Revised Curriculum Structure

(to be effective from 2018-19 admission batch)

JIS College of Engineering

Department: Electrical Engineering

M. Tech.

Specialization: Electrical Devices & Power Systems

Semester I							
Sr. No.	**Core/ Elective**	**Code**	**Course Name**	**L**	**T**	**P**	**Credit**
1	**Core 1**	EDPM 101	Power System Analysis	3	0	0	3
2	**Core 2**	EDPM102	Modeling and Analysis of Electrical Machines	3	0	0	3
3	**PE 1**	EDPM103	(a) Power System Dynamics (b) Power System Operation & Control (c) High Voltage Engineering (d) Mathematical Methods for Power Engineering	3	0	0	3
4	**PE 2**	EDPM 104	(a) Renewable Energy System (b) Distributed Generation (c) Smart grids (d) High Power Converters	3	0	0	3
5	**MLC**	MLC101	Research Methodology and IPR	2	0	0	2
6	**Lab 1**	EDPM 191	Power System Analysis Lab / Renewable Energy Lab	0	0	4	2
7	**Lab2**	EDPM 192	Electrical Machines Laboratory / Electrical Drives Laboratory	0	0	4	2
8	**Audit-I**	EDPM 182	Audit I	2	0	0	0
Total				**16**	**0**	**8**	**18**

Semester II							
Sr. No.	**Core/ Elective**	**Code**	**Course Name**	**L**	**T**	**P**	**Credit**
1	**Core 3**	EDPM 201	Power System Protection	3	0	0	3
2	**Core 4**	EDPM 202	FACTS and Custom Power Devices	3	0	0	3
3	**PE 3**	EDPM 203	(a) Power System Transient (b) Power Quality Management (c) Dynamics of Linear Systems (d) Energy Efficient Motor	3	0	0	3
4	**PE 4**	EDPM 204	(a) Electrical Power Distribution System (b) SCADA System and Applications (c) Advanced Micro-Controller Based Systems (d) EHV AC Power Transmission	3	0	0	3
5	**Minor Project**	EDPM 281	Mini Project with Seminar	0	0	4	2
6	**Lab 3**	EDPM291	Power System Protection Lab / Power Quality Lab	0	0	4	2
7	**Lab4**	EDPM 292	Power System Transient Lab / PLC & SCADA Lab / Electrical Power Distribution System	0	0	4	2
8	**Audit-II**	EDPM 282	Audit II	2	0	0	0
Total				**14**	**0**	**12**	**18**

Semester III							
Sr. No.	**Core/ Elective**		**Course Name**	**L**	**T**	**P**	**Credit**
1	**PE5**	EDPM 301	(a) Restructured Power Systems (b) Electric & Hybrid Vehicles (c) Power System Planning & Reliability (d) Engineering Optimization	3	0	0	3
2	**OE**	EDPM 302	(a) Business Analytics (b) Industrial Safety (c) Operations Research (d) Cost Management of Engineering Projects (e) Energy Auditing and Management	3	0	0	3

			(f) Waste to Energy				
3	**Major Project**	EDPM381	Phase – I Dissertation	0	0	20	10
Total				**6**	**0**	**20**	**16**

Semester IV							
Sr. No.	**Core/ Elective**	**Code**	**Course Name**	**L**	**T**	**P**	**Credit**
1	Major Project	EDPM 481	Phase – II Dissertation	0	0	32	**16**

GRAND TOTAL CREDITS= 68

FIRST SEMESTER

CORE-1: POWER SYSTEM ANALYSIS

Course Objectives-
Students will be able to:
1. Study various methods of load flow and their advantages and disadvantages
2. Understand how to analyze various types of faults in power system
3. Understand power system security concepts and study the methods to rank the contingencies
4. Understand need of state estimation and study simple algorithms for state estimation
5. Study voltage instability phenomenon

Units: 1
Load flow: Overview of Newton-Raphson ,Gauss-Siedel, fast decoupled methods, convergence properties, sparsity techniques, handling Qmax, violations in constant matrix, inclusion in frequency effects, AVR in load flow, handling of discrete variable in load flow.

Units: 2
Fault Analysis: Simultaneous faults, open conductors faults, generalized method of fault analysis.

Units: 3
Security Analysis: Security state diagram, contingency analysis, generator shift distribution factors, line outage distribution factor, multiple line outages, overload index ranking
Units: 4
Power System Equivalents: WARD, REI.equivalents

Units: 5
State Estimation: Sources of errors in measurement, Virtual and Pseudo, Measurement, Observability, Tracking state estimation, WSL method, bad data correction.

Units: 6
Voltage Stability: Voltage collapse, P-V curve, multiple power flow solution, continuation power flow, optimal multiplies load flow, voltage collapse proximity indices.

Suggested reading

1. J.J. Grainger &W.D.Stevenson, "Power system analysis ", McGraw Hill ,2003
1. A. R. Bergen & Vijay Vittal , "Power System Analysis" ,Pearson , 2000
2. L.P. Singh , "Advanced Power System Analysis and Dynamics", New Age International, 2006
3. G.L. Kusic, "Computer aided power system analysis" ,Prentice Hall India, 1986
4. A.J. Wood, " Power generation, operation and control" , John Wiley, 1994
5. P.M. Anderson, "Faulted power system analysis" , IEEE Press , 1995

Course outcomes-
Students will be able to:
1. Able to calculate voltage phasors at all buses , given the data using various methods of load flow
2. Able to calculate fault currents in each phase
3. Rank various contingencies according to their severity
4. Estimate the bus voltage phasors given various quantities viz. power flow, voltages, taps , CB status etc
5. Estimate closeness to voltage collapse and calculate PV curves using continuation power flow

CORE-2: MODELING AND ANALYSIS OF ELECTRICAL MACHINES

Course Objectives:
Students will be able to:
1. To understand the operation of an electrical machine mathematically.
2. To understand how a machine can be represented as its mathematical equivalent.
3. To develop mathematical model of AC & DC machines and perform transient analysis on them.

Unit 1: Principles of Electromagnetic Energy Conversion. General expression of stored magnetic energy, Co-energy and force/torque, example using single and doubly excited system.

Unit 2: Basic Concepts of Rotating Machines-Calculation of air gap mmf and per phase machine inductance using physical machine data; Voltage and torque equation of dc machine.

Unit 3: Three phase symmetrical induction machine and salient pole synchronous machines in phase variable form, Application of reference frame theory to three phase symmetrical induction and synchronous machines, Dynamic direct and quadrature axis model in arbitrarily rotating reference frames.

Unit 4: Determination of Synchronous machine dynamic equivalent circuit parameters, Analysis and dynamic modeling of two phase asymmetrical induction machine and single phase induction machine.

Unit 5: Special Machines - Permanent magnet synchronous machine, Surface permanent magnet (square and sinusoidal back emf type) and interior permanent magnet machines, Construction and operating principle, Dynamic modelling and self-controlled operation.

Unit 6: Analysis of Switch Reluctance Motors, Brushless D.C. Motor for space Applications, Recent trends.

Suggested reading

1. Charles Kingsle,Jr., A.E. Fitzgerald, Stephen D.Umans, "Electric Machinery", Tata Mcgraw Hill
2. R. Krishnan, "Electric Motor & Drives: Modeling, Analysis and Control", Prentice Hall of India
3. Miller, T.J.E., "Brushless Permanent Magnet and Reluctance Motor Drives", Clarendon Press
4. P.C.Krause "Analysis of Electric Machine" Wiley IEEE Press 3rd Edition

Course Outcomes:

Students will be able to:

1. Knowledge about the dynamic behavior rotating machines.
2. Able to understand equivalent circuit of synchronous machines.
3. To understand various practical issues of different machines.

PE-1: POWER SYSTEM DYNAMICS-I

Course Objectives:- Students will be able to:

1. Study of system dynamics and its physical interpretation
2. Development of mathematical models for synchronous machine
3. Modeling of induction motor

Unit-1: Synchronous Machines: Per unit systems, Park's Transformation (modified), Flux-linkage equations. (5)

Unit-2: Voltage and current equations, Formulation of State-space equations, Equivalent circuit. (6)

Unit-3: Sub-transient and transient inductance and Time constants, Simplified models of synchronous machines (6)

Unit-4: Small signal model: Introduction to frequency model. (6)

Unit-5: Excitation systems and Philips-Heffron model, PSS Load modeling. (6)

Unit-6: Modeling of Induction Motors, Prime mover controllers. (5)

Suggested reading:-

1. P. M. Anderson & A. A. Fouad "Power System Control and Stability", Galgotia , New Delhi, 1981
2. J Machowski, J Bialek& J. R W. Bumby, "Power System Dynamics and Stability", John Wiley & Sons, 1997
3. P.Kundur, "Power System Stability and Control", McGraw Hill Inc., 1994.
4. E.W. Kimbark, "Power system stability", Vol. I & III, John Wiley & Sons, New York 2002

Course Outcomes:
Students will be able to:
1. Understand the modeling of synchronous machine in details
2. Carry out simulation studies of power system dynamics using MATLAB-SIMULINK, MI POWER
3. Carry out stability analysis with and without power system stabilizer (PSS)
4. Understand the load modeling in power system

PE-1: POWER SYSTEM OPERATION & CONTROL

Optimal Generation Scheduling: Thermal System Dispatching with Network Losses Considered, The Lambda-Iteration Method, Gradient Methods of Economic Dispatch - Gradient Search, Newton's Method, Economic Dispatch with Piecewise Linear Cost Functions, Economic Dispatch Using Dynamic Programming, Base Point and Participation Factors, Economic Dispatch Versus Unit Commitment, Coordination Equations, Incremental Losses, and Penalty Factors, The ***B*** Matrix Loss Formula, Exact Methods of Calculating Penalty Factors, Reference Bus Versus Load Center Penalty Factors Reference-Bus Penalty Factors Direct from the AC Power Flow. (8)

Optimal Power flow:
Optimal var control problem, controllable variables- Transformer taps, Generator voltages, Switchable shunt capacitors and Reactors, Objective functions, network performance constraints, constraints on state variables, Mathematical formulation, Solution of the Optimal

Power Flow- The Gradient Method, Newton's Method, Linear Sensitivity Analysis, Linear Programming Methods, Sensitivity Coefficients of an **AC** Network Model
Linear Programming Method with Only Real Power Variables, Linear Programming with AC Power Flow Variables and Detailed Cost Functions, Security-Constrained Optimal Power Flow, Interior Point Algorithm, Bus Incremental Costs (10)

Load Frequency Control: control area concept, Block diagram and LFC of an isolated power system, Governor droop characteristic, AGC, primary and secondary frequency control, LFC of inter-connected power systems, Modes of tie line operation-flat frequency, flat tie line, tie line with frequency bias, Area control error, State space representation of two area system (10)

State Estimation:
Types of estimators–static, dynamic, tracking estimators. Least Squares and Weighted Least squares estimation, formulation, solution techniques, Bad data identification and detection. (4)

***References*:**
1. Power generation, operation, and control, Allen J. Wood, Bruce F, Wollenberg

PE-1: HIGH VOLTAGE ENGINEERING

Course Objectives:-Students will be able to:
1. To get introduced to high voltage engineering
2. To understand different high voltage measurements and the necessary instruments

Unit 1: Voltage doubler - cascade circuits, electrostatic machines (6)

Unit 2: Generation of Impulse voltages and curreningle stage and multistage circuits, wave shaping-tripping and control of impulse generators (8)

Unit 3: Generation of switching surge voltage and impulse current Measurement of high voltages and currents DC,AC and impulse voltages and currents, DSO-electrostatic and peak, Voltmeters sphere gaps-factors affecting measurements-potential dividers(capacitive and resistive) series impedance ammeters-rogowski coils-hall effect generators, Digital techniques in HV measurements. (8)

Unit 4: Measurement of electric field, Sources of EMI, Principles of EMC, Filtering, Shielding, Grounding techniques

Unit 5: Introduction to relevant national and international standards, Layout and clearances as well as shielding and grounding of HV lab

Unit 6: Safety regulations for high voltage tests, Calibration of HV measuring instruments, Indian Standards for HV clearances. Recent trends in HV Engineering.

Suggested reading

1. M. S. Naidu, V. Kamaraju, "High Voltage Engineering", McGraw-Hill, 1995.
2. M. Khalifa, "High Voltage Engineering: Theory and Practice", Dekker, 1990
3. H. M. Ryan, "High Voltage Engineering and Testing", Peter Peregrinus, 1994
4. Wadhwa C L."High Voltage Engineering", Wiley Eastern Limited, NewDelhi,1994
5. Ott, H.W.,"Noise Reduction Techniques in Electronic Systems", John Wiley, New York, 1989

Course Outcomes:-
Students will be able to:
1. Knowledge about the need for high voltage generation
2. Acquaint with the different methods for generating high voltage AC/DC and impulse voltages and current
3. Knowledge about the measurement techniques for high voltage AC/DC and impulse voltages and currents
4. To learn sources of EMI and its mitigation techniques
5. Safety precautions to be taken while designing an HV lab

PE1: MATHEMATICAL METHODS FOR POWER ENGINEERING

Course Objectives: -Students will be able to:
1. To understand the relevance of mathematical methods to solve engineering problems.
2. To understand how to apply these methods for a given engineering problem.

Unit 1: Vector spaces, Linear transformations Matrix representation of linear transformation (6)
Unit 2: Eigen values and Eigen vectors of linear operator (6)

Unit 3: Linear Programming Problems, Simplex Method, Duality, Non Linear Programming problems (6)

Unit 4: Unconstrained Problems, Search methods, Constrained Problems (6)

Unit 5: Lagrange method, Kuhn-Tucker conditions, Random Variables, Distributions (6)

Unit 6: Independent Random Variables, Marginal and Conditional distributions, Elements of stochastic processes (6)

Suggested reading
1. Kenneth Hoffman and Ray Kunze, "Linear Algebra", 2nd Edition, PHI, 1992
2. Erwin Kreyszig, "Introductory Functional Analysis with Applications", John Wiley & Sons, 2004

3. Irwin Miller and Marylees Miller, John E. Freund's "Mathematical Statistics", 6th Edn, PHI, 2002
4. J. Medhi, "Stochastic Processes", New Age International, New Delhi., 1994
5. A Papoulis, "Probability, Random Variables and Stochastic Processes", 3rd Edition, McGraw Hill, 2002
6. John B Thomas, "An Introduction to Applied Probability and Random Processes", John Wiley, 2000
7. Hillier F S and Liebermann G J, "Introduction to Operations Research", 7th Edition, McGraw Hill, 2001
8. Simmons D M, "Non Linear Programming for Operations Research", PHI, 1975

Course Outcomes: -

Students will be able to:

1. Knowledge about vector spaces, linear transformation, eigenvalues and eigenvectors of linear operators
2. To learn about linear programming problems and understanding the simplex method for solving linear programming problems in various fields of science and technology
3. Acquire knowledge about nonlinear programming and various techniques used for solving constrained and unconstrained nonlinear programming problems
4. Understanding the concept of random variables, functions of random variable and their probability distribution
5. Understand stochastic processes and their classification

PE2: RENEWABLE ENERGY SYSTEM

Course Objectives

Students will be able to

1. Learn various renewable energy sources
2. Gain understanding of integrated operation of renewable energy sources
3. Understand Power Electronics Interface with the Grid

Unit 1: Introduction, Distributed vs Central Station Generation, Sources of Energy such as Micro-turbines, Internal Combustion Engines. (4)

Unit 2: Introduction to Solar Energy, Wind Energy, Combined Heat and Power, Hydro Energy, Tidal Energy, Wave Energy, Geothermal Energy, Biomass, Fuel Cells (6)

Unit 3: Power Electronic Interface with the Grid (4)

Unit 4: Impact of Distributed Generation on the Power System, Power Quality Disturbances (6)

Unit 5: Transmission System Operation, Protection of Distributed Generators. (8)

Unit 6: Economics of Distributed Generation, Case Studies (4)

Suggested reading

1. RanjanRakesh, Kothari D.P, Singal K.C, "Renewable Energy Sources and Emerging Technologies", 2nd Ed. Prentice Hall of India, 2011
2. Math H.Bollen, FainanHassan,"Integration of Distributed Generation in the Power System", July 2011, Wiley –IEEE Press
3. Loi Lei Lai, Tze Fun Chan, "Distributed Generation: Induction and Permanent Magnet Generators", October 2007, Wiley-IEEE Press.
4. Roger A.Messenger, Jerry Ventre, "Photovoltaic System Engineering", 3rd Ed, 2010
5. James F.Manwell, Jon G.McGowan, Anthony L Rogers, "Wind energy explained: Theory Design and Application", John Wiley and Sons 2nd Ed, 2010

Course Outcomes

Students will be able to

1. Gain Knowledge about renewable energy
2. Understand the working of distributed generation system in autonomous/grid connected modes
3. Know the Impact of Distributed Generation on Power System

PE2: DISTRIBUTED GENERATION

Course Objectives:

Students will be able to:

1. To understand renewable energy sources.
2. To gain understanding of the working of off-grid and grid-connected renewable energy generation schemes.

Unit 1: Need for Distributed generation, Renewable sources in distributed generation and current scenario in Distributed Generation. (3)

Unit 2: Planning of DGs, Sitting and sizing of DGs optimal placement of DG sources in distribution systems, Grid integration of DGs Different types of interfaces, Inverter based DGs and rotating machine based interfaces, Aggregation of multiple DG units. (7)

Unit 3: Technical impacts of DGs, Transmission systems Distribution Systems De-regulation Impact of DGs upon protective relaying, Impact of DGs upon transient and dynamic stability of existing distribution systems, Steady-state and Dynamic analysis. (6)

Unit 4: Economic and control aspects of DGs Market facts, Issues and challenges Limitations of DGs, Voltage control techniques, Reactive power control, Harmonics Power quality issues, Reliability of DG based systems. (6)

Unit 5: Introduction to micro-grids, Types of micro-grids: autonomous and non-autonomous grids Sizing of micro-grids, Modeling & analysis of Micro-grids with multiple DGs, Micro-grids with power electronic interfacing units. (6)

Unit 6: Transients in micro-grids, Protection of micro-grids, Case studies (6)

Suggested reading

1. H. Lee Willis, Walter G. Scott, "Distributed Power Generation – Planning and Evaluation", Marcel Decker Press.
2. M.GodoySimoes, Felix A.Farret, "Renewable Energy Systems – Design and Analysis with Induction Generators", CRC press.
3. Stuart Borlase. "Smart Grid: Infrastructure Technology Solutions" CRC Press

Course outcomes

Students will be able to:
1. To understand the planning and operational issues related to Distributed Generation.
2. Acquire Knowledge about Distributed Generation Learn Micro-Grids

PE2: SMART GRIDS

Course Objectives:

Students will be able to:
1. Understand concept of smart grid and its advantages over conventional grid.
2. Know smart metering techniques.
3. Learn wide area measurement techniques.
4. Understanding the problems associated with integration of distributed generation & its solution through smart grid.

Unit 1: Introduction to Smart Grid, Evolution of Electric Grid, Concept of Smart Grid, Definitions, Need of Smart Grid, Concept of Robust &Self-Healing Grid, Present development & International policies in Smart Grid

Unit 2: Introduction to Smart Meters, Real Time Prizing, Smart Appliances, Automatic Meter Reading (AMR), Outage Management System (OMS), Plug in Hybrid Electric Vehicles(PHEV), Vehicle to Grid, Smart Sensors, Home & Building Automation, Smart Substations, Substation Automation, Feeder Automation

Unit 3: 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 4: 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.

Unit 5: 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 6: Advanced Metering Infrastructure (AMI), Home Area Network (HAN), Neighbourhood Area Network (NAN), Wide Area Network (WAN), Bluetooth, ZigBee, GPS, Wi-Fi, Wi-Max based communication, Wireless Mesh Network. Basics of CLOUD Computing &Cyber Security for Smart Grid, Broadband over Power line (BPL), IP based protocols

Suggested reading

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.
3. JanakaEkanayake, Nick Jenkins, KithsiriLiyanage, "Smart Grid: Technology and Applications", Wiley 2012.
4. Stuart Borlas'e, "Smart Grid:Infrastructure, Technology and solutions "CRC Press.
5. A.G.Phadke , "Synchronized Phasor Measurement and their Applications",Springer.

Course Outcomes

Students will be able to:

1. Appreciate the difference between smart grid & conventional grid.
2. Apply smart metering concepts to industrial and commercial installations.
3. Formulate solutions in the areas of smart substations, distributed generation and wide area measurements.
4. Come up with smart grid solutions using modern communication technologies

PE 2 : HIGH POWER CONVERTERS

Course Objectives:- Students will be able to:

1. Understand the requirements of high power rated converters
2. Understand the different topologies involved for these converters
3. Able to understand the design of protection circuits for these converters

Unit 1: Power electronic systems, An overview of PSDs, multipulse diode rectifier, multipulse SCR rectifier. (4)

Unit 2: Phase shifting transformers, multilevel voltage source inverters: two level voltage source inverter, cascaded H bridge multilevel inverter. (6)

Unit 3: Diode clamped multilevel inverters, flying capacitor multilevel inverter (5)

Unit 4: PWM current source inverters, DC to DC switch mode converters (5)

Unit 5: AC voltage controllers : Cyclo-converters, matrix converter, Power conditioners and UPS. (6)

Unit 6: Design aspects of converters, protection of devices and circuits (5)

Suggested reading

1. N. Mohan, T. M. Undeland and W. P. Robbins, "Power Electronics: Converter, Applications and Design", John Wiley and Sons, 1989
2. M.H. Rashid, "Power Electronics", Prentice Hall of India, 1994
3. B. K .Bose, "Power Electronics and A.C. Drives", Prentice Hall, 1986
4. Bin Wu, "High power converters and drives", IEEE press, Wiley Enter science

Course Outcomes:-

Students will be able to:
1. Learn the characteristics of PSDs such as SCRs, GTOs, IGBTs and use them in practical systems
2. Knowledge of working of multi-level VSIs, DC-DC switched mode converters, cyclo-converters and PWM techniques and the ability to use them properly
3. Acquire knowledge of power conditioners and their applications
4. Ability to design power circuit and protection circuit of PSDs and converters

RESEARCH METHODOLOGY AND IPR

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.

Syllabus Contents:

Unit 1: 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 2: Effective literature studies approaches, analysis Plagiarism, Research ethics.

Unit 3: 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 4: 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 5: Patent Rights: Scope of Patent Rights, Licensing and transfer of technology, Patent information and databases, Geographical Indications.

Unit 6: 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.

References:

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

LAB 1: POWER SYSTEM ANALYSIS LAB

1. Write a program to form Y bus by Inspection method.
2. Write a program for formation of Y bus by singular matrix transformation
3. Study of load flow methods
   a) Gauss-Siedel method
   b) Newton Raphson Method
4. Write a program for fault analysis for
   a) LG b)LLG c)LLL
5. Write a program for security analysis using load flow & ranking of contingency
6. Write a program for ranking of contingency using overload security analysis
7. Study of ready-made industry standard / commercial software packages for above analysis
8. Write a program to form Zbus matrix.

LAB 2: ELECTRICAL MACHINES LABORATORY

List of experiments:

1. Load test on dc shunt motor to draw speed – torque and horse power – efficiency characteristics.
2. Field Test on dc series machines.

3. Speed control of dc shunt motor by armature and field control.
4. Swinburne's Test on dc motor.
5. Retardation test on dc shunt motor.
6. Regenerative test on dc shunt machines.
7. Load test on three phase induction motor.
8. No load and Blocked rotor test on three phase induction motor to draw (i) equivalent circuit and (ii) circle diagram. Determination of performance parameters at different load conditions from (i) and (ii).
9. Load test on induction generator.
10. Load test on single phase induction motor to draw output versus torque, current, power and efficiency characteristics.
11. Conduct suitable tests to draw the equivalent circuit of single phase induction motor and determine performance parameters.
12. Conduct an experiment to draw V and _ curves of synchronous motor at no load and load conditions.

AUDIT COURSE I & II

1. English for Research Paper Writing
2. Disaster Management
3. Sanskrit for Technical Knowledge
4. Value Education
5. Constitution of India
6. Pedagogy Studies
7. Stress Management by Yoga
8. Personality Development through Life Enlightenment Skills.

EDPM 201: Power System Protection

Introduction: Relay types & Fault detection principles, CT & PT specification, Sequence filters
Non-Pilot over current protection: principles, Time and/or current grading co-ordination, Directional over current relaying
Differential protection: principles, CT requirements
Non-Pilot Distance Protection: stepped distance protection principles, distance relay types & polar characteristics, phase relays and poly phase relays, distance relay performance and SIR, power swing blocking , distance schemes, under reach and over reach, protection of parallel and multiended feeders
Pilot-Distance-protection: Communication channels, Tripping and blocking modes, directional comparison blocking and unblocking, under reaching transfer trip, PUR/POR transfer trip, phase comparison.
Single and three pole auto reclosing in HV and EHV transmission systems.
Bus protection: High & moderately high impedance relaying, CT requirements
Unit Protection of Feeder: Feeder differential protection, including pilot wire, current differential and phase comparison schemes

Protection of transformers: including biased and high impedance differential schemes, CT connections, 2 & 3 point differential protection, earthing transformers
Protection of high voltage capacitor banks: including consideration of inrush currents, over current, over voltage, and differential protection schemes
Protection of large motors: including differential and earth fault protection, thermal overload considerations, starting and stalling currents and the effect of negative phase sequence currents
Protection of large generators: including stator & rotor earth fault protection, biased differential, high impedance differential, negative sequence, under frequency, over/under excitation, reverse power and outof-step protections

References:
1. Power System Relaying, Stanley H. Horowitz, Arun G. Phadke, John Wiley & Sons
2. Protective Relays Application & Guide, GEC measurements
3. Power system protection, PM Anderson, IEEE Press book

EDPM 202: FACTS AND CUSTOM POWER DEVICES

Course Objectives:
Students will be able to:
1. To learn the active and reactive power flow control in power system
2. To understand the need for static compensators
3. To develop the different control strategies used for compensation

Unit 1: (6)
- 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 2: (8)
- 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.

Unit 3: (6)
- Static series compensation: TSSC, SSSC -Static voltage and phase angle regulators – TCVR and TCPAR Operation and Control –Applications, Static series compensation – GCSC,TSSC, TCSC and Static synchronous series compensators and their Control.

Unit 4: (6)

- 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.

Unit 5: (6)

- Introduction to interline power flow controller. Modeling and analysis of FACTS Controllers – Simulation of FACTS controllers 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 6: (6)

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

Suggested reading

1. K R Padiyar, "FACTS Controllers in Power Transmission and Distribution", New Age InternationalPublishers, 2007.
2. X P Zhang, C Rehtanz, B Pal, "Flexible AC Transmission Systems- Modelling and Control",Springer Verlag, 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.

Course Outcomes:

Students will be able to:

1. Acquire knowledge about the fundamental principles of Passive and Active Reactive Power Compensation Schemes at Transmission and Distribution level in Power Systems.
2. Learn various Static VAR Compensation Schemes like Thyristor / GTO Controlled.
3. Reactive Power Systems, PWM Inverter based Reactive Power Systems and their controls.
4. To develop analytical modeling skills needed for modeling and analysis of such Static VARSystems.

POWER SYSTEM TRANSIENTS

Course Objectives: -Students will be able to:
1. Learn the reasons for occurrence of transients in a power system
2. Understand the change in parameters like voltage & frequency during transients
3. To know about the lightning phenomenon and its effect on power system

Unit 1: (8)
- Fundamental circuit analysis of electrical transients
- Laplace Transform method of solving simple Switching transients
- Damping circuits -Abnormal switching transients, Three-phase circuits and transients
- Computation of power system transients

Unit 2: (8)
- Principle of digital computation – Matrix method of solution
- Modal analysis- Z transform- Computation using EMTP
- Lightning, switching and temporary over voltages, Lightning
- Physical phenomena of lightning.

Unit 3: (8)
- Interaction between lightning and power system
- Influence of tower footing resistance and Earth Resistance
- Switching: Short line or kilometric fault
- Energizing transients - closing and re-closing of lines
- line dropping, load rejection – over voltages induced by faults

Unit 4: (8)
- Switching HVDC lineTravelling waves on transmission line
- Circuits with distributed Parameters Wave Equation
- Reflection, Refraction, Behaviour of Travelling waves at the line terminations
- Lattice Diagrams – Attenuation and Distortion
- Multi-conductor system and Velocity wave

Unit 5: (6)

- Insulation co-ordination: Principle of insulation co-ordination in Air Insulated substation (AIS) and Gas Insulated Substation (GIS) Coordination between insulation and protection level
- Statistical approach

Unit 6: (6)
- Protective devices
- Protection of system against over voltages
- lightning arresters, substation earthling

Suggested reading

1. Allan Greenwood, “Electrical Transients in Power System”, Wiley & Sons Inc. New York, 1991

Course Outcomes: -

Students will be able to:

1: Knowledge of various transients that could occur in power system and their mathematical formulation
2: Ability to design various protective devices in power system for protecting equipment and personnel
3: Coordinating the insulation of various equipments in power system
4: Modelling the power system for transient analysis

PE5: Power System Planning & Reliability

Code : EDPM 301(C)
Lecture : 3 / Week
Credit : 3

Load Forecasting: Load Forecasting Categories-Long term, Medium term, short term, very short term Applications of Load Forecasting, Methodology of forecasting, energy forecasting, Factors Affecting Load Patterns Medium and long term load forecasting methods- end use models, econometric models, statistical model based learning.

Short Term Load Forecasting (STLF): Applications of Load Forecasting, methods-similar day approach, regression methods, time series, ANN, Expert systems, Fuzzy logic based method, support vector machines ANN architecture for STLF, Seasonal ANN, Adaptive Weight, Multiple-Day Forecast, STLF Using MATLAB'S ANN Toolbox, Training and Test Data, Stopping Criteria for Training Process, sensitivity analysis.

Power System Reliability: Basic Notions of Power System Reliability- sub systems, reliability indices, outage classification, value of reliability tools, Concepts and methodologies, power system structure, Reliability based planning in power systems, Effect of failures on power system, Planning criteria, Risk analysis in power system planning, multi-state systems.

Basic Tools and Techniques- random processes methods & MARCOV models, Computation of power system reliability measures by using Markov reward models, Evaluation of reliability indices, Universal Generating Function (UGF) Method, Monte Carlo simulation.

Reliability of Generation Systems- capacity outage calculations, reliability indices using the loss of load probability method, unit commitment and operating constraints, optimal reserve management, single and multi-stage expansion.

Reliability Assessment for Elements of Transmission and Transformation Systems- reliability indices of substations based on the overload capability of the transformers, evaluation and analysis of substation configurations, Reliability analysis of protection systems for high voltage transmission lines.

References:

1. Markey operations in electric power systems Forecasting, Scheduling, and Risk Management, Shahidehpour M, Yamin H, Li z, John Wlley & sons
2. Reliability evaluation of power systems, Billinton R, Allan R (1996) Plenum Press New York
3. Computational Methods in Power system Reliability, D. Elmakias, Springer-Verlag