COURSE STRUCTURE
AND
SYLLABUS

ELECTRICAL POWER SYSTEMS

(R21)

For

M. TECH. TWO YEAR DEGREE COURSE

(Applicable for the batches admitted from 2021-2022)

VIGNANA BHARATHI INSTITUTE OF TECHNOLOGY

(An Autonomous Institution)

Aushapur (V), Ghatkesar (M), Hyderabad, Medchal Dist.-501301

DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING

EPS M. TECH - COURSE STRUCTURE (R21)

M.TECH - I YEAR I – SEMESTER R21

S.No.	Course Type	Course Code	Name of the Course	L	T	P	Credits
1	Professional Core –I	21PS6111	Advanced Power System Analysis	3	0	0	3
2	Professional Core –II	21PS6112	Economic Operation of Power Systems	3	0	0	3
3	Professional Elective -I	21PE6171 21PS6171 21PS6172	1.Renewable Energy Systems 2.Smart Grid Technologies 3.AI Techniques in Power Systems	3	0	0	3
4	Professional Elective -II	21PE6172 21PS6173 21PS6174	1.FACTS and Custom Power Devices 2.Power System Transients 3. Electrical Power Distribution and Automation	3	0	0	3
5	Professional Core Lab-I	21PS6151	Power System Computation Lab - I	0	0	4	2
6	Professional Core Lab-II	21PS6152	Advanced Power Systems Lab	0	0	4	2
7	Mandatory Course	21MC6111	Research Methodology & IPR	2	0	0	2
8	Audit	21AU6101	Stress Management by Yoga	2	0	0	0
						Total	**18**

M.TECH - I YEAR II – SEMESTER R21

S No	Category	Course Code	Course Title	L	T	P	Credits
1	Professional Core -III	21PS6211	Power System Dynamics and Control	3	0	0	3
2	Professional Core -IV	21PS6212	Digital Protection of Power System	3	0	0	3
3	Professional Elective -III	21PS6271 21PE6271 21PS6272	1. Reactive Power Compensation and Management 2. Power Electronics For Renewable Energy Systems 3. Restructured Power Systems	3	0	0	3
4	Professional Elective -IV	21PS6273 21PS6274 21PS6275	1.HVDC Transmission 2.Power System Reliability and Planning 3. Power Quality	3	0	0	3
5	Professional Core Lab-III	21PS6251	Power System Computation Lab II	0	0	4	2
6	Professional Core Lab-IV	21PS6252	Power System Protection Lab	0	0	4	2
7	Project Work	21PS6291	Mini project with Seminar	0	0	4	2
8	Audit	21MC6201	English for Research Paper Writing	2	0	0	0
						Total	**18**

M.TECH - II YEAR I – SEMESTER **R21**

S.No.	Category	Course Code	Course Title	L	T	P/D	Credits
1	Professional Elective –V	21PS7171 21PE7172 21PS7172	1.Energy Auditing Conservation and Management 2.Electric and Hybrid Vehicles 3.SCADA System and Applications	3	0	0	3
2	Open Elective			3	0	0	3
3	Project Work	21PS7181	Dissertation Work Review – I	0	0	12	6
						Total	**12**

M.TECH - I I YEAR I I– SEMESTER **R21**

S.No.	Category	Course Code	Course Title	L	T	P	Credits
1	Project Work	2PS7281	Dissertation Work Review — II	0	0	12	6
2	Project Work	2PS7282	Dissertation Viva-Voce	0	0	24	14
						Total	**20**

ADVANCED POWER SYSTEM ANALYSIS

	L	T	P	C
M.Tech (EPS) I Year I semester	**L**	**T**	**P**	**C**
Course code: 21PS6111	**3**	**0**	**0**	**3**

Prerequisite: Computer Methods in Power Systems

Course Objectives: Prepare the students to

- Build the Nodal admittance and Nodal impedance matrices of a practical network.
- Study various methods of load flow.
- Analyze various types of faults in power system.
- Understand power system security concepts
- Understand state estimation and study simple algorithms for state estimation.

Course Outcomes: At the end of this course**,** Students will be able to

- To Build/construct Y_{BUS} and Z_{BUS} of any practical network.
- Calculate voltage phasors at all buses, given the data using various methods of load flow.
- Calculate fault currents in each phase.
- Rank various contingencies according to their severity.
- Estimate the bus voltage phasors given various quantities viz. power flow, voltages, taps , CB status etc.

UNIT-I: NETWORK MATRICES

Introduction, per unit system, Bus Admittance Matrix, Network Solution, Network Reduction (Kron Reduction), YBUS structure and manipulation, Bus Impedance matrix, Methods to determine columns of ZBUS.

UNIT-II: LOAD FLOW STUDIES

Overview of Gauss-Siedel, Newton-Raphson load flow methods, fast decoupled method, convergence properties, sparsity techniques, handling Qmax violations in constant matrix, handling of discrete variable in load flow.

UNIT-III: FAULT CALCULATIONS

Symmetrical faults-Fault calculations using ZBUS - Fault calculations using ZBUS equivalent circuits, symmetrical components, unsymmetrical faults - Problems on various types of faults.

UNIT-IV: CONTINGENCY ANALYSIS

Security Analysis: Security state diagram, contingency analysis, generator shift distribution factors, line outage distribution factor, multiple line outages, overload index ranking

UNIT-V: STATE ESTIMATION

Sources of errors in measurements, Virtual and Pseudo measurements, Observability concepts, Tracking state Estimation, Weighted Least Square method, Bad Data detection and estimation.

TEXT BOOKS

1. John J. Grainger and W. D. Stevenson, “Power System Analysis”- T.M.H. Edition, McGraw Hill ,2003.
2. Modern Power System Analysis– by I. J. Nagrath& D. P. Kothari Tata McGraw – Hill Publishing Company Ltd, IInd edition.

REFERENCE BOOKS

1. Power System Analysis and Design by J. Duncan Glover and M.S. Sarma., Cengage 3rd Edition.
2. Olle. L.Elgard, “Electrical Energy Systems Theory”-T.M.H. Edition.
3. Power systems stability and control, PrabhaKundur, The McGraw – Hill companies.
4. Power System Operation and Control, Dr. K. Uma Rao, Wiley India Pvt. Ltd.
5. Operation and Control in Power Systems, PSR Murthy, Bs Publications.
6. Power System Operation, Robert H. Miller, Jamesh H. Malinowski, The McGraw – Hill companies.
7. Power Systems Analysis, operation and control by AbhijitChakrabarti, SunithaHalder, PHI 3/e , 2010
8. Ali Abur&Antinio Gomez Exposito, 'Power System State Estimation Theory &Implementation', Marcel Dekker, Inc., Newyork, USA,2004.
9. NPTEL Course, A. K. Sinha, Power System Analysis,
10. PradeepYemula, Power System Practice, online course

ECONOMIC OPERATION OF POWER SYSTEMS

M.Tech (EPS) I Year I semester	**L**	**T**	**P**	**C**
Course code: 21PS6112	**3**	**0**	**0**	**3**

Prerequisite: Electrical Power Systems

Course Objectives: Prepare the students to
- Understand economic load scheduling problem and unit commitment problem.
- Understand hydro-thermal scheduling problem.
- Understand load frequency control (LFC)
- Understand the optimal power flow (OPF) problem.

Course Outcomes: At the end of this course**,** Students will be able to
- Distinguish between economic load dispatch and unit commitment problem
- Solve economic load scheduling (with and without network losses) and unit commitment problem
- Solve hydro-thermal scheduling problem
- Analyze the single area and two area systems for frequency deviation
- Solve the OPF problem using ac and dc load flow methods.

UNIT-I: ECONOMIC LOAD SCHEDULING
Characteristics of Steam Turbine, Variations in steam unit characteristics, Economic dispatch with piecewise linear cost functions, Lambda Iterative method, LP method, Economic dispatch under composite generation production cost function, Base point and Participation factors, Thermal system Dispatching with Network losses.

