K.L.N. COLLEGE OF ENGINEERING

Pottapalayam-630612, Sivagangai District

(An Autonomous Institution, Affiliated to Anna University, Chennai)

Estd: 1994

CURRICULUM AND SYLLABUS

I to IV Semesters

REGULATIONS 2024

For Post Graduate Program

M.E. POWER SYSTEMS ENGINEERING

CHOICE BASED CREDIT SYSTEM

(For the students admitted from the academic year 2024-2025 onwards)

Dr.S.M.Kannan
PROF & HEAD/EEE DEPARTMENT
K.L.N.COLLEGE OF ENGINEERING
POTTAPALAYAM

K.L.N. COLLEGE OF ENGINEERING, POTTAPALAYAM

(An Autonomous Institution, Affiliated to Anna University, Chennai)

VISION OF THE INSTITUTION

To become a Centre of Excellence in Technical Education and Research in producing Competent and Ethical professionals to the society

MISSION OF THE INSTITUTION

To impart Value and Need based curriculum to the students with enriched skill development in the field of Engineering, Technology, Management and Entrepreneurship and to nurture their character with social concern and to pursue their career in the areas of Research and Industry.

VISION OF THE DEPARTMENT

To become high standard of excellence in education, training, and research in the field of Electrical and Electronics Engineering and allied applications

MISSION OF THE DEPARTMENT

1. To create graduates possessing excellent knowledge in the fundamentals of Electrical and Electronics Engineering.
2. To produce industry-ready and employable graduates capable of undertaking high-quality research.
3. To emphasize ethics and professional conduct for societal development.

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PROGRAM EDUCATIONAL OBJECTIVES (PEOs)

PEO1 Ability to engage in applications oriented work and management of the electrical power industry, including generation, transmission, distribution, electrical machines and machine control.

PEO2 Ability to work as teaching faculty in reputed institutions and work as engineer in IT industries.

PEO3 Ability to engage in research and development activities

PROGRAM SPECIFIC OUTCOMES (PSOs):

PSO1.Ability to apply knowledge of Electrical Power System principles and techniques for power system operation, control and applications, economical operation and state of art techniques to protect Power System

PSO2.Ability to develop steady-state and dynamic models of various Power System components to perform system studies for generation and transmission system expansion planning.

PSO3. Ability to analyze various electricity market models with distributed energy resources and demand response management and to incorporate interdisciplinary knowledge to address the recent problems in the electrical power industry

PROGRAM OUTCOMES (POs):

Students should be able to

PO1: Critically analyze complex challenges in power systems and apply engineering principles to support sustainable development goals.

PO2: Demonstrate the application of systems and processes to address challenges in power systems, employing modern engineering tools and resources to meet societal needs, with a strong focus on public health, safety, and environmental protection.

PO3: Independently carry out research /investigation and development work to solve practical problems

PO4: Write and present a substantial technical report/document

PO5: Apply ethical principles, human values adhere to national and International Laws

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REGULATIONS 2024
CHOICE BASED CREDIT SYSTEM
M.E. POWER SYSTEMS ENGINEERING (FULL TIME)

CATEGORY OF COURSES

i. Foundation Courses (FC) may include Mathematics or other basic courses

ii. Professional Core Courses (PCC) include the core courses relevant to the chosen specialization/branch.

iii. Professional Elective Courses (PEC) include the elective courses relevant to the chosen specialization/ branch

iv. Research Methodology and IPR Course (RMC) covers topics on the process of research and patenting

v. Employability Enhancement Courses (EEC) include Project Work and/or Internship, Seminar, Professional Practices, Summer Project, Case Study, Term paper writing and Industrial / Practical Training

vi. Open Elective Courses (OEC) include the courses credited from other post graduate programs of M.E and online courses

vii. Audit courses (AC) include the courses such as Constitution of India, Natramizh Ilakiam, etc.

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REGULATIONS 2024
CHOICE BASED CREDIT SYSTEM
M.E. POWER SYSTEMS ENGINEERING (FULL TIME)
CURRICULUM AND SYLLABUS I TO IV SEMESTERS

SEMESTER I

S.No	COURSE CODE	COURSE TITLE	CATEGORY	CONTACT PERIODS	L	T	P	C
THEORY								
1.	24MA101	Applied Mathematics for Power Systems Engineers	FC	4	4	0	0	4
2.	24RM101	Research Methodology and IPR	RMC	3	3	0	0	3
3.	24PS102	Computer Aided Power System Analysis	PCC	4	3	1	0	4
4.	24PS103	Power System Operation and Control	PCC	3	3	0	0	3
5.	24PS104	System Theory	PCC	3	3	0	0	3
6.	24PS105	Analysis of Power Converters	PCC	4	3	1	0	4
7.		Audit Course I*	AC	2	2	0	0	0
PRACTICAL								
8.	24PS1L1	Power System Laboratory – I	PCC	3	0	0	3	1.5
9.	24PS1L2	Power Converters Laboratory	PCC	3	0	0	3	1.5
TOTAL				**29**	**21**	**2**	**6**	**24**

SEMESTER II

S.No	COURSE CODE	COURSE TITLE	CATEGORY	CONTACT PERIODS	L	T	P	C
THEORY								
1.	24PS201	Advanced Power System Protection	PCC	3	3	0	0	3
2.	24PS202	Power System Dynamics	PCC	3	3	0	0	3
3.	24PS203	Power System Transients	PCC	3	3	0	0	3
4.	24PS204	Restructured Power System	PCC	3	3	0	0	3
5.		Professional Elective I	PEC	3	3	0	0	3
6.		Professional Elective II	PEC	3	3	0	0	3
7.		Audit Course II*	AC	2	2	0	0	0
PRACTICAL								
8.	24PS2L1	Power System Laboratory – II	PCC	4	0	0	4	2
9.	24PS2L2	Technical Seminar	EEC	4	0	0	4	2
TOTAL				**28**	**20**	**0**	**8**	**22**

*** Audit Course is optional**

SEMESTER III

S.No	COURSE CODE	COURSE TITLE	CATEGORY	CONTACT PERIODS	L	T	P	C
THEORY								
1.	24PS301	HVDC and FACTS	PCC	3	3	0	0	3
2.		Professional Elective III	PEC	3	3	0	0	3
3.		Professional Elective IV	PEC	3	3	0	0	3
4.		Open Elective	OEC	3	3	0	0	3
PRACTICAL								
5.	24PS3L1	Project Work I	EEC	12	0	0	12	6
TOTAL				**24**	**12**	**0**	**12**	**18**

SEMESTER IV

S.No	COURSE CODE	COURSE TITLE	CATEGORY	CONTACT PERIODS	L	T	P	C
PRACTICAL								
1.	24PS4L1	Project Work II	EEC	24	0	0	24	12
TOTAL				**24**	**0**	**0**	**24**	**12**

TOTAL NO. OF CREDITS: 76

FOUNDATION COURSE (FC)

S.No	COURSE CODE	COURSE TITLE	CATEGORY	CONTACT PERIODS	L	T	P	C
THEORY								
1.	24MA101	Applied Mathematics for Power Systems Engineers	FC	4	4	0	0	4
TOTAL CREDITS								**4**

PROFESSIONAL CORE COURSES (PCC)

S.No	COURSE CODE	COURSE TITLE	CATEGORY	CONTACT PERIODS	L	T	P	C
1.	24PS102	Computer Aided Power System Analysis	PCC	4	3	1	0	4
2.	24PS103	Power System Operation and Control	PCC	3	3	0	0	3
3.	24PS104	System Theory	PCC	3	3	0	0	3
4.	24PS105	Analysis of Power Converters	PCC	4	3	1	0	4
5.	24PS1L1	Power System Laboratory-I	PCC	3	0	0	3	1.5
6.	24PS1L2	Power Converters Laboratory	PCC	3	0	0	3	1.5
7.	24PS201	Advanced Power System Protection	PCC	3	3	0	0	3
8.	24PS202	Power System Dynamics	PCC	3	3	0	0	3
9.	24PS203	Power System Transients	PCC	3	3	0	0	3
10.	24PS204	Restructured Power System	PCC	3	3	0	0	3
11.	24PS2L1	Power System Laboratory-II	PCC	4	0	0	4	2
12.	24PS301	HVDC and FACTS	PCC	3	3	0	0	3
TOTAL CREDITS								**34**

RESEARCH METHODOLOGY AND IPR COURSES (RMC)

S.No	COURSE CODE	COURSE TITLE	CATEGORY	CONTACT PERIODS	L	T	P	C
THEORY								
1.	24RM101	Research Methodology and IPR	RMC	3	3	0	0	3
TOTAL CREDITS								**3**

EMPLOYABILITY ENHANCEMENT COURSES

S.No	COURSE CODE	COURSE TITLE	CATEGORY	CONTACT PERIODS	L	T	P	C
PRACTICAL								
1.	24PS2L2	Technical Seminar	EEC	4	0	0	4	2
2.	24PS3L1	Project Work I	EEC	12	0	0	12	6
3.	24PS4L1	Project Work II	EEC	24	0	0	24	12
TOTAL CREDITS								**20**

PROFESSIONAL ELECTIVES COURSES (PEC)
SEMESTER II

ELECTIVE I

S.No	COURSE CODE	COURSE TITLE	CATEGORY	CONTACT PERIODS	L	T	P	C
1.	24PS2A1	Power System State Estimation and Security Assessment	PEC	3	3	0	0	3
2.	24PS2A2	Optimization Techniques to Power System Engineering	PEC	3	3	0	0	3
3.	24PS2A3	Computational Intelligence Techniques to Power Systems	PEC	3	3	0	0	3
4.	24PS2A4	IoT for Smart Energy management Systems	PEC	3	3	0	0	3
5.	24PS2A5	Renewable Energy and Grid Integration	PEC	3	3	0	0	3
6.	24PS2A6	Smart Grid	PEC	3	3	0	0	3

SEMESTER II

ELECTIVE II

S.No	COURSE CODE	COURSE TITLE	CATEGORY	CONTACT PERIODS	L	T	P	C
1.	24PS2B1	Electrical Power Distribution System	PEC	3	3	0	0	3
2.	24PS2B2	Wind and Solar Energy Systems	PEC	3	3	0	0	3
3.	24PS2B3	Distributed Generation and Micro Grid	PEC	3	3	0	0	3
4.	24PS2B4	Energy Storage Technologies	PEC	3	3	0	0	3
5.	24PS2B5	Power Quality	PEC	3	3	0	0	3
6.	24PS2B6	Machine Learning and Deep Learning	PEC	3	3	0	0	3

SEMESTER III

ELECTIVE III

S.No	COURSE CODE	COURSE TITLE	CATEGORY	CONTACT PERIODS	L	T	P	C
1.	24PS3A1	Power System Reliability	PEC	3	3	0	0	3
2.	24PS3A2	EHV AC Transmission	PEC	3	3	0	0	3
3.	24PS3A3	Electromagnetic Interference and Compatibility in System Design	PEC	3	3	0	0	3
4	24PS3A4	Industrial Power System Analysis and Design	PEC	3	3	0	0	3
5	24PS3A5	Advanced Power System Dynamics	PEC	3	3	0	0	3
6.	24PS3A6	Python Programming for Machine Learning	PEC	3	3	0	0	3

SEMESTER III

ELECTIVE IV

S.No	COURSE CODE	COURSE TITLE	CATEGORY	CONTACT PERIODS	L	T	P	C
1.	24PS3B1	Computer Relaying and Wide Area Measurement Systems	PEC	3	0	0	0	3
2.	24PS3B2	Application of DSP To Power System Protection	PEC	3	0	0	0	3
3.	24PS3B3	Power System Instrumentation	PEC	3	0	0	0	3
4.	24PS3B4	High Voltage Technology	PEC	3	0	0	0	3
5.	24PS3B5	Electric Vehicles and Power Management	PEC	3	0	0	0	3
6.	24PS3B6	Energy Management and Auditing	PEC	3	0	0	0	3

AUDIT COURSES (AC)

S.No	COURSE CODE	COURSE TITLE	CATEGORY	CONTACT PERIODS	L	T	P	C
1.	24AC101	English for Research Paper Writing	AC	2	2	0	0	0
2.	24AC102	Disaster Management	AC	2	2	0	0	0
3.	24AC105	Constitution of India	AC	2	2	0	0	0
4.	24AC109	Natramizh Ilakiam	AC	2	2	0	0	0

LIST OF OPEN ELECTIVES FOR OTHER PG PROGRAMMES

S.No	COURSE CODE	COURSE TITLE	CATEGORY	CONTACT PERIODS	L	T	P	C
1.	24PSOE1	Energy Conservation and Management in Domestic Sectors	OE	3	3	0	0	3
2.	24PSOE2	Electric Vehicle Technology	OE	3	3	0	0	3
3.	24PSOE3	Smart Grid	OE	3	3	0	0	3
4.	24PSOE4	Renewable Energy Technology	OE	3	3	0	0	3

SUMMARY

<table>
<tr><th rowspan="3">S.No</th><th colspan="6">Name of the Program: M.E.POWER SYSTEMS ENGINEERING</th></tr>
<tr><th rowspan="2">CATEGORY</th><th colspan="4">CREDITS AS PER SEMESTER</th><th rowspan="2">TOTAL CREDITS</th></tr>
<tr><th>I</th><th>II</th><th>III</th><th>IV</th></tr>
<tr><td>1.</td><td>FC</td><td>4</td><td></td><td></td><td></td><td>4</td></tr>
<tr><td>2.</td><td>PCC</td><td>17</td><td>14</td><td>3</td><td></td><td>34</td></tr>
<tr><td>3.</td><td>PEC</td><td>-</td><td>6</td><td>6</td><td></td><td>12</td></tr>
<tr><td>4.</td><td>RMC</td><td>3</td><td></td><td></td><td></td><td>3</td></tr>
<tr><td>5.</td><td>OEC</td><td></td><td></td><td>3</td><td></td><td>3</td></tr>
<tr><td>6.</td><td>EEC</td><td></td><td>2</td><td>6</td><td>12</td><td>20</td></tr>
<tr><td>7.</td><td>Audit Course</td><td>0</td><td>0</td><td></td><td></td><td>0</td></tr>
<tr><td></td><td>TOTAL CREDIT</td><td>24</td><td>22</td><td>18</td><td>12</td><td>76</td></tr>
</table>

24MA101	APPLIED MATHEMATICS FOR POWER SYSTEMS ENGINEERS	L	T	P	C
		4	0	0	4

OBJECTIVES:

- The primary objective of this course is to demonstrate various analytical skills in applied mathematics and extensive experience with the tactics of problem solving and Logical thinking applicable in Power system Engineering.

