Planning capacitor placement – Retrofitting of capacitor banks - KVAR requirements for domestic appliances – Purpose of using capacitors – Selection of capacitors – Deciding factors – Types of available capacitor, characteristics and Limitations.

UNIT-V : REACTIVE POWER MANAGEMENT IN ELECTRIC TRACTION SYSTEMS AND ARC FURNACES

Typical layout of traction systems – Reactive power control requirements – Distribution transformers - Electric arc furnaces – Basic operations- Furnaces transformer – Filter requirements – Remedial measures – Power factor of an arc furnace.

TEXT BOOKS:

1. J.E.Miller, Reactive Power Control in Electric Power Systems, John Wiley and Sons, 1982 (Units I to IV).
2. D.M.Tagare, Reactive power Management, Tata McGraw Hill, 2004 (Units V toVIII).

15D21206 EHVAC TRANSMISSION SYSTEMS

UNIT – I: PRELIMINARIES

Necessity of EHV AC transmission – Advantages and problems – Power handling capacity and line losses- Mechanical considerations – Resistance of conductors – Properties of bundled conductors – Bundle spacing and bundle radius - Examples.

UNIT – II: LINE AND GROUND REACTIVE PARAMETERS

Line inductance and capacitances – Sequence inductances and capacitances – Modes of propagation – Ground return – Examples. Electrostatics – Field of sphere gap – Field of line changes and properties – Charge – potential relations for multi-conductors – Surface voltage gradient on conductors – Distribution of voltage gradient on sub-conductors of bundle – Examples.

UNIT – III: CORONA EFFECTS

Power loss and audible noise (AN) – corona loss formulae – Charge voltage diagram – Generation, characteristics - Limits and measurements of AN – Relation between 1-phase and 3 -phase AN levels – Radio interference (RI) - Corona pulses generation, properties, limits – Frequency spectrum – Modes of propagation – Excitation function – Measurement of RI, RIV and excitation functions - Examples.

UNIT – IV: ELECTRO STATIC FIELD & TRAVELING WAVE THEORY

Electrostatic field: calculation of electrostatic field of EHV/AC lines – Effect on humans, animals and plants – Electrostatic induction in unenergised circuit of double - circuit line – Electromagnetic interference - Examples. Traveling wave expression and solution - Source of excitation - Terminal conditions - Open circuited and short circuited end - Reflection and refraction coefficients - Lumped parameters of distributed lines - Generalized constants - No load voltage conditions and charging current.

UNIT –V: VOLTAGE CONTROL

Power circle diagram and its use – Voltage control using synchronous condensers – Cascade connection of shunt and series compensation – Sub synchronous resonance in series capacitor – Compensated lines – Static VAR compensating system.

TEXT BOOKS:

1. R. D. Begamudre, EHVAC Transmission Engineering, New Age International (p) Ltd.
2. S. Rao, HVAC and DC Transmission.

15D21207 SOLAR ENERGY CONVERSION SYSTEMS

UNIT-I: SOLAR CELL FUNDAMENTALS

Place of PV in 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 - Fundamentals of semiconductors – charge carriers and their motion in semiconductor – P-N Junction Diode – an introduction to solar cells.

UNIT-II: DESIGN OF SOLAR CELLS

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 – solar cell design – design for high I_{SC} – Design for high V_{OC} – design for high FF – 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, PHI publications.

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.

15D21208 WIND ENERGY CONVERSION SYSTEMS

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

Power speed characteristics - 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 generation – the self-excitation process – circuit model for the self – excited induction generator – analysis of steady state operation – the steady state characteristics – 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.

JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY ANANTAPUR
JNTUA COLLEGE OF ENGINEERING (AUTONOMOUS) :: ANANTHAPURAMU
Ananthapuramu – 515 002, Andhra Pradesh, India

Course Structure of R21 Academic Regulations for M.Tech (Regular) Programs with effect from AY 2021-2022

DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING

ELECTRICAL POWER SYSTEMS

I SEMESTER

S.No.	Course Code	Subject Name	Cate Gory	Hours Per Week			Credits
				L	T	P	
1	21D21101	Advanced Power System Protection	PC	3	0	0	3
2	21D21102	Power System Security and State Estimation	PC	3	0	0	3
3	**Professional Elective – I**						
	21D21103	Machine Learning Application to Power Systems	PE	3	0	0	3
	21D21104	Modeling and Analysis of HVDC Systems					
	21D21105	Power System Optimization					
4	**Professional Elective – II**						
	21D21106	Solar & Wind Energy Conversion Systems	PE	3	0	0	3
	21D21107	Smart Grid Technologies					
	21D21108	Electric Vehicle Engineering					
5	21D11109	Research Methodology and IPR	MC	2	0	0	2
6	21D11110	English for Research Paper Writing	AC	2	0	0	0
	21D11111	Value Education					
	21D11112	Pedagogy Studies					
7	21D21109	Machine & Power Systems Lab	PC	0	0	4	2
8	21D21110	Power Systems Simulation Lab	PC	0	0	4	2
Total				**16**	**00**	**08**	**18**

ELECTRICAL POWER SYSTEMS

II SEMESTER

S.No.	Course Code	Subject Name	Cate Gory	Hours Per Week			Credits
				L	T	P	
1	21D21201	Power System Stability and Control	PC	3	0	0	3
2	21D21202	FACTS Controllers	PC	3	0	0	3
3	**Professional Elective – III**						
	21D21203	Power System Wide Area Monitoring & Control	PE	3	0	0	3
	21D23104	Modern Control Theory					
	21D21204	Reactive power Compensation & Management					
4	**Professional Elective – IV**						
	21D21205	Power Quality	PE	3	0	0	3
	21D21206	Distributed Generation and Micro grid Control					
	21D21207	EHVAC Transmission Systems					
5	21D11209	Technical Seminar	PR	0	0	4	2
6	21D11210	Disaster Management	AC	2	0	0	0
	21D11211	Constitution of India					
	21D11212	Stress Management by Yoga					
7	21D21208	Renewable Energy Systems Lab	PC	0	0	4	2
8	21D21209	FACTS Devices & Simulation Lab	PC	0	0	4	2
Total				**14**	**00**	**12**	**18**

ELECTRICAL POWER SYSTEMS

III SEMESTER

S.No.	Course Code	Subject Name	Cate Gory	Hours Per Week			Credits
				L	T	P	
1	**Professional Elective – V**						
	21D21301	Restructured power systems	PE	3	0	0	3
	21D21302	Risk Assessment of Electrical Power Systems					
	21D21303	Power System Automation					
2	**Open Elective**						
	21D20301	Waste to Energy	OE	3	0	0	3
3	21D21304	Dissertation Phase -I	PR	0	0	20	10
4	21D00301	Co-curricular Activities	PR				2
Total				**06**	**00**	**20**	**18**

IV SEMESTER

S.No.	Course Code	Subject Name	Cate Gory	Hours Per Week			Credits
				L	T	P	
1	21D21401	Dissertation Phase – II	PR	0	0	32	16
Total				**00**	**00**	**32**	**16**

R21 COURSE STRUCTURE & SYLLABUS FOR M.TECH COURSES
DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING
(ELECTRICAL POWER SYSTEMS)

Course Code	21D21101	ADVANCED POWER SYSTEM PROTECTION (21D21101)	L	T	P	C
Semester	I		3	0	0	3

Course Objectives: To make the student

- To know construction of static relays.
- To understand the operation of amplitude and phase comparators.
- To comprehend the concepts of Static over current, static differential and static distance relays.
- To understand multi-input comparators and concept of power swings on the distance relays.
- To know the operation of microprocessor based protective relays.

Course Outcomes (CO): Student will be able to

CO 1: Describe the construction of static relay and identify the advantages of static relay over electromagnetic relay and analyze the importance of reliability in various fields.
CO 2: Explore the operation of rectifier bridge comparators, instantaneous comparators, phase comparators, multi input comparators, static differential and distance relays.
CO 3: Describe instantaneous, definite time and inverse definite minimum time over current relays.
CO 4: Analyze the concept of power swings on distance relays and to identify the microprocessor based protective relays and their operation.

UNIT – I	**STATIC RELAYS & COMPARATORS**	Lecture Hrs: 8

Introduction to Static relays - Basic construction of Static relays – Level detectors – Replica Impedance-Mixing circuits-General equation for two input phase and Amplitude Comparators – their types – Duality between Amplitude and Phase Comparator –Conic section characteristics– Three input Amplitude Comparator – Hybrid comparator – Switched distance schemes – Polyphase distance schemes-Phase faults scheme –Three phase scheme–Combined and Ground fault scheme.

UNIT - II	**TYPES OF STATIC RELAYS**	Lecture Hrs:9

Introduction-Instantaneous over current relay – Time over current relays - Basic principles - Definite time and Inverse definite time over current relays, directional over current relays - Static Differential Relays-Analysis of static differential relays–Static relay schemes-Dual bias transformer differential protection – Harmonic restraint relay.

UNIT - III	**NUMERICAL RELAYS**	Lecture Hrs: 9

Advantages of Numerical Relays – Numerical network-Digital Signal processing–Estimation of Phasors – Full Cycle Fourier Algorithm – Half Cycle Fourier Algorithm- practical considerations for selection of Algorithm–Discrete Fourier Transform

UNIT - IV	**DISTANCE RELAYS AND POWER SWINGS**	Lecture Hrs: 12

Static Distance Relays - Static Impedance - reactance - MHO and Angle Impedance relay sampling comparator – Realization of reactance and MHO relay using a sampling comparator. Effect of power swings on the performance of Distance relays- Power swing analysis - Principle of out of step tripping and blocking relays - Effect of line length and source impedance on distance relays.

UNIT - V	**MICROPROCESSOR BASED PROTECTIVE RELAYS**	Lecture Hrs: 10

Over current relays – Impedance relays – Directional relay – Reactance relay (Block diagram and flowchart approach only). Generalized mathematical expression for distance relays-Measurement of resistance and reactance – MHO and offset MHO relays – Realization of MHO characteristics – Realization of Offset MHO characteristics (Block diagram and flow chart approach only) - Basic principle of Digital computer relaying.

Textbooks:

1. T.S. Madhava Rao, Power system Protection static relay, Tata McGrawHill Publishing Company limited, 2nd Edition, 2004.
2. Badri Ram and D.N. Vishwakarma, Power system Protection and Switchgear, Tata McGraw Hill Publication Company limited, 2nd Edition, 2013.

Reference Books:

1. Bhavesh Bhalja, R. P. Maheshwari, N. G. Chothani, Protection and Switchgear, Oxford University Press, 2nd Edition, New Delhi, India, 2018.
2. Oza, B. A., N. C. Nair, R. P. Mehta, et al., Power System Protection & Switchgear, Tata McGraw Hill, New Delhi, 1st Edition, 2011.

Online Learning Resources:

R21 COURSE STRUCTURE & SYLLABUS FOR M.TECH COURSES
DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING
(ELECTRICAL POWER SYSTEMS)

Course Code	21D21102	POWER SYSTEM SECURITY AND STATE ESTIMATION (21D21102)	L	T	P	C
Semester	I		3	0	0	3

Course Objectives: To make the student

- Understand the basic concepts of network matrices, power flow methods, state estimation, and applications of power system state estimation and structure of deregulated power system.
- Analyze about admittance/impedance matrices, factors influencing power system security, network problems and power wheeling transactions.
- Implement the methods for determining the bus matrices, optimal ordering, DC power flow, AC power flow, estimating a value and Available Transfer Capability (ATC).
- Develop the algorithm for orthogonal matrix, method to identify network problems and congestion management methods and electricity sector structure.

Course Outcomes (CO): Student will be able to

CO 1: Understand the concepts of network matrices, power flow methods, contingency analysis, state estimation, and need and conditions for deregulation.
CO 2: Analyze the bus admittance/impedance matrices methods, power system security, sensitivity factors, state estimation and electricity structure model.
CO 3: Apply the methods for evaluating the bus matrices, sparsity, DC power flow, AC power flow, estimating a value and Available Transfer Capability (ATC).
CO 4: Develop the methods for state estimation, method to identify network problems and methods for congestion management.

UNIT - I	**Power System Network Matrices**	Lecture Hrs: 10

Formation of bus admittance matrices by direct inspection method and singular transformation method – Algorithm for formation of Bus impedance matrix: addition of a branch and addition of a link, removal element in Bus impedance matrix– Sparsity programming and Optimal Ordering – Numerical problems – ∏-representation of off-nominal tap transformers.

UNIT - II	**Power System Security-I**	Lecture Hrs:9

Review of power flow methods (qualitative treatment only)– DC power flow method-simple problems – Introduction to power system security – Factors influencing power system security.

UNIT - III	**Power System Security-II**	Lecture Hrs: 10

Introduction to contingency analysis – Contingency analysis: Detection of Network problems, linear sensitivity factors –AC power flow methods– Contingency selection– Simple problems.

UNIT - IV	**State Estimation in Power System**	Lecture Hrs: 10

Power system state estimation – SCADA –EMS center, Methods of state estimation – Method of least squares, Orthogonal matrix–Properties– Givens rotation–Orthogonal decomposition–Bad data detection, Pseudo measurements and applications of power system state estimation – Simple problems.

UNIT - V	**Security in Deregulated Environment**	Lecture Hrs:9
Need and conditions for deregulation–Electricity sector structure model – Power wheeling transactions –Congestion management methods– Available Transfer Capability (ATC) – System security in deregulation.		

Textbooks:

1. Allen J. Wood and Wollenberg B.F., Power Generation Operation and control, John Wiley & Sons, 3rd edition, 2013.
2. P. Venkatesh, B.V. Manikandan, S. Charles Raja and A.Srinivasan, Electrical power systems analysis, security, and deregulation, PHI learning private limited, Delhi, 1st edition 2014.

Reference Books:

1. Nagrath I.J. and Kothari D.P., Modern Power System Analysis, TMH, New Delhi, 3rd Edition, 2004.
2. John J. Grainger and William D. Stevenson, Power System Analysis, Tata McGraw-Hill, 1st edition, 2003.

Online Learning Resources:

1. https://nptel.ac.in/content/storage2/courses/108106022/LECTURE%205.pdf
2. https://nptel.ac.in/content/storage2/courses/108101040/download/Lec-26.pdf

R21 COURSE STRUCTURE & SYLLABUS FOR M.TECH COURSES
DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING
(ELECTRICAL POWER SYSTEMS)

Course Code	**21D21103**	**MACHINE LEARNING APPLICATION TO POWER SYSTEMS (21D21103)** (PE-I)	**L**	**T**	**P**	**C**
Semester	**I**		**3**	**0**	**0**	**3**

Course Objectives: To make the student

- Understand the concepts of machine learning algorithms, artificial neural network.
- Analyze about the reinforcement learning, concepts of genetic algorithm.
- Apply the methods to evaluate the genetic modeling and load forecasting.
- Develop the techniques using machine learnings to determine the economic load dispatch.

Course Outcomes (CO): Student will be able to

CO 1: Understand importance of machine learning and the concepts of learning algorithms.
CO 2: Analyse about the artificial neural network, training and testing of ANN, concepts of genetic algorithm.
CO 3: Apply the algorithms to determine the constrained and unconstrained problem using genetic algorithm.
CO 4: Develop the techniques using machine learnings to determine the load forecasting, fault identification.

UNIT - I	**Machine Learning Concepts**	Lecture Hrs: 10

Basic Concepts of Machine learning, History and early works, techniques, comparison and relation to artificial intelligence, optimization and statistics.

UNIT - II	**Machine Learning Algorithms**	Lecture Hrs:9

Theoretical aspects of ML, different types of Machine Learning algorithms such as Linear regression, Logistic regression, K - Nearest Neighbor, Artificial Neural Networks, Random Forest, and Support Vector Machine, learning approaches: Supervised learning, unsupervised learning, semi supervised learning, reinforcement learning, self-learning and association rules.

UNIT - III	**Concepts of Artificial Neural Network**	Lecture Hrs: 10

Artificial Neural Network, Basic Concept, early NN Architectures, Characteristics, Neural Network architectures, Single layer feed forward Network, Multi-layer feed forward network, recurrent networks, Non-linear activation operators, learning methods like Back propagation, LM etc., training and testing of ANN.

UNIT - IV	**Concepts of Genetic Algorithm**	Lecture Hrs:10

Genetic Algorithms: Fundamentals, History, working principal, genetic modeling, encoding, fitness function, Genetic operators: reproduction, cross over, mutation, Similarities and differences between GA and traditional methods; Unconstrained and constrained optimization using Genetic Algorithm.

UNIT - V	Applications of Machine Learning	Lecture Hrs:9
Applications of machine learning in power systems operation and control for solving problems of load forecasting, renewable energy forecasting, load flow studies, Economic load dispatch, Unit commitment, power plant monitoring, fault identification and security assessment etc.		
Textbooks:		
1. Trevor Hastie, Robert Tibshirani, Jerome H. Friedman, "The Elements of Statistical Learning", Springer, 2nd Edition, 2017. 2. Christopher Bishop, "Pattern Recognition and Machine Learning", Springer, 1st Edition, 2006.		
Reference Books:		
1. NP Padhy, "Artificial Intelligence and Intelligent Systems", Oxford University Press, 1st Edition, 2005. 2. Goldberg D.E. "Genetic Algorithms in Search Optimization & Machine Learning", Addition Wesley Co., New York, 1st Edition, 1989.		
Online Learning Resources:		
1. https://nptel.ac.in/courses/108/104/108104112/ 2. https://nptel.ac.in/courses/108/104/108104049/		

Course Code	21D21104	MODELLING AND ANALYSIS OF HVDC SYSTEMS (21D21104) (PE-I)	L	T	P	C
Semester	I		3	0	0	3

Course Objectives: To make the student

- To understand the concept, planning of DC power transmission.
- To analyze HVDC converters, Transient and Dynamic Stability.
- To apply modelling of power flow analysis.
- To design digital dynamic simulation of converters and DC systems

Course Outcomes (CO): Student will be able to

CO 1: To identify the electrical requirements for HVDC lines.
CO 2: Analyze the different modes of operation for six pulse & twelve pulse converter unit in the context of HVDC system.
CO 3: Apply the knowledge of HVDC transmission in Power networks.
CO 4: Determine the appropriate HVDC transmission line parameters under different physical conditions.

UNIT – I	HVDC CONVERTERS AND SYSTEM CONTROL	Lecture Hrs: 10

Analysis of HVDC Converters: Pulse number – choice of converter configuration – simplified analysis of Graetz circuit – converter bridge characteristics. Converter and HVDC system control: Principles of DC link control – converter control characteristics – system control hierarchy – firing angle control – current and extinction angle control – starting and stopping of DC link power control.

UNIT – II	MODELING FOR POWER FLOW ANALYSIS OF AC/DC SYSTEMS	Lecture Hrs:9

Modelling of HVDC Components: HVDC Converter model - Converter control - Modelling of DC network - Modelling of AC Network - Power flow analysis in AC/DC systems: Modelling of DC links –Multi terminal DC links- Solution of DC load flow –per unit system for DC qualities – Solution of AC/DC power flow.

UNIT - III	TRANSIENT AND DYNAMIC STABILITY ANALYSIS	Lecture Hrs: 10

Transient stability Analysis – Converter model – Converter control models – DC network models – solution methodology – Direct methods for stability Evaluation - Dynamic Stability and power modulation - Power modulation for damping low frequency oscillations – Basic principles – practical consideration in the application of power modulation controllers – Gamma or reactive power modulation – power modulation in MTDC system – voltage stability in AC/DC system.

UNIT – IV	HARMONIC AND TORSIONAL INTERACTIONS	Lecture Hrs: 10

Harmonic and Torsional Interactions: Harmonic Interactions - Torsion Interactions – Torsional interactions with in HVDC systems – counter measures to torsion interactions with DC systems - Simulation of HVDC systems: System simulation – philosophy & Tools – HVDC system simulation – modeling of HVDC systems Digital dynamic simulation.

UNIT – V	MODELING OF HVDC SYSTEMS	Lecture Hrs:9
Digital dynamic simulation of converters and DC systems: Valve model, Gate pulse generation – generation of control voltage – transformer model – converter model – transient simulation of DC and AC systems.		
Textbooks:		
1. K.R. Padiyar, HVDC Power Transmission Systems – Technology & System Interactions, New Age International Publishers, 3rd Edition, 2017 2. S Kamakshaiah and V Kamaraju, HVDC Transmission, Tata Mc Graw Hill, New Delhi, 2nd Edition, 2021.		
Reference Books:		
1. E.W. Kimbark, Direct current transmission, Wiely Inter Science – New York, 1st Edition, 1971. 2. J. Arillaga, HVDC Transmission, Peregrinus Ltd., London UK 2nd Edition, 1998. 3. E. Uhlman, Power transmission by direct current, Springer Verlag, Berlin Helberg, 1st Edition, 1985.		
Online Learning Resources:		
https://nptel.ac.in/courses/108/106/108106160/		

R21 COURSE STRUCTURE & SYLLABUS FOR M.TECH COURSES
DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING
(ELECTRICAL POWER SYSTEMS)

Course Code	21D21105	POWER SYSTEM OPTIMIZATION (21D21105)	L	T	P	C
Semester	I	(PE-I)	3	0	0	3

Course Objectives: To make the student

- Understand the fundamental concepts of Optimization Techniques.
- Analyze the importance of optimizations in real life scenarios.
- Apply the concepts of various classical and modern methods for constrained and unconstrained problems in both single and multivariable.
- Design the algorithms for different optimizations techniques.

Course Outcomes (CO): Student will be able to

CO 1: Understand the concept of optimality criteria for various type of optimization problems.
CO 2: Analyze the concept of different optimization techniques in real world applications.
CO 3: Solve various constrained and unconstrained problems in single variable as well as multivariable.
CO 4: Design the methods of optimization for real life situation.

UNIT – I	CONVENTIONAL OPTOMIZATION TECHNIQUES & FUNDAMENTALS OFPARTICLESWARMOPTIMIZATION(PSO)TECHNIQUES	Lecture Hrs: 10

Concepts & Terms related to Optimization -Quadratic optimization problem - Karush - Kuhn - Tucker (KKT) necessary and sufficient conditions for quadratic programming problem- Interior point method for convex optimization - linear programming-Background of PSO – Original PSO – Variation of PSO – Discrete PSO – PSO for MINLPs – Constriction Factor Approach (CFA) – Hybrid PSO (HPSO) – L best Model – Adaptive PSO(APSO) Evolutionary PSO (EPSO)– Applications.

UNIT – II	FUNDAMENTALSOFANTCOLONYSEARCHALGORITHMS	Lecture Hrs: 9

Introduction – Ant Colony Search Algorithm – Behaviour of Real Ants– Ant Colony Algorithms – The Ant System – The Ant Colony System – The Max-Min Ant System – Major Characteristics of Ant Colony Search Algorithm – Distributed Computation: Avoid Premature Convergence – Positive Feedback: Rapid Discovery of Good Solution – Use of Greedy Search and Constructive Heuristic Information: Find Acceptable Solutions in the Early Stage of the Process.

UNIT - III	FUNDAMENTALS OFTABUSEARCH	Lecture Hrs: 12

Introduction–Overview of the Tabu Search Approach – Problem Formulation – Coding and Representation – Neighborhood Structure – Characterization of the Neighborhood–Functions and Strategies in Tabu Search – Recency- Based Tabu Search – Basic Tabu Search Algorithm – Candidate List Strategies – Tabu tenure – Aspiration Criteria – The Use of Long Term Memory in Tabu Search – Frequency-Based Memory – Intensification – Diversification – Other TS Strategies – Path Relinking – Strategic Oscillation–Applications of Tabu Search.

UNIT – IV	APPLICATIONTOPOWERSYSTEMS	Lecture Hrs: 9
Introduction to power system applications – Model identifications – Dynamic load modeling – Short term load forecasting – Distribution system applications – Network reconfiguration for loss reduction – Optimal protection and switching devices placements – Examples.		
UNIT – V	**POWERSYSTEMCONTROLS**	Lecture Hrs: 9
Overview – Power system controls: Particle Swarm Technique – Problem formulation of VVC – State variables – Problem formulation – Expansion of PSO for MINLP – Voltage security assessment – VVC using PSO – Treatment of state variables – VVC algorithm using PSO – Numerical Examples – IEEE 14 Bus system.		

Textbooks:

1. A Ravindran, K.M. Ragsdell, and G.V. Reklaitis, "Engineering optimization: Methods and applications", Wiley India Edition.
2. KwangY. Lee and Mohamed A. EI- Sharkawi "Modern Heuristic Optimization Techniques Theory and Applications to Power Systems", A. John Wiley & Sons. INC. Publication, 1st edition, 2020
3. D. P. Kothari and J. S. Dhillon, "Power System Optimization", PHI Learning Private Limited, 2ndEdition, 2011.

Reference Books:

1. Jizhong Zhu, "Optimization of power system operation", IEEE Press, John Wiley & Sons, Inc., Publication, 2nd edition, 2015.
2. Joshua adam Taylor, "Convex optimization of power systems'', Cambridge University Press, 1st edition, 2015.

Online Learning Resources:

https://nptel.ac.in/courses/112/106/112106064/

R21 COURSE STRUCTURE & SYLLABUS FOR M.TECH COURSES
DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING
(ELECTRICAL POWER SYSTEMS)

Course Code	21D21106	SOLAR & WIND ENERGY CONVERSION SYSTEM (21D21106) (PE-II)	L	T	P	C
Semester	I		3	0	0	3

Course Objectives: To make the student

- To introduce photo voltaic systems and principle of wind turbines.
- To deal with various technologies of solar PV cells.
- To understand details about manufacture, sizing and operating techniques in solar energy conversion systems.
- Understand the concepts of fixed speed and variable speed, wind energy conversion systems.
- To have knowledge of design considerations and analyze grid integration issues.

Course Outcomes (CO): Student will be able to

CO 1: Understand the fundamentals of solar cell, Solar PV Modules from solar cells, system types, Standalone PV system configuration, Maximum Power Point tracking (MPPT) and fundamentals the concepts of fixed speed and variable speed, wind energy conversion systems.

CO 2: Apply the concept of various technologies of solar PV cells, manufacture, sizing and operating techniques.

CO 3: Analyze the concept of Effect of series and shunt resistance on efficiency, Effect of solar radiation on efficiency, Analytical techniques, Hot spots in the module, Algorithms for MPPT.

CO 4: Design of PV powered DC fan without battery, Standalone system with DC load using MPPT, PV powered DC pump, standalone system with battery and AC/DC load and control principles of Wind turbine.

UNIT – I	**SOLAR& WINDFUNDAMENTALS**	Lecture Hrs: 10

Need for sustainable energy sources –solar radiation – the sun and earth movement – angle of sunrays on solar collectors – sun tracking – estimating solar radiation–measurement of solar radiation - 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	**SOLARPHOTOVOLTAICMODULES**	Lecture Hrs: 9

Solar PV Modules from solar cells– model of a solar cell, effect of series and shunt resistance on efficiency, effect of solar radiation on efficiency - 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 - III	**PVSYSTEM DESIGNANDAPPLICATIONS**	Lecture Hrs: 10
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.		
UNIT – IV	**WINDTURBINECONTROLSYSTEMS&SITEANALYSIS**	Lecture Hrs: 10
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. 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 APPLICATIONS**	Lecture Hrs: 11
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.		

Textbooks:

1. "Solar Photovoltaics Fundamentals, Technologies and Applications" by Chetan singh solanki, PHI Publications, 3rd edition, 2015.
2. S.N.Bhadra, D.Kastha, S.Banerjee, "Wind Electrical Systems" Oxford University Press, 1st edition, 2013.
3. Banshi D. Shukla, "Engineering of Wind Energy", Jain Brothers, 1st edition, 2018.

Reference Books:

1. H.P. Garg, J. Prakash, Solar Energy Fundamentals and applications Tata McGraw-Hill Publishers1st edition, 2000.
2. S.Rao & B.B. Parulekar, Energy Technology, Khanna publishers, 4th edition, 2005.
3. N.K. Bansal, M. Kleemann, Michael Meliss, Renewable Energy sources & Conversion Technology, Tata Mcgraw Hill Publishers & Co., 1st edition, 1990.

Online Learning Resources:

R21 COURSE STRUCTURE & SYLLABUS FOR M.TECH COURSES
DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING
(ELECTRICAL POWER SYSTEMS)

Course Code	21D21107	SMARTGRIDTECHNOLOGIES (21D21107) (PE-II)	L	T	P	C
Semester	I		3	0	0	3

Course Objectives: To make the student

- 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 enhance the quality, efficiency and security of power supply.
- To impart an understanding of economics, policies and technical regulations for DG integration.

Course Outcomes (CO): Student will be able to

CO 1: Understand the importance of smart grid technology functions over the present grid.
CO 2: Apply the knowledge about the measurement system and communication technology of smart grid.
CO 3: Determine the quality, efficiency and security of power supply.
CO 4: Impart an understanding of economics, policies and technical regulations for DG integration.

UNIT – I	SMART GRIDS	Lecture Hrs: 10

Smart grid overview- ageing assets and lack of circuit capacity- thermal constraints, operational constraints, security of supply- national initiatives- early smart grid initiatives- active distribution networks- virtual power plant- other initiatives and demonstrations- overview of the technologies required for the smart grid.

UNIT – II	TRANSMISSION AND DISTRIBUTION MANAGEMENT	Lecture Hrs: 10

Data Sources- Energy Management System-Wide Area Applications, Visualization Techniques- Data Sources and Associated External Systems- SCADA- Customer Information System- Modeling and Analysis Tools, Distribution System Modeling- Topology Analysis- Load Forecasting- Power Flow Analysis- Fault Calculations- State Estimation- Applications-System Monitoring- Operation- Management- Outage Management System-Overview of energy storage technologies.

UNIT - III	SMART METERING AND DEMAND SIDE INTEGRATION	Lecture Hrs: 11

Overview- Smart metering – Evolution of electricity metering- key components of smart metering- smart meters: an overview of the hardware used – signal acquisition- signal conditioning-analogue to digital conversion- computation-input/output and communication. Communication infrastructure and protocols for smart metering - Home area network, Neighborhood Area Network- Data Concentrator- meter data management system- Protocols for communication. Demand Side Integration- Services Provided by DSI-Implementation of DSI- Hardware Support- Flexibility Delivered by consumers from the Demand Side- System Support from DSI.

UNIT – IV	COMMUNICATION TECHNOLOGIES FOR THE SMART GRID	Lecture Hrs: 10

Data Communications: Dedicated and Shared Communication Channels, Switching Techniques, Circuit Switching, Message Switching, Packet Switching- Communication Channels, Introduction to TCP/IP - Communication Technologies: IEEE 802 Series- Mobile Communications-Multi-Protocol Label Switching-Power line Communication.

UNIT – V	INFORMATION SECURITY FOR THE SMART GRID	Lecture Hrs: 10

Overview- Encryption and Decryption, Symmetric Key Encryption- Public Key Encryption-Authentication- Authentication Based on Shared Secret Key- Authentication Based on Key Distribution Center- Digital Signatures- Secret Key Signature-Public Key Signature- Message Digest-Impact of Stability.

Textbooks:

1. Janaka Ekanayake, Kithsiri Liyanage, et.al., Smart Grid Technology and Applications, Wiley Publications, 1st edition, 2012.
2. James Momoh, Smart Grid: Fundamentals of Design and Analysis, Wiley, IEEE Press, 1st edition, 2012.
3. Bharat Modi, Anuprakash, Yogesh Kumar, Fundamentals of Smart Grid Technology, S.K Kataria& Sons, 1st edition, 2019.

Reference Books:

1. Eric D. Knapp, Raj Samani, Applied Cyber Security and the Smart Grid-Implementing Security Controls into the Modern Power Infrastructure, Syngress Publishers, 1st edition, 2013.
2. Nouredine Hadjsaid, Jean Claude Sabonnadiere, Smart Grids, Wiley Blackwell Publications, 1st edition, 2012.
3. Peter-Fox Penner, Smart Power: Climate Changes, the Smart Grid and the future of electric utilities, Island Press, 1st edition, 2010.

Online Learning Resources:

www.indiasmartgrid.org

Course Code	21D21108	ELECTRIC VEHICLE ENGINEERING (21D21108) (PE-II)	L	T	P	C
Semester	I		3	0	0	3

Course Objectives: To make the student

- Remember and understand the differences between conventional Vehicle and Electric Vehicles, electro mobility and environmental issues of EVs.
- Analyze various EV configurations, parameters of EV systems and Electric vehicle dynamics.
- Analyze the basic construction, operation and characteristics of fuel cells and battery charging techniques in HEV systems.
- Design and analyze the various control structures for Electric vehicle.

Course Outcomes (CO): Student will be able to

CO 1: To understand and differentiate between Conventional Vehicle and Electric Vehicles, electro mobility and environmental issues of EVs.
CO 2: To remember and understand various configurations in parameters of EV system and dynamic aspects of EV.
CO 3: To analyze fuel cell technologies in EV and HEV systems.
CO 4: To analyze the battery charging and controls required of EVs.

UNIT – I | Introduction to EV Systems and Energy Sources | Lecture Hrs: 10

Past, Present and Future of EV - EV Concept- EV Technology- State-of-the Art of EVs- EV configuration- EV system- Fixed and Variable gearing- Single and multiple motor drive- In-wheel drives- EV parameters: Weight, size, force and energy, performance parameters.
Electro mobility and the environment- History of Electric power trains- Carbon emissions from fuels- Green houses and pollutants- Comparison of conventional, battery, hybrid and fuel cell electric systems.

UNIT – II | EV Propulsion and Dynamics | Lecture Hrs: 10

Choice of electric propulsion system- Block diagram- Concept of EV Motors- Single and multi- motor configurations- Fixed and variable geared transmission- In-wheel motor configuration- Classification - Electric motors used in current vehicle applications - Recent EV Motors- Vehicle load factors- Vehicle acceleration.

UNIT - III | Fuel Cells | Lecture Hrs: 10

Introduction of fuel cells- Basic operation- Model - Voltage, power and efficiency- Power plant system – Characteristics- Sizing - Example of fuel cell electric vehicle - Introduction to HEV- Brake specific fuel consumption - Comparison of Series-Parallel hybrid systems- Examples.

UNIT – IV | Battery Charging and Control | Lecture Hrs: 12

Battery charging: Basic requirements- Charger architecture- Charger functions- Wireless charging- Power factor correction.
Control: Introduction- Modeling of electro mechanical system- Feedback controller design approach- PI controller's designing- Torque-loop, Speed control loop compensation- Acceleration of battery electric vehicle.

UNIT – V	Energy Storage Technologies	Lecture Hrs: 10
Role of Energy Storage Systems- Thermal- Mechanical-Chemical- Electrochemical- Electrical - Efficiency of energy storage systems- Super capacitors-Superconducting Magnetic Energy Storage (SMES)- SOC- SoH -fuel cells - G2V- V2G- Energy storage in Micro-grid and Smart grid- Energy Management with storage systems- Battery SCADA		

Textbooks:

1. C.C Chan, K.T Chau: Modern Electric Vehicle Technology, Oxford University Press Inc., New York 2001,1st Edition
2. Ali Emadi, "Advanced Electric Drive Vehicles", CRC Press, 2017,1st Edition

Reference Books:

1. Electric and Hybrid Vehicles Design Fundamentals, Iqbal Husain, CRC Press 2021, 3rd Edition.
2. Francisco Díaz-González, Andreas Sumper, Oriol Gomis-Bellmunt," Energy Storage in Power Systems" Wiley Publication, ISBN: 978-1-118-97130-7, Mar 2016,1st Edition
3. A.G.Ter-Gazarian, "Energy Storage for Power Systems", the Institution of Engineering and Technology (IET) Publication, UK, (ISBN – 978-1-84919-219-4), Second Edition, 2011.
4. Mehrdad Ehsani, Yimi Gao, Sebastian E. Gay, Ali Emadi, "Modern Elelctric, Hybrid Elelctric and Fuel Cell Vehicles: Fundamentals, Theory and Design", CRC Press, 2004,1st Edition
5. James Larminie, John Lowry, "Electric Vehicle Technology Explained", Wiley, 2003,2nd Edition.

Online Learning Resources:

1. https://nptel.ac.in/courses/108/102/108102121/
2. https://nptel.ac.in/syllabus/108103009

R21 COURSE STRUCTURE & SYLLABUS FOR M.TECH COURSES

COMMON SUBJECTS TO ALL THE SPECIALIZATIONS

Course Code		Research Methodology and IPR (21D11109)	L	T	P	C
Semester	I		2	0	0	2

Course Objectives: This Course Will Enable Students:

Course Outcomes (CO): Student will be able to

At the end of this course, students will be able to

- Understand research problem formulation.
- Analyze research related information
- Follow research ethics
- Understand that today's world is controlled by Computer, Information
- Technology, but tomorrow world will be ruled by ideas, concept, and creativity.
- Understanding that when IPR would take such important place in growth of individuals & nation, it is needless to emphasis the need of information about Intellectual Property Right to be promoted among students in general & engineering in particular.
- Understand that IPR protection provides an incentive to inventors for further research work and investment in R & D, which leads to creation of new and better products, and in turn brings about, economic growth and social benefits.

UNIT - I | Lecture Hrs:

Meaning of research problem, Sources of research problem, Criteria Characteristics of a good research problem, Errors in selecting a research problem, Scope and objectives of research problem. Approaches of investigation of solutions for research problem, data collection, analysis, interpretation, Necessary instrumentations

UNIT - II | Lecture Hrs:

Effective literature studies approaches, analysis Plagiarism, Research ethics,

UNIT - III | Lecture Hrs:

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

UNIT - IV | Lecture Hrs:

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

UNIT - V | Lecture Hrs:

Patent Rights: Scope of Patent Rights. Licensing and transfer of technology. Patent information and databases. Geographical Indications. New Developments in IPR: Administration of Patent System. New developments in IPR; IPR of Biological Systems, Computer Software etc. Traditional knowledge Case Studies, IPR and IITs.

Textbooks:

1. Structural Dynamics for Earthquake Engineering,A.K.Chopra,Pearson Pubilications
2. Dynamics of Structures by Clough & Penziem
3. Structural Dynamics by Roy. R. Craig John willy & fours.

Reference Books:

- Stuart Melville and Wayne Goddard, "Research methodology: An introduction for science & engineering students'"
- Wayne Goddard and Stuart Melville, "Research Methodology: An Introduction"
- Ranjit Kumar, 2nd Edition, "Research Methodology: A Step by Step Guide• for beginners"
- Halbert, "Resisting Intellectual Property", Taylor & Francis Ltd ,2007.
- Mayall, "Industrial Design", McGraw Hill, 1992.
- Niebel, "Product Design", McGraw Hill, 1974.
- Asimov, "Introduction to Design", Prentice Hall, 1962.
- Robert P. Merges, Peter S. Menell, Mark A. Lemley, " Intellectual Property in New Technological Age", 2016.
- T. Ramappa, "Intellectual Property Rights Under WTO", S. Chand, 2008

R21 COURSE STRUCTURE & SYLLABUS FOR M.TECH COURSES

COMMON SUBJECTS TO ALL THE SPECIALIZATIONS

Course Code		**ENGLISH FOR RESEARCH PAPER WRITING**	**L**	**T**	**P**	**C**
Semester	**I**	**(21D11110)**	**2**	**0**	**0**	**0**

Course Objectives: This Course Will Enable Students:

Course Outcomes (CO): Student will be able to

At the end of this course, students will be able to
1. Understand that how to improve your writing skills and level of readability
2. Learn about what to write in each section
3. Understand the skills needed when writing a Title Ensure the good quality of paper at very first-time submission

UNIT - I	Lecture Hrs:

Planning and Preparation, Word Order, Breaking up long sentences, Structuring Paragraphs and Sentences, Being Concise and Removing Redundancy, Avoiding Ambiguity and Vagueness

UNIT - II	Lecture Hrs:

Clarifying Who Did What, Highlighting Your Findings, Hedging and Criticising, Paraphrasing and Plagiarism, Sections of a Paper, Abstracts. Introduction 4

UNIT - III	Lecture Hrs:

Review of the Literature, Methods, Results, Discussion, Conclusions, The Final Check.

UNIT - IV	Lecture Hrs:

key skills are needed when writing a Title, key skills are needed when writing an Abstract, key skills are needed when writing an Introduction, skills needed when writing a Review of the Literature

UNIT - V	Lecture Hrs:

skills are needed when writing the Methods, skills needed when writing the Results, skills are needed when writing the Discussion, skills are needed when writing the Conclusions. useful phrases, how to ensure paper is as good as it could possibly be the first- time submission

Textbooks:

1. Goldbort R (2006) Writing for Science, Yale University Press (available on Google Books) 2. Day R (2006) How to Write and Publish a Scientific Paper, Cambridge University Press
3. Highman N (1998), Handbook of Writing for the Mathematical Sciences, SIAM. Highman'sbook .
4. Adrian Wallwork , English for Writing Research Papers, Springer New York Dordrecht Heidelberg London, 2011

R21 COURSE STRUCTURE & SYLLABUS FOR M.TECH COURSES

COMMON SUBJECTS TO ALL THE SPECIALIZATIONS

Course Code		**VALUE EDUCATION (21D11111)**	**L**	**T**	**P**	**C**
Semester	**I**		**2**	**0**	**0**	**0**

Course Objectives: This Course Will Enable Students:

Course Outcomes (CO): Student will be able to

1. Understand value of education and self- development
2. Imbibe good values in students
3. Let the should know about the importance of character

UNIT - I		Lecture Hrs:

Values and self-development –Social values and individual attitudes, Work ethics, Indian vision of humanism. Moral and non- moral valuation. Standards and principles.,Value judgements

UNIT - II		Lecture Hrs:

Importance of cultivation of values., Sense of duty. Devotion, Self-reliance. Confidence, Concentration, Truthfulness, Cleanliness. Honesty, Humanity. Power of faith, National Unity, Patriotism. Love for nature ,Discipline

UNIT - III		Lecture Hrs:

Personality and Behavior Development - Soul and Scientific attitude, Positive Thinking. Integrity and discipline. Punctuality, Love and Kindness. Avoid fault Thinking. Free from anger, Dignity of labour., Universal brotherhood and religious tolerance.

UNIT - IV		Lecture Hrs:

True friendship., Happiness Vs suffering, love for truth. Aware of self-destructive habits. Association and Cooperation. Doing best for saving nature

UNIT - V		Lecture Hrs:

Character and Competence –Holy books vs Blind faith. Self-management and Good health. Science of reincarnation. Equality, Nonviolence, Humility, Role of Women. All religions and same message. Mind your Mind, Self-control. Honesty, Studying effectively

Textbooks:

1 Chakroborty, S.K. “Values and Ethics for organizations Theory and practice”, Oxford University Press, New Delhi

Course Code		PEDAGOGY STUDIES (21D11112)	L	T	P	C
Semester	I		2	0	0	0

Course Objectives: This Course Will Enable Students:

1. Review existing evidence on the review topic to inform programme design and policy making undertaken by the DfID, other agencies and researchers.
2. Identify critical evidence gaps to guide the development

Course Outcomes (CO): Student will be able to

UNIT - I		Lecture Hrs:

Introduction and Methodology, Aims and rationale, Policy background, Conceptual framework and terminology Theories of learning, Curriculum, Teacher education. Conceptual framework, Research questions, Overview of methodology and Searching.

UNIT - II		Lecture Hrs:

Thematic overview: Pedagogical practices are being used by teachers in formal and informal classrooms in developing countries. Curriculum, Teacher education.

UNIT - III		Lecture Hrs:

Evidence on the effectiveness of pedagogical practices, Methodology for the in depth stage: quality assessment of included studies. How can teacher education (curriculum and practicum) and the school, curriculum and guidance materials best support effective pedagogy? Theory of change. Strength and nature of the body of evidence for effective pedagogical, practices. Pedagogic theory and pedagogical approaches. Teachers' attitudes and beliefs and Pedagogic strategies

UNIT - IV		Lecture Hrs:

Professional development: alignment with classroom practices and followup support Peer support Support from the head teacher and the community. Curriculum and assessment Barriers to learning: limited resources and large class sizes

UNIT - V		Lecture Hrs:

Research gaps and future directions Research design Contexts Pedagogy Teacher education Curriculum and assessment Dissemination and research impact.

Textbooks:

1. Ackers J, Hardman F (2001) Classroom interaction in Kenyan primary schools, Compare, 31 (2): 245-261.
2. Agrawal M (2004) Curricular reform in schools: The importance of evaluation, Journal of Curriculum Studies, 36 (3): 361-379.
3. Akyeampong K (2003) Teacher training in Ghana - does it count? Multi-site teacher education research project (MUSTER) country report 1. London: DFID.
4. Akyeampong K, Lussier K, Pryor J, Westbrook J (2013) Improving teaching and learning of basic maths and reading in Africa: Does teacher preparation count? International Journal Educational Development, 33 (3): 272–282.
5. Alexander RJ (2001) Culture and pedagogy: International comparisons in primary education. Oxford and Boston: Blackwell.
6. Chavan M (2003) Read India: A mass scale, rapid, 'learning to read' campaign.
7. www.pratham.org/images/resource%20working%20paper%202.pdf.

Course Code	21D21109	MACHINES & POWER SYSTEMS LAB (21D21109)	L	T	P	C
Semester	I		0	0	4	2

Course Objectives: To make the student

- Understand the experiments ensuring the safety of equipment and personnel.
- Analyze the power system data fault studies.
- Interpret the experimental results and correlating them with the practical power system.
- Design the relays for power system protection purpose.

Course Outcomes (CO): Student will be able to

CO 1: Understand the concept of different experiments.
CO 2: Analyze the data for and compute the data to obtain results.
CO 3: Apply the computational results to solve the original power system problems.
CO 4: Develop advanced relays to identify various faults.

List of Experiments:

1. Determination of Subtransient Reactance of a Salient Pole Machine
2. Determination of Sequence Impedances of a Cylindrical Rotor Synchronous Machine
3. Fault Analysis
   i) LG Fault ii) LL Fault iii) LLG Fault iv) LLLG Fault
4. Equivalent Circuit of a Three Winding Transformer
5. Separation of No Load losses of a Three Phase Squirrel Cage Induction Motor
6. Power Angle Characteristics of a Salient Pole Synchronous Machine
7. Characteristics of Static/Numeric Over Current Relay
8. Characteristics of Static Negative Sequence Relay
9. Characteristics of Static/Numeric Over Voltage Relay
10. Characteristics of Static/Numeric Percentage Biased Differential Relay
11. Testing of Buchholz relay
12. Testing of Frequency Relay.
13. Testing of Reverse Power Relay.
14. Testing of Earth fault Relay

Web Sources: https://www.vlab.co.in

R21 COURSE STRUCTURE & SYLLABUS FOR M.TECH COURSES
DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING
(ELECTRICAL POWER SYSTEMS)

Course Code	21D21110	POWER SYSTEMS SIMULATION LAB (21D2111)	L	T	P	C
Semester	I		0	0	4	2

Course Objectives: To make the student

- Understand how to write the coding in simulation
- Analyze the data related to load flows, economic dispatch problem and transient stability analysis.
- Apply the computational results in real life power system problems.
- Have the capabilities to develop new software's to optimize the results.

Course Outcomes (CO): Student will be able to

CO 1: Understand the coding in simulation.
CO 2: Analyze the power system data for load-flow and stability studies.
CO 3: Apply computational methods for large scale power system studies.
CO 4: Develop software for power system industry to solve various issues.

List of Experiments:

1. Y - Bus Formation
2. Gauss – Seidel Load Flow Analysis
3. Fast Decoupled Load Flow Analysis
4. Fast Decoupled Load Flow Analysis for Distribution Systems
5. Point by Point Method
6. Computation of Available Transfer Capabilities.
7. Contingency analysis.
8. State estimation using Weighted Least Square, linear and non-linear methods.
9. Simulation of power quality problems (Sag/Swell, interruption, transients, harmonics, flickers etc.)
10. Harmonic analysis and Single tuned filter design to mitigate harmonics.
11. Harmonic analysis and Double tuned filter design to mitigate harmonics.

Web Sources: https://www.vlab.co.in

R21 COURSE STRUCTURE & SYLLABUS FOR M.TECH COURSES
DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING
(ELECTRICAL POWER SYSTEMS)

Course Code	21D21201	POWER SYSTEM STABILITY & CONTROL	L	T	P	C
Semester	II		3	0	0	3

Course Objectives: To make the student

- Understand about linear and nonlinear models of multi-machine power systems.
- Analyze various types of stability properties of power systems.
- Identify power system models from dynamic data and simulate excitation mechanisms in synchronous machines.
- Design excitation systems and their state space model equations for further stability applications.

Course Outcomes (CO): Student will be able to

CO 1: Understand the concepts of single and multi-machine systems connected to infinite bus bar.
CO 2: Analyze system responses to small disturbances and concept of dynamic stability and power system stabilizers.
CO 3: Apply the various stability methods to evaluate the stability of the system.
CO 4: Design the state space model equations for excitation systems and methods for finding voltage and angle instability.

UNIT - I THEELEMENTARYMATHEMATICALMODEL — Lecture Hrs: 10

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

UNIT - II SYSTEM RESPONSE TO SMALL DISTURBANCES AND DYNAMIC STABILITY — Lecture Hrs: 8

The unregulated synchronous Machine – Modes of oscillation of an unregulated multi-machine 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 POWERSYSTEMSTABILIZERS — Lecture Hrs: 12

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 EXCITATIONSYSTEMS — Lecture Hrs:12

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 STABILITYANALYSIS — Lecture Hrs:10

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 – Lyapunov function 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.

Textbooks:
1. Vijay Vittal, James D. McCalley, Paul M. Anderson "Power System Control and Stability", Jhon Willey and Sons, 3rd edition, 2019. 2. Prabha Kundur, "Power System Control and Stability", McGraw Hill Education India, 1st edition, 5th reprint, 2008.
Reference Books:
1. Dr Jan Machowski, Dr Janusz W. Bialek, Dr Jim Bumby · "Power System Dyanmics: Stability and Control", Jhon willey and Sons, 2nd Edition, 2011. 2. M.A. Pai, Power System Stability Analysis by the direct method of Lyapunov, North Holland Publishing Company,NewYork,1st edition,1981.
Online Learning Resources:

R21 COURSE STRUCTURE & SYLLABUS FOR M.TECH COURSES
DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING
(ELECTRICAL POWER SYSTEMS)

Course Code	21D21202	FACTS CONTROLLERS	L	T	P	C
Semester	II		3	0	0	3

Course Objectives: To make the student

- To understand the fundamentals of FACTS Controllers, Importance of controllable parameters and types of FACTS controllers & their benefits.
- To explain control of STATCOM and SVC and their comparison and the regulation of STATCOM.
- To remember the objectives of Shunt and Series compensation.
- To analyze the functioning and control of GCSC, TSSC and TCSC.

Course Outcomes (CO): Student will be able to

CO 1: Understand various control techniques for the purpose of identifying the scope and for selection of specific FACTS controllers.
CO 2: Remember different types of controllable VAR generation and variable impedance techniques.
CO 3: Design simple converters using FACTS controllers.
CO 4: Understand the operation of Unified Power Controller and Hybrid Arrangements.

UNIT - I FACTS CONCEPTS, VSI AND CSI — Lecture Hrs: 10

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. Single phase three phase full wave bridge converters transformer connections for 12pulse 24 and 48 pulse operation. Three level voltage source converter, pulse width modulation converter, basic concept of current source Converters, and comparison of current source converters with voltage source converters.

UNIT - II SHUNT COMPENSATION — Lecture Hrs: 8

Objectives of shunt compensation - Methods of controllable var generation - Variable impedance type static var generators - switching converter type var generators - hybrid var generators – Comparison of SVC and STATCOM.

UNIT - III SERIES COMPENSATION — Lecture Hrs: 12

Objectives of series compensation–GTO Thyristor Controlled Series Capacitor (GCSC)-Thyristor Switched Series Capacitor (TSSC) - Thyristor Controlled Series Capacitor (TCSC) - Control schemes for TCSC, TSSC and TCSC.

UNIT - IV UNIFIED POWER FLOW CONTROLLER (UPFC) — Lecture Hrs:12

Introduction - 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-Hybrid Arrangements: UPFC With a Phase Shifting Transformer.

UNIT - V INTERLINE POWER FLOW CONTROLLER (IPFC) — Lecture Hrs:10

Introduction, basic operating principle and characteristics of IPFC, control structure, practical and application considerations, generalized and multifunctional FACTS controllers

Textbooks:

1. Understanding FACTS–Concepts and technology of Flexible AC Transmission systems, Narain G. Hingorani, Laszlo Gyugyi, IEEEPress, WILEY,1st Edition,2000, Reprint2015.
2. FACTS Controllers in Power Transmission and Distribution, Padiyar K.R., New Age International Publishers, 1st Edition, 2007.

Reference Books:

1. Flexible AC Transmission Systems: Modelling and Control, Xiao–Ping Zhang, Christian Rehtanz, Bikash Pal, Springer, 2012, First Indian Reprint,2015.
2. FACTS–Modelling and Simulationin Power Networks, Enrigue Acha, Claudio R. Fuerte – Esquival, Huge Ambriz –perez, Cesar Angeles –Camacho, WILEY, 1st edition, 2004.

Online Learning Resources:

JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY ANANTAPUR
JNTUA COLLEGE OF ENGINEERING (AUTONOMOUS) :: ANANTHAPURAMU
Ananthapuramu – 515 002, Andhra Pradesh, India

R21 COURSE STRUCTURE & SYLLABUS FOR M.TECH COURSES
DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING
(ELECTRICAL POWER SYSTEMS)

Course Code	21D21203	POWER SYSTEM WIDE AREA MONITORING & CONTROL (PE–III)	L	T	P	C
Semester	II		3	0	0	3

Course Objectives: To make the student

- To know the necessity of real-time computer control of power systems and wide area measurement system.
- To get the knowledge of different automation systems.
- To know the complete fundamentals of SCADA and its importance in real time power systems.
- To get the knowledge about Substation Automation, New Digital Substation and traditional approach and IED-based approach of Integrated Protective Functions.
- To study about Voltage stability, prevention of voltage collapse and dynamic stability analysis.

Course Outcomes (CO): Student will be able to

CO 1: Know the necessity of real-time computer control of power systems and wide area measurement system.
CO 2: Get the knowledge of different automation systems.
CO 3: Know the complete fundamentals of SCADA and its importance in real time power systems.
CO 4: Get the knowledge about Substation Automation, New Digital Substation and traditional approach and IED-based approach of Integrated Protective Functions.
CO 5: Study about Voltage stability, prevention of voltage collapse and dynamic stability analysis.

UNIT - I	**COMPUTER CONTROL OF POWER SYSTEMS**	Lecture Hrs: 10

Need for computer control of power systems, Operating states of a power system, Supervisory Control and Data Acquisition system, Energy control centers.
Wide Area Measurement system (WAMS): Architecture, Components of WAMS, Applications: Voltage Stability Assessment, Frequency stability Assessment, Power Oscillation Assessment, Communication needs of WAMS, Wide Area Monitoring Protection & Control, and Remedial Action Scheme.

UNIT - II	**POWER SYSTEM AUTOMATION**	Lecture Hrs: 8

Introduction, Evolution of Automation Systems, History of Automation Systems, Supervisory Control and Data Acquisition (SCADA) Systems, Components of SCADA Systems, SCADAApplications,SCADAinPowerSystems,SCADABasicFunctions,SCADAApplicationFunctions, Advantages of SCADA in Power Systems, Deferred Capital Expenditure, Optimized Operation and Maintenance Costs, Equipment Condition Monitoring (ECM), Sequence of Events (SOE) Recording, Power Quality Improvement, Data Warehousing for Power Utilities, Power System Field, Transmission and Distribution Systems, Customer Premises, Types of Data and Signals in Power Systems, Flow of Data from the Field to the SCADA Control Center

UNIT - III	**SCADA FUNDAMENTALS**	Lecture Hrs: 12

Introduction, Open System: Need and Advantages, Building Blocks of SCADA Systems, Remote Terminal Unit (RTU), Evolution of RTUs, Components of RTU, Communication Subsystem, Logic Subsystem Termination Subsystem, Testing and Human-Machine Interface (HMI) Subsystem, Power Supplies, Advanced RTU Functionalities, Intelligent Electronic Devices (IEDs), Evolution of IEDs, IED Functional Block Diagram, Hardware and Software Architecture of the IED, IED Communication Subsystem, IED Advanced Functionalities, Tools for Settings, Commissioning, and Testing, Programmable LCD Display, Typical IEDs, Data Concentrators and Merging Units, RTUs, IEDs, and Data Concentrator, Merging Units and IEDs.

UNIT - IV	**SUBSTATION AUTOMATION**	Lecture Hrs:12

Substation Automation: Technical Issues, System Responsibilities, System Architecture, Substation Host Processor, Substation LAN, User Interface, Communications Interfaces, Protocol Considerations. The New Digital Substation, Process Level, Protection and Control Level, Station Bus and Station Level, Substation Automation Architectures, Legacy Substation Automation System, Digital Substation Automation Design, New versus Existing Substations. Drivers of Transition, Migration Paths and the Steps Involved, Value of Standards in Substation Automation, Substation Automation (SA) Application Functions, Integrated Protection Functions: Traditional Approach and IED-Based Approach. Automation Functions, Enterprise-Level Application Functions.

UNIT - V	**VOLTAGE STABILITY**	Lecture Hrs:10

Basic concepts, Voltage collapse–general characterization, classification, Voltage stability analysis–modeling, dynamic analysis, static analysis, shortest distance to instability, continuation power flow analysis, prevention of voltage collapse – design measures, operating measures.

Textbooks:

1. AllenJ.WoodandBruceWoolenberg,PowerSystemGeneration,OperationandControl,JohnWiley andSons, 3rd edition, 2013.
2. Prabha Kundur, "PowerSystem Control andStability", McGraw Hill Education India, 1st edition, 5th reprint, 2008.
3. MiniS.ThomasandJohnDouglasMcDonald,PowerSystemSCADAandSmartGrids,CRCPress, 1st edition, 2015.

Reference Books:

1. E.Handschin,Real-timeControlofElectricalPowerSystems,ElsevierPublications&Co,1st edition,1988.
2. SpecialIssueonComputerControlofPowerSystems,IEEEProc,July1974.

Online Learning Resources:

Course Code	21D23104	MODERN CONTROL THEORY (21D23104) (PE-III)	L	T	P	C
Semester	I		3	0	0	3

Course Objectives: To make the student

- Remember and understand the concept of state space representation, Solution of state equation, STM, linearization of nonlinear systems, controllability and observability concepts, principles of duality, concepts of optimal and Lyapunov stability.
- Apply the above concepts to analyze controllability, Observability and pole placement by state feedback.
- Analyze the concept of regulator, stability and sensitivity using various methods and disturbance rejection.
- Design Full order observer and reduced order observer.

Course Outcomes (CO): Student will be able to

- Understand the state space representation, controllability and observability concepts, principles of duality, concepts of optimal and Lyapunov stability.
- Apply the state equations, pole placement by state feedback.
- Analyze controllability & observability of state models.
- Design full order observer and reduced order observer.

UNIT - I	STATE VARIABLE DISCRIPTION	Lec Hrs: 9

Introductory matrix algebra and linear Vector Space, State space representation of systems- Linearization of a non-linear System- Solution of state equations- Evaluation of State Transition Matrix (STM).

UNIT - II	TRANSFORMATION, POLE PLACEMENT AND CONTROLLABILITY	Lec Hrs: 10

Similarity transformation and invariance of system properties due to similarity transformations. Minimal realization of SISO, SIMO and MISO transfer functions. Discretization of a continuous time state space model- Conversion of state space model to transfer function model using Fadeeva algorithm- Fundamental theorem of feedback control - Controllability and Controllable canonical form - Pole assignment by state feedback using Ackermann‘s formula– Eigen structure assignment problem.

UNIT - III	OPTIMAL CONTROL	Lec Hrs: 10

Linear Quadratic Regulator (LQR) problem and solution of algebraic Riccati equation using Eigen value and Eigen vector methods- iterative method- Controller design using output feedback.

UNIT - IV	OBSERVERS	Lec Hrs: 9

Observability and observable canonical form-Design of full order observer using Ackermann‘s formula -Bass Gura algorithm- Duality between controllability and observability- Full order Observer based controller design- Reduced order observer design.

UNIT - V	STABILITY ANALYSIS AND SENSITIVITY	Lec Hrs: 10

Internal stability of a system- Stability in the sense of Lyapunov- Asymptotic stability of linear time invariant continuous and discrete time systems- Solution of Lyapunov type equation- Model decomposition and decoupling by state feedback- Disturbance rejection- sensitivity and complementary sensitivity functions.

Textbooks:

1. K. Ogata, "Modern Control Engineering", Prentice Hall, India, 5th edition, 2010.
2. T. Kailath, "Linear Systems", Perntice Hall, 2016.
3. N.K. Sinha, "Control Systems", New Age International, 4th edition, 2013.

Reference Books:

1. Panos J Antsaklis, and Anthony N.Michel,"Linear Systems", New-age international (P) LTD. Publishers, 2009.
2. John JDAzzoand C. H. Houpis, "LINEAR Control System Analysis And Design With Matlae", Marcel Dekker, Inc., 5Th edition, 2003.
3. B.N.Dutta, "Numerical Methods for linear Control Systems", Elsevier Publication, 2007.
4. C.T. Chen "Linear System Theory and Design- Oxford Series 3rdEdition, ,1998.
5. Richard C. Dorf and Robert H. Bishop, "Modern Control Systems", 12th Edition, Pearson Edu., India, 2014

Online Learning Resources:

Course Code	21D21204	REACTIVE POWER COMPENSATION & MANAGEMENT (PE–III)	L	T	P	C
Semester	II		3	0	0	3

Course Objectives: To make the student

- To identify the necessity of reactive power compensation.
- To describe load compensation and various types of reactive power compensation in transmission systems.
- To illustrate reactive power coordination system.
- To characterize distribution side and utility side reactive power management.

Course Outcomes (CO): Student will be able to

CO 1: Understand the importance of load compensation in symmetrical as well as unsymmetrical loads.
CO 2: Analyze various compensation methods in transmission lines.
CO 3: Design model for reactive power coordination.
CO 4: Distinguish demand side reactive power management & user side reactive power management.

UNIT - I LOAD COMPENSATION — Lecture Hrs: 10

Objectives and specifications–Reactive power characteristics–Inductive and capacitive approximate biasing – Load compensator as a voltage regulator – Phase balancing and power factor correction of unsymmetrical loads-Examples.

UNIT - II STEADY STATE & TRANSIENT STATE REACTIVE POWER COMPENSATION IN TRANSMISSION SYSTEM — Lecture Hrs: 8

Uncompensated line – Types of compensation – Passive shunt and series and dynamic shunt compensation–Characteristic time periods–Passive shunt compensation–Static compensation-Series capacitor compensation–Compensation using synchronous condensers –Examples.

UNIT - III REACTIVE POWER COORDINATION & DEMAND SIDE MANAGEMENT — Lecture Hrs: 12

Objective–Mathematical modeling–Operation planning–Transmission benefits–Basic concepts of quality of power supply – Disturbances - Steady – state variations – Effects of under Voltages – Frequency – Harmonics, radio frequency and electromagnetic interferences. Load patterns – Basic methods - load shaping – Power tariffs - KVAR based tariffs - penalties for voltage flickers and Harmonic voltage levels.

UNIT - IV DISTRIBUTION & USER SIDE REACTIVE POWER MANAGEMENT — Lecture Hrs:12

System losses – Loss reduction methods – Examples – Reactive power planning – Objectives – Economics-Planning capacitor placement–Retrofitting of capacitor banks-KVAR requirements for domestic appliances – Purpose of using capacitors – Selection of capacitors –Deciding factors– Types of capacitors, characteristics and Limitations.

UNIT - V REACTIVE POWER MANAGEMENT IN ELECTRIC TRACTION SYSTEMS AND ARC FURNACES — Lecture Hrs:10

Typical layout of traction systems–Reactive power control requirements–Distribution transformers - Electric arc furnaces – Furnaces transformer – Filter requirements – Remedial measures –Power factor of an arc furnace.

Textbooks:
1. T.J.E.Miller, "Reactive Power Control in Electric Systems", John Wiley and Sons, 5th edition, 2017. 2. D.M.Tagare, Reactive power Management, Tata Mc Graw Hill, 1st edition, 2004.
Reference Books:
1. Dr. Hidaia alassouli, "Reactive Power Compensation", Kindle Edition.2018. 2. Wolfgang Hofmann, Jurgen Schlabbach, Wolfgang Just "Reactive Power Compensation: A Practical Guide, Wiely publication, 4th edition, April, 2012.
Online Learning Resources:
http://nptel.iitm.ac.in

Course Code	21D21205	POWER QUALITY	L	T	P	C
Semester	II	(PE- IV)	3	0	0	3

Course Objectives: To make the student

- To understand power quality definition, power quality standards.
- To remember measuring & solving power quality problems.
- To apply the various types of linear and nonlinear loads.
- To analyse harmonic methodology, mitigation techniques and case study.

Course Outcomes (CO): Student will be able to

CO 1: Understand the fundamentals & terminology of power quality.
CO 2: Apply the concept of power frequency disturbances, types of transients & transient waveforms.
CO 3: Analyze the harmonic methodology & Electromagnetic Interference concepts.
CO 4: Remember the necessity of grounding and methods of grounding.
CO 5: Understand different techniques of measuring & solving power quality problems.

UNIT - I	INTRODUCTION TO POWER QUALITY	Lecture Hrs: 10

Definition of Power Quality - Power Quality Progression - Power Quality Terminology - Power Quality Issues– Responsibilities of Power Suppliers and Users-Power Quality Standards.

UNIT - II	POWER FREQUENCY DISTURBANCE&TRANSIENTS	Lecture Hrs: 8

Introduction to Power Frequency Disturbance - Common Power Frequency Disturbances – Characteristics of Low Frequency Disturbances - Voltage Tolerance Criteria- ITIC Graph - Introduction to Transients -Transient System Model - Examples of Transient Models and Their Response - Power System Transient Modeling-Types and Causes of Transients -Examples of Transient Waveforms.

UNIT - III	HARMONICS & ELECTRO-MAGNETIC INTERFERENCE (EMI)	Lecture Hrs: 12

Definition of Harmonics - Harmonic Number (h) - Odd and Even Order Harmonics - Harmonic Phase Rotation and Phase Angle - 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 - Introduction to EMI - Frequency Classification –Electrical Fields-Magnetic Fields-EMI Terminology-Power Frequency Fields-High Frequency Interference-EMI Susceptibility-EMI Mitigation-Cable Shielding-Health Concerns of EMI.

UNIT - IV	GROUNDINGANDBONDING	Lecture Hrs:12

Introduction to Grounding and Bonding-Shock and Fire Hazards-NEC Grounding Requirements-Essentials of a Grounded System-Ground Electrodes-Earth Resistance Tests-Earth Ground Grid Systems-Power Ground System-Signal Reference Ground(SRG)-SRG Methods-Single and Multipoint Grounding –Ground Loops –Electro chemical Reaction -Examples of Grounding Anomalies.

UNIT - V	MEASURING AND SOLVING POWER QUALITY PROBLEMS	Lecture Hrs:10

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

Textbooks:
1. Power quality by C. Sankaran, CRC Press, 1st Edition, 2001. 2. Electrical Power Systems Quality, Roger C. Dugan, Mark F. Mc Granaghan, Surya Santoso, H. Wayne Beaty, 2nd Edition, TMH Education Pvt. Ltd, 1996.
Reference Books:
1. Understanding Power quality problems by Math H. J.Bollen IEEE Press, 1st edition, 2000. 2. Power quality enhancement using custom power devices by Arindam, Ghosh, Gerard Ledwich, Kluwer, Academic publishers, 1st edition, 2002.
Online Learning Resources:

Course Code	21D21206	DISTRIBUTED GENERATION AND MICRO GRID CONTROL (PE– IV)	L	T	P	C
Semester	II		3	0	0	3

Course Objectives: To make the student

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

Course Outcomes (CO): Student will be able to

CO 1: Understand the concept of distributed generation, distribution network & the concept of Micro grid, its configuration, advantages & limitations.

CO 2: Understand the basic concepts in combined heat and power, Wind energy conversion systems, solar photo voltaic systems & other renewable energy sources.

CO 3: The impact of Micro grid & Active distribution network management system on various factors.

CO 4: Understand 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 MICRO GRID CONCEPT	Lecture Hrs: 10

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	Lecture Hrs: 8

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	Lecture Hrs: 12

Introduction - Impact on 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 - IV	SCADAANDACTIVEDISTRIBUTION NETWORKS	Lecture Hrs:12

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	Lecture Hrs:10
Introduction - Power quality disturbances - Power quality sensitive customers - Power quality improvement technologies-Impact of DG integration-Issues of premium power in DG integration.		
Textbooks:		
1. S.Chowdhury, S.P.ChowdhuryandP.Crossley,"Microgrid sand Active Distribution Networks", the Institution of Engineering and Technology,2009. 2. Rajeev Kumar Chuahan, Kalpana Chuahan, "Distributed Energy Resources in Microgrids: Integration, Chalenges and Optimization", Academic Press, 1st Edition, 2019.		
Reference Books:		
1. Magdi S. Mahmoud, "MICROGRID Advanced Control Methods and Renewable Energy System Integration", Joc Hayton, 1st Edition, 2016.		
Online Learning Resources:		

Course Code	21D21207	EHVAC TRANSMISSION SYSTEMS (PE-IV)	L	T	P	C
Semester	II		3	0	0	3

Course Objectives: To make the student

- To understand the basic concepts of EHVAC.
- To identify the factors affecting AC-DC transmission.
- To analyze travelling waves and the effects of corona like audible noise.
- To estimate field intensity at any point in EHV system with the help of different computational method.

Course Outcomes (CO): Student will be able to

CO 1: Understand the basic concepts of EHVAC.
CO 2: Identify the factors affecting AC-DC transmission.
CO 3: Analyze travelling waves and the effects of corona like audible noise.
CO 4: Estimate field intensity at any point in EHV system with the help of different computational method.

UNIT - I PRELIMINARIES Lecture Hrs: 10

Necessity of EHV AC transmission – Advantages and problems – Power handling capacity and line losses- Mechanical considerations – Resistance of conductors – Properties of bundled conductors – Bundle spacing and bundle radius - Examples.

UNIT - II LINE AND GROUND REACTIVE PARAMETERS Lecture Hrs: 8

Line inductance and capacitances – Sequence inductances and capacitances – Modes of propagation – Ground return – Examples. Electrostatics – Field of sphere gap – Field of line changes and properties – Charge – potential relations for multi-conductors – Surface voltage gradient on conductors – Distribution of voltage gradient on sub-conductors of bundle – Examples.

UNIT - III CORONA EFFECTS Lecture Hrs: 12

Power loss and audible noise (AN) – corona loss formulae – Charge voltage diagram – Generation, characteristics - Limits and measurements of AN – Relation between 1-phase and 3 -phase AN levels – Radio interference (RI) - Corona pulses generation, properties, limits – Frequency spectrum – Modes of propagation – Excitation function – Measurement of RI, RIV and excitation functions - Examples.

UNIT - IV ELECTROSTATIC FIELD & TRAVELING WAVE THEORY Lecture Hrs:12

Electrostatic field: calculation of electrostatic field of EHV/AC lines – Effect on humans, animals and plants – Electrostatic induction in un-energised circuit of double - circuit line – Electromagnetic interference - Examples. Traveling wave expression and solution - Source of excitation - Terminal conditions - Open circuited and short circuited end - Reflection and refraction coefficients - Lumped parameters of distributed lines - Generalized constants - No load voltage conditions and charging current.

UNIT - V VOLTAGE CONTROL Lecture Hrs:10

Power circle diagram and its use – Voltage control using synchronous condensers – Cascade connection of shunt and series compensation – Sub synchronous resonance in series capacitor – Compensated lines – Static VAR compensating system.

Textbooks:

1. Sanjay Kumar Sharma, "EHV-AC, HVDC Transmission and Distribution Engineering" 2nd Edition, 2016.
2. R. D. Begamudre, "EHVAC Transmission Engineering", New Age International (p) Ltd.2nd revised edition, 2012.
3. M. G. Dwek, EHV Transmission, Elsevier Sc., 3rd edition, 1992.

Reference Books:

1. R. Padiyar, HVDCTransmission Systems, Wiley Eastern Ltd., New Delhi, 2nd revised edition, 1992.
2. J. Arrilaga, High Voltage Direct Current Transmission, peter pereginver Ltd. London, U.K., 2nd edition, 1998.
3. E.W. Kimbark, Direct Current Transmission-vol.1, Wiley Inter science, New York, 1st edition, 1971.

Online Learning Resources:

1. https://www.ae.pwr.wroc.pl/filez/20110606092353_HEV.pdf
2. https://www.afdc.energy.gov/pdfs/52723.pdf 5.https://www.leb.eei.uni
3. langen.de/winterakademie/2010/report/content/course03/pdf/0308.pdf

Course Code		DISASTER MANAGEMENT	L	T	P	C
Semester	II		2	0	0	0

Course Objectives: Students will be able to:

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

Course Outcomes (CO): Student will be able to

UNIT - I	Introduction	Lecture Hrs: 04

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

UNIT – II	Repercussions Of Disasters And Hazards	Lecture Hrs: 04

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

UNIT – III	Disaster Prone Areas In India	Lecture Hrs: 04

Study Of Seismic Zones; Areas Prone To Floods And Droughts, Landslides And Avalanches; Areas Prone To Cyclonic And Coastal Hazards With Special Reference To Tsunami; Post-Disaster Diseases And Epidemics.

UNIT – IV	Disaster Preparedness And Management Preparedness:	Lecture Hrs: 04

Monitoring Of Phenomena Triggering A Disaster Or Hazard; Evaluation Of Risk: Application Of Remote Sensing, Data From Meteorological And Other Agencies, Media Reports: Governmental And Community Preparedness.

UNIT – V	Risk Assessment Disaster Risk:	Lecture Hrs: 04

Concept And Elements, Disaster Risk Reduction, Global And National Disaster Risk Situation. Techniques Of Risk Assessment, Global Co-Operation In Risk Assessment And Warning, People's Participation In Risk Assessment. Strategies for Survival.

UNIT – VI		Lecture Hrs: 04

Disaster Mitigation Meaning, Concept And Strategies Of Disaster Mitigation, Emerging Trends In Mitigation. Structural Mitigation And Non-Structural Mitigation, Programs Of Disaster Mitigation In India.

Suggested Readings::

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

R21 COURSE STRUCTURE & SYLLABUS FOR M.TECH COURSES
Audit Subjects for All Specializations

Course Code		CONSTITUTION OF INDIA	L	T	P	C
Semester	II		2	0	0	0

Course Objectives: Students will be able to:

1. Understand the premises informing the twin themes of liberty and freedom from a civil rights perspective.
2. To address the growth of Indian opinion regarding modern Indian intellectuals' constitutional role and entitlement to civil and economic rights as well as the emergence of nationhood in the early years of Indian nationalism.
3. To address the role of socialism in India after the commencement of the Bolshevik Revolution in 1917 and its impact on the initial drafting of the Indian Constitution.

Course Outcomes (CO): Student will be able to

1. Discuss the growth of the demand for civil rights in India for the bulk of Indians before the arrival of Gandhi in Indian politics.
2. Discuss the intellectual origins of the framework of argument that informed the conceptualization of social reforms leading to revolution in India.
3. Discuss the circumstances surrounding the foundation of the Congress Socialist Party (CSP) under the leadership of Jawaharlal Nehru and the eventual failure of the proposal of direct elections through adult suffrage in the Indian Constitution.
4. Discuss the passage of the Hindu Code Bill of 1956.

UNIT - I — **Lecture Hrs: 04**

History of Making of the Indian Constitution: History Drafting Committee, (Composition & Working); Philosophy of the Indian Constitution: Preamble Salient Features

UNIT – II — **Lecture Hrs: 04**

Contours of Constitutional Rights & Duties: Fundamental Rights, Right to Equality, Right to Freedom, Right against Exploitation, Right to Freedom of Religion, Cultural and Educational Rights, Right to Constitutional Remedies, Directive Principles of State Policy, Fundamental Duties

UNIT – III — **Lecture Hrs: 04**

Organs of Governance, Parliament Composition, Qualifications and Disqualifications, Powers and Functions, Executive, President, Governor, Council of Ministers, Judiciary, Appointment and Transfer of Judges, Qualifications, Powers and Functions.

UNIT – IV — **Lecture Hrs: 04**

Local Administration: District's Administration head: Role and Importance, Municipalities: Introduction, Mayor and role of Elected Representative, CEO of Municipal Corporation. Pachayati raj: Introduction, PRI: ZilaPachayat. Elected officials and their roles, CEO ZilaPachayat: Position and role. Block level: Organizational Hierarchy (Different departments), Village level: Role of Elected and Appointed officials, Importance of grass root democracy.

UNIT – V — **Lecture Hrs: 04**

Election Commission: Election Commission: Role and Functioning. Chief Election Commissioner and Election Commissioners. State Election Commission: Role and Functioning. Institute and Bodies for the welfare of SC/ST/OBC and women.

Suggested Readings::

1. The Constitution of India, 1950 (Bare Act), Government Publication.
2. Dr. S. N. Busi, Dr. B. R. Ambedkar framing of Indian Constitution, 1st Edition, 2015.
3. M. P. Jain, Indian Constitution Law, 7th Edn., Lexis Nexis, 2014.
4. D.D. Basu, Introduction to the Constitution of India, Lexis Nexis, 2015.

Audit Subjects for All Specializations

Course Code		STRESS MANAGEMENT BY YOGA	L	T	P	C
Semester	II		2	0	0	0

Course Objectives: Students will be able to:

1. To achieve overall health of body and mind
2. To overcome stress

Course Outcomes (CO): Student will be able to

1. Develop healthy mind in a healthy body thus improving social health also
2. Improve efficiency

UNIT - I	Lecture Hrs: 04

Definitions of Eight parts of yog. (Ashtanga)

UNIT – II	Lecture Hrs: 04

Yam and Niyam: Do`s and Don'ts in life, Ahinsa, satya, astheya, bramhacharya and aparigraha

UNIT – III	Lecture Hrs: 04

Yam and Niyam: Do`s and Don'ts in life, Shaucha, santosh, tapa, swadhyay, ishwarpranidhan

UNIT – IV	Lecture Hrs: 04

Asan and Pranayam: Various yog poses and their benefits for mind & body

UNIT – V	Lecture Hrs: 04

Asan and Pranayam: Regularization of breathing techniques and its effects-Types of pranayam

Suggested Readings::

1. 'Yogic Asanas for Group Training-Part-I" : Janardan Swami Yogabhyasi Mandal, Nagpur
2. "Rajayoga or conquering the Internal Nature" by Swami Vivekananda, Advaita Ashrama (Publication Department), Kolkata

R21 COURSE STRUCTURE & SYLLABUS FOR M.TECH COURSES
DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING
(ELECTRICAL POWER SYSTEMS)

Course Code	21D21208	RENEWABLE ENERGY SYSTEMS LAB	L	T	P	C
Semester	II		0	0	4	2

Course Objectives: To make the student

- Understand how to write the coding in MATLAB/Mipower.
- Apply the SVC, STATCOM for voltage profile improvements & UPFC in power system networks.
- Analyze the data related to load flows incorporating SVC & STATCOM.
- Analyze operation of TCSC, STATCOM & SSSC for a transmission line fed by an AC supply.

Course Outcomes (CO): Student will be able to

CO 1: To observe the I-V and P-V curves and Series and Parallel connection of Solar systems.
CO 2: To study the sun tracking and MPPT Charge Controllers of Solar systems.
CO 3: To analyze Power, Voltage & Frequency Measurement of Wind Generator.
CO 4: To Understand the Effect of temperature variation and Irradiation on Photovoltaic Array.

LIST OF EXPERIMENTS:

1. Draw the I-V and P-V curves of Solar Panel using PV Panel
2. Study of Series and Parallel connection of Solar Panels
3. Study of Sun tracking system
4. Maximum Power Point Tracking Charge Controllers
5. Inverter control for Solar PV based systems
6. Power, Voltage & Frequency Measurement of output of Wind Generator
7. Impact of load and wind speed on power output and its quality
8. Performance of frequency drop characteristics of induction generator at different loading condition
9. Charging and Discharging characteristics of Battery

Simulation Experiments

1. Modelling of PV Cell
2. Effect of temperature variation on Photovoltaic Array
3. Effect of Irradiation on a Photovoltaic Array
4. Design of solar PV boost converter using P&O MPPT technique

Web Sources: https://www.vlab.co.in

Note: Conduct any 7 experiments from 1-9 list and minimum 3 experiments from 1-4 of Simulation experiments

R21 COURSE STRUCTURE & SYLLABUS FOR M.TECH COURSES
DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING
(ELECTRICAL POWER SYSTEMS)

Course Code	21D21209	FACTS DEVICES & SIMULATION LAB	L	T	P	C
Semester	II		0	0	4	2

Course Objectives: To make the student

- Understand how to write the coding in MATLAB/Mipower.
- Apply the SVC, STATCOM for voltage profile improvements & UPFC in power system networks.
- Analyze the data related to load flows incorporating SVC & STATCOM.
- Analyze operation of TCSC, STATCOM & SSSC for a transmission line fed by an AC supply.

Course Outcomes (CO): Student will be able to

CO 1: Understand Load balancing using compensators.
CO 2: Apply load balancing using Compenasators.
CO 3: Analyse load flow incorporating SVC & STATCOM.
CO 4: Develop a Simulation model for STATCOM & UPFC.

LIST OF EXPERIMENTS:

1. Voltage regulation using shunt and series compensation
2. Load balancing in power system network using compensators
3. Simulation of TCSC
4. Voltage profile improvement using SVC
5. Voltage profile improvement using STATCOM
6. Transient Stability enhancement using STATCOM.
7. Simulation of UPFC with mathematical models
8. Load flow incorporating SVC
9. Load flow incorporating STATCOM
10. Simulation of DVR
11. Transmission Line Characteristics (P vs δ, Q vs δ, P vs Distance, Q vs Distance and V vs Distance) with and without Compensation
12. Sizing- simulation and operation of TCR and FC-TCR for a transmission line fed by an ac supply and feeding
    (a) Resistive/inductive/capacitive load one at a time
    (b) A load which can have leading as well as lagging behaviour

13. Sizing- simulation and operation of TCSC for a transmission line fed by an ac supply and feeding
    (a) Resistive/inductive/capacitive load one at a time
    (b) A load which can have leading as well as lagging behaviour
14. Sizing- simulation and operation of STATCOM for a transmission line fed by an ac supply and feeding
    (a) Resistive/inductive/capacitive load one at a time
    (b) A load which can have leading as well as lagging behavior
15. Sizing- simulation and operation of SSSC for a transmission line fed by an AC supply and feeding
    (a) Resistive/inductive/capacitive load one at a time
    (b) A load which can have leading as well as lagging behaviour

Web Sources: https://www.vlab.co.in

R21 COURSE STRUCTURE & SYLLABUS FOR M.TECH COURSES
DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING
(ELECTRICAL POWER SYSTEMS)

Course Code	21D21301	RESTRUCTURED POWER SYSTEMS (PE-V)	L	T	P	C
Semester	III		3	0	0	3

Course Objectives: To make the student

1. Understand basic concepts of the restructuring of power industry and market models.
2. Analyze about the fundamental concepts of congestion management, Transfer Capability issues and ancillary service management.
3. Apply the transmission cost allocation methods to evaluate the cost.
4. Develop the operational planning activities in different competitive environment.

Course Outcomes (CO): Student will be able to

CO 1: Understand the differences between the conventional power system operation and the restructured one and basics concepts of market power, electricity pricing and competitive environment.
CO 2: Analyze the concepts of Independent System Operator (ISO) and Open Access Same-Time Information System (OASIS).
CO 3: Apply the methods to find Available Transfer Capability (ATC) and to allocate the Transmission cost.
CO 4: Develop power markets and market architectural aspects and short time Price forecasting.

UNIT – I	KEYISSUESINELECTRICUTILITIES	Lecture Hrs: 9

Introduction–Restructuring models–Independent System Operator (ISO)–Power Exchange–Marketoperations–MarketPower–Standardcost–TransmissionPricing–Congestion Pricing–Management of Inter zonal/Intra zonal Congestion.

UNIT - II	OPEN ACCESS SAME-TIME INFORMATION SYSTEM (OASIS) & MARKET POWER	Lecture Hrs: 8

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	Lecture Hrs: 10

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	Lecture Hrs: 9

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	Lecture Hrs: 10

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.

Textbooks:
1. Kankar Bhattacharya, Math H.J. Boller and Jaap E.Daalder, Operation of Restructured Power System, Kulwer Academic Publishers, 1st Edition, 2001. 2. Mohammad Shahidehpour and Muwaffaq Alomoush, Restructured Electrical Power Systems, Marcel Dekker, Inc., 1st Edition, 2001.
Reference Books:
1. Loi Lei Lai, Power System Restructuring and Deregulation, John Wiley & Sons Ltd., England, 2001.
Online Learning Resources:
1. https://nptel.ac.in/courses/108/101/108101005/

R21 COURSE STRUCTURE & SYLLABUS FOR M.TECH COURSES
DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING
(ELECTRICAL POWER SYSTEMS)

Course Code	21D21302	RISK ASSESSMENT OF POWER SYSTEMS (PE - V)	L	T	P	C
Semester	III		3	0	0	3

Course Objectives: To make the student

1. Understand the basic concepts of risk assessment and risk evaluation.
2. Analyze the risk evaluation methods and risk evaluation techniques.
3. Apply the risk evaluation techniques and correlation methods to identify the risk in power systems.
4. Develop the risk evaluation models for renewable energy systems.

Course Outcomes (CO): Student will be able to

CO 1: Understand the risk evaluation concepts, independent and dependent outages, Distribution of failure data.
CO 2: Analyze the concepts of outages, correlation measures, models, contingency analysis.
CO 3: Apply the methods to evaluate the frequency, correlation and load curtailments.
CO 4: Develop the sampling methods and risk evaluation methods for renewable energy systems.

UNIT – I	Risk Assessment and Outage Models	Lecture Hrs: 8

Basic concepts of power system risk assessment: System risk evaluation, Data in risk evaluation, Unit interruption cost - Models of independent outages: Repairable forced failure, Aging failure, Non-repairable chance failure, Planned outage, Semi forced outage, Partial failure mode, Multiple failure mode - Models of dependent outages: Common-Cause outage, Component-Group outage, Station-Originated outage, Cascading outage, Environment-Dependent failure

UNIT - II	Parameter Estimation in Outage Models	Lecture Hrs: 12

Point Estimation on Mean and Variance of Failure Data - Interval Estimation on Mean and Variance of Failure Data - Estimating Failure Frequency of Individual Components - Estimating Probability from a Binomial Distribution - Experimental Distribution of Failure Data and Its Test - Estimating Parameters in Aging Failure Models

UNIT - III	Elements of Risk Evaluation Methods	Lecture Hrs: 10

Methods for Simple Systems: Probability Convolution, Series and Parallel Networks, Minimum Cutsets, Markov Equations, Frequency-Duration Approaches - Methods for Complex Systems: State Enumeration, Non-sequential Monte Carlo Simulation, Sequential Monte Carlo Simulation - Correlation Models in Risk Evaluation: Correlation Measures, Correlation Matrix Methods

UNIT - IV	Risk Evaluation Techniques	Lecture Hrs: 14

Techniques Used in Generation-Demand Systems: Convolution Technique, State Sampling Method, State Duration Sampling Method - Techniques Used in Radial Distribution Systems: Analytical Technique, State Duration Sampling Method - Techniques Used in Substation Configurations: Failure Modes and Modelling, Connectivity Identification, Stratified State Enumeration Method, State Duration Sampling Method - Techniques Used in Composite Generation and Transmission Systems: Basic Procedure, Component Failure Models, Load Curve Models, Contingency Analysis, Optimization Models for Load Curtailments, State

Enumeration Method, State Sampling Method

UNIT - V	Application of Risk Evaluation to Renewable Energy Systems	Lecture Hrs: 10

Risk Evaluation of Wind Turbine Power Converter System (WTPCS): Power Losses and Temperatures of WTPCS Components, Risk Evaluation of WTPCS - Risk Evaluation of Photovoltaic Power Systems: Two Basic Structures of Photovoltaic Power Systems, Risk Parameters of Photovoltaic Inverters, Risk Evaluation of Photovoltaic Power System

Textbooks:

1. Wenyuan Li, "Risk Assessment of Power Systems Models, Methods and Applications", Wiley Publications, 2nd Edition, 2014.
2. Billinton, Wenyuan Li, "Reliability Assessment of Electric Power Systems Using Monte Carlo Methods", Plenum Press, 1st Edition, 1994.

Reference Books:

1. Nicholas J Bahr, "System Safety Engineering and Risk Assessment – A Practical Approach", CRC Press Publications, 2nd Edition, 2018.

Online Learning Resources:

1. https://cleanenergysolutions.org/training/risk-assessment-power-projects
2. https://www.graceport.com/help/nfpa-70e-importance-of-risk-assessment-in-electrical-safety-programs

Course Code	21D21303	POWER SYSTEM AUTOMATION (PE-V)	L	T	P	C
Semester	III		3	0	0	3

Course Objectives: To make the student

1. Understand the basic concepts of deregulation, power system automation.
2. Analyze about the energy control centers and applications of automation.
3. To apply the techniques to solve the problems in deregulated system and automation.
4. Develop the models to control the system and energy control centers.

Course Outcomes (CO): Student will be able to

CO 1: Understand the concepts of evolution of automation systems, SACADA, Congestion management.
CO 2: Analyze the techniques to resolve problems in energy control centers, data ware housing.
CO 3: Apply the techniques to get the optimum control in the system by using automation at the substation level and distribution level.
CO 4: Develop the real time case studies to solve the critical problems in power system automation.

UNIT – I	POWER SYSTEM CONTROL AND DEREGULATION	Lecture Hrs: 10

Introduction – Operation of power systems and modes – Organization and operator activities, Investment factor and control centre experiences – Deregulation – need for deregulation and Advantages of deregulation in power system – Restructuring Models PoolCo. Model – Bilateral Model and Hybrid Model – Independent system operator (ISO) – Role of ISO – Congestion Management.

UNIT - II	POWER SYSTEM AUTOMATION	Lecture Hrs: 9

Evolution of automation systems – SCADA in Power system – Building blocks of SCADA system – Remote terminal unit – Intelligent electronic devices – Data concentrators and merging units – SCADA communication systems – Master station – Human-machine interface – Classification of SCADA systems.

UNIT - III	SUBSTATION AUTOMATION	Lecture Hrs: 10

Substation automation–Conventional automation–New smart devices for substation automation–new integrated digital substation–Technical issues new digital simulation–Substation automation architectures–Substation automation applications functions–Benefits of data warehousing.

UNIT - IV	ENERGY CONTROL CENTERS	Lecture Hrs: 10

Introduction – Energy control centers – EMS framework – Data acquisition and communication – Generation operation and management – Transmission operations – Real time Study-mode Simulations – Post-event analysis and energy scheduling and accounting – Dispatcher training simulator – Smart transmission.

UNIT - V	DISTRIBUTION AUTOMATION	Lecture Hrs: 10

Introduction to Distribution automation–Customer, feeder and substation automation–Subsystems in a distribution control center–Distributed Management System (DMS) framework integration with subsystems–Advanced real-time DMS applications–Advanced analytical DMS applications–DMS coordination with other systems.

Textbooks:

1. M Shahidehpour, Muwaffaq Alomoush, Restructured electrical power systems operation, trading and volatility, CRC Press, 1st Edition, 2001.
2. Mini S Thomas and John D Mcdonald, Power System SCADA and Smart Grids, CRC Press, 1stEdition 2015.

Reference Books:

1. Torsten cegrell, Power systems control Technology, Prentice Hall, 1st Edition, 1986.
2. James Northcote-Green and Robert Wilson, Control and Automation of Electrical Power Distribution Systems, CRC Press, 1st Edition, 2013.
3. Edmund Handschin, Real time control of Electric Power System, Elsevier Publishing Company, 1stEdition, 1972.

Online Learning Resources:

1. https://nptel.ac.in/courses/108/106/108106022/

R21 COURSE STRUCTURE & SYLLABUS FOR M.TECH COURSES
DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING
(ELECTRICAL POWER SYSTEMS)

Course Code	21D20301	WASTE TO ENERGY (OPEN ELECTIVE)	L	T	P	C
Semester	III		3	0	0	3

Course Objectives: To make the student

1. To understand the concept of waste to energy.
2. To analyze technical and management principles for production of energy from waste.
3. To apply the best available technologies for waste to energy.
4. To develop the process for thermal conversion, bio-chemical and waste to energy conversion.

Course Outcomes (CO): Student will be able to

CO 1: Understand the concept of waste to energy.
CO 2: Analyze technical and management principles for production of energy from waste.
CO 3: Apply the best available technologies for waste to energy.
CO 4: Develop the process for thermal conversion, bio-chemical and waste to energy conversion.

UNIT – I	Introduction to Energy from Waste	Lecture Hrs: 9

Classification of waste as fuel – Agro based – Forest residue – Industrial waste– MSW– Conversion devices–Incinerators – Gasifiers – Digestors.

UNIT - II	Biomass Pyrolysis	Lecture Hrs: 9

Pyrolysis – Types – Slow fast – Manufacture of charcoal – Methods – Yields and application– Manufacture of pyro lytic oils and gases – Yields and applications.

UNIT - III	Biomass Gasification	Lecture Hrs: 10

Gasifiers – Fixed bed system – Downdraft and updraft gasifiers – Fluidized bed gasifiers – Design, construction and operation – Gasifier burner arrangement for thermal heating –Gasifier engine arrangement and electrical power – Equilibrium and kinetic consideration in gasifier operation.

UNIT - IV	Biomass Combustion	Lecture Hrs: 10

Biomass stoves – Improved challahs – Types, Some exotic designs – Fixed bed combustors– Types – Inclined grate combustors – Fluidized bed combustors – Design – Construction and operation– Operation of all the above biomass combustors.

UNIT - V	Introduction to Biogas	Lecture Hrs: 10

Properties of biogas (Calorific value and composition)–Biogas plant technology and status – Bio energy system–Design and constructional features–Biomass resources and their classification–Biomass conversion processes–Thermochemical conversion– Direct combustion–Biomass gasification– Pyrolysis and liquefaction– Biochemical conversion– an aerobic digestion Types of biogas Plants–Applications–Alcohol production from biomass–Biodiesel production–Urban waste to energy conversion – Biomass energy programme in India.

Textbooks:

1. Non-Conventional Energy, Desai, Ashok V.,WileyEasternLtd., 1st Edition,1990.
2. Biogas Technology– A Practical Hand Book- Khandelwal,K.C. and Mahdi, S.S.,Vol. I & II, Tata McGraw Hill Publishing Co.Ltd., 1st Edition,1983.

Reference Books:
1. Food, Feed and Fuel from Biomass, Challal, D.S., IBH Publishing Co. Pvt. Ltd., 1st Edition, 1991. 2. Biomass Conversion and Technology, C.Y. WereKo-Brobby and E.B.Hagan, John Wiley & Sons, 1st Edition, 1996.
Online Learning Resources:
1. https://www.digimat.in/nptel/courses/video/103107125/L01.html 2. https://nptel.ac.in/courses/103/107/103107125/