UNIT-II: UNIT COMMITMENT
Unit Commitment – Definition – Constraints in Unit Commitment–Unit Commitment solution methods – Priority–List Methods – Dynamic Programming Solution.

UNIT-III: HYDRO THERMAL SCHEDULING
Characteristics of Hydroelectric units, Introduction to Hydrothermal coordination, Long-Range and Short-Range Hydro-Scheduling, Hydroelectric plant models, Hydrothermal scheduling with storage limitations, Dynamic programming solution to hydrothermal scheduling.

UNIT-IV: LOAD FREQUENCY CONTROL
Control of generation – models of power system elements – single area and two area block diagrams – implementation of Automatic Generation control (AGC) – AGC features.

UNIT-V: OPTIMAL POWER FLOW

Introduction to Optimal power flow problem, OPF calculations combining economic dispatch and power flow, OPF using DC power flow, Algorithms for solution of the ACOPF, Optimal Reactive Power Dispatch.

TEXT BOOKS:

1. Olle l. Elgerd, "Electric Energy Systems Theory an Introduction", TMH, 2nd Edition, 1983
2. J.J. Grainger &W.D.Stevenson, "Power system analysis ", McGraw Hill ,2003

REFERENCES:

1. Allen J. Wood, Bruce F. Wollenberg, Gerald B. Sheblé-Power Generation, Operation and
2. Control-Wiley-Interscience (2013)
3. NPTEL Course, Prof. S. N. Singh, Power System Operation and Control,

RENEWABLE ENERGY SYSTEMS

	L	T	P	C
M.Tech (EPS) I Year I semester	**L**	**T**	**P**	**C**
Course code: 21PE6171	**3**	**0**	**0**	**3**

Prerequisite: Power Systems and Electrical Machines

Course Objectives: Prepare the students

- To recognize the awareness of energy conservation in students
- To identify the use of renewable energy sources for electrical power generation
- To collect different energy storage methods
- To detect about environmental effects of energy conversion

Course Outcomes: At the end of this course**,** the student will be able to

- Find different renewable energy sources to produce electrical power
- Estimate the use of conventional energy sources to produce electrical energy
- Role-play the fact that the conventional energy resources are depleted
- Arrange Store energy and to avoid the environmental pollution

UNIT-I SOLAR PV SYSTEMS

Photo voltaic power generation ,spectral distribution of energy in solar radiation, solar cell configurations, voltage developed by solar cell, photo current and load current, practical solar cell performance, commercial photo voltaic systems, test specifications for PV systems, applications of super conducting materials in electrical equipment systems.

UNIT-II WIND ENERGY SYSTEMS

Wind Energy conversion: Power from wind, properties of air and wind, types of wind Turbines, operating characteristics.

UNIT-III OCEAN, WAVE ENERGY CONVERSION& MHD

Ocean energy conversion:

Tides and tidal power stations, modes of operation, tidal project examples, turbines and generators for tidal power generation.

Wave energy conversion: properties of waves and power content, vertex motion of Waves, device applications. Types of ocean thermal energy conversion systems Application of OTEC systems examples.

MHD: Principles of MHD power generation, ideal MHD generator performance, practical MHD generator, MHD technology.

UNIT-IV MISCELLANEOUS ENERGY CONVERSION SYSTEMS

coal gasification and liquefaction, biomass conversion, geothermal energy, thermo electric energy conversion, principles of EMF generation, description of fuel cells, Co-generation and energy storage, combined cycle co- generation, energy storage.

UNIT-V BATTERIES & FUEL CELLS

Types of fuel cells, H2-O2 Fuel cells, Application of fuel cells – Batteries, Description of batteries, Battery application for large power. Environmental effects of energy conversion systems, pollution from coal and preventive measures steam stations and pollution, pollution free energy systems..

TEXT BOOKS

1. D.P.Kothari, K.C.Singal, R.Ranjan,"Renewable Energy Resources and emerging technologies"- PHI 2/e 2011.
2. Rakosh das Begamudre,"Energy conversion systems" New age International publishers, New Delhi - 2000.
3. John Twidell and Tony Weir, "Renewable Energy Resources" by, 2nd Edition, Fspon&Co.

REFERENCE BOOKS

1. "Understanding Renewable Energy Systems" , by Volker Quaschning, 2005, UK.
2. Faner Lin LuoHoner Ye, "Renewable Energy Systems Advanced energy conversion Technologies & Applications" by CRC press, Taylor & Francis group
3. NPTEL Course on Non-Conventional Energy Sources,

SMART GRID TECHNOLOGIES

M. (EPS) I Year I semester	**L**	**T**	**P**	**C**
Course code: 21PS6171	**3**	**0**	**0**	**3**

Prerequisite: Power Systems

Course Objectives: Prepare the students to

- Understand concept of smart grid and its advantages over conventional grid
- Know smart metering techniques
- Learn wide area measurement techniques
- Understand the problems associated with integration of distributed generation & its solution through smart grid.

Course Outcomes: At the end of this course, Students will be able to

- Distinguish between conventional grid and smart grid
- Apply smart metering concepts to industrial and commercial installations
- Formulate solutions in the areas of smart substations, distributed generation and wide area measurements
- Develop smart grid solutions using modern communication technologies

UNIT-I INTRODUCTION TO SMART GRID & SMART METERS

Evolution of Electric Grid, Concept of Smart Grid, Definitions, Need of Smart Grid, Concept of Robust & Self-Healing Grid, Indian Smart Grid – Key Challenges for Smart. Introduction to Smart Meters, Real Time Pricing, Automatic Meter Reading(AMR), Outage Management System (OMS), Transmission Automation, Distribution Automation.

UNIT-II INFORMATION AND STORAGE SYSTEMS

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

UNIT-III MICROGRID

Concept of micro-grid, need & applications of micro-grid, formation of micro-grid, Issues of interconnection, protection & control of micro-grid, Plastic & Organic solar cells, thin film solar cells, Variable speed wind generators, fuel-cells, micro-turbines, Captive power plants, Integration of renewable energy sources. Plug in Hybrid Electric Vehicles (PHEV), Vehicle to Grid.

UNIT-IV POWER QUALITY

Power Quality & EMC in Smart Grid, Power Quality issues of Grid connected Renewable Energy Sources, Power Quality Conditioners for Smart Grid, Web based Power Quality monitoring, Power Quality Audit.

UNIT-V COMMUNICATION TECHNIQUES IN SMART GRID

Advanced Metering Infrastructure (AMI), Home Area Network (HAN), Neighborhood Area,Network(NAN), Wide Area Network (WAN), Bluetooth, Zig Bee, GPS, Wi-Fi, Wi-Max based communication.

TEXT BOOKS

1. Ali Keyhani, "Design of smart power grid renewable energy systems", Wiley IEEE, 2011
2. Clark W. Gellings, "The Smart Grid: Enabling Energy Efficiency and Demand Response", CRC Press , 2009.

REFERENCE BOOKS

1. JanakaEkanayake, Nick Jenkins, KithsiriLiyanage, "Smart Grid: Technology and Applications", Wiley 2012
2. Stuart Borlase, "Smart Grid: Infrastructure, Technology and solutions " CRC Press
3. A.G.Phadke, "Synchronized Phasor Measurement and their Applications", Springer.

AI TECHNIQUES IN POWER SYSTEMS

	L	T	P	C
M.Tech (EPS) I Year I semester	**L**	**T**	**P**	**C**
Course code: 21PS6172	**3**	**0**	**0**	**3**

Prerequisites: Power Systems

Course Objectives:

- To understand the ANN Networks and Learning methods.
- To observe the concepts of ANN models.
- To practice the concept of fuzziness involved in various systems and comprehensive knowledge of fuzzy logic control and to design the fuzzy control
- To analyze genetic algorithm and genetic operations.
- To Apply the AI techniques in Power System Applications.

Course Outcomes: Upon the completion of this course, the student will be able to

- Understand the artificial neural networks, feed forward neural networks and Learning methods.
- Understand the concepts of BPA, SOM and FLN models.
- Develop fuzzy logic control for applications in electrical engineering
- Develop genetic algorithm for applications in electrical engineering.
- Apply the AI knowledge for Fault diagnosis and load forecasting.