UNIT - I MATRIX THEORY 12

The Cholesky decomposition - Generalized Eigenvectors - Canonical basis - QR factorization - Singular value decomposition - Pseudo inverses - Least square approximation.

UNIT - II LAPLACE TRANSFORM TECHNIQUES FOR PARTIAL DIFFERENTIAL EQUATIONS 12

Definitions - Properties - Transform error function - Bessel's function - Dirac Delta function - Unit step function - Convolution theorem - Inverse Laplace transform - Complex inversion formula - Solutions to partial differential equations: Heat and Wave equations.

UNIT III FOURIER SERIES 12

Fourier Trigonometric series: Periodic function as power signals - Convergence of series - Even and odd functions: Cosine and sine series - Non periodic function - Extension to other intervals - Power signals: Exponential Fourier series - Parseval's theorem and power spectrum - Eigenvalue problems and orthogonal functions - Regular Sturm –Liouville systems - Generalized Fourier series.

UNIT IV LINEAR PROGRAMMING PROBLEMS 12

Formulation - Graphical solution - Simplex method - Big M method - Transportation and Assignment models.

UNIT V NON–LINEAR PROGRAMMING PROBLEMS 12

Lagrange multipliers – Equality constraints – Inequality constraints – Kuhn – Tucker Conditions –Quadratic programming.

TOTAL: 60 PERIODS

REFERENCES:

1. Richard Bronson, Matrix Operation, Schaum's outline series, Second Edition, McGraw Hill, New Delhi, 2011.
2. Sankara Rao. K, Introduction to partial differential equations, Prentice Hall of India Pvt. Ltd, New Delhi, 1997.
3. Andrews. L.C, and Phillips. R.L, MATHEMATICAL TECHNIQUES FOR ENGINEERS AND SCIENTISTS, Prentice Hall, New Delhi, 2005.
4. Prem Gupta.Er, Dr.Hira D.S., “Problems in Operations Research “,Fourth Edition, S.Chand & Company Pvt. Ltd, New Delhi.2015.
5. Winston, “Operations Research”, Thomson Learning, 2003.

OUTCOMES:
AT THE END OF THE COURSE, LEARNERS WILL BE ABLE TO:

Course Code & Name : 24MA101- APPLIED MATHEMATICS FOR POWER SYSTEMS ENGINEERS			
CO	**Course Outcomes**	**Unit**	**K –CO**
CO1	Solve system of linear equations by using Pseudo inverse	1	K3
CO2	Solve boundary value problems associated with engineering applications	2	K3
CO3	Solve problems using Fourier series associated with engineering applications	3	K3
CO4	Apply simplex method to solve LPP	4	K3
CO5	Solve problems using non - linear programming techniques by optimality condition.	5	K3

24RM101	RESEARCH METHODOLOGY AND IPR	L	T	P	C
		3	0	0	3

OBJECTIVES:

To give an overview of the research methodology and explain the technique of defining a research problem and to explain the functions of the literature review in research. This course can explain the art of interpretation and the art of writing research reports. Also, it explains various forms of the intellectual property its relevance and business impact in the changing global business environment.

UNIT I RESEARCH METHODOLOGY 9

Meaning of research problem, Sources of research problem, Criteria Characteristics of a good research problem, Error sin selecting are search 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 EFFECTIVE TECHNICAL WRITING 9

How to write report, Paper Developing a Research Proposal, Format of research proposal, a presentation and Assessment by are view committee

UNIT III INTELLECTUAL PROPERTY AND INTERNATIONAL SCENARIO 9

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 9

Scope of Patent Rights, Licensing and transfer of technology, Patent information and databases, Geographical Indications

UNIT V NEW DEVELOPMENTS IN IPR 9

Administration of Patent System, New developments in IPR, IPR of Biological Systems, Computer Software etc. Traditional knowledge Case Studies, IPR and IITs.

TOTAL: 45 PERIODS

TEXT BOOKS:

1. Debora J. Halbert, “Resisting Intellectual Property (RIPE Series in Global Political Economy)”, Taylor & Francis Ltd.,2006.
2. W.H. Mayall, “Industrial Design for Engineers”, London Iliffe Books Ltd. 1967.
3. Benjamin W. Niebel, “Product Design and Process Engineering”,Mc Graw-Hill Inc.,US,1974.
4. Morris Asimow,“An IntroductionTo Design”,Prentice-Hall,Inc.First Edition,1962.
5. Robert P. Merges, Peter S. Menell and Mark A. Lemley, “Intellectual Property in New Technological Age”, Aspen Law&Business,2012.
6. T.Ramappa,“Intellectual Property Rights Under WTO: Tasks Before India”, AH Wheeler Publishing Co.Ltd.,2002.

REFERENCES:

1. S. Melville and W.Goddard, “Research Methodology: An Introduction for Science and Engineering Students”, Juta &Co. Ltd., 1996.
2. Ranjit Kumar, “Research Methodology: A Step-by-Step Guide for Beginners”, Third Edition, SAGE Publications Ltd.,2010

OUTCOMES:
AT THE END OF THE COURSE, LEARNERS WILL BE ABLE TO:

Course Name : INTELLIGENT CONTROL OF ELECTRIC VEHICLES			
CO	**Course Outcomes**	**Unit**	**K –CO**
CO1	Explain the scope and objectives of research problem	1	K2
CO2	Develop effective technical writing for research proposal	2	K3
CO3	Classify the Intellectual property in IPR	3	K3
CO4	Illustrate patent rights, indications	4	K3
CO5	Predict the new development in IPR.	5	K3

24PS102	COMPUTER AIDED POWER SYSTEM ANALYSIS	L	T	P	C
		3	1	0	4

OBJECTIVES:

- To introduce various solution techniques to solve the large scale power systems.
- To impart in-depth knowledge on different power flow solution methods for large power system networks.
- To perform various optimal power flow methods involving operating and security constraints.
- To perform short circuit fault analysis for various fault conditions on three phase basis.
- To Illustrate different numerical integration methods and factors influencing transient stability

UNIT - I SOLUTION TECHNIQUE 9+3

Sparse Matrix techniques for large scale power systems - Optimal ordering schemes for preserving sparsity - Flexible packed storage scheme for storing matrix as compact arrays - Factorization by Bi- factorization and Gauss elimination methods - Repeat solution using Left and Right factors and L and U matrices.

UNIT - II POWER FLOW ANALYSIS 9+3

Power flow equation in real and polar forms - Review of Newton Raphson method for solution; Adjustment of P-V buses - Review of Fast Decoupled Power Flow method - Sensitivity factors for P-V bus adjustment.

UNIT - III OPTIMAL POWER FLOW 9+3

Problem statement - Solution of Optimal Power Flow (OPF) - The gradient method - Newton's method- Linear Sensitivity Analysis - LP methods - With real power variables only - LP method with AC power flow variables and detailed cost functions - Security constrained Optimal Power Flow - Interior point algorithm - Bus Incremental costs.

UNIT - IV SHORT CIRCUIT ANALYSIS 9+3

Formation of bus impedance matrix with mutual coupling (single phase basis and three phase basis) - Computer method for fault analysis using Z_{BUS} and sequence components - Derivation of equations for bus voltages -fault current and line currents - both in sequence and phase - symmetrical and unsymmetrical faults.

UNIT - V TRANSIENT STABILITY ANALYSIS 9+3

Introduction - Numerical Integration Methods - Euler and Fourth Order Runge-Kutta methods - Algorithm for simulation of SMIB and multi-machine system with classical synchronous machine model- Factors influencing transient stability - Numerical stability and implicit Integration methods.

TOTAL: 60 PERIODS

TEXT BOOKS:

1. A. J. Wood and B. F. Wollenberg, “Power Generation Operation and Control”, John Wiley and sons, New York,2016.
2. M. A. Pai,” Computer Techniques in Power System Analysis”, Tata McGraw Hill Publishing Company Limited, New Delhi, 2006.

REFERENCES:

1. G W Stagg, A.H El. Abiad, “Computer Methods in Power System Analysis”, McGraw Hill,1968.
2. P. Kundur, “Power System Stability and Control”, McGraw Hill,1994.
3. D.P.Kothari and I.J. Nagrath, ‘Modern Power System Analysis’, Fourth Edition, Tata McGraw Hill Publishing Company Limited, New Delhi, 2011.

OUTCOMES:

AT THE END OF THE COURSE, LEARNERS WILL BE ABLE TO:

Course Code & Name : 24PS102- COMPUTER AIDED POWER SYSTEM ANALYSIS			
CO	**Course Outcomes**	**Unit**	**K –CO**
CO1	Solve large scale simultaneous linear equations and the ordering schemes for Preserving sparsity	1	K3
CO2	Solve large scale power flow problems	2	K3
CO3	Solve optimal power flow problem using various solution methods	3	K3
CO4	Determine fault current under various fault conditions on three phase basics	4	K3
CO5	Analyze stability under various disturbances using numerical integration methods.	5	K4

24PS103	POWER SYSTEM OPERATION AND CONTROL	L	T	P	C
		3	0	0	3

OBJECTIVES:

- To understand the fundamentals of speed governing system and the concept of control areas.
- To get the insight of load frequency control and its modelling.
- To provide knowledge about Hydrothermal scheduling, Unit commitment and solution techniques.
- To realize the requirements and methods of real and reactive power control in power system.
- To be familiar with the power system security issues and contingency studies.

UNIT - I INTRODUCTION 9

System load variation: System load characteristics, load curves - daily, weekly and annual, load- duration curve, load factor, diversity factor. Reserve requirements: Installed reserves, spinning reserves, cold reserves, hot reserves. Load forecasting, techniques of forecasting, Indian power sector – Past and present status: Recent growth of power sector in India –A time line of the Indian power sector, Players in the Indian power sector.

UNIT - II LOAD FREQUENCY CONTROL 9

Need for frequency and voltage control - Plant and system level control - modeling of LFC of single area system - static and dynamic analysis - LFC of two area system - static and dynamic analysis - Tie line bias control - development of state variable model of single and two area system.

UNIT - III HYDROTHERMAL SCHEDULING PROBLEM 9

Hydrothermal coordination – hydro electric plant models - short term and long term scheduling problem – gradient approach – Hydro units in series - Hydro-thermal scheduling with pumped hydro plant: Scheduling of systems using Dynamic programming and linear programming.

UNIT - IV UNIT COMMITMENT AND ECONOMIC DISPATCH 9

Statement of Unit Commitment (UC) problem; constraints in UC: spinning reserve, thermal unit constraints, hydro constraints, fuel constraints and other constraints; UC solution methods: Priority-list methods, forward dynamic programming approach, numerical problems. Incremental cost curve, co- ordination equations without loss and with loss, solution by direct method and λ-iteration method. Gradient method- Newton's method – Base point and participation factor method. Economic dispatch controller added to LFC control.

UNIT - V POWER SYSTEM SECURITY 9

Need for power system Security- - Contingency analysis – linear sensitivity factors – AC power flow methods – contingency selection – concentric relaxation – bounding-security constrained optimal power flow- Bus incremental costs.

TOTAL: 45 PERIODS

TEXT BOOKS:

1. Allen J. Wood, Bruce F. Wollenberg, 'Power Generation, Operation and Control', Wiley India Edition, 2nd Edition,2009.
2. D.P. Kothari and I.J. Nagrath, "Modern Power System Analysis", Third Edition, Tata Mc Graw Hill Publishing Company Limited, New Delhi, 2003.

REFERENCES:

1. Robert H. Miller, James H. Malinowski, ‘Power system operation’, Tata McGraw-Hill, 2009
2. Olle. I. Elgerd, “Electric Energy Systems Theory – An Introduction”, Tata McGraw Hill Publishing Company Ltd, New Delhi, Second Edition, 2003.

OUTCOMES:
AT THE END OF THE COURSE, LEARNERS WILL BE ABLE TO:

Course Code & Name : 24PS103 - POWER SYSTEM OPERATION AND CONTROL			
CO	**Course Outcomes**	**Unit**	**K –CO**
CO1	Explain about the operation and control of power system and List the past and present status of Indian power sector	1	K2
CO2	Develop the static and dynamic model of Load Frequency Control in single and two area system	2	K3
CO3	Analyze the problems associated with hydro thermal Scheduling and to construct the algorithm for feasible load management	3	K4
CO4	Distinguish between various methods involved in unit commitment and economic dispatch problems	4	K4
CO5	Define about the power system security factors and analyse the algorithms used for optimal power flow	5	K4

24PS104	SYSTEM THEORY	L	T	P	C
		3	0	0	3

OBJECTIVES:

1. To educate on modeling and representing systems in state variable form.
2. To train on solving linear and non-linear state equations.
3. To illustrate the properties of control system.
4. To classify non–linearities and examine stability of systems in the sense of Lyapunov's theory.
5. To educate on modal concepts, design of state, output feedback controllers and estimators.

UNIT - I STATE VARIABLE REPRESENTATION 9

Introduction-Concept of State-Space equations for Dynamic Systems -Time invariance and linearity- Non uniqueness of state model- Physical Systems and State Assignment - free and forced responses- State Diagrams.

UNIT - II SOLUTION OF STATE EQUATIONS 9

Existence and uniqueness of solutions to Continuous-time state equations - Solution of Nonlinear and Linear Time Varying State equations - State transition matrix and its properties – Evaluation of matrix exponential- System modes- Role of Eigen values and Eigen vectors.

UNIT - III PROPERTIES OF THE CONTROL SYSTEM 9

Controllability and Observability-Stabilizability and Detectability-Test for Continuous time Systems- Time varying and Time invariant case-Output Controllability-Reducibility-System Realizations.

UNIT - IV NON-LINEARITIES AND STABILITY ANALYSIS 9

Equilibrium Points-Stability in the sense of Lyapunov-BIBO Stability-Stability of LTI Systems. Equilibrium Stability of Nonlinear Continuous Time Autonomous Systems - Direct Method of Lyapunov and the Linear Continuous-Time Autonomous Systems-Lyapunov Functions for Nonlinear Continuous Time Autonomous Systems-Krasovskii and Variable - Gradiant Method

UNIT - V MODAL ANALYSIS 9

Controllable and Observable Companion Forms - SISO and MIMO Systems – Effect of State Feedback on Controllability and Observability-Pole Placement by State Feedback for both SISO and MIMO Systems-Full Order and Reduced Order Observers.

TOTAL: 45 PERIODS

TEXT BOOKS:

1. M. Gopal, "Modern Control System Theory", New Age International,2005.
2. K. Ogata, "Modern Control Engineering", PHI,2002

REFERENCES:

1. B.N. Sarkar "Advanced Control systems", PHI Learning Pvt. Ltd, 2013.
2. Z. Bubnicki," Modern Control Theory", Springer,2005
3. John S. Bay, "Fundamentals of Linear State Space Systems", McGraw-Hill,1999
4. D. Roy Choudhury, "Modern Control Systems", New Age International,2005

OUTCOMES:
AT THE END OF THE COURSE, LEARNERS WILL BE ABLE TO:

Course Code & Name : 24PS104 - SYSTEM THEORY			
CO	**Course Outcomes**	**Unit**	**K –CO**
CO1	Develop the state model for electrical and mechanical systems	1	K3
CO2	Derive the solution techniques of state equations	2	K3
CO3	Realize the properties of control systems in state space form	3	K3
CO4	Evaluate the stability of the system using Lyapunov	4	K4
CO5	Explain Modal analysis and design controller and observer in state space form	5	K3

24PS105	ANALYSIS OF POWER CONVERTERS	L	T	P	C
		3	1	0	4

OBJECTIVES:

- To provide the mathematical fundamentals necessary for deep understanding of power converter operating modes.
- To introduce the electrical circuit concepts behind the different working modes of power converters so as to enable deep understanding of their operation.
- To impart required skills to formulate and design inverters for generic load and for machine loads.
- To equip with required skills to derive the criteria for the design of power converters starting from basic fundamentals.
- To inculcate knowledge to perform analysis and comprehend the various operating modes of different configurations of power converters.

UNIT - I SINGLE PHASE AC-DC CONVERTER 9 + 3

Static Characteristics of power diode, SCR and GTO, half controlled and fully controlled converters with R-L, R-L-E loads and freewheeling diodes – continuous and discontinuous modes of operation- inverter operation and its limit –Sequence control of converters – performance parameters –effect of source impedance and overlap-reactive power and power balance in converter circuit.

UNIT - II THREE PHASE AC-DC CONVERTER 9 + 3

Half controlled and fully controlled converters with R, R-L, R-L-E loads and freewheeling diodes –inverter operation and its limit – performance parameters – effect of source impedance and overlap- 12 pulse converter –Applications - Excitation system, DC drive system.

UNIT - III SINGLE PHASE INVERTERS 9 + 3

Introduction to self-commutated switches : MOSFET and IGBT - Principle of operation of half and full bridge inverters – Performance parameters – Voltage control of single phase inverters using PWM techniques –harmonic elimination techniques – Design of UPS - VSR operation

UNIT - IV THREE PHASE INVERTERS 9 + 3

180 degree and 120 degree conduction mode inverters with star and delta connected loads – voltage control of three phase inverters: single, multi pulse, sinusoidal, space vector modulation techniques – VSR operation-Application – Induction heating, AC drive system – Current source inverters.

UNIT - V MODERN INVERTERS 9 + 3

Multilevel concept – diode clamped – flying capacitor – cascaded type multilevel inverters - Comparison of multilevel inverters - application of multilevel inverters – PWM techniques for MLI – Single phase &Three phase Impedance source inverters – Filters.

TOTAL: 45 +15 PERIODS

TEXT BOOKS:

1. Rashid M.H., “Power Electronics Circuits, Devices and Applications ", Pearson, fourth Edition, 10th Impression2021.
2. P.S.Bimbra, “Power Electronics”, Khanna Publishers, Eleventh Edition,2003

REFERENCES:

1. Bimal.K.Bose "Modern Power Electronics and AC Drives", Pearson Education, Second Edition,2003
2. Ned Mohan, T.M.Undeland and W.P.Robbins, "Power Electronics: converters, Application and design", 3rd edition Wiley,2007.

OUTCOMES:

AT THE END OF THE COURSE, LEARNERS WILL BE ABLE TO:

Course Code & Name : 24PS105 - ANALYSIS OF POWER CONVERTERS			
CO	**Course Outcomes**	**Unit**	**K –CO**
CO1	Acquire and apply knowledge of mathematics in power converter analysis	1	K3
CO2	Model, analyze and understand power electronic systems and equipments	2	K4
CO3	Formulate, design and simulate phase controlled rectifiers for generic load and for machine loads	3	K4
CO4	Design and simulate switched mode inverters for generic load and for machine loads	4	K4
CO5	Select device and calculate performance parameters of power converters under various operating modes	5	K3

24PS1L1 POWER SYSTEM LABORATORY- I

L	T	P	C
0	0	3	1.5

OBJECTIVES:

1. Illustrate the power system issues under normal and abnormal conditions
2. Analyze the performance of power system under normal and abnormal conditions using simulation software
3. Evaluate the existing system and system under smart environment
4. To study the effects of faults, stability issues, and power quality disturbances in electrical power systems.
5. To evaluate modern power system techniques and smart grid technologies for reliable and efficient system operation

LIST OF EXERCISES:

1. Power flow analysis by Newton-Raphson/
2. Power flow analysis by Fast decoupled method
3. Transient stability analysis of single machine-infinite bus system using classical machine model
4. Economic load dispatch using lambda-iteration method
5. Unit commitment: Priority-list scheme
6. Unit commitment: Dynamic programming
7. Contingency analysis: Generator shift factors and line outage distribution factors
8. Load flow analysis of two-bus system with STATCOM
9. Available Transfer Capability (ATC) calculation using an existing load flow program in deregulated environment.
10. Harmonic Analysis of Power system with nonlinear load

TOTAL: 45 PERIODS

OUTCOMES:
AT THE END OF THE COURSE, LEARNERS WILL BE ABLE TO:

Course Code & Name : 24PS1L1 - POWER SYSTEM LABORATORY- I			
CO	**Course Outcomes**	**Unit**	**K –CO**
CO1	Acquire expertise in usage of simulation software as applied to power system	1	K3
CO2	Apply tools to simulate the mathematical model of power network for power system Analysis	2	K3
CO3	Analyze the power system through various numerical methods under normal and Abnormal conditions	3	K4
CO4	Evaluate the stability, contingency, and economic operation of power systems using modern analytical techniques	4	K4
CO5	Develop practical solutions for power quality improvement and smart power system applications using simulation software	5	K4

24PS1L2	POWER CONVERTERS LABORATORY	L	T	P	C
		0	0	3	1.5

OBJECTIVES:

- To provide the basic understanding of the dynamic behavior of the power electronic switches
- To make the students familiar with the digital processors used in generation of gate pulses for the power electronic switches
- To make the students acquire knowledge on the design of power electronic circuits and implementing the same using simulation tools
- To facilitate the students to design gate drive circuits for power converters
- To provide the fundamentals of DC-AC power converter topologies and analyze the harmonics.

LIST OF EXERCISES:

1. Study of switching characteristics of Power MOSFET & IGBT.
2. Circuit Simulation of Three-phase semi-converter with R, RL& RLE load.
3. Circuit Simulation of Three-phase fully controlled converter with R, RL & RLE load.
4. Circuit Simulation of Three-phase Voltage Source Inverter in 180 and 120 degree mode of conduction
5. Circuit simulation of Three-phase PWM inverter
6. Simulation of Four quadrant operation of DC Chopper.
7. Generation of Gating pulse using Arduino/Micro Controller/PIC microcontroller for a DC- DC converter and single-phase voltage source inverter.
8. Simulation of a single-phase Z-source inverter with R load.
9. Simulation of three-phase AC voltage Controller with R load.
10. Simulation of a five-level cascaded multilevel inverter with R load.

TOTAL: 45 PERIODS

OUTCOMES:
AT THE END OF THE COURSE, LEARNERS WILL BE ABLE TO:

Course Code & Name : 24PS1L2 - POWER CONVERTERS LABORATORY			
CO	**Course Outcomes**	**Unit**	**K –CO**
CO1	Understand on the switching behaviour of Power Electronic Switches	1	K3
CO2	Understand on mathematical modeling of power electronic system and implement the same using simulation tools	2	K3
CO3	Use Arduino/microcontroller for power electronic applications	3	K4
CO4	Design and simulate various topologies of inverters and analyze their harmonic spectrum	4	K4
CO5	Design and fabricate the gate drive power converter circuits. Analyze the three- phase controlled rectifiers and isolated DC-DC converters for designing the power supplies	5	K4

24PS201	ADVANCED POWER SYSTEM PROTECTION	L	T	P	C
		3	0	0	3

OBJECTIVES:

- To illustrate concepts of transformer protection
- To describe about the various schemes of Over current protection
- To analyze distance and carrier protection
- To familiarize the concepts of Generator protection and Numerical protection

UNIT - I OVER CURRENT & EARTH FAULT PROTECTION 9

Zones of protection – Primary and Backup protection – operating principles and Relay Construction - Time – Current characteristics-Current setting – Time setting-Over current protective schemes –Concept of Coordination - Protection of parallel / ring feeders - Reverse power or directional relay –Polarisation Techniques – Cross Polarisation – Quadrature Connection -Earth fault and phase fault protection - Combined Earth fault and phase fault protection scheme - Phase fault protective - scheme directional earth fault relay - Static over current relays – Numerical over – current protection; numerical coordination example for a radial feeder

UNIT - II TRANSFORMER & BUSBAR PROTECTION 9

Types of transformers –Types of faults in transformers- Types of Differential Protection – High Impedance – External fault with one CT saturation – Actual behaviors of a protective CT – Circuit model of a saturated CT - Need for high impedance – Disadvantages - Percentage Differential Bias Characteristics – Vector group & its impact on differential protection - Inrush phenomenon – Zero Sequence filtering – High resistance Ground Faults in Transformers – Restricted Earth fault Protection - Inter-turn faults in transformers – Incipient faults in transformers - Phenomenon of over fluxing in transformers - Transformer protection application chart. Differential protection of busbars external and internal fault - Supervisory relay-protection of three – Phase busbars – Numerical examples on design of high impedance busbar differential scheme –Biased Differential Characteristics – Comparison between Transformer differential & Busbar differential.

UNIT - III DISTANCE AND CARRIER PROTECTION OF TRANSMISSION LINES 9

Drawback of over – Current protection – Introduction to distance relay – Simple impedance relay – Reactance relay – mho relays comparison of distance relay – Distance protection of a three – Phase line-reasons for inaccuracy of distance relay reach - Three stepped distance protection - Trip contact configuration for the three - Stepped distance protection - Three-stepped protection of three-phase line against all ten shunt faults - Impedance seen from relay side - Three-stepped protection of double end fed lines-need for carrier – Aided protection – Various options for a carrier – Coupling and trapping the carrier into the desired line section - Unit type carrier aided directional comparison relaying – Carrier aided distance schemes for acceleration of zone II; numerical example for a typical distance protection scheme for a transmission line.

UNIT - IV GENERATOR PROTECTION 9

Electrical circuit of the generator –Various faults and abnormal operating conditions – Stator Winding Faults – Protection against Stator (earth) faults – third harmonic voltage protection – Rotor fault – Abnormal operating conditions - Protection against Rotor faults – Potentiometer Method – injection method – Pole slipping – Loss of excitation – Protection against Mechanical faults; Numerical examples for typical generator protection schemes

UNIT - V NUMERICAL PROTECTION 9

Introduction–Block diagram of numerical relay - Sampling theorem- Correlation with a reference wave–Least error squared (LES) technique-Digital filtering-numerical over - Current protection– Numerical transformer differential protection-Numerical distance protection of transmission line

TOTAL: 45 PERIODS

REFERENCES:

1 Y.G. Paithankar and S.R Bhide, “Fundamentals of Power System Protection”, Prentice-Hall of India, 2022
2 Badri Ram and D.N. Vishwakarma, “Power System Protection and Switchgear”, Tata McGraw- Hill Publishing Company, 2002.
3 T.S.M. Rao, “Digital Relay / Numerical relays”, Tata McGraw Hill, New Delhi, 1989.
4 P.Kundur, “Power System Stability and Control”, McGraw-Hill, 1993.

OUTCOMES:
AT THE END OF THE COURSE, LEARNERS WILL BE ABLE TO:

Course Code & Name : **24PS201 - ADVANCED POWER SYSTEM PROTECTION**			
CO	**Course Outcomes**	**Unit**	**K –CO**
CO1	Analyze Overcurrent protection	1	K3
CO2	: Explain the various schemes available in Transformer protection	2	K3
CO3	Apply Distance and Carrier scheme for the protection of transmission lines.	3	K3
CO4	Explain about Generator protection	4	K3
CO5	Describe numerical protection.	5	K3

24PS202	POWER SYSTEM DYNAMICS	L	T	P	C
		3	0	0	3

OBJECTIVES:

- To impart knowledge on mathematical modeling of a synchronous machine in detail.
- To enable the students to develop the transfer function model for excitation and speed governing systems.
- To offer an opportunity to innovate newer procedures and better methods for effective design.
- To enable the students to model the single and multi-machine power systems with controllers for stability analysis
- To provide knowledge on enhancing small signal stability concepts in power system

UNIT - I SYNCHRONOUS MACHINE MODELLING 9

Physical description of a synchronous machine: armature and field structure - direct and quadrature axes- Mathematical Description: Basic equations of a synchronous machine: stator circuit equations, stator self, stator mutual and stator to rotor mutual inductances, dq0 Transformation: flux linkage and voltage equations for stator and rotor in dq0 coordinates, Physical interpretation of dq0 transformation, Per Unit Representations: power invariant form of Park's transformation; Equivalent Circuits for direct and quadrature axes, Steady-state Analysis: Voltage, current and flux-linkage phasor relationships, Computation of steady-state values.

UNIT - II MODELLING OF EXCITATION AND SPEED GOVERNING SYSTEMS 9

Elements of an Excitation System: Types of Excitation System; Control and protective functions; Modeling of Excitation system components: Modeling of IEEE type ST1A (1992) excitation model, Turbine and Governing System Modeling: Classical transfer function of a hydraulic turbine (no derivation), Special characteristics of a hydraulic turbine, Electrical analogue of a hydraulic turbine, Governor for Hydraulic Turbine: Requirement for a transient droop, Block diagram of governor with transient droop compensation, Modeling of Single reheat tandem compounded type Steam Turbine.

UNIT - III SMALL-SIGNAL STABILITY ANALYSIS WITHOUT CONTROLLERS 9

Classification of Stability, Concepts of Stability of Dynamic Systems: State-space representation, Eigen properties of the state matrix: Eigen values and eigenvectors for stability, Participation factor, Single-Machine Infinite Bus (SMIB) Configuration: Classical Machine Model stability analysis with numerical example, Effects of Field Circuit Dynamics: Block diagram representation with K- constants; expression for K-constants (no derivation), effect of field flux variation on system stability

UNIT - IV SMALL-SIGNAL STABILITY ANALYSIS WITH CONTROLLERS 9

Effects of Excitation System: Thyristor Excitation System with AVR, Block diagram representation with Exciter and AVR, Effect of AVR on Synchronizing and Damping torque components, Power System Stabilizer: Block diagram representation with AVR and PSS, System state matrix including PSS- Illustration of principle of PSS application with numerical example -Small Signal Stability of Multi machine systems: illustration of formation of system state matrix for a two-machine system with classical models for synchronous machines

UNIT - V ENHANCEMENT OF SMALLSIGNAL STABILITY 9

Power System Stabilizer – Stabilizer based on shaft speed signal (delta omega) – Delta P- Omega stabilizer-Frequency-based stabilizers – Digital Stabilizer – Excitation control design – Exciter gain –Phase lead compensation – Stabilizing signal washout and stabilizer gain – Stabilizer limits, Selection of PSS location

TOTAL: 45 PERIODS

TEXT BOOKS:

1 Prabha Kundur, “Power System Stability and Control”, Tata McGraw-Hill,2014.
2 R.Ramanujam,” Power System Dynamics: Analysis and Simulation, PHI Learning Private Limited, Second print, New Delhi, 2013.

REFERENCES:

1 J.Machowski, Bialek, Bumby, Power System Dynamics and Stability”, John wiley and sons,3rdedition, 2020.
2 P. W. Sauer and M. A. Pai,” Power System Dynamics and Stability”, Stipes Publishing Co,2007.

OUTCOMES:
AT THE END OF THE COURSE, LEARNERS WILL BE ABLE TO:

Course Code & Name : 24PS202 - POWER SYSTEM DYNAMICS			
CO	**Course Outcomes**	**Unit**	**K –CO**
CO1	Analyze the mathematical modeling and inductance calculations in a synchronous machine.	1	K4
CO2	Develop the transfer function model for excitation, speed governing and turbine systems.	2	K3
CO3	Analyze the small signal stability of SMIB power systems.	3	K4
CO4	Analyze the small signal stability of SMIB and Multi-machine power systems with damping controllers.	4	K4
CO5	Describe feedback controllers for small signal stability enhancement in power systems.	5	K3

24PS203	POWER SYSTEM TRANSIENTS	L	T	P	C
		3	0	0	3

OBJECTIVES:

- To gain knowledge in sources of transients like lightning, switching and temporary over voltages.
- To model power system components and estimate the over voltages in power system
- To analyze travelling wave phenomena against different over voltages
- To compute transient over voltages using Electromagnetic Transient Program (EMTP).
- To coordinate the insulation of power system and protective devices.

UNIT - I LIGHTNING OVERVOLTAGES 9

Classification of over voltages- Mechanism and parameters of lightning flash, protective shadow, striking distance, electro geometric model for lightning strike, Grounding for protection against lightning — Steady state and dynamic tower-footing resistance, substation grounding Grid, Direct lightning strokes to overhead lines, without and with shield Wires

UNIT - II SWITCHING AND TEMPORARY OVERVOLTAGES 9

Switching transients – concept – phenomenon – system performance under switching surges- Ferranti Effect, Temporary over voltages – load rejection – line faults – ferro resonance, VFTO

UNIT - III TRAVELLING WAVES ON TRANSMISSIONLINE 9

Circuits and distributed constants, wave equation, reflection and refraction – behaviour of travelling waves at the line terminations – Lattice Diagrams – attenuation and distortion – multi conductor system and multi velocity waves

UNIT - IV INSULATION CO-ORDINATION 9

insulation co-ordination –volt –time characteristics, Insulation strength and their selection- Evaluation of insulation strength standard BILs-Characteristics of protective devices, applications, location of arresters – insulation co-ordination in AIS and GIS

UNIT - V COMPUTATION OF POWER SYSTEM TRANSIENTS 9

Computation of transients using electromagnetic transient program-Modelling of power system components- Simple case studies - Application of simplified method: single line station, two line station, gas insulated substations, comparison with IEEE and IEC guides

TOTAL: 45 PERIODS

TEXT BOOKS:

1. Allan Greenwood, “Electrical Transients in Power System”, Wiley & Sons Inc. New York,2012.
2. R. Ramanujam, “Computational Electromagnetic Transients: Modeling, Solution Methods and Simulation”, I.K. International Publishing House Pvt. Ltd, New Delhi - 110 016,2014

REFERENCES:

1. Rakosh Das Begamudre, "Extra High Voltage AC Transmission Engineering", (Second edition) New age International (P) Ltd., New Delhi, 2006.
2. Naidu M S and Kamaraju V, "High Voltage Engineering", Tata McGraw-Hill Publishing Company Ltd., New Delhi,2004.

OUTCOMES:
AT THE END OF THE COURSE, LEARNERS WILL BE ABLE TO:

Course Code & Name : 24PS203 - POWER SYSTEM TRANSIENTS

CO	Course Outcomes	Unit	K –CO
CO1	Analyze various sources of transients	1	K4
CO2	Compute possible over voltages in power systems	2	K3
CO3	Predict over voltages in power system using travelling wave theory	3	K3
CO4	Compute over voltages using EMTP with multiple sources	4	K3
CO5	Coordinate the insulation level of the power system	5	K3

24PS204	RESTRUCTURED POWER SYSTEM	L	T	P	C
		3	0	0	3

OBJECTIVES:

- Describe the behavior of deregulated markets in power system.
- Describe the technical and non-technical issues in deregulated power industry.
- Identify the methods of Local Marginal prices calculation in transmission and the function offinancial transmission rights.
- Analyze the energy and ancillary services management in deregulated power industry.
- Discriminate the restructuring framework US and Indian power sectors

UNIT - I INTRODUCTION **9**

Reasons for restructuring - Understanding the restructuring process - objectives of deregulation of various power systems across the world - Consumer behavior - Supplier behavior - Market equilibrium- Short-run and Long-run costs - Various costs of production. The Philosophy of Market Models**:** Market models based on contractual arrangements - Market architecture -.

UNIT - II TRANSMISSION CONGESTION MANAGEMENT **9**

Importance of congestion management in deregulated environment - Classification of congestion management methods - Calculation of ATC - Non-market methods - Market based methods - Nodal pricing - Inter-zonal Intra-zonal congestion management - Price area congestion management - Capacity alleviation method.

UNIT - III LOCATIONAL MARGINAL PRICES AND FINANCIAL TRANSMISSION RIGHTS **9**

Fundamentals of locational marginal pricing - Lossless DCOPF model for LMP calculation - Loss compensated DCOPF model for LMP calculation - ACOPF model for LMP calculation - Risk Hedging Functionality Of financial Transmission Rights - FTR issuance process - Treatment of revenue shortfall - Secondary trading of FTRs **-** Flow Gate rights - FTR and market power

UNIT - IV ANCILLARY SERVICE MANAGEMENT AND PRICING OF TRANSMISSION NETWORK **9**

Types of ancillary services -Load-generation balancing related services - Voltage control and reactive power support services - Black start capability service - Mandatory provision of ancillary services -Markets for ancillary services - Co-optimization of energy and reserve services - International comparison. Pricing of transmission network**:** wheeling - principles of transmission pricing - transmission pricing methods - Marginal transmission pricing paradigm - Composite pricing paradigm -loss allocation methods.

UNIT - V MARKET EVOLUTION **9**

US markets: PJM market - The Nordic power market **-** Reforms in Indian power sector**:** Framework of Indian power sector - Reform initiatives - availability based tariff (ABT) - The Electricity Act 2012 - Open Access issues — Power exchange

TOTAL: 45 PERIODS

TEXT BOOKS:

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

REFERENCES:

1. Paranjothi, S.R., “Modern Power Systems the Economics of Restructuring”, New Age International Publishers, First Edition:2017.
2. A. Khaparde, A. R. Abhyankar, "Restructured Power Systems", NPTEL Course,

OUTCOMES:

AT THE END OF THE COURSE, LEARNERS WILL BE ABLE TO:

Course Name : 24PS204 - RESTRUCTURED POWER SYSTEM			
CO	**Course Outcomes**	**Unit**	**K –CO**
CO1	Describe the requirement for deregulation of the electricity market and the principles of market models in power systems.	1	K3
CO2	Analyze the methods of congestion management in deregulated power system	2	K4
CO3	Analyze the locational marginal pricing and financial transmission rights	3	K4
CO4	Analyze the ancillary services management	4	K4
CO5	Differentiate the framework of US and Indian power sectors	5	K3

24PS2L1	POWER SYSTEM LABORATORY-II	L	T	P	C
		0	0	4	2

OBJECTIVES:

1. Solve the power system problems using computational intelligent techniques
2. Analyze the solution obtained for power system under normal and abnormal conditions using simulation software
3. Expose with real time monitoring of power system
4. Evaluate the new techniques used for power system problems with the conventional one.
5. Educate to integrate renewable energy sources

LIST OF EXERCISES

1. AC-DC power flow analysis
2. Application of neural networks to load forecasting and contingency analysis
3. Solution of Unit commitment Problem through Evolutionary algorithm
4. Solution of Economic Dispatch using Evolutionary algorithm
5. Automatic Voltage Regulator with Power System Stabilizer
6. Study of Relay Coordination
7. Simulation of Solar PV & Wind Energy Conversion System
8. Intelligent control techniques for Automatic Generation Control
9. Soft Computing Techniques for Power System Problems
10. State Estimation of Power System
11. Analysis of Power grid in presence of Renewable Energy Sources

(Any 10 for Conduct of end semester examination)

TOTAL: 60 PERIODS

OUTCOMES:

AT THE END OF THE COURSE, LEARNERS WILL BE ABLE TO:

Course Code & Name : 24PS2L1 - POWER SYSTEM LABORATORY-II			
CO	**Course Outcomes**	**Unit**	**K –CO**
CO1	Apply advanced tools to simulate the model of power network for power system problems	1	K3
CO2	Acquire expertise in usage of modern techniques for Power System Issues	2	K4
CO3	Apply soft computing techniques to Power System problems and evaluate the solution	3	K3
CO4	Analyze the solution obtained through soft computing techniques	4	K4
CO5	Suggest suitable technique as applicable to power system problem	5	K3

24PS2L2	TECHNICAL SEMINAR	L	T	P	C
		0	0	4	2

OBJECTIVES:

- To encourage the students to study advanced engineering developments in the emerging areas
- To prepare and present technical reports.
- To encourage the students to use various teaching aids such as, power point presentation, Videos and demonstrative models.

METHOD OF EVALUATION:

During the seminar session each student is expected to prepare and present a topic on engineering/ technology/emerging areas, for duration of about 8 to 10 minutes. In a session of two periods per week, 15 students are expected to present the seminar. Each student is expected to present at least twice during the semester and the student is evaluated based on that. At the end of the semester, he / she can submit a report on his / her topic of seminar and marks are given based on the report. A Faculty guide is to be allotted and he / she will guide and monitor the progress of the student and maintain attendance also. Evaluation is 100% internal.

TOTAL: 60 PERIODS

OUTCOMES:

AT THE END OF THE COURSE, LEARNERS WILL BE ABLE TO:

Course Code & Name : 24PS2L2 - TECHNICAL SEMINAR			
CO	**Course Outcomes**	**Unit**	**K –CO**
CO1	Apply advanced engineering concepts and modern tools to solve complex technical problems	1	K3
CO2	Design and develop innovative solutions for multidisciplinary engineering applications	2	K4
CO3	Conduct research-oriented experiments, analyze results, and interpret technical data effectively.	3	K3
CO4	Communicate technical ideas effectively through reports, presentations, and professional discussions	4	K4
CO5	Demonstrate professional ethics, teamwork, leadership qualities, and lifelong learning abilities in engineering practice.	5	K3

24PS301	HVDC AND FACTS	L	T	P	C
		3	0	0	3

OBJECTIVES:

- To emphasis the need for FACTS controllers.
- To learn the characteristics, applications and modeling of series and shunt FACTS controllers.
- To analyze the interaction of different FACTS controller and perform control coordination
- To impart knowledge on operation, modelling and control of HVDC link.
- To perform steady state analysis of AC/DC system.

UNIT - I INTRODUCTION 9

Need for FACTS controllers- types of FACTS controllers-Need for HVDC system-MTDC system- Review of basics of LCC and VSC HVDC system, Configurations-Monopolar Asymmetric and Symmetric MMC-HVDC Scheme- Bipolar and Homopolar HVDC Scheme-Multi-Terminal HVDC Configuration- Layout of HVDC system (LCC, VSC)

UNIT - II THYRISTOR BASED FACTS CONTROLLERS 9

Configuration of SVC- voltage regulation by SVC- Modelling of SVC for power flow analysis- Stability studies- Applications: transient stability enhancement and power oscillation damping of SMIB system with SVC connected at the mid-point of the line- Concepts of Controlled Series Compensation – Operation of TCSC- Analysis of TCSC – Modelling of TCSC for power flow and stability studies.

UNIT - III ANALYSIS OF LCC HVDC CONVERTERS AND HVDC SYSTEM CONTROL 9

Choice of converter configuration – Simplified analysis of Graetz circuit Converter bridge characteristics –characteristics of a twelve pulse converter- detailed analysis of converters. General principles of DC link control – Converter control characteristics – System control hierarchy - Firing angle control – Current and extinction angle control – Generation of harmonics and filtering - power control – Higher level controllers. Modelling of LCC HVDC system and controllers, transformer derating and core saturation instability, Concepts of Power Oscillation Damping Controller, Frequency Controller and Sub synchronous Damping controller in LCC HVDC.

UNIT - IV VOLTAGE SOURCE CONVERTER BASED FACTS CONTROLLERS 9

Static synchronous compensator (STATCOM) - Static synchronous series compensator (SSSC) Operation of STATCOM and SSSC-Power flow control with STATCOM and SSSC-Modelling of STATCOM and SSSC for power flow and transient stability studies –operation of Unified and Interline power flow controllers (UPFC) - Modelling of UPFC and IPFC for power flow and transient stability studies-Concepts of Power Oscillation Damping using FACTS controllers

UNIT - V VOLTAGE SOURCE CONVERTER BASED HVDC SYSTEM AND CONTROLS 9

Applications VSC based HVDC: Operation, Modelling for steady state and dynamic studies, Introduction to Modular Multilevel converters- Main circuit design-Converter Operating Principle and Averaged Dynamic Model- Per-Phase Output-Current Control - Arm-Balancing (Internal) Control- Vector Output-Current Control- Higher-Level Control-Modulation and Sub module Energy Balancing- Offshore HVDC integration System Studies -Control and Protection of MMC-HVDC under AC and DC Network Fault Contingencies- Modeling and Simulation of MMC based MTDC Simulation exercises, Steady state, Fault recovery characteristics - Solution of DC load flow-Solution of AC-DC power flow: Sequential and Simultaneous methods.

TOTAL: 45 PERIODS

TEXT BOOKS:

1. Mohan Mathur, R., Rajiv. K. Varma, “Thyristor – Based Facts Controllers for Electrical Transmission Systems”, IEEE press and John Wiley & Sons, Inc.
2. K.R.Padiyar, “HVDC Power Transmission Systems”, New Age International (P) Ltd., New Delhi,2002.

REFERENCES:

1. K.R.Padiyar, “FACTS Controllers in Power Transmission and Distribution”, New Age International (P) Ltd., Publishers, New Delhi, Reprint2008.
2. J.Arrillaga, “High Voltage Direct Current Transmission”, Peter Pregrinus, London,1983.

OUTCOMES:

AT THE END OF THE COURSE, LEARNERS WILL BE ABLE TO:

Course Code & Name : 24PS301 - HVDC AND FACTS			
CO	**Course Outcomes**	**Unit**	**K –CO**
CO1	Knowledge on basics of power transmission networks and need for FACTS controllers	1	K3
CO2	Design series and shunt compensating devices for power transfer enhancement	2	K4
CO3	Understand the significance about different voltage source converter based FACTS controllers	3	K3
CO4	Knowledge on AC/DC system coordinated control with FACTS and HVDC link	4	K4
CO5	Explore the MMC converter applications FACTS and MTDC system	5	K3

24PS2A1	POWER SYSTEM STATE ESTIMATION AND SECURITY ASSESSMENT	L	T	P	C
		3	0	0	3

OBJECTIVES:

- To introduce the state estimation on DC network.
- To impart in-depth knowledge on power system state estimation.
- To study alternative formulations of WLS state estimation.
- To get insight of network observability and bad data identification.
- To gain knowledge on Power System Security Assessment.

UNIT - I INTRODUCTION TO STATE ESTIMATION 9

Need for state estimation – Measurements – Noise - Measurement functions – Measurement Jacobian – Weights - Gain matrix - State estimation as applied to DC networks – Comparison of Power flow andState Estimation problems - Energy Management System.

UNIT - II WEIGHTED LEAST SQUARE ESTIMATION 9

Modeling of transmission lines - Shunt capacitors and reactors - Tap changing and phase shifting transformers - loads and generators - Building network models - Maximum likelihood estimation - Measurement model and assumptions - WLS State Estimation Algorithm - Measurement functions - Measurement Jacobian matrix - Gain matrix - Cholesky decomposition and performing forward and backward substitutions-Decoupled formulation of WLS State estimation-DC State estimation model- Role of Phasor Measurement Units (PMU) in state estimation.

UNIT - III ALTERNATIVE FORMULATION OF WLS STATE ESTIMATION 9

Weakness of normal equation formulation, Orthogonal factorization, Hybrid method, Method of Peters and Wilkinsons, Equality constraints WLS State estimation, Augmented matrix approach, Blocked formulation and comparison of techniques.

UNIT - IV NETWORK OBSERVABILITY AND BAD DATA DETECTION 9

Network and graphs, Network matrices, loop equations, Methods Observability analysis, Numerical Method based on Nodal Variable formulation and branch variable formulation, Topological Observability analysis, Determination of critical measurements — Role of PMU in network observability. Properties of measurement residuals - Classification of measurements - Bad data detection and identification using Chi-squares distribution and normalized residuals - Bad data identification - Largest normalized residual test and Hypothesis testing identification. bad data detection using PMU

UNIT - V POWER SYSTEM SECURITY ASSESSMENT 9

Introduction to Security Assessment -Static Security Assessment-Summary of Different Types of Static Security Indices-Methods for Assessing Power System Security-Methods for Assessing Power System Security-Dynamic Security Assessment-Future Trends to Assessing Dynamic Security-Issues Related to Integration of Renewable Energies-Security Enhancement-Issues and Methods to Solve SCOPF Problem-Deal with the Challenges for Enhancing Dynamic Security.

TOTAL: 45 PERIODS

TEXT BOOKS:

1. J J Grainger and W D Stevension, " Power System Analysis", McGraw-Hill, Inc.,1994.
2. A Monticelli,"State Estimation in Electric Power Systems",Kluwer Academic Publishers,1999.

REFERENCES:

1. Ali Abur and Antonio Gomez Exposito ,"Power System State Estimation Theory and Implementation", Marcel Dekker, Inc., New York . Basel,2004.
2. Mukhtar Ahmad, "Power System State Estimation", Lap Lambert Acad Publishers,2013.

OUTCOMES:
AT THE END OF THE COURSE, LEARNERS WILL BE ABLE TO:

Course Code & Name : 24PS2A1 - POWER SYSTEM STATE ESTIMATION AND SECURITY ASSESSMENT

CO	Course Outcomes	Unit	K –CO
CO1	Define various concepts implied in State estimation and its need in DC networks.	1	K3
CO2	Apply State estimation algorithms in modelling of transmission lines.	2	K4
CO3	Compare the different types of formulation techniques of State estimation.	3	K3
CO4	Analyze network observability and identify the bad data detection using different methods.	4	K4
CO5	List the different types of assessing power system security and solve the issues.	5	K3

24PS2A2	OPTIMIZATION TECHNIQUES TO POWER SYSTEM ENGINEERING	L	T	P	C
		3	0	0	3

OBJECTIVES:

- Discriminate the capabilities of bio-inspired system and conventional methods in solving optimization problems
- Examine the importance of exploration and exploitation swarm intelligent system to attain nearglobal optimal solution
- Distinguish the functioning of various swarm intelligent systems
- Employ various bio-inspired algorithms for Power systems engineering applications

UNIT - I FUNDAMENTALS OF SOFT COMPUTING TECHNIQUES 9

Definition-Classification of optimization problems - Unconstrained and Constrained optimization Optimality conditions - Introduction to intelligent systems - Soft computing techniques - Conventional Computing versus Swarm Computing - Classification of meta-heuristic techniques - Single solution based and population based algorithms — Exploitation and exploration in population based algorithms -Properties of Swarm intelligent Systems - Application domain - Discrete and continuous problems - Single objective and multi-objective problems.

UNIT - II GENETIC ALGORITHM AND PARTICLE SWARM OPTIMIZATION 9

Genetic algorithms - Genetic Algorithm versus Conventional Optimization Techniques - Genetic representations and selection mechanisms; Genetic operators - different types of crossover and mutation operators - Bird flocking and Fish Schooling — anatomy of a particle - equations based on velocity and positions - PSO topologies - control parameters — GA and PSO algorithms for solving ELD problem.

UNIT - III ANT COLONY OPTIMIZATION AND ARTIFICIAL BEE COLONY ALGORITHMS 9

Biological ant colony system - Artificial ants and assumptions - Stigmergic communications - Pheromone updating - local-global - Pheromone evaporation - ant colony system- ACO Models - Touring ant colony system -max min ant system - Concept of elistic Ants - Task partitioning in honey bees - Balancing foragers and receivers - Artificial bee colony (ABC) algorithms - binary ABC algorithms — ACO and ABC algorithms for solving Economic Dispatch of thermal units.

UNIT - IV SHUFFLED FROG-LEAPING ALGORITHM and BAT OPTIMIZATION ALGORITHM 9

Bat Algorithm - Echolocation of bats - Behaviour of microbats - Acoustics of Echolocation - Movement of Virtual Bats - Loudness and Pulse Emission - Shuffled frog algorithm - virtual population of frogs - comparison of memes and genes - memeplex formation — memeplex updation - BA and SFLA algorithms for solving ELD and optimal placement and sizing of the DG problem.

UNIT - V MULTIOBJECTIVE OPTIMIZATION 9

Multi-Objective Optimization Introduction - Concept of Pareto optimality - Non-dominant sorting Technique - Pareto fronts-best compromise solution - min-max method-NSGA-II algorithm and applications to power systems.

TOTAL: 45 PERIODS

TEXT BOOKS:

1. Kalyanmoy Deb, “Multi-Objective Optimization using Evolutionary Algorithms”,John Wiley& Sons,2001.
2. James Kennedy and Russel E Eberheart, “Swarm Intelligence”, The Morgan Kaufmann Series in Evolutionary Computation,2001.

REFERENCES:

1. Xin-She Yang, “Recent Advances in Swarm Intelligence and Evolutionary Computation”, Springer International Publishing, Switzerland, 2015.
2. David Goldberg, “Genetic Algorithms in Search, Optimization and Machine Learning”, Pearson Education,2007.

OUTCOMES:
AT THE END OF THE COURSE, LEARNERS WILL BE ABLE TO:

Course Code & Name : **24PS2A2 - OPTIMIZATION TECHNIQUES TO POWER SYSTEM ENGINEERING**			
CO	**Course Outcomes**	**Unit**	**K –CO**
CO1	Understand the capabilities of bio-inspired system and conventional methods in solving optimization problems	1	K3
CO2	Implement the genetic algorithm and particle swarm optimization technique to solve the ED problems	2	K4
CO3	Understand and implement the ant colony algorithm and artificial bee colony algorithms to PS problems	3	K3
CO4	Implement the shuffled frog-leaping algorithm and bat optimization algorithm for solving ELD and optimal placement and sizing of the DG problem	4	K4
CO5	Understand and implement the multi-objective optimization techniques to implement in power system problems	5	K3

24PS2A3	COMPUTATIONAL INTELLIGENCE TECHNIQUES TO POWER SYSTEMS	L	T	P	C
		3	0	0	3

UNIT - I INTRODUCTION **9**

Application of genetic algorithm to power system load forecasting, participle swam optimization for reactive power optimization, Optimization Techniques for emission dispatch of power plant, Differential Evolution Algorithm, Optimization Techniques for pole placement and state feedback algorithms, – Problem formulation and forms of optimal Control– Selection of performance measures. Necessary conditions for optimal control – State inequality constraints – Minimum time problem

UNIT - II LINEAR QUADRATIC TRACKING PROBLEMS AND NUMERICAL TECHNIQUES FOR OPTIMAL CONTROL **9**

Linear tracking problem – LQG problem – Computational procedure for solving optimal control problems – Characteristics of dynamic programming solution – Dynamic programming application to discrete and continuous systems – Hamilton Jacobi Bellman equation, Numerical solution of 2- point boundary value problem by steepest descent and Fletcher Powell method - solution of Ricatti equation by negative exponential and interactive Methods.

UNIT - III MODEL DECOMPOSITION AND CONVOLUTIONAL NEURAL NETWORK **9**

CNN Classification, CNN Algorithm, model decomposition techniques, application of model decomposition and CNN based techniques for various power system fault diagnosis problems, model predictive controllers for power system for power system stabilizers

UNIT - IV FILTERING AND ESTIMATION **9**

Filtering – Linear system and estimation – System noise smoothing and prediction – Gauss Markov discrete time model – Estimation criteria – Minimum variance estimation Least square estimation – Recursive estimation

UNIT - V KALMAN FILTER **9**

Filter problem and properties – Linear estimator property of Kalman Filter – Time invariance and asymptotic stability of filters – Time filtered estimates and signal to noise ratio improvement – Extended Kalman filter, Application of Kalman filter for power system protection applications

TOTAL: 45 PERIODS

TEXT BOOKS:

1. Ajith Abraham and Swagatham Das.” Computational Intelligence in Power Engineering”, 2010 Springer Verlag

REFERENCES:

1. Yong Hua Song, Johns Allen, Aggarwal Raj, ‘Computational Intelligence Application to Power System’, Springer Netherlands., 1997.

OUTCOMES:
AT THE END OF THE COURSE, LEARNERS WILL BE ABLE TO:

Course Code & Name : 24PS2A3 - COMPUTATIONAL INTELLIGENCE TECHNIQUES TO POWER SYSTEMS			
CO	**Course Outcomes**	**Unit**	**K –CO**
CO1	Understand the concept of Optimal Optimization Technique for power system.	1	K3
CO2	Identify, Formulate and measure the performance of Optimal Controllers for power system.	2	K4
CO3	Understand the Linear Quadratic Tracking Problems and implement dynamic programming application for discrete and continuous systems.	3	K3
CO4	Apply Filtering and Estimation techniques for power system applications.	4	K3
CO5	Design Kalman filter for power system protection application	5	K4

24PS2A4	IOT FOR SMART ENERGY MANAGEMENT SYSTEMS	L	T	P	C
		3	0	0	3

OBJECTIVES:

- To provide fundamental knowledge of the Internet of Things, Protocols, smart measuring devices, security threats and applications in real-time monitoring, control, and optimization.
- To familiarize students with IoT technologies used in smart grids, renewable integration, and demand-side energy management.

UNIT - I FUNDAMENTALS OF IOT 9

Internet of Things - Physical Design- Logical Design- IoT Enabling Technologies – IoT Levels& Deployment Templates - Domain Specific IoTs - IoT Platforms Design Methodology -IoT reference architecture.

UNIT - II COMMUNICATION TECHNOLOGIES AND IOT PROTOCOLS 9

Protocol Standardization for IoT - IEEE 802.15.4, Zigbee, LoRa, NB-IoT, Network design for IoT-enabled smart grids, Cloud platforms and edge computing in IoT.

UNIT - III SMART MEASURING DEVICES 9

Phasor Measurement Unit (PMU), Limitations of RTU, GPS Time Synchronization, Location &Placement, Features - Wide Area Monitoring Systems (WAMS) - Sub-station Automation Systems (SAS). Distribution Automation Systems (DAS)- Architecture of Smart Metering Systems, Integration of IoT with SCADA and AMI, Energy usage monitoring and load profiling, Real-time data acquisition and analytics, Use of Raspberry Pi/Arduino for data acquisition.

UNIT - IV IOT APPLICATIONS IN ENERGY MANAGEMENT 9

Smart homes and buildings: Smart Lighting, Air Conditioning, and Temperature Controls, Energy efficiency through IoT, Green Energy Management: Integration and monitoring of wind/solar/hybrid systems with IoT-based controls.

UNIT - V IOT APPLICATIONS IN POWER SYSTEMS 9

Load forecasting using IoT and AI, Demand Response and IoT, Smart Storage systems- Smart inverter- Interoperability and standards (IEEE, IEC), Microgrids and IoT coordination in connected power plants.

TOTAL: 45 PERIODS

TEXT BOOKS:

1. Arshdeep Bahga and VijaiMadisetti : A Hands-on Approach “Internet of Things”, UniversitiesPress2015.
2. Oliver Hersent, David Boswarthick and Omar Elloumi “ The Internet of Things”,Wiley, 2016.

REFERENCES:

1. Hanes David, Salgueiro Gonzalo, Grossetete Patrick , Barton Rob, Henry Jerome, 'IoT Fundamentals', Pearson India, 2017.
2. Janaka B. Ekanayake, Nick Jenkins, Kithsiri M. Liyanage, Jianzhong Wu, Akihiko Yokoyama, 'Smart Grid: Technology and Applications', Wiley, 2012.
3. Fei Hu (Editor), 'Security andPrivacyinInternet of Things: Models, Algorithms, andImplementations', CRC Press, 2016.
4. Eric D. Knapp, Raj Samani, 'Applied Cyber Security and the Smart Grid: Implementing Security Controls into the Modern Power Infrastructure', Syngress; 1st edition, 2013.
5. Qasim Alazzawi, M., Sánchez-Aarnoutse, J.-C., Martínez-Sala, A.S. and Cano, M.-D. (2025), 'Green IoT: Energy Efficiency, Renewable Integration, and Security Implications'. IET Netw, 14: e70003. https://doi.org/10.1049/ntw2.70003
6. https://onlinecourses.nptel.ac.in/noc21_ee85/preview

OUTCOMES:
AT THE END OF THE COURSE, LEARNERS WILL BE ABLE TO:

Course Code & Name : 24PS2A4 - IOT FOR SMART ENERGY MANAGEMENT SYSTEMS			
CO	**Course Outcomes**	**Unit**	**K –CO**
CO1	Acquire the fundamentals of IoT and Analyze IoT communication protocols.	1	K3
CO2	Identify the role of IoT in Power systems Measurements.	2	K3
CO3	Apply and Analyze IoT for smart Energy Management Systems.	3	K3
CO4	Apply and Analyze IoT for Power Systems.	4	K3
CO5	Analyze security challenges and cyberattack prevention for smart grid.	5	K4

24PS2A5	RENEWABLE ENERGY AND GRID INTEGRATION	L	T	P	C
		3	0	0	3

OBJECTIVES:

- To provide knowledge about the stand alone and grid connected renewable energy systems.
- To equip with required skills to derive the criteria for the design of power converters for renewable energy applications.
- To analyse and comprehend the various operating modes of wind electrical generators and solar energy systems.
- To 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.

UNIT - I INTRODUCTION 9

Introduction to renewable energy systems, environmental aspects of electric energy conversion, impacts of renewable energy penetration to grid. Grid Codes in India and other countries. Basic power electronic converters for renewable energy integration to grid-Qualitative analysis -Boost and buck-boost converters, three phase AC voltage controllers-AC-DC-AC converters, PWM Inverters, Grid Interactive Inverters-matrix converters.

UNIT - II PHOTO VOLTAIC ENERGY CONVERSION SYSTEMS 9

Introduction, Photo Voltaic (PV) effect, Solar Cell, Types, Equivalent circuit of PV cell, PV cell characteristics (I/V and P/V) for variation of insolation, temperature and shading effect, Stand- alone PV system, Grid connected PV system, Design of PV system-load calculation, array sizing, selection of converter/inverter, battery sizing.

UNIT - III WIND ENERGY CONVERSION SYSTEMS 9

Introduction, Power contained in wind, Efficiency limit in wind, types of wind turbines, Wind control strategies, Power curve and Operating area, Types of wind generators system based on Electrical machines-Induction Generator and Permanent Magnet Synchronous Generator(PMSG), Grid Connected-Single and Double output system, Self-excited operation of Induction Generator and Variable Speed PMSG.

UNIT - IV MPPT TECHNIQUES IN SOLAR ANDWIND SYSTEMS 9

Case studies of PV-Maximum Power Point Tracking (MPPT) and Wind Energy system

UNIT - V HYBRID STORAGE SYSTEMS AND GRID MANAGEMENT 9

Energy Storage systems, Need for Hybrid Systems, Features of Hybrid Systems, Range and types of Hybrid systems (Wind-Diesel, PV-Diesel and Wind-PV),

TOTAL: 45 PERIODS

TEXT BOOKS:

1. S.N.Bhadra, D. Kastha, & S. Banerjee “Wind Electrical Systems”, Oxford University Press, 2009.
2. Haitham Abu-Rub, Mariusz Malinowski and Kamal Al-Haddad, “Power Electronics for Renewable Energy Systems, Transportation and Industrial Applications”, IEEE Press andJohn Wiley & Sons Ltd Press,2014.

REFERENCES:

1. Rashid .M. H “power electronics Hand book”, Academic press, 2001.
2. Gray, L. Johnson, “Wind energy system”, prentice hall linc,1995

OUTCOMES:

AT THE END OF THE COURSE, LEARNERS WILL BE ABLE TO:

Course Code & Name : 24PS2A5 - RENEWABLE ENERGY AND GRID INTEGRATION			
CO	**Course Outcomes**	**Unit**	**K –CO**
CO1	Relate the power generation of different renewable energy sources to grid impact and grid codes	1	K3
CO2	Explain the design principles of solar energy management systems	2	K3
CO3	Understand the power conversion system of wind generators	3	K3
CO4	Analyze the different Maximum Power Point tracking Techniques	4	K4
CO5	Build grid connected and stand alone renewable energy management system	5	K4

24PS2A6	SMART GRID	L	T	P	C
		3	0	0	3

OBJECTIVES:

- To Study about Smart Grid technologies, different smart meters and advanced metering infrastructure.
- To know about the function of smart grid.
- To familiarize the power quality management issues in Smart Grid.
- To familiarize the high-performance computing for Smart Grid applications
- To get familiarized with the communication networks for Smart Grid applications

UNIT - I INTRODUCTION TO SMART GRID 9

Evolution of Electric Grid, Concept, Definitions and Need for Smart Grid, Smart grid drivers, functions, opportunities, challenges and benefits, Difference between conventional & Smart Grid, Comparison of Micro grid and Smart grid, Present development & International policies in Smart Grid, Smart Grid Initiative for Power Distribution Utility in India – Case Study.

UNIT - II SMART GRID TECHNOLOGIES 9

Technology Drivers, Smart Integration of energy resources, Smart substations, Substation Automation, Feeder Automation, Transmission systems: EMS, FACTS and HVDC, Wide area monitoring, Protection and control, Distribution systems: DMS, Volt/Var control, Fault Detection, Isolation and service restoration, Outage management, High-Efficiency Distribution Transformers, Phase Shifting Transformers, Plug in Hybrid Electric Vehicles (PHEV) – Grid to Vehicle and Vehicle to Grid charging concepts.

UNIT - III SMART METERS AND ADVANCED METERING INFRASTRUCTURE 9

Introduction to Smart Meters, Advanced Metering infrastructure (AMI) drivers and benefits, AMI protocols, standards and initiatives, AMI needs in the smart grid, Phasor Measurement Unit(PMU) & their application for monitoring & protection. Demand side management and demand response programs, Demand pricing and Time of Use, Real Time Pricing, Peak Time Pricing.

UNIT - IV POWER QUALITY MANAGEMENT IN SMARTGRID 9

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 HIGH PERFORMANCE COMPUTING FOR SMARTGRID APPLICATIONS 9

Architecture and Standards -Local Area Network (LAN), House Area Network (HAN), Wide Area Network (WAN), Broadband over Power line (BPL), PLC, Zigbee, GSM, IP based Protocols, Basics of Web Service and CLOUD Computing, Cyber Security for Smart Grid.

TOTAL: 45 PERIODS

TEXT BOOKS:

1. Stuart Borlase ‘Smart Grid: Infrastructure, Technology and Solutions’, CRC Press2012.
2. Janaka Ekanayake, Nick Jenkins, Kithsiri Liyanage, Jianzhong Wu, Akihiko Yokoyama,‘SmartGrid: Technology and Applications’, Wiley,2012.

REFERENCES:

1. Mini S. Thomas, John D McDonald, ‘Power System SCADA and Smart Grids’, CRC Press, 2015
2. SMART GRID Fundamentals of Design and Analysis, James Momoh, IEEE press, A John Wiley & Sons, Inc., Publication.

OUTCOMES:
AT THE END OF THE COURSE, LEARNERS WILL BE ABLE TO:

Course Code & Name : 24PS2A6 - SMART GRID			
CO	**Course Outcomes**	**Unit**	**K –CO**
CO1	Relate with the smart resources, smart meters and other smart devices	1	K3
CO2	Explain the function of Smart Grid.	2	K3
CO3	Experiment the issues of Power Quality in Smart Grid.	3	K3
CO4	Analyze the performance of Smart Grid.	4	K4
CO5	Recommend suitable communication networks for smart grid applications	5	K4

24PS2B1	ELECTRICAL POWER DISTRIBUTION SYSTEM	L	T	P	C
		3	0	0	3

OBJECTIVES:

- To detail the function of electric power distribution network.
- To derive the voltage profile enhancement and protection schemes.
- To evaluate the reliability of the electrical distribution system.
- To detail the automation schemes in various sections like substation, feeder, etc.,
- To derive the strategies for distribution system expansion.
- To acquire wide knowledge in distribution system operation, protection, control and expansion planning of distribution system architecture

UNIT - I DISTRIBUTION SYSTEMS 9

Distribution systems: Types of distribution systems - Section and size of feeders – Primary and secondary distribution – Distribution substations – Effect of working voltage on the size of feeders and distributors – Effect of system voltage on economy – Voltage drop and efficiency of transmission - Qualitative treatment of rural distribution and industrial distribution.

UNIT - II CONTROL AND PROTECTION 9

Voltage control: Application of shunt capacitance for loss reduction – Harmonics in the system – Static VAR systems – Voltage profile enhancement schemes. System protection: Fuses and section analyzers - Over current protection - Under voltage and under frequency protection – Coordination of protective device.

UNIT - III RELIABILITY ANALYSIS 9

Primary and secondary system design considerations - Primary circuit configurations - Primary feeder loading - Secondary networks design- Economic design -Unbalance loads and voltage considerations.

UNIT - IV DISTRIBUTION AUTOMATION 9

Definitions – Automation switching control – Management information systems (MIS) – Remote terminal units – Communication methods for data transfer – Consumer information service (CIS) – Graphical information systems (GIS) - Automatic meter reading (AMR) – Remote control load management. Substation automation – Requirements – Control aspects in substations – Feeder automation – Consumer side automation.

UNIT - V EXPANSION PLANNING 9

Distribution system planning: short term planning - long term planning - dynamic planning - Sub- transmission and substation design. Sub-transmission networks configurations - Substation bus schemes - Distribution substations ratings - Service areas calculations. Distribution system expansion: Planning – Load characteristics – Load forecasting – Design concepts – Optimal location of substation — Design of radial lines – Solution technique.

TOTAL: 45 PERIODS

TEXT BOOKS:

1. C.L. Wadhwa, “Electrical Power Systems”, New Age International Publishers, Sixth Edition,2014.
2. A.S. Pabla, “Electrical Power Distribution Systems”, Tata McGraw Hill Books Company, Sixth Edition,2011.

REFERENCES:

1. V. Kamaraju, "Electrical Power Distribution Systems", Tata McGraw Hill Books Company, Sixth Edition,2009.
2. Anthony J. Pansini, "Electrical Distribution Engineering", CRC Press,2005.

OUTCOMES:
AT THE END OF THE COURSE, LEARNERS WILL BE ABLE TO:

Course Code & Name : 24PS2B1 - ELECTRICAL POWER DISTRIBUTION SYSTEM			
CO	**Course Outcomes**	**Unit**	**K –CO**
CO1	Obtain fundamental knowledge in electric power distribution system.	1	K3
CO2	Be proficient in control and protection schemes for distribution systems.	2	K3
CO3	Gain familiarity to evaluate reliability of distribution systems.	3	K3
CO4	Demonstrate the methodologies for distribution automation.	4	K3
CO5	Able to develop strategies for expanding the existing distribution systems.	5	K4

24PS2B2	WIND AND SOLAR ENERGY SYSTEMS	L	T	P	C
		3	0	0	3

OBJECTIVES:

- To study the concepts of wind energy system
- To understand the new developments in solar energy system
- To provide students with a solid foundation in mathematical, scientific and engineering fundamentals required to solve wind and solar energy problems

UNIT - I WIND ENERGY CONVERSION 9

Wind resources – Nature and occurrence of wind – Power in the wind – Wind characteristics – Principles of wind energy conversions – Components of wind energy conversion system (WECS) — Classification of WECS – Advantages and disadvantages of WECS.

UNIT - II WIND ELECTRIC GENERATORS 9

Characteristics of Induction generators – Permanent magnet generators – Single phase operation of induction generators – Doubly fed generators – Grid connected and standalone systems – Controllers for wind driven self-excited systems and capacitor excited isolated systems – Synchronized operation with grid supply – Real and reactive power control.

UNIT - III PHOTOVOLTAIC MODELS 9

Solar cells and panels – Structure of PV cells – Semiconductor materials for PV cells – I-V characteristics of PV systems – PV models and equivalent circuits- Effects of irradiance and temperature on PV characteristics.

UNIT - IV PHOTO VOLTAIC ENERGY CONVERSION SYSTEM 9

Basic photo voltaic system for power generation – Advantages and disadvantages of photo voltaic solar energy conversion –Application of solar photo voltaic system – Components of PV systems- Design of PV systems- Power conditioning and storage arrangement — Maximum power point tracking (MPPT) - Introduction to string inverters.

UNIT - V RECENT ADVANCEMENTS IN WIND AND PV SYSTEMS 9

Wind farms and grid connections – Grid related problems on absorption of wind – Grid interfacing arrangement – Operation, control and technical issues of wind generated electrical energy – Interconnected operation – Hybrid systems. Recent Advances in PV Applications: Building Integrated PV systems, Grid Connected PV systems, Hybrid systems, Solar cars, Solar energy storage system and their economic aspects.

TOTAL: 45 PERIODS

TEXT BOOKS:

1. G.N. Tiwari, “Solar Energy: Fundamentals, Design, Modeling & Application”, Narosa Publishing House,2013.
2. G.D. Rai, “Non-conventional Energy Resources”, Sixth Ed., Khanna Publishers,2018.

REFERENCES:

1. B.H. Khan, “Non-conventional Energy Resources”, Tata McGraw Hill Education India Pvt. Ltd., Third Edition,2017.
2. D.P.Kothari and K.C.Singhal, ”Renewable Energy Sources and Emerging Technologies”, P.H.I. 2nd Ed.,2011.

OUTCOMES:
AT THE END OF THE COURSE, LEARNERS WILL BE ABLE TO:

Course Code & Name : 24PS2B2 & WIND AND SOLAR ENERGY SYSTEMS			
CO	**Course Outcomes**	**Unit**	**K –CO**
CO1	Understand the basics of wind energy conversion systems & solar energy conversion systems	1	K2
CO2	Implement the appropriate power extraction techniques.	2	K3
CO3	Apply power electronics to the renewable energy systems.	3	K3
CO4	Understand the grid integration techniques, and power quality issues.	4	K3
CO5	Apply the technology & techniques in variety of applications.	5	K4

24PS2B3	DISTRIBUTED GENERATION AND MICRO GRID	L	T	P	C
		3	0	0	3

OBJECTIVES:

- To familiarize with the concept of Distributed Generation
- To expose the various distributed energy resources
- To focus on the planning and protection of Distributed Generation
- To study the concept of Micro Grid and to analyze the impact of Micro Grid
- To understand the major issues on Micro Grid economics

UNIT - I INTRODUCTION TO DISTRIBUTED GENERATION 9

DG definition - Reasons for distributed generation-Benefits of integration - Distributed generation and the distribution system - Technical, Environmental and Economic impacts of distributed generation on the distribution system - Impact of distributed generation on the transmission system-Impact of distributed generation on central generation

UNIT - II DISTRIBUTED ENERGY RESOURCES 9

Combined heat and power (CHP) systems-Wind energy conversion systems (WECS)-Solar photovoltaic (PV) systems-Small-scale hydroelectric power generation-Other renewable energy sources-Storage devices-Inverter interfaces

UNIT - III DG PLANNING AND PROTECTION 9

Generation capacity adequacy in conventional thermal generation systems-Impact of distributed generation-Impact of distributed generation on network design-Protection of distributed generation- Protection of the generation equipment from internal Faults-Protection of the faulted distribution network from fault currents supplied by the distributed generator-Impact of distributed generation on existing distribution system protection.

UNIT - IV CONCEPT OF MICROGRID 9

Microgrid Definition-A typical Microgrid configuration- Functions of Micro source controller and central controller- Energy Management Module (EMM) and Protection Co-ordination Module (PCM)- Modes of Operation- Grid connected and islanded modes- Modelling of Microgrid- Micro turbine Model- PV Solar Cell Model- Wind Turbine Model-Role of Microgrid in power market competition.

UNIT - V IMPACTS OF MICROGRID 9

Technical and economical advantages of Microgrid-Challenges and disadvantages of Microgrid development-Management and operational issues of a Microgrid- Impact on heat utilization-Impact on process optimization-Impact on market-Impact on environment-Impact on distribution system-Impact on communication standards and protocols. Microgrid economics-Main issues of Microgrid economics- Microgrids and traditional power system economics-Emerging economic issues in Microgrids- Economic issues between Microgrids and bulk power systems-Potential benefits of Microgrid economics.

TOTAL: 45 PERIODS

TEXT BOOKS:

1. Nick Jenkins, Janaka Ekanayake,GoranStrbac,“Distributed Generation”, Institution of Engineering and Technology, London, UK,2010.
2. S. Chowdhury, S.P. Chowdhury and P. Crossley, “Microgrids and Active Distribution Networks”, The Institution of Engineering and Technology, London, United Kingdom, 2009.

REFERENCES:

1. Math H. Bollen, Fainan Hassan, “Integration of Distributed Generation in the Power System”, John Wiley &Sons, New Jersey,2011.
2. Magdi S. Mahmoud, Fouad M. AL-Sunni, “Control and Optimization of Distributed Generation Systems”, Springer International Publishing, Switzerland,2015.

OUTCOMES:
AT THE END OF THE COURSE, LEARNERS WILL BE ABLE TO:

Course Code & Name : 24PS2B3 - DISTRIBUTED GENERATION AND MICRO GRID			
CO	**Course Outcomes**	**Unit**	**K –CO**
CO1	Understand the concepts of Distributed Generation and Microgrids.	1	K2
CO2	Gain Knowledge about the various DG resources.	2	K3
CO3	Familiarize with the planning and protection schemes of Distributed Generation.	3	K3
CO4	Learn the concept of Microgrid and its mode of operation.	4	K3
CO5	Acquire knowledge on the impacts of Microgrid.	5	K3

24PS2B4	ENERGY STORAGE TECHNOLOGIES	L	T	P	C
		3	0	0	3

OBJECTIVES:

- To understand the various types of energy storage Technologies
- To analyze thermal storage system
- To analyze different battery storage technologies
- To analyze the thermodynamics of Fuel Cell
- To understand the various types of energy storage Technologies

UNIT - I INTRODUCTION 9

Necessity of energy storage – types of energy storage –energy storage technologies – Applications.

UNIT - II THERMAL STORAGE SYSTEM 9

Thermal storage – Types – Modeling of thermal storage units – Simple water and rock bed storage system – Pressurized water storage system – Modelling of phase change storage system – Simple units, Packed bed storage units - Modelling using porous medium approach,

UNIT - III ELECTRICAL ENERGY STORAGE 9

Fundamental concept of batteries – Measuring of battery performance, charging and dis charging of a battery, storage density, energy density, and safety issues - Types of batteries: – Lead Acid, Nickel- Cadmium, Zinc-Manganese dioxide - Mathematical Modelling for Lead Acid Batteries – Flow Batteries.

UNIT - IV FUEL CELL 9

Fuel Cell – History of Fuel cell, Principles of Electrochemical storage – Types: Hydrogen oxygen cells, Hydrogen air cell, Hydrocarbon air cell, Alkaline fuel cell -Detailed analysis – Advantages and disadvantages –Fuel Cell Thermodynamics.

UNIT - V ALTERNATE ENERGY STORAGE TECHNOLOGIES 9

Flywheel, Super capacitors, Principles& Methods – Applications, Compressed air Energy storage, Concept of Hybrid Storage – Applications, Pumped Hydro Storage – Applications.

TOTAL: 45 PERIODS

TEXT BOOKS:

1. James Larminie and Andrew Dicks, 'Fuel cell systems Explained', Wiley publications,2003.

REFERENCES:

1. Schmidt.F.W. and Willmott.A.J., "Thermal Storage and Regeneration", Hemisphere Publishing Corporation,1981
2. Luisa F. Cabeza (Editor), "Advances in Thermal Energy Storage Systems: Methods and Applications", Woodhead Publishers,2020.

OUTCOMES:
AT THE END OF THE COURSE, LEARNERS WILL BE ABLE TO:

Course Code & Name : 24PS2B4 - ENERGY STORAGE TECHNOLOGIES			
CO	**Course Outcomes**	**Unit**	**K –CO**
CO1	Understand the physics of energy storage	1	K2
CO2	Model the different energy technologies	2	K3
CO3	Recognize the applications of various techniques.	3	K3
CO4	Design and analyze the energy storage technologies.	4	K4
CO5	Select and apply the appropriate technique based on the application.	5	K3

24PS2B5	POWER QUALITY	L	T	P	C
		3	0	0	3

OBJECTIVES:

- To provide knowledge about various power quality issues.
- To understand the concept of power and power factor in single phase and three phase systems supplying nonlinear loads.
- To equip with required skills to design conventional compensation techniques for power factor correction and load voltage regulation.
- To introduce the control techniques for the active compensation.
- To understand the mitigation techniques using custom power devices such as DSTATCOM, DVR & UPQC

UNIT - I INTRODUCTION 9

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

UNIT - II ANALYSIS OF SINGLE PHASE AND THREE PHASE SYSTEM 9

Single phase linear and non-linear loads – single phase sinusoidal, non-sinusoidal source – supplying linear and nonlinear loads – three phase balanced system – three phase unbalanced system – three phase unbalanced and distorted source supplying non-linear loads – concept of power factor – three phase- three wire – three phase four wire system.

UNIT - III CONVENTIONAL LOAD COMPENSATION METHODS 9

Principle of load compensation and voltage regulation – classical load balancing problem : open loop balancing – closed loop balancing, current balancing – harmonic reduction and voltage sag reduction– analysis of unbalance – instantaneous of real and reactive powers – Extraction of fundamental sequence component from measured.

UNIT - IV LOAD COMPENSATION USING DSTATCOM 9

Compensating single – phase loads – Ideal three phase shunt compensator structure – generating reference currents using instantaneous PQ theory – Instantaneous symmetrical components theory – Generating reference currents when the source is unbalanced –Realization and control of DSTATCOM – DSTATCOM in Voltage control mode

UNIT - V SERIES COMPENSATION OF POWER DISTRIBUTION SYSTEM 9

Rectifier supported DVR – DC Capacitor supported DVR – DVR Structure – Voltage Restoration – Series Active Filter – Unified Power Quality Conditioner.

TOTAL: 45 PERIODS

TEXT BOOKS:

1. Arindam Ghosh and Gerad Ledwich “Power Quality Enhancement Using Custom Power Devices”,Kluwer Academic Publishers, First Edition,2002
2. G.T.Heydt, “Electric Power Quality”, Stars in a Circle Publications, Second Edition, 1994

REFERENCES:

1. R.C.Duggan “Electric Power Systems Quality”, Tata MC Graw Hill Publishers, Third Edition,2012
2. Arrillga “Power System Harmonics”, John Wiely and Sons,2003

OUTCOMES:
AT THE END OF THE COURSE, LEARNERS WILL BE ABLE TO:

Course Code & Name : 24PS2B5 & POWER QUALITY			
CO	**Course Outcomes**	**Unit**	**K –CO**
CO1	Comprehend the consequences of Power Quality issues.	1	K3
CO2	Conduct harmonic analysis of single phase and three phase systems supplying non-linear loads.	2	K3
CO3	Design passive filter for load compensation.	3	K4
CO4	Design active filters for load compensation.	4	K4
CO5	Understand the mitigation techniques using custom power devices such as distribution static compensator (DSTATCOM), dynamic voltage restorer (DVR) & UPQC.	5	K3

24PS2B6	MACHINE LEARNING AND DEEP LEARNING	L	T	P	C
		3	0	0	3

OBJECTIVES:

The course is aimed at

1. Understanding about the learning problem and algorithms
2. Providing insight about neural networks
3. Introducing the machine learning fundamentals and significance
4. Enabling the students to acquire knowledge about pattern recognition.
5. Motivating the students to apply deep learning algorithms for solving real life problems.

UNIT - I LEARNING PROBLEMS AND ALGORITHMS 9

Various paradigms of learning problems, Supervised, Semi-supervised and Unsupervised algorithms

UNIT - II NEURAL NETWORKS 9

Differences between Biological and Artificial Neural Networks - Typical Architecture, Common Activation Functions, Multi-layer neural network, Linear Separability, Hebb Net, Perceptron, Adaline, Standard Back propagation Training Algorithms for Pattern Association - Hebb rule and Delta rule, Hetero associative, Auto associative, Kohonen Self Organising Maps, Examples of Feature Maps, Learning Vector Quantization, Gradient descent, Boltzmann Machine Learning.

UNIT - III MACHINE LEARNING – FUNDAMENTALS & FEATURE SELECTIONS & CLASSIFICATIONS 9

Classifying Samples: The confusion matrix, Accuracy, Precision, Recall, F1- Score, the curse of dimensionality, training, testing, validation, cross validation, over fitting, under-fitting the data, early stopping, regularization, bias and variance. Feature Selection, normalization, dimensionality reduction, Classifiers: KNN, SVM, Decision trees, Naïve Bayes, Binary classification, multi class classification, clustering.

UNIT - IV DEEP LEARNING: CONVOLUTIONAL NEURAL NETWORKS 9

Feed forward networks, Activation functions, back propagation in CNN, optimizers, batch normalization, convolution layers, pooling layers, fully connected layers, dropout, Examples of CNNs.

UNIT - V DEEP LEARNING: RNNS, AUTOENCODERS AND GANS 9

State, Structure of RNN Cell, LSTM and GRU, Time distributed layers, Generating Text, Auto encoders: Convolutional Auto encoders, Denoising auto encoders, Variational auto encoders, GANs: The discriminator, generator, DCGANs

TOTAL: 45 PERIODS

TEXT BOOKS:

1. J. S. R. Jang, C. T. Sun, E. Mizutani, Neuro Fuzzy and Soft Computing - A Computational Approach to Learning and Machine Intelligence, 2012, PHI learning
2. Deep Learning, Ian Good fellow, YoshuaBengio and Aaron Courville, MIT Press,ISBN: 9780262035613, 2016.

REFERENCES:

1. The Elements of Statistical Learning. Trevor Hastie, Robert Tibshirani and Jerome Friedman. Second Edition.2009.
2. Pattern Recognition and Machine Learning. Christopher Bishop. Springer.2006.

OUTCOMES:
AT THE END OF THE COURSE, LEARNERS WILL BE ABLE TO:

Course Code & Name : 24PS2B6 - MACHINE LEARNING AND DEEP LEARNING			
CO	**Course Outcomes**	**Unit**	**K –CO**
CO1	Illustrate the categorization of machine learning algorithms.	1	K3
CO2	Compare and contrast the types of neural network architectures, activation functions	2	K3
CO3	Acquaint with the pattern association using neural networks	3	K3
CO4	Elaborate various terminologies related with pattern recognition and architectures of convolutional neural networks	4	K3
CO5	Construct different feature selection and classification techniques and advanced neural network architectures such as RNN, Auto encoders, and GANs.	5	K3

24PS3A1	POWER SYSTEM RELIABILITY	L	T	P	C
		3	0	0	3

OBJECTIVES:

- To introduce the basic concepts of reliability engineering
- To understand hierarchical levels in power system reliability assessment
- To study the formation of system model
- To learn the importance of reliability indices in power system planning, expansion, operation and control

UNIT - I INTRODUCTION 9

Definition of Reliability and Failure - Bathtub Curve - Concepts of Probability- Evaluation Techniques: Markov Process, Recursive Technique - Security levels of system – Reliability cost – Adequacy indices – Functions of system security – Contingency analysis – Linear sensitivity factors- Hierarchical Levels in Power System Reliability Assessment.

UNIT - II GENERATING CAPACITY: BASIC PROBABILITY METHODS 9

Generation system models –Capacity outage probability tables – Loss of load indices – Equivalent forced outage rate – Capacity expansion analysis – Scheduled outages – Evaluation methods on period basis– Loss of energy indices.

UNIT - III GENERATING CAPACITY: FREQUENCY AND DURATION METHOD 9

Introduction – Generation model with no derated states– System risk indices with individual and cumulative load model– Practical system studies.

UNIT - IV COMPOSITE GENERATION AND TRANSMISSION SYSTEM 9

Introduction – Radial configurations – Conditional probability approach – Network configurations – State selection – System and load point indices – Application to practical system – Data requirements for composite system reliability evaluation.

UNIT - V DISTRIBUTION SYSTEM 9

Introduction – Evaluation techniques –Interruption indices: Customer oriented, Load and Energy oriented – Application to radial systems – Effects of lateral distributor protection, disconnects, protection failures and transferring loads – Probability distribution of reliability indices.

TOTAL: 45 PERIODS

TEXT BOOKS:

1. Dr. K. Uma Rao, “Power system operation & control”, Wiley-India, First edition,2013.
2. Ali Chowdhury, Don Koval, “Power Distribution System Reliability: Practical Methods and Applications”, Wiley-IEEE Press,2009.

REFERENCES:

1. Cepin, Marko, “Assessment of Power System Reliability”, Springer,2011.
2. Roy Billinton, R.N. Allan, “Reliability Evaluation of Power Systems”, Springer,1996.

OUTCOMES:
AT THE END OF THE COURSE, LEARNERS WILL BE ABLE TO:

Course Code & Name : 24PS3A1 - POWER SYSTEM RELIABILITY			
CO	**Course Outcomes**	**Unit**	**K –CO**
CO1	Acquire design knowledge of system components in reliability point of view.	1	K3
CO2	Understand the importance of customer oriented and system oriented indices.	2	K3
CO3	Familiarize with reliability evaluation methodