Academic Program: PG

Academic Year 2024-25

Department of Electrical & Electronics Engineering

Power Systems Engineering

I Semester M.Tech.

Syllabus

SHRI DHARMASTHALA MANJUNATHESHWARA COLLEGE OF ENGINEERING & TECHNOLOGY,

DHARWAD – 580 002

(An Autonomous Institution Approved by AICTE & Affiliated to VTU, Belagavi)

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SDM College of Engineering & Technology, Dharwad
Department of Electrical Engineering
*(Our motto: **P**rofessional **C**ompetence with **P**ositive **A**ttitude)*

College Vision and Mission

Vision:

To develop competent professionals with human values.

Mission:

1. To have contextually relevant Curricula.
2. To promote effective Teaching Learning Practices supported by Modern Educational Tools and Techniques.
3. To enhance Research Culture.
4. To involve Industrial Expertise for connecting classroom content to real life situations.
5. To inculcate Ethics and impart soft-skills leading to overall Personality Development.

SDMCET- Quality Policy

- In its quest to be a role model institution, committed to meet or exceed the utmost interest of all the stake holders.

SDMCET- Core Values

- Competency
- Commitment
- Equity
- Team work and
- Trust

Department Vision and Mission

Vision:

To develop globally acceptable Electrical and Electronics Engineering professionals with human values.

Mission:

1. Adopting the state of the art curricula
2. Practicing effective and innovative teaching-learning methodologies
3. Initiating complementary learning activities to enhance competence
4. Inculcating positive attitude and commitment to society.

SDM College of Engineering & Technology, Dharwad

It is certified that the scheme and syllabus for I & II semester M.Tech in Power Systems Engineering is recommended by the Board of Studies of Electrical and Electronics Engineering Department and approved by the Academic Council, SDM College of Engineering & Technology, Dharwad. This scheme and syllabus will be in force from the academic year 2024-25 till further revision.

Chairman BoS & HoD **Principal**

Program Educational Objectives (PEOs):

The Program Educational Objectives (PEOs):

I. To prepare graduates who will be successful professionals in industry, government, academia, research, entrepreneurial pursuit and consulting firms

II. To prepare graduates who will contribute to society as broadly educated, expressive, ethical and responsible citizens with proven expertise

III. To prepare graduates who will achieve peer-recognition; as an individual or in a team; through demonstration of good analytical, research, design and implementation skills

IV. To prepare graduates who will thrive to pursue life-long reflective learning to fulfill their goals

Program Outcomes (POs):

PO1: An ability to independently carry out research / investigation and development work to solve practical problems.

PO2: An ability to write and present a substantial technical report / document.

PO3: Student should be able to demonstrate a degree of mastery over the area of power systems engineering

PO4: Exposure to the state of the art practices in the domain of power systems engineering

Scheme of Teaching and Examinations – 2024-25
M.Tech. (Power Systems Engineering)
I Semester M.Tech.

Course	Course Code	Course Title	Teaching		Examination				
			L-T-P (Hrs/Week)	Credits	CIE	Theory (SEE)		Practical (SEE)	
					Max. Marks	*Max. Marks	Duration in hours	Max. Marks	Duration in hours
BSC	24PEPC100	Applied Mathematics	3-0-0	3	50	100	3	-	-
PCC	24PEPC101	Digital Protection of Power System	3-0-0	3	50	100	3	-	-
PCC	24PEPC102	Power System Analysis	3-0-0	3	50	100	3	-	-
PCC	24PEPC103	Power System Modeling and Dynamics	3-0-0	3	50	100	3	-	-
PCC	24PEPC104	Distributed Generation and Micro grids	3-0-0	3	50	100	3	-	-
PCC	24PRMC105	Research Methodology and IPR	2-0-0	2	50	100	3	-	-
PCCL	24PEPL106	Power System Laboratory-1	0-0-2	1	50	-	-	50	3
		Total	**17-0-2**	**18**	**350**	**600**		**50**	

CIE: Continuous Internal Evaluation **SEE**: Semester End Examination

L: Lecture **T**: Tutorials **P**: Practical

***SEE** for theory courses is conducted for 100 marks and reduced to 50 marks.

I - Semester M.Tech. (Power Systems Engineering)

24PEPC100	Applied Mathematics	(3 - 0 - 0) 3

Contact Hours: 39

Course Learning Objectives (CLOs):

Learn the idea of random variable and probability distribution. To prepare the students to formulate and solve linear programming problem. Study Numerical methods to solve algebraic, transcendental equations. Learn to solve system of linear equations. Introducing students to the fundamental concepts of Graph theory and linear algebra.

Course Outcomes (COs):

Description of the Course Outcome: At the end of the course the student will be able to:		**Mapping to POs (1 to 4)**		
		Substantial Level (3)	**Moderate Level (2)**	**Slight Level (1)**
CO-1	Learn the idea of random Variables (discrete/continuous) and probability distributions in analyzing the probability models arising in power system engineering.		1,2	
CO-2	Apply the concept of optimization to Solve system of linear and non-linear programming problems.		1,2	
CO-3	Learn the Concept of graph theory in engineering problems.		1,2	
CO-4	Employ numerical techniques in order to achieve more accurate values in the computation of roots of algebraic and non-linear equations		1,2	
CO-5	Apply standard iterative methods to compute Eigen values		1,2	

PO's	**PO-1**	**PO-2**	**PO-3**	**PO-4**
Mapping Level	2.0	2.0		

Prerequisites: [1] Differentiation Matrices [2] Vectors [3] Basic Probability Theory

Contents:

1) Probability Theory

Review of basic probability theory. Definitions of random variables and probability distributions, probability mass and density functions, expectation, moments, central moments, characteristic functions, probability generating and moment generating functions-illustrations. Binomial, Poisson, Exponential, Gaussian, and Rayleigh distributions example. **08 Hrs.**

2) Linear and Nonlinear Programming

Formulation of LPP problem. Simplex Algorithm-Two Phase and Big M techniques– Duality theory-Dual Simplex method. Nonlinear Programming Constrained extremal problems-Lagrange's multiplier method- Kuhn-Tucker conditions and solutions. **08 Hrs.**

3) Graph Theory

Basic terminologies, types of graphs, sub graphs, graphs isomorphism, connected graphs-walks, paths, circuits, connected and disconnected graphs, operations on graphs, Eulerian paths and circuits, Hamiltonian paths and circuits, shortest path algorithms, applications of graphs. **08 Hrs.**

4) Numerical Methods

Solution of algebraic and transcendental equations- iterative methods based on second degree equation – Muller method (no derivation), Chebyshev method. Fixed point iteration method (first order), acceleration of convergence, Δ - Aitken's method. Bairstow's method, Graeffe's root squaring method. **08 Hrs.**

5) Linear Algebra

Computation of Eigen values and Eigen vectors of real symmetric matrices- Given's method. Orthogonal vectors and orthogonal bases. Gram-Schmidt orthogonalization process. QR decomposition, singular value decomposition, least square approximations**.** **07 Hrs.**

Reference Books:

1) M K Jain, S R K Iyengar, and R K Jain, "Numerical Methods for Scientific and Engineering Computations", New Age International, 2004.
2) B. S. Grewal, "Higher Engineering Mathematics", 41st Edition, Khanna Publishers, 2011.
3) Narsingh Deo, "Graph Theory with Applications to Engineering and Computer Science", PHI, 2012.
4) Kenneth Hoffman and Ray Kunze, "Linear Algebra", 2nd Edition, PHI, 2011.
5) Richard Bronson, "Schaum's Outlines of Theory and Problems of Matrix Operations", McGraw-Hill, 1988.

24PEPC101 Digital Protection of Power System (3- 0 - 0) 3

Contact Hours: 39

Course Learning Objectives (CLOs):

1) To introduce the components of the Power System to be protected.
2) To discuss hardware resource required to develop the digital relay.
3) To introduce basics of DSP hardware, algorithms, and relaying schemes to protect power system.
4) To introduce to the concept of existing digital relays for motor protection, transformer protection and other components in power system.

Course Outcomes (COs):

Description of the Course Outcome: At the end of the course the student will be able to:		**Mapping to POs (1 to 4)**		
		Substantial Level (3)	**Moderate Level (2)**	**Slight Level (1)**
CO-1	Apply the knowledge of hardware to develop the digital relay for different components of Power System	4	3	2
CO-2	Develop DSP based relay algorithms	4	3	2
CO-3	Apply concepts of programming to simulate and study the behavior of developed hardware resource to protect components of power system.	1, 4	3	2
CO-4	Apply concepts of Digital Protection to protect transformers, Motors, and Busbar.	4	3	2

PO's	**PO-1**	**PO-2**	**PO-3**	**PO-4**
Mapping Level	3.0	1.0	2.0	3.0

Prerequisites: Power system protection

Contents:

1) Introduction to Computer Relaying:

Development of computer relaying, Historical background, Expected benefits of computer relaying, Computer relay architecture, Protection Generations,

Analog to digital converters, Anti-aliasing filters, Digital Signal Processing, Hierarchical Structure of Protection and Control. **06 Hrs.**

2) **Relaying practices:**
Introduction to protection systems, Functions of a protection system, Protection transmission lines, Performance of current and voltage transformers. **06 Hrs.**

3) **Relaying Algorithm**
Algorithms Based on Undistorted single frequency sine wave: Mann and Morrison Algorithm, Three Sample technique, First and second derivative algorithm, two sample technique.
Algorithms Based on Solution of Differential Equation: Differential Equation Algorithm, Solution of Differential Equation Algorithm using Numerical Integration, Application of Differential Equation Algorithm to Three-Phase Line.
Algorithms Based on Least Squared Error: LSQ Technique, LSQ and Pseudo inverse, LSQ Algorithm by Sachdev. **10 Hrs.**

4) **Digital Protection of transformers and machines:** Introduction, Power transformer algorithms, Generator protection, Motor protection. **06 Hrs.**

5) **Digital Bus Differential Protection:** Introduction, Busbar Protection Techniques, New Differential Bus Protection Algorithm, Differential Principle, CT Saturation Detection. **06 Hrs.**

6) **Hardware organization in integrated systems:** The nature of hardware issues, Computers for relaying, The substation environment, Industry environmental standards, Countermeasures against EMI, Supplementary Equipment. **05 Hrs.**

Reference Books:

1) Arun G. Phadke, James S. Thorp, “Computer Relaying for Power Systems”, John Wiley and Sons Inc, 2nd Edition, 2009.
2) A. T. Johns and S. K. Salman, “Digital Protection for Power Systems” Peter Peregrinus Ltd,
3) S. R. Bhide, “Digital Power System Protection” PHI Learning Private Limited, 1st Edition, 2013.
4) Waldemar Rebizant, Janusz Szafran, Andrzej Wiszniewski, “Digital Signal Processing in Power System Protection and Control, Springer, 1st Edition, 2011.
5) GER-3984 Reference Manual, General Electric, Digital Low-Impedance Bus Differential Protection: Principles and Approaches.

24PEPC102 Power System Analysis (3 - 0 - 0) 3

Contact Hours: 39

Course Learning Objectives (CLOs):

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 and analyze various stability aspects of power system.
4) Study voltage instability phenomenon.
5) Understand need of state estimation and study simple algorithms for state estimation.

Course Outcomes (COs):

Description of the Course Outcome: At the end of the course the student will be able to:		**Mapping to POs (1 to 4)**		
		Substantial Level (3)	**Moderate Level (2)**	**Slight Level (1)**
CO-1	Perform load flow studies for a multi-machine system	1	3	2
CO-2	Analyze for various faults in power system	1	3	2
CO-3	Explain stability aspects of power system and voltage stability phenomenon	1	3	2
CO-4	Estimate the state of power system using algorithms	1	3,4	2

PO's	**PO-1**	**PO-2**	**PO-3**	**PO-4**
Mapping Level	3.0	1.0	2.0	2.0

Prerequisites: Power System Analysis

Contents:

1) **Load Flow:** Formation of Y_{bus} by inspection, importance of Y_{bus} and properties of Y_{bus}. Review of Gauss-Seidel, Newton-Raphson, De-coupled and Fast De-coupled methods, including bus loadings, line flow and line loss equations, handling the Q_{limit} violations and convergence properties. **08 Hrs.**
2) **Fault Analysis:** Classification of faults, probability of occurrence**.** Review of symmetrical & unsymmetrical faults. Analysis of simultaneous faults by generalized method. **08 Hrs.**

3) **Stability Aspects of Power System:** Steady state stability of a multi-machine power system, Transient Stability Studies- Swing equation, Runge Kutta Method, Long term transient stability studies. Dynamic Stability Studies- Concept, effect of saliency and saturation on stability, dynamic stability assessment using torque angle loop analysis, effect of excitation on stability. **08 Hrs.**

4) **Voltage Stability:** Voltage collapse, P-V curve, multiple power flow solution, continuation power flow, optimal multiples load flow, voltage collapse proximity indices. **08 Hrs.**

5) **State Estimation:** Sources of errors in measurement, virtual and Pseudo measurement, Observability, Tracking state estimation, WSL method, bad data correction. Role of PMU in state estimation. **07 Hrs.**

Reference Books:

1) J.J. Grainger &W. D. Stevenson, “Power System Analysis”, McGraw Hill, 2003
2) A. R. Bergen & Vijay Vittal, “Power System Analysis”, Pearson, 2000.
3) L.P. Singh, “Advanced Power System Analysis and Dynamics”, New Age International, 2006.
4) G. L. Kusic, “Computer Aided Power System Analysis”, Prentice Hall India,1986.
5) A. J. Wood, “Power generation, operation and control”, John Wiley, 1994
6) P.M. Anderson, “Faulted power system analysis”, IEEE Press, 1995
7) Prabha Kundur, “Power System Stability and control, 1st Edition, 1994
8) Nagarath & Kothari, “Modern Power System Analysis”, 4th Edition, TMH, 2011.

24PEPC103 Power System Modeling and Dynamics (3 - 0 - 0) 3

Contact Hours: 39

Course Learning Objectives (CLOs):

1) To impart knowledge on dynamic modeling of a synchronous machine excitation and prime mover controllers.
2) To describe the modeling of transmission lines, SVC and loads.
3) To explain the dynamics of single machine connected to infinite bus.
4) To describe the analysis of single systems and evaluation of transient stability.

Course Outcomes (COs):

Description of the Course Outcome: At the end of the course the student will be able to:		Mapping to POs (1 to 4)		
		Substantial Level (3)	Moderate Level (2)	Slight Level (1)
CO-1	Model and analyze synchronous machines and transients respectively	1	3	2
CO-2	Develop appropriate models of individual power system elements for power system dynamics studies.	1, 3	4	2
CO-3	Model and analyze single machine connected to infinite bus for transient stability.	1, 3	4	2
CO-4	Use compensation technique for smooth operation of power system and decide on choosing necessary power system stabilizers	1	3, 4	2

PO's	PO-1	PO-2	PO-3	PO-4
Mapping Level	3.0	1.0	2.5	2.0

Prerequisites: [1] Computer Techniques in Power System
[2] Electric machines
[3] Electric Power generation and transmission

Contents:

1) **Modeling of Synchronous Machine:** Review of classical methods, modeling of Synchronous machine, Park's Transformation, Transformation of flux linkages, Transformation of stator voltage equations and rotor equations, Analysis of steady state performance, per unit quantities, Equivalent circuits of synchronous machine - determination of parameters of equivalent circuits. **08 Hrs.**
2) **Excitation System and prime mover controllers:** Excitation system modeling, excitation systems block Diagram system representation by state equations, Prime mover control system. **06 Hrs.**
3) **Transmission lines and loads:** Modeling of transmission lines, D-Q transformation, modeling of SVC and loads, modeling of Induction motors. **06 Hrs.**

4) Dynamics of a Synchronous Generator Connected to Infinite Bus:

System model, Synchronous machine model, stator equations, rotor equations, Synchronous machine model x x, calculation of Initial conditions. **08 Hrs.**

5) Analysis 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. **07 Hrs.**

6) Application 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. **04 Hrs.**

Reference Books:

1) K. R. Padiyar, “Power System Dynamics”, B. S. Publications, Hyderabad.
2) P. M. Anderson and A. A. Fouad, “Power System Control and Stability”, 2nd Edition, B. S. Publications Hyderabad.
3) Peter W. Sauer & M. A. Pai, “Power System Dynamics and Stability” Prentice Hall.

24PEPC104 Distributed Generation and Micro grids (3 - 0 - 0) 3

Contact Hours: 39

Course Learning Objectives (CLOs):

1) To illustrate the concept of distributed generation
2) To analyze the impact of grid integration.
3) To study concept of Microgrid and its configuration
4) To study protection issues and communication protocols

Course Outcomes (COs):

Description of the Course Outcome: At the end of the course the student will be able to:		**Mapping to POs (1 to 4)**		
		Substantial Level (3)	**Moderate Level (2)**	**Slight Level (1)**
CO-1	Review the conventional power generation	1	3	2
CO-2	Analyze the concept of distributed generation and installation	1	3	2
CO-3	Design the grid integration system with conventional and	4	3	2

	non-conventional energy sources			
CO-4	Design the dc and ac micro grid, Analyze power quality issues, control operation	4	3	2
CO-5	Understand protection concepts and communication protocols in Microgrids	4	3	2

PO's	PO-1	PO-2	PO-3	PO-4
Mapping Level	3.0	1.0	2.0	3.0

Prerequisites: AC Generation, Transmission and Distribution

Contents:

1) **Introduction:**
   Conventional power generation: advantages and disadvantages, Energy crises, Non-conventional energy (NCE) resources: review of Solar PV, Wind Energy systems, Fuel Cells, micro-turbines, biomass, and tidal sources. **06 Hrs.**
2) **Distributed Generations (DG):**
   Concept of distributed generations, topologies, selection of sources, regulatory standards/ framework, Standards for interconnecting Distributed resources to electric power systems: IEEE 1547. DG installation classes, security issues in DG implementations. Energy storage elements: Batteries, ultra-capacitors, flywheels. Captive power plants. **07 Hrs.**
3) **Basics of Microgrid:**
   Concept and definition of microgrid, microgrid drivers and benefits, review of sources of microgrids, typical structure and configuration of a micro grid, AC and DC microgrids, Power Electronics interfaces in DC and AC micro grids. **06 Hrs.**
4) **Impact of Grid Integration:**
   Requirements for grid interconnection, limits on operational parameters, voltage, frequency, THD, response to grid abnormal operating conditions, islanding issues. Impact of grid integration with NCE sources on existing power system: reliability, stability, and power quality issues. **06 Hrs.**
5) **Control and Operation of Microgrid:**
   Modes of operation and control of microgrid: grid connected and islanded mode, Active and reactive power control, protection issues, anti-islanding schemes: passive, active and communication-based techniques, microgrid communication infrastructure, Power quality issues in microgrids, regulatory standards, Microgrid economics, Introduction to smart microgrids. **08 Hrs.**

6) Protection Issues for Microgrids:

Introduction, Islanding, Different islanding scenarios, Major protection issues of Stand-alone Microgrid - Impact of DG integration on electricity market, environment, distribution system, communication standards and protocols.

06 Hrs.

Reference Books:

1) Amirnaser Yezdani, and Reza Iravani, "Voltage Source Converters in Power Systems: Modeling, Control and Applications", IEEE John Wiley Publications, 2009.
2) Dorin Neacsu, "Power Switching Converters: Medium and High Power", CRC Press, Taylor & Francis, 2006.
3) Chetan Singh Solanki, "Solar Photo Voltaics", PHI learning Pvt. Ltd., New Delhi, 2009
4) J. F. Manwell, J.G "Wind Energy Theory Design and Applications". Wiley publication, 2nd Edition, 2009.
5) D. D. Hall and R. P. Grover, "Biomass Renewable Energy", John Wiley, New York, 1987.
6) John Twidell and Tony Weir, "Renewable Energy Resources", Taylor and Francis Publications, Second Edition, 2006.
7) S. Chowdhury, S. P. Chowdhury, and P. Crossley, "Microgrids and Active Distribution Networks" ISBN 978-1-84919-014-5, IET, 2009.

24PRMC105	Research Methodology and IPR	(2 – 0 - 0) 2

Contact Hours: 26

Course Learning Objectives (CLOs):

The students are expected to learn about the needs and types of research, problem formulation, literature review, measurement, scaling, data collection, testing of hypothesis, result interpretation, and report writing. Further, the students shall know about intellectual property rights, copyrights, trademarks, patents, patent filing procedures, infringement & remedies, and the Information Technology Act, etc.

Course Outcomes (COs):

Description of the Course Outcome: At the end of the course, the student will be able to:		Mapping to POs (1 to 4)		
		Substantial Level (3)	Moderate Level (2)	Slight Level (1)
CO-1	Formulate their search problem, carryout literature survey and decide the methodology.		1	
CO-2	Use measurement and scaling and carryout data collection.		1	
CO-3	Test the hypothesis, interpret & analyze the results, and write the report.	2	3	
CO-4	Explain the need of IPR, copy right, patents, trademarks, & the filing procedure and know about infringement, remedies, and regulatory framework.		2	

PO's	PO-1	PO-2	PO-3	PO-4
Mapping Level	2.0	2.5	2.0	--

Contents:

1) **Research Methodology:** Introduction, meaning of research, objectives of research, motivation in research, types of research, research approaches, research process, criteria of good research and problems encountered by researchers in India.
   Defining the Research Problem: Research problem, selecting the problem, technique involved in defining a problem, an illustration. **04 Hrs.**
2) **Reviewing the literature:** How to review the literature, searching the existing literature, reviewing the selected literature.
   Research Design: Meaning of research design, need for research design, features of a good design, important concepts relating to research design, different research designs. **04 Hrs.**
3) **Measurement and Scaling:** Measurement in research, measurement scales, sources of error in measurement.
   Data Collection: Collection of primary data, collection of secondary data. **04 Hrs.**
4) **Testing of Hypotheses:** What is a Hypothesis? Basic concepts concerning testing of hypotheses, procedure for hypothesis testing, flow diagram for hypothesis testing, measuring the power of a hypothesis test, tests of

hypotheses. **04 Hrs.**

5) **Interpretation and Report Writing:** Meaning of interpretation, technique of interpretation, precaution in interpretation, significance of report writing, different steps in writing report, layout of the research report, precautions for writing research reports, plagiarism and its significance.**03 Hrs.**
6) **Introduction to Intellectual Property Rights:** Meaning and conception of IPR, competing, rationale for protection, international conventions, world court.

Copy right: Meaning, content, substance, ownership, primary, special rights, obligations, period, assignment, and relinquishment of copyrights. License and application for registration of copyright.

Patents: Meaning of Patent, purpose and policy object of patent law, gains to the inventor, application of patents, joint application, discovery and invention, patentable and non-patentable inventions. .

Industrial design: Concepts & Significance

Trademarks: Definitions and conceptions of Trademark, advantages of registration, marks which are not registrable, known, and well-known trademarks, application for registration and procedure for registration, procedure, and certification of Trademarks.

Infringement and Remedies: Meaning of infringement, acts of infringement.

07 Hrs.

Self-Study-

The Information Technology Act: Definitions, certifying authority, meaning of compromise of digital signature, offences and penalties, the applicability of IPRs, cybercrimes, adjudicating officer, violation, damages and penalties, Cyber regulation appellate tribunal, World Wide Web and domain names and cyber flying.

Reference Books:

1) C.R. Kothari, Gaurav Garg, Research Methodology: Methods and Techniques, New Age International, 4th Edition, 2018.
2) Ranjit Kumar, Research Methodology a step-by-step guide for beginners, SAGE Publications, 3rd Edition, 2011.
3) Fink A, Conducting Research Literature Reviews: From the Internet to Paper, Sage Publications, 2009.
4) N. K. Acharya, “Textbook on Intellectual Property Rights”, 4th Edition, Asia Law House, Hyderabad.

24PEPL106	Power System Laboratory – 1	(0 - 0 - 2) 1

Contact Hours: 26

Course Learning Objectives:

1) Conduct experiment for operator request power flow analysis, contingency analysis and ranking for an interconnected power system.
2) Conduct experiments for fault analysis including different configurations of transformers in power system.
3) Conduct experiment for relay coordination.
4) Conduct experiments to perform stability studies.
5) Conduct experiment for observability analysis, state estimation and bad data detection.

Course Outcomes (COs):

Description of the Course Outcome: At the end of the course the student will be able to:		**Mapping to POs (1 to 4)**		
		Substantial Level (3)	**Moderate Level (2)**	**Slight Level (1)**
CO-1	Apply the knowledge of power system engineering in conducting different experiment in the laboratory.	4	1,3	2
CO-2	Use suitable simulation software package for the conduction of experiments and analyze the results.	4	1,3	2

PO's	**PO-1**	**PO-2**	**PO-3**	**PO-4**
Mapping Level	2.0	1.0	2.0	3.0

List of Experiments

1) Operator request load flow using voltage and frequency dependent load modeling and generator droop characteristic.
2) Contingency analysis and ranking for a given interconnected power system.
3) Frequency and voltage dependency model of the load and under frequency load shedding.
4) Sequence impedance diagram development and distribution of earth fault current computation in a practical power system having auto transformers with tertiary delta winding, star-delta and delta-star configurations.

5) Over current relay co-ordination with and without instantaneous setting for a given network with NI relay characteristic curves.
6) Transient stability studies for a given system having minimum 10 buses, machines, and an infinite grid to determine (i) Critical clearing time (ii) Natural frequency of oscillations of electro-mechanical system considering classical representation of the machine and detailed modeling (sub-transient model) of the machine.
7) The AVR and Governor modeling and their effect on system stability.
8) Obtain PV &QV curve for a given power system with load buses and voltage instability analysis.
9) Eigen value computation and small signal stability studies for a given power system with at least 3 machines and 10 buses using IEEE-Type 1 AVR and turbine-governor models.
10) Observability analysis, state estimation and bad data detection for a given power system using measurement data.