UNIT-I: ARTIFICIAL NEURAL NETWORKS

Biological foundations to intelligent Systems, Artificial Neural Networks, Single layer and Multilayer Feed Forward NN, learning process-supervised learning-unsupervised learning– Hebbian learning.

UNIT-II: ANN PARADIGMS

Back propagation Algorithm (BPA), Self –Organizing Map (SOM), Radial Basis Function Network-Functional Link Network (FLN), Hopfield Network.

UNIT-III: FUZZY LOGIC

Fuzzy Logic, Knowledge Representation and Inference Mechanism, Fuzzy versus crisp, Fuzzy sets-Membership function –Basic Fuzzy set operations, Properties of Fuzzy sets-Operations on Fuzzy relations –Fuzzy logic–Fuzzy Quantifiers, Defuzzification methods.

UNIT-IV: GENETIC ALGORITHMS

Evolution of genetic algorithm –Basic concepts-Encoding –Fitness Function-Reproduction operators, Genetic Modeling -Cross over-Single site cross over, Two point cross over –Multi point cross over Uniform cross over, Matrix cross over -Mutation operator.

UNIT-V: APPLICATIONS OF AI TECHNIQUES

Fault diagnosis and load forecasting, Economic load dispatch, Load frequency control, Single area system and two-area system.

TEXT BOOKS

1. S.Rajasekaran and G.A.V.Pai Neural Networks, Fuzzy Logic & Genetic Algorithms, PHI, New Delhi, 2003.
2. Rober J. Schalkoff, Artificial Neural Networks, Tata McGraw Hill Edition, 2011.

REFERENCES:

1. P.D.Wasserman; Neural Computing Theory & Practice, Van Nostrand Reinhold, New York, 1989.
2. Bart Kosko; Neural Network & Fuzzy System, Prentice Hall,1992
3. D.E.Goldberg, Genetic Algorithms, Addison-Wesley 1999.
4. Kevin warwick, arthurekwue, raj agrawal: Artificial intelligence techniques in power systems, Institution of Engineering and Technology (1 March 1997).

FACTS AND CUSTOM POWER DEVICES

M.Tech (EPS) I Year I semester	**L**	**T**	**P**	**C**
Course code: 21PE6172	**3**	**0**	**0**	**3**

Prerequisite: Power Systems and Power Electronics

Course Objectives:

- To learn the active and reactive power flow control in power system
- To understand the need for static compensators
- To develop the different control strategies used for compensation

Course Outcomes: At the end of the course, the student will be able to

- Understand the concepts of FACTS
- Apply the knowledge of static Var and UPFC concepts
- Analyze the concept of voltage sag and swell

UNIT I REACTIVE POWER FLOW CONTROL

Reactive power flow control in Power Systems – Control of dynamic power unbalances in Power System, Power flow control -Constraints of maximum transmission line loading – Benefits of FACTS Transmission line compensation. Uncompensated line -Shunt compensation - Series compensation–Phase angle control. Reactive power compensation, Shunt and Series compensation principles – Reactive compensation at transmission and distribution level.

UNIT II SHUNT & SERIES COMPENSATION

Static versus passive VAR compensator, Static shunt compensators: SVC, and STATCOM - Operation and control of TSC, TCR and STATCOM -Compensator control, Comparison between SVC and STATCOM, Static series compensation: TSSC, SSSC -Static voltage and phase angle regulators – TCVR and TCPAR Operation and Control –Applications, Static series compensation – GCSC, , TCSC and Static synchronous series compensators and their Control.

UNIT III UPFC & IPFC

SSR and its damping Unified Power Flow Controller: Circuit Arrangement, Operation and control of UPF, Basic Principle of P and Q control- Independent real and reactive power, flow control- Applications. Interline power flow controller

UNIT IVMITIGATION OF HARMONICS

Introduction to Power quality, problems in distribution systems, harmonics. Loads that create harmonics, modeling, harmonic propagation, series and parallel resonances, mitigation of harmonics, passive filters, active filtering, – shunt, series and hybrid and their control.

UNIT VPOWER QUALITY ISSUSES

Voltage swells, sags, flicker, unbalance and mitigation of these problems by power line conditioners- IEEE standards on power quality.

TEXT BOOKS

1. K R Padiyar, "FACTS Controllers in Power Transmission and Distribution", New AgeInternationalPublishers, 2007.
2. X P Zhang, C Rehtanz, B Pal, "Flexible AC Transmission Systems- Modelling and Control",SpringerVerlag, Berlin, 2006.
3. N.G. Hingorani, L. Gyugyi, "Understanding FACTS: Concepts and Technology of Flexible AC Transmission Systems", IEEE Press Book, Standard Publishers and Distributors, Delhi, 2001.
4. K.S.Sureshkumar, S.Ashok , "FACTS Controllers & Applications", E-book edition, Nalanda Digital Library, NIT Calicut, 2003.
5. G. T.Heydt, "Power Quality", McGraw-Hill Professional, 2007.
6. T. J. E. Miller, "Static Reactive Power Compensation", John Wiley and Sons, Newyork, 1982.

POWER SYSTEM TRANSIENTS

M.Tech (EPS) II Year I semester	**L**	**T**	**P**	**C**
Course code: 21PS6173	**3**	**0**	**0**	**3**

Prerequisite: Power Systems, High Voltage Engineering

Course Objectives: Prepare the students to:

- Understand the Generation of switching transients and their control using circuit – theoretical concept.
- Analyse power system behaviour during switching transients and lightning surges.
- Mechanism of lighting strokes and the production of lighting surges.
- Propagation, reflection and refraction of travelling waves.
- Voltage transients caused by faults, circuit breaker action, and load rejection on integrated power system.

Course Outcomes: At the end of the course, Students will be able to:

- Ability to understand and analyze switching and lightning transients.
- Ability to acquire knowledge on generation of switching transients and their control.
- Ability to analyze the mechanism of lighting strokes.
- Ability to understand the importance of propagation, reflection and refraction of travelling waves.
- Ability to understand the concept of circuit breaker action, load rejection on integrated power system.

UNIT-I: INTRODUCTION

Review and importance of the study of transients - causes for transients. RL circuit transient with sine wave excitation - basic transforms of the RLC circuit transients. Different types of power system transients - effect of transients on power systems.

UNIT-II: SWITCHING TRANSIENTS

Over voltages due to switching transients - resistance switching and the equivalent circuit for interrupting the resistor current - load switching and equivalent circuit - waveforms for transient voltage across the load and the switch - normal and abnormal switching transients. Current suppression - current chopping -. Capacitance switching - capacitance switching with a restrike, with multiple restrikes.

UNIT-III: LIGHTNING TRANSIENTS

Review of the theories in the formation of clouds and charge formation - rate of charging of thunder clouds – mechanism of lightning discharges and characteristics of lightning strokes – model for lightning stroke - factors contributing to good line design - protection using ground wires - tower footing resistance.

UNIT-IV: TRAVELING WAVES ON TRANSMISSION LINE COMPUTATION OF TRANSIENTS

Computation of transients - transient response of systems with series and shunt lumped parameters and distributed lines. Traveling wave concept - step response - Bewely's lattice diagram - standing waves and natural frequencies - reflection and refraction of travelling waves.

UNIT-V: TRANSIENTS IN INTEGRATED POWER SYSTEM

The short line and kilometric fault - distribution of voltages in a power system – Line dropping and load rejection - voltage transients on closing and reclosing lines - over voltage induced by faults -switching surges on integrated system. Qualitative application of EMTP for transient computation.

TEXT BOOKS:

1. Allan Greenwood, 'Electrical Transients in Power Systems', Wiley Inter Science, New York, 2ndEdition, 1991.
2. PritindraChowdhari, "Electromagnetic transients in Power System", John Wiley and Sons Inc., Second Edition, 2009.
3. C.S. Indulkar, D.P.Kothari, K. Ramalingam, 'Power System Transients – A statistical approach', PHI Learning Private Limited, Second Edition, 2010

REFERENCES:

1. M.S.Naidu and V.Kamaraju, 'High Voltage Engineering', McGraw Hill, Fifth Edition, 2013.
2. R.D. Begamudre, 'Extra High Voltage AC Transmission Engineering', Wiley Eastern Limited, 1986.
3. Y.Hase, Handbook of Power System Engineering," Wiley India, 2012.
4. J.L.Kirtley, "Electric Power Principles, Sources, Conversion, Distribution and use," Wiley, 2012.
5. Akihiro ametani," Power System Transient theory and applications", CRC press, 2013.

ELECTRICAL POWER DISTRIBUTION AND AUTOMATION

M.Tech (EPS) I Year I semester	**L**	**T**	**P**	**C**
Course code: 21PS6174	**3**	**0**	**0**	**3**

Prerequisite: Power Systems

Course Objectives: Prepare the Students to

- Learn about power distribution system
- Learn SCADA System
- Understand Distribution Automation

Course Outcomes: At the end of the course, Students will be able to

- Describe about power distribution system
- Demonstrate the Distribution automation and its application in practice
- Explain SCADA system

UNIT-I LOAD FORECASTING

Distribution of Power, Management, Power Loads, Load Forecasting Short-term &Longterm, Power System Loading, Technological Forecasting.

UNIT-II DISTRIBUTION AUTOMATION

Advantages of Distribution Management System (D.M.S.) Distribution Automation: Definition, Restoration / Reconfiguration of Distribution Network, Different Methods and Constraints, Power Factor Correction

UNIT-III OPTIMALITY PRINCIPLES

Calculation of Optimum Number of Switches, Capacitors, Optimum Switching Device Placement in Radial, Distribution Systems, Sectionalizing Switches – Types, Benefits, Bellman's Optimality Principle, Remote Terminal Units, Energy efficiency in electrical distribution & Monitoring

UNIT-IV ENERGY MANAGEMENT

Maintenance of Automated Distribution Systems, Difficulties in Implementing Distribution. Automation in Actual Practice, Urban/Rural Distribution, Energy Management, AI techniques applied to Distribution Automation

UNIT-V CONTROL AND COMMUNICATION

Interconnection of Distribution, Control & Communication Systems, Remote Metering, Automatic Meter Reading and its implementation. SCADA: Introduction, Block Diagram, SCADA Applied To Distribution Automation. Common Functions of SCADA, Advantages of Distribution Automation through SCADA.

TEXT BOOKS

1. A.S. Pabla, "Electric Power Distribution", Tata McGraw Hill Publishing Co. Ltd., Fourth Edition.
2. M.K. Khedkar, G.M. Dhole, "A Text Book of Electrical power Distribution Automation", University Science Press, New Delhi.

REFERENCE BOOKS

1. Anthony J Panseni, "Electrical Distribution Engineering", CRC Press
2. James Momoh, "Electric Power Distribution, automation, protection & control", CRC Press

POWER SYSTEMS COMPUTATION LAB-I

M.Tech (EPS) I Year I semester	**L**	**T**	**P**	**C**
Course code: 21PS6151	**0**	**0**	**4**	**2**

Prerequisite: power systems

Course Objectives: Prepare the students to

- Construction of Y-bus, z-bus for an n-bus system.
- Analyze various Load flow studies.
- Understand the steady state, transient stability analysis.
- Economic load dispatch problem.
- Compute the transmission line parameters
- State estimation of power system.

Course Outcomes: At the end of the course, Students will be able to

- Construct Y-bus and Z-bus
- Compare the different load flow methods
- Analyze the different stability analysis of variety of power systems
- Understood Economic load dispatch of power system.
- Understood State estimation of power system.

List of Experiments

1. Develop Program for Y BUS formation by direct inspection method.
2. Develop Program for Y BUS formation by Singular Transformation method.
3. Develop Program for G-S Load Flow Algorithm.
4. Develop Program for N-R Load Flow Algorithm in Polar Coordinates.
5. Develop Program for FDLF Algorithm.
6. Develop Program for DC load Flow Algorithm.
7. Develop Program for Z BUS Building Algorithm.
8. Develop Program for Short Circuit Analysis using Z BUS Algorithm.
9. Develop Program for Transient Stability Analysis for Single Machine connected to Infinite Bus
10. Develop Program for Economic Load Dispatch Problem using Lambda Iterative Method.
11. Computation of Parameters and Modeling of Transmission Lines.
12. Develop Program for State Estimation of Power System.

Note: From the above list **minimum 10** experiments are to be conducted

ADVANCED POWER SYSTEMS LAB

M. Tech (EPS) I Year I semester	**L**	**T**	**P**	**C**
Course code: 21PS6152	**0**	**0**	**4**	**2**

Prerequisite: Power Systems

Course Objectives: Prepare the Students to

- Determine transmission line parameters
- Determine transmission line regulation and efficiency
- Determine various fault calculations

Course Outcomes: At the end of the course, Students will be able to:

- Calculate transmission line parameters
- Calculate transmission line regulation and efficiency
- Calculate various fault parameters
- Perform testing of CT, PT's

List of Experiments

1. Determination of Line Parameters R, L and C.
2. Determination of Transmission Line efficiency and Regulation for a given load.
3. Analysis of Ferranti effect on Transmission Lines under light loadings.
4. Determination of ABCD parameters of a given Transmission Line Network.
5. Fault Analysis:
    I. Single Line to Ground fault (L-G).
    II. Line to Line fault (L-L).
    III. Double Line to Ground fault (L-L-G).
    IV. Triple Line to Ground fault (L-L-L-G).
6. Equivalent circuit of three phase winding transformer
7. Sequence impedance of cylindrical rotor synchronous machine
8. Sub-Transient reactance of salient pole synchronous machine
9. Testing of C. Ts and P.T.s
10. Analysis of Transmission lines under Surge Impedance Loading.
11. Determination of Sequence impedance of three phase transformer.

Note: From the above list **minimum 10** experiments are to be conducted

RESEARCH METHODOLOGY AND IPR

M.Tech (EPS) I Year I semester	**L**	**T**	**P**	**C**
Course code: 21MC6111	**2**	**0**	**0**	**2**

Prerequisite: Research theory

Course Objectives:

- To understand the research problem
- To know the literature studies, plagiarism and ethics
- To get the knowledge about technical writing
- To analyze the nature of intellectual property rights and new developments
- To know the patent rights

Course Outcomes: 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: INTRODUCTION

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

UNIT-II: TECHNICAL WRITING

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

UNIT-III: INTELLECTUAL PROPERTY

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

UNIT-IV: PATENT RIGHTS

Patent Rights: Scope of Patent Rights. Licensing and transfer oftechnology. Patent information and data bases.Geographical Indications.

UNIT-V: INTELLECTUAL PROPERTY RIGHTS

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

TEXT BOOKS

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

REFERENCE BOOKS

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

STRESS MANAGEMENT BY YOGA

M.Tech (EPS) I Year I semester	L	T	P	C
Course code: 21MC6101	2	0	0	0

Prerequisite: None

Course Objectives:

- To achieve overall health of body and mind
- To overcome stress

Course Outcomes: At the end of the course**,** Students will be able to:

- Develop healthy mind in a healthy body thus improving social health also
- Improve efficiency

UNIT-I:

Definitions of Eight parts of yog. (Ashtanga)

UNIT-II:

Yam and Niyam.

UNIT-III:

Do`s and Don't's in life.

i) Ahinsa, satya, astheya, bramhacharya and aparigraha

ii) Shaucha, santosh, tapa, swadhyay, ishwarpranidhan

UNIT-IV:

Asan and Pranayam

UNIT-V:

i) Various yog poses and their benefits for mind & body

ii) Regularization of breathing techniques and its effects-Types of pranayam

TEXT BOOKS/ REFERENCES:

1. 'Yogic Asanas for Group Tarining-Part-I": Janardan Swami YogabhyasiMandal, Nagpur

2. "Rajayoga or conquering the Internal Nature" by Swami Vivekananda, AdvaitaAshrama (Publication Department), Kolkata

POWER SYSTEM DYNAMICS AND CONTROL

M.Tech (EPS) I Year II semester	**L**	**T**	**P**	**C**
Course code: 21PS6211	**3**	**0**	**0**	**3**

Prerequisite: Computer Methods in Power Systems

Course objectives:

- To remember the dynamic characteristics of power system equipment,
- To recognize dynamic performance of power systems
- To illustrate the system stability and controls.

Course Outcomes: Upon the completion of the subject, the student will be able to

- Choose the fundamental dynamic behavior and controls of power systems to perform basic stability analysis.
- Comprehend concepts in modeling and simulating the dynamic phenomena of power systems
- Interpret results of system stability studies
- Analyze theory and practice of modeling main power system components, such as synchronous machines, excitation systems and governors

UNIT-IBASIC CONCEPTS

Power system stability states of operation and system security - system dynamics - problems system model analysis of steady State stability and transient stability - simplified representation of Excitation control.

UNIT-IIMODELING OF SYNCHRONOUS MACHINE:

Synchronous machine - park's Transformation-analysis of steady state performance, per - unit quantities-Equivalent circuits of synchronous machine-determination of parameters of equivalent circuits.

UNIT-IIIEXCITATION SYSTEM

Excitation system modeling-excitation systems block Diagram - system representation by state equations- Dynamics of a synchronous generator connected to infinite bus - system model Synchronous machine model-stator equations rotor equations - Synchronous machine model with field circuit - one equivalent damper winding on q axis (model 1.1) - calculation of Initial conditions.

UNIT-IVANALYSIS OF SINGLE MACHINE SYSTEM

Small signal analysis with block diagram - Representation Characteristic equation and application of Routh Hurwitz criterion- synchronizing and damping torque analysis-small signal model - State equations.

UNIT-VAPPLICATION OF POWER SYSTEM STABILIZERS

Basic concepts in applying PSS - Control signals - Structure and tuning of PSS - Washout circuit - Dynamic compensator analysis of single machine infinite bus system with and without PSS.

TEXT BOOKS

1. K.R. PADIYAR," Power system dynamics "- B.S. Publications.
2. 2. P.M. Anderson andA.A. Fouad, "Power system control and stability",IEEE Press

REFERENCE BOOKS

1. R. Ramanujam, "Power Systems Dynamics"- PHI Publications.

DIGITAL PROTECTION OF POWER SYSTEMS

M.Tech (EPS) I Year II semester	**L**	**T**	**P**	**C**
Course code: 21PS6212	**3**	**0**	**0**	**3**

Prerequisite: Power System Protection

Course Objectives: Prepare the students to

- Study numerical relays.
- Develop mathematical approach towards protection.
- Study algorithms for numerical protection.

Course Outcomes: At the end of the course, Students will be able to:

- Understand the importance of Digital Relays.
- Apply mathematical approach towards protection.
- Develop various protection algorithms.

UNIT-I: Mathematical Background to Digital Protection

Overview of static relays, Transmission line protection, Transformer protection, Need for Digital protection. Performance and operational characteristics of Digital protection, Basic structure of Digital relays, Finite difference techniques, Interpolation formulas, Numerical differentiation, Curve fitting and smoothing, Fourier analysis, Walsh function analysis.

UNIT-II: Basic Elements of Digital Protection

Basic components of a digital relay, Signal conditioning subsystems, Conversion subsystem, Digital relay subsystem, the digital relay as a unit.

UNIT-III: Digital Relaying Algorithms-I

Sinusoidal-Wave-Based algorithms: Sample and first-derivative methods, First and second-derivative methods, Two-sample technique, Three-sample technique, An early relaying scheme.

Fourier analysis based algorithms: Full cycle window algorithm, Fractional-cycle window algorithms, Fourier-transform based algorithm. Walsh-function-based algorithms.

UNIT-IV: Digital Relaying Algorithms-II

Least squares based methods: Integral LSQ fit, Power series LSQ fit, Multi-variable series LSQ technique, Determination of measured impedance estimates.

Travelling-wave based protection: Fundamentals of Travelling-wave based protection, Bergeron’s equation based protection scheme, Ultra-high-speed polarity comparison scheme, Ultra-high-speed wave differential scheme, Discrimination function based scheme, Superimposed component trajectory based scheme.

UNIT-V: Digital protection of Transformers and Transmission lines

Principles of transformer protection, Digital protection of Transformer using: FIR filter based algorithm, Least squares curve fitting based algorithms, Fourier-based algorithm, Flux-restrained current differential relay. Digital Line differential protection: Current-based differential schemes, Composite voltage- and current based scheme.

TEXT BOOKS:

1. A.G. Phadke and J. S. Thorp, "Computer Relaying for Power Systems", Wiley/Research studies Press, 2009.
2. A.T. Johns and S. K. Salman, "Digital Protection of Power Systems", IEEE Press,1999.

REFERENCES:

1. Gerhard Zeigler, "Numerical Distance Protection", SiemensPublicis Corporate Publishing, 2006.
2. S.R.Bhide "Digital Power System Protection" PHI Learning Pvt.Ltd.2014.

REACTIVE POWER COMPENSATION AND MANAGEMENT

M.Tech (EPS) I Year II semester	**L**	**T**	**P**	**C**
Course code: 21PS6271	**3**	**0**	**0**	**3**

Prerequisite: Power Systems

Course Objectives:

- To identify the necessity of reactive power compensation
- To describe load compensation
- To select 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: Upon the completion of this course, the student will be able to

- Distinguish the importance of load compensation in symmetrical as well as un symmetrical
- loads
- Observe various compensation methods in transmission lines
- Construct model for reactive power coordination
- Distinguish demand side reactive power management & user side reactive power 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 AND TRANSIENT REACTIVE POWER COMPENSATION IN TRANSMISSION SYSTEM

Uncompensated line –types of compensation – Passive shunt and series and dynamic shunt compensation – examples. Characteristic time periods – passive shunt compensation – static compensations - series capacitor compensation – compensation using synchronous condensers – examples

UNIT- III: REACTIVE POWER COORDINATION

Objective – Mathematical modeling – Operation planning – transmission benefits – Basic concepts of quality of power supply – disturbances- steady –state variations – effects of under voltages – frequency –Harmonics, radio frequency and electromagnetic interferences

UNIT- IV DISTRIBUTION SIDE REACTIVE POWER MANAGEMENT:

Load patterns, basic methods load shaping, power tariffs- KVAR based tariffs penalties for voltage flickers and Harmonic voltage levels System losses, loss reduction methods, economics planning, capacitor placement, retrofitting of capacitor banks

UNIT- V: USER SIDE REACTIVE POWER MANAGEMENT

KVAR requirements for domestic appliances – Purpose of using capacitors – selection of capacitors – deciding factors – types of available capacitor, characteristics and Limitations

Reactive power management in electric traction systems and 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

3. Reactive power control in Electric power systems by T.J.E.Miller, John Wiley and sons, 1982.
4. Reactive power Management by D.M.Tagare, Tata McGraw Hill, 2004.

REFERENCE BOOKS

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

POWER ELECTRONICS FOR RENEWABLE ENERGY SYSTEMS

M.Tech (EPS) I Year II semester	**L**	**T**	**P**	**C**
Course code: 21PE6271	**3**	**0**	**0**	**3**

Prerequisite: Power Electronics, Renewable Energy Systems

Course Objectives: to prepare students to

- Provide knowledge about the stand alone and grid connected renewable energy systems.
- Equip with required skills to derive the criteria for the design of power converters for renewable energy applications.
- Analyse and comprehend the various operating modes of wind electrical generators and solar energy systems.
- Design different power converters namely AC to DC, DC to DC and AC to AC converters for renewable energy systems. To develop maximum power point tracking algorithms.
-

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

- Ability to understand and analyze power system operation, stability, control and protection.
- Ability to handle the engineering aspects of electrical energy generation and utilization.

UNIT-I:

INTRODUCTION

Environmental aspects of electric energy conversion: impacts of renewable energy generation on environment (cost-GHG Emission) - Qualitative study of different renewable energy resources: Solar,wind, ocean, Biomass, Fuel cell, Hydrogen energy systems and hybrid renewable energy systems.

UNIT-II:

ELECTRICAL MACHINES FOR RENEWABLE ENERGY CONVERSION

Reference theory fundamentals-principle of operation and analysis: IG, PMSG, SCIG and DFIG.

UNIT-III:

HIGH POWER CONVERTERS: KEY TECHNOLOGY FOR WIND TURBINES

Development of Wind Power Generation, Wind Power Conversion, Basic Control Variables for Wind Turbines, Wind Turbine Concepts, Power Converters for Wind Turbines - Two-Level, Multilevel, Multi-cell Converter, Power Semiconductors for Wind Power Converter, Controls and Grid Requirements for Modern Wind Turbines - Active Power Control, Reactive Power Control, Total Harmonic Distortion, Fault Ride-Through Capability.

UNIT-IV: PHOTOVOLTAIC ENERGY CONVERSION SYSTEMS

Introduction, Power Curves and Maximum Power Point of PV Systems, Grid-Connected PV System Configurations – Centralized, String, Multi-string, Control of Grid-Connected PV Systems, Recent Developments in Multilevel Inverter-Based PV Systems

UNIT-V: HYBRID RENEWABLE ENERGY SYSTEMS

Introduction, Diesel generator and photovoltaic systems – Diesel engine – PV power generation, wind – diesel hybrid system – system with no storage, system with battery, wind – PV systems.

TEXT BOOKS:

1. Abu-Rub, H., Malinowski, M., & Al-Haddad, K. (Eds.) Power Electronics for Renewable Energy Systems, Transportation and Industrial Applications,John Wiley & Sons, Ltd,2014.

2. B.H.Khan Non-conventional Energy sources Tata McGraw-hill Publishing Company, New Delhi, 2009.

3. S. N. Bhadra, D.Kastha, S.Banerjee, “Wind Electrical Systems”, Oxford University Press, 2005.

RESTRUCTURED POWER SYSTEMS

M.Tech (EPS) I Year II semester	**L**	**T**	**P**	**C**
Course code: 21PS6272	**3**	**0**	**0**	**3**

Prerequisite: Power Systems

Course Objectives: Prepare students to

- Understand restructuring of the electricity market
- Understand deregulation of the electricity market
- Understand the money, power & information flow in a deregulated power system

Course Outcomes: At the end of the course**,** Students will be able to

- Know about various types of regulations in power systems.
- Identify the need of regulation and deregulation.
- Understand technical and Non-technical issues in deregulated Power Industry.
- Identify existing electricity markets.
- Classify different market mechanisms and summarize the role of various entities in the market.

UNIT-I: INTRODUCTION

Fundamentals of restructured system, Market architecture, Load elasticity, Social welfare maximization

UNIT-II: OPF

Optimal power flow (OPF) Role in vertically integrated systems and in restructured markets, congestion management

UNIT-III: PRICING OF TRANSMISSION NETWORK

Optimal bidding, Risk assessment, Hedging, Transmission pricing, Tracing of power

UNIT-IV:DG MARKETS

Ancillary services, Standard market design, Distributed generation in restructured markets, renewable energy markets

UNIT-V: MARKET EVOLUTION

Developments in India, IT applications in restructured markets, working of restructured power systems, Pennsylvania-New Jersey-Maryland Interconnection (PJM) market, Recent trends in Restructuring

TEXT BOOKS:

1. Lorrin Philipson, H. Lee Willis, "Understanding electric utilities and de-regulation", Marcel Dekker Pub., 1998.
2. Steven Stoft, "Power system economics: designing markets for electricity", John Wiley and Sons, 2002.

REFERENCES:

1. Kankar Bhattacharya, Jaap E. Daadler, Math H.J. Boolen, "Operation of restructured power systems", Kluwer Academic Pub., 2001.
2. Mohammad Shahidehpour, Muwaffaq Alomoush, "Restructured electrical power systems: operation, trading and volatility", Marcel Dekker.

HVDC TRANSMISSION

M.Tech (EPS) I Year II semester	**L**	**T**	**P**	**C**
Course code: 21PS6273	**3**	**0**	**0**	**3**

Prerequisite: Power Systems and Power Electronics

Course Objectives:

- To prepare the students to understand the state-of-the-art of HVDC technology.
- To enable the students to model and analyze HVDC systems

Course Outcomes: At the end of the course**,** Students will be able to:

- Understand the state-of-the-art of HVDC technology.
- Model and analyze the HVDC system for inter-area power flow regulation.
- Analyze the converter and dc grid faults and adopt methods to mitigate them.
- Analyze the HVDC converter reactive power requirements and address the issues.

UNIT-I: GENERAL ASPECTS OF DC TRANSMISSION

Evolution of HVDC transmission, Comparison of HVDC and HVAC systems, Types of DC links, Components of a HVDC system, Valve characteristics, Properties of converter circuits, assumptions, single phase and Three-phase Converters, Pulse number, choice of best circuit for HVDC converters.

UNIT-II: ANALYSIS OF BRIDGE CONVERTER

Analysis of simple rectifier circuits, Required features of rectification circuits for HVDC transmission.

Analysis of HVDC converter: Different modes of converter operation, Output voltage waveforms and DC voltage in rectification, Output voltage waveforms and DC in inverter operation, Thyristor/Valve voltages. Equivalent electrical circuit.

UNIT-III: DC LINK CONTROL

Grid control, basic means of control, power reversal, limitations of manual control, Constant current versus Constant Voltage, 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**,** Power control and current limits, frequency control.

UNIT-IV: CONVERTER FAULTS & PROTECTION

Converter mal-operations, Commutation failure, Starting and shutting down the converter bridge, Converter protection.

UNIT-V: REACTIVE POWER MANAGEMENT

Smoothing reactor and DC Lines, Reactive power requirements, Harmonic analysis, Filter design

TEXT BOOKS:

1. J. Arrillaga, "High Voltage Direct Transmission", Peter Peregrinus Ltd. London, 1983.
2. K. R. Padiyar, "HVDC Power Transmission Systems", New Age International Publishers, 3rd Edition, 2015.

REFERENCES:

1. High Voltage Direct Current Transmission, NPTEL Lectures by Prof. S. N. Singh,

POWER SYSTEM RELIABILITY AND PLANNING

M.Tech (EPS) I Year II semester	**L**	**T**	**P**	**C**
Course code: 21PS6274	**3**	**0**	**0**	**3**

Prerequisite: Reliability Engineering

Course Objectives: Prepare the students to:

- Describe the generation system model and recursive relation for capacitive model building
- Explain the equivalent transitional rates, cumulative probability and cumulative frequency
- Develop the understanding of risk, system and load point reliability indices
- Explain the basic and performance reliability indices

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

- Understand the importance of maintaining reliability of power system components.
- Apply the probabilistic methods for evaluating the reliability of generation and transmission systems.
- Assess the different models of system components in reliability studies.
- Assess the reliability of single area and multi area systems.

UNIT-I: BASIC RELIABILITY CONCEPTS:

The general reliability function, exponential distribution – Mean time to failures – series and parallel systems. Markov process – continuous Markov process – Recursive techniques – Simple series and parallel system models.

UNIT-II: GENERATING CAPACITY – BASIC PROBABILITY METHODS:

The generation system model – Loss of load indices – Capacity expansion analysis – scheduled outages. Load forecast uncertainty Loss of energy indices. The frequency and duration method.

UNIT-III: TRANSMISSION SYSTEMS RELIABILITY EVALUATION:

Radial configuration – Conditional probability approach – Network configurations – State selection.

UNIT-IV: GENERATION PLANNING:

Comparative economic assessment of individual generation projects – Investigation and simulation models – Heuristic and linear programming models – Probabilistic generator and load models.

UNIT-V: TRANSMISSION AND DISTRIBUTION PLANNING:

Deterministic contingency analysis – Probabilistic transmission system – reliability analysis. Reliability calculations for single area and multi–area power systems. Network configuration design–consisting of schemes – security criteria configuration synthesis.

TEXT BOOKS:

1. Roy Billinton and Ronald Allan Pitam: Reliability Evaluation of Power Systems,1996.
2. R.L. Sullivan: Power System Planning, McGraw Hill International, 1977.

REFERENCES:

1. Wheel Wright and Makridakis: Forecasting methods and Applications, John Wiley, 1992.
2. J. Endremyl: Reliability Modelling in Electric Power Systems, John Wiley, 2005.
3. International Renewable Energy Agency , Bonn Lecture Series: Planning for the Transformation of Power Systems https://www.youtube.com/watch?v=sbZ2sY_E4QU

POWER QUALITY

M.Tech (EPS) I Year II semester	**L**	**T**	**P**	**C**
Course code: 21PS6275	**3**	**0**	**0**	**3**

Prerequisite: Power Systems and Power Electronics

Course Objectives: Prepare the students to

- Know different terms of power quality.
- Illustrate power quality issues for short and long interruptions.
- Construct study of characterization of voltage sag magnitude and three phase unbalanced voltage sag.
- Know the behavior of power electronics loads, induction motors, synchronous motor etc. by the power quality issues
- Know mitigation of power quality problems by using VSI converters.

Course Outcomes: Upon the completion of this course, the student will be able to

- Know the severity of power quality problems in distribution system;
- Understand the concept of voltage sag transformation from up-stream (higher voltages) to down-stream (lower voltage)
- Compute the power quality improvement by using various mitigating custom power devices.

UNIT- I: INTRODUCTION

Introduction of the Power Quality (PQ) problem: Terms used in PQ - Voltage, Sag, Swell, Surges, Harmonics, over voltages, spikes, Voltage fluctuations, Transients, Interruption, overview of power quality phenomenon, Remedies to improve power quality, power quality monitoring. Introduction to standardization, IEC Electromagnetic compatibility standards, European voltage characteristics standards, PQ surveys.

UNIT- II: LONG & SHORT INTERRUPTIONS

Interruptions – Definition – Difference between failures, outage, Interruptions – causes of Long Interruptions – Origin of Interruptions – Limits for the Interruption frequency – Limits for the interruption duration – costs of Interruption – Overview of Reliability evaluation to power quality, comparison of observations and reliability evaluation.

Short interruptions: definition, origin of short interruptions, basic principle, fuse saving, voltage magnitude events due to re-closing, voltage during the interruption, monitoring of short interruptions, difference between medium and low voltage systems. Multiple events, single phase tripping – voltage and current during fault period, voltage and current at post fault period, stochastic prediction of short interruptions.

UNIT-III: SINGLE - PHASE & THREE - PHASE VOLTAGE SAG CHARACTERIZATION

Voltage sag – definition, causes of voltage sag, voltage sag magnitude, and monitoring, theoretical calculation of voltage sag magnitude, voltage sag calculation in non-radial systems, meshed systems, and voltage sag duration. Three phase faults, phase angle jumps, magnitude and phase angle jumps for three phase unbalanced sags, load influence on voltage sags.

UNIT-IV: POWER QUALITY CONSIDERATIONS IN INDUSTRIAL POWER SYSTEMS

Voltage sag – equipment behavior of Power electronic loads, induction motors, synchronous motors, computers, consumer electronics, adjustable speed AC drives and its operation. Mitigation of AC Drives, adjustable speed DC drives and its operation, mitigation methods of DC drives.

UNIT-V: MITIGATION OF INTERRUPTIONS & VOLTAGE SAGS

Overview of mitigation methods – from fault to trip, reducing the number of faults, reducing the fault clearing time changing the power system, installing mitigation equipment, improving equipment immunity, different events and mitigation methods. System equipment interface – voltage source converter, series voltage controller, shunt controller, combined shunt and series controller.

TEXT BOOKS:

1. Math H J Bollen “Understanding Power Quality Problems”, IEEE Press.
2. R.C. Dugan, M.F. McGranaghan and H.W. Beaty, “Electric Power Systems Quality.” NewYork: McGraw-Hill.1996

REFERENCES:

1. G.T. Heydt, ‘Electric Power Quality’, 2nd Edition. (West Lafayette, IN, Stars in a Circle Publications, 1994).
2. Power Quality VAR Compensation in Power Systems, R. SastryVedamMulukutlaS.Sarma,CRC Press.
3. A Ghosh, G. Ledwich, Power Quality Enhancement Using Custom Power Devices. KluwerAcademic, 2002

POWER SYSTEM COMPUTATION LAB II

M.Tech (EPS) I Year II semester	**L**	**T**	**P**	**C**
Course code: 21PS6251	**0**	**0**	**4**	**2**

Prerequisite: Power systems and AI Techniques in Power Systems

Course Objectives: Students will be able to:

- Known fuzzy logic tool box
- Know the various Evolutionary Algorithms
- Apply various Evolutionary Algorithms to power system problems

Course Outcomes: At the end of the course the student will be able to:

- Understood fuzzy logic tool box
- Understood various Evolutionary Algorithms
- Solved power system problems by applying various Evolutionary Algorithms

List of Experiments

1. Load Flow analysis using forward backward sweep method
2. Load Flow analysis using PSO
3. Fuzzy Logic based AGC – Single area system – Two area system
4. Fuzzy Logic based small signal stability analysis
5. Economic Dispatch of Thermal Units using PSO
6. Economic Dispatch of Thermal Units using GA
7. Unit commitment problem by using GA
8. Unit commitment problem by using PSO
9. Optimal location and sizing of capacitor in distribution system using PSO
10. Security constrained optimal power dispatch using GA
11. Security constrained optimal power dispatch using PSO
12. Optimal Reactive power dispatch using PSO

Note: From the above list **minimum 10** experiments are to be conducted

POWER SYSTEM PROTECTION LAB

M.Tech (EPS) I Year II semester	**L**	**T**	**P**	**C**
Course code: 21PS6252	**0**	**0**	**4**	**2**

Prerequisite: Power systems protection

Course Objectives: Prepare the students to

- Study Different types of Faults occurring in power systems
- Study Characteristics of different types of relays
- Study Protection schemes

Course Outcomes: At the end of the course, the student will be able to:

- Calculate various faults
- Analyze the various time-current characteristics of protective relays
- Know the Performance and Testing of various electrical models and systems

List of Experiments

1. Characteristics of Electromechanical Non-Directional over current relay
2. Characteristics of numerical over Current Relay
3. Characteristics of Differential protection relay
4. Testing of transformer protection system for over current
5. Characteristics of Integrated Numerical under Voltage Relay
6. Testing of transformer protection system for earth fault
7. Characteristics of static negative sequence relay
8. Differential protection on Single Phase Transformer
9. Performance and Testing of Feeder Protection System
10. Milli volt drop test to determine the voltage drop across a joint
11. Measurement of insulator string efficiency

Note: From the above list **minimum 10** experiments are to be conducted

ENGLISH FOR RESEARCH PAPER WRITING

M.Tech (EPS) I Year II semester	L	T	P	C
Course code: 21MC6201	2	0	0	0

Prerequisite: English grammar

Course objectives: Students will be able to:

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

UNIT-I: INTRODUCTION TO RESEARCH PAPER WRITING

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

UNIT-II: PRESENTATION SKILLS

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

UNIT-III: TITLE WRITING SKILLS I

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

UNIT-IV: TITLE WRITING SKILLS II

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: RESULT WRITING SKILLS

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

TEXT BOOKS/ REFERENCES:

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

ENERGY AUDITING CONSERVATION AND MANAGEMENT

	L	T	P	C
M.Tech (EPS) II Year I semester	**L**	**T**	**P**	**C**
Course code: 21PS7171	**3**	**0**	**0**	**3**

Prerequisite: Electrical Machines

Course Objectives:

- To know the necessity of conservation of energy
- To generalize the methods of energy management
- To illustrate the factors to increase the efficiency of electrical equipment
- To detect the benefits of carrying out energy audits.

Course Outcomes: Upon the completion of this course, the student will be able to

- Tell energy audit of industries
- Predict management of energy systems
- Sequence the methods of improving efficiency of electric motor
- Analyze the power factor and to design a good illumination system
- Determine pay back periods for energy saving equipment

UNIT- I: ENERGY AUDIT

Energy audit- definitions, concept , types of audit, energy index, cost index , load profiles, audit instruments, Energy conservation schemes- Energy audit of industries- energy saving potential, energy audit of process industry, thermal power station, building energy audit.

UNIT- II: ENERGY MANAGEMENT

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

UNIT- III: ENERGY EFFICIENT MOTORS

Energy efficient motors, factors affecting efficiency, loss distribution, constructional details , characteristics, Efficient Control strategies - variable speed , variable duty cycle systems, voltage variation-voltage unbalance- over motoring.

UNIT- IV: PEAK DEMAND CONTROLS:

Peak Demand controls- Methodologies-Types of Industrial loads-Optimal Load- scheduling case study- Lighting- Energy efficient light sources-Energy conservation in LightingSchemes Electronic ballast-Power quality issues-Luminaries, case study.

UNIT- V: COGENERATION:

Cogeneration-Types and Schemes- Optimal operation of cogeneration plants-case study Electric loads of Air conditioning &Refrigeration Energy conservation measures- Cool storage-Types- Optimal operation case study Electric water heating- Geysers-Solar Water Heaters- - Energy conservation measures –Electrolytic Process.

TEXT BOOKS:

1. Anthony J. Pansini, Kenneth D. Smalling, .Guide to Electric Load Management. Pennwell Pub; (1998)
2. W.R. Murphy & G. Mckay Butter worth Energy management, Heinemann publications.
3. Energy management by Paul o' Callaghan, Mc-graw Hill Book company-1st edition, 1998
4. Giovanni Petrecca, .Industrial Energy Management: Principles and Applications., TheKluwerinternational series -207,1999

REFERENCES:

1. Energy efficient electric motors by John .C. Andreas, Marcel Dekker Inc Ltd-2nd edition, 1995
2. Energy management hand book by W. C. Turner, John wiley and sons
3. Energy management and good lighting practice : fuel efficiency- booklet 12- EEO

ELECTRIC AND HYBRID VEHICLES

	L	T	P	C
M.Tech (EPS) II Year I semester	**L**	**T**	**P**	**C**
Course code: 21PE6172	**3**	**0**	**0**	**3**

Prerequisite: Power Semiconductor Drives, Electrical Machines

Course Objectives:

- To understand the fundamental concepts of conventional vehicles
- To understand the fundamental concepts, principles, analysis and design of hybrid and electric vehicles.
- To understand the performance of electrical propulsion units with different motor drives.
- To understand electrical energy storage using batteries, fuel cells and super capacitors.
- To understand various energy management strategies in electric vehicles.

Course Outcomes: At the end of this course, students shall be

- Able to analyze mechanical design of conventional vehicles
- Able to describe hybrid vehicles and their performance.
- Able to analyze various motor drives used in electrical vehicles
- Able to understand different possible ways of energy storage.
- Able to Understand the different strategies related to energy storage systems.

UNIT-I: INTRODUCTION

Conventional Vehicles: Basics of vehicle performance, vehicle power source characterization, transmission characteristics, mathematical models to describe vehicle performance.

UNIT-II: INTRODUCTIONTOHYBRIDELECTRICVEHICLES

History of hybrid and electric vehicles, social and environmental importance of hybrid and electric vehicles, impact of modern drive-trains on energy supplies.

HYBRID ELECTRICDRIVE TRAINS: Basic concept of hybrid traction, introduction to various hybrid drive-train topologies, power flow control in hybrid drive-train topologies.

UNIT III ELECTRIC TRAINS

Electric Drive-trains: Basic concept of electric traction, introduction to various electric drive train topologies, power flow control in electric drive-train topologies.

ELECTRIC PROPULSION UNIT: Introduction to electric components used in hybrid and electric vehicles, Configuration and control of DC Motor drives, Configuration and control of Induction Motor drives, configuration and control of Permanent Magnet Motor drives, Configuration and control of Switch Reluctance Motor drives.

UNIT-IV: ENERGYSTORAGE

Energy Storage: Introduction to Energy Storage Requirements in Hybrid and Electric Vehicles, Battery based energy storage, battery management system, Fuel Cell based energy storage, Super Capacitor based energy storage, Fly wheel-based energy storage, Hybridization of different energy storage devices.

UNIT-V: ENERGYMANAGEMENTSTRATEGIES

Energy Management Strategies: Introduction to energy management strategies used in hybrid and electric vehicles, classification of different energy management strategies, comparison of different energy management strategies. Review of various Energy management strategies.

TEXT BOOKS:

1. C.Mi,M.A.MasrurandD.W.Gao,"Hybrid Electric Vehicles: Principles and ApplicationswithPracticalPerspectives",JohnWiley&Sons,2011.
2. S.Onori,L.SerraoandG.Rizzoni,"HybridElectricVehicles:EnergyManagementStrategies", Springer,2015.

REFERENCES:

1. M.Ehsani,Y.Gao,S.E.GayandA.Emadi,"ModernElectric,HybridElectric,andFuelCellVehicles:Fundamentals,Theory,andDesign",CRCPress,2004.
2. T. Denton,"ElectricandHybridVehicles",Routledge,2016.
3. AishwaryaPanday, Hari Om Bansal, "A Review of Optimal Energy Management Strategies for Hybrid Electric Vehicle", International Journal of Vehicular Technology, vol. 2014, Article ID 160510, 19 pages, 2014. https://doi.org/10.1155/2014/160510

SCADA SYSTEM AND APPLICATIONS

M.Tech (EPS) II Year I semester	**L**	**T**	**P**	**C**
Course code: 21PS7172	**3**	**0**	**0**	**3**

Prerequisite: Power System

Course Objectives: Prepare students to:

- Understand about Supervisory Control and Data Acquisition System (SCADA)
- Know SCADA communication and its functions
- Get an insight into its application

Course Outcomes: At the end of the course Students will be able to:

- Describe the basic tasks of SCADA
- Describe knowledge about SCADA architecture, various advantages and disadvantages of each System.
- Explain about single unified standard architecture IEC 61850.
- Describe about SCADA system components: remote terminal units, PLCs, intelligent electronic devices, HMI systems, SCADA server.
- Apply SCADA systems in transmission and distribution sectors

UNIT–I: Introduction to SCADA,

Data acquisition systems, Evolution of SCADA, Communication technologies.Monitoring and supervisory functions, SCADA applications in Utility Automation, Industries SCADA.

UNIT–II: SCADA Components

Industries SCADA System Components, Schemes- Remote Terminal Unit (RTU), Intelligent Electronic Devices(IED), Programmable Logic Controller (PLC), Communication Network, SCADA Server, SCADA/HMI Systems.

UNIT–III: SCADA Architecture

Various SCADA architectures, advantages and disadvantages of each System, single unified standard architecture -IEC 61850.

UNIT–IV: SCADA Communication

Various industrial communication technologies, wired and wireless methods and fiber optics, Open standard communication protocols.

UNIT–V: SCADA Applications:

Utility applications, Transmission and Distribution sector operations, monitoring, analysis and improvement, Industries - oil, gas and water, Case studies, Implementation, Simulation Exercises.

TEXT BOOKS:

1. Stuart A. Boyer: "SCADA-Supervisory Control and Data Acquisition", Instrument Society of America Publications, USA, 2004.
2. Gordon Clarke, Deon Reynders: "Practical Modern SCADA Protocols: DNP3, 60870.5 and Related Systems", Newnes Publications, Oxford, UK, 2004.

REFERENCES:

1. William T. Shaw, "Cybersecurity for SCADA systems", PennWell Books, 2006.
2. David Bailey, Edwin Wright, "Practical SCADA for industry", Newnes, 2003.
3. Michael Wiebe, "A guide to utility automation: AMR, SCADA, and IT systems for electric power", PennWell 1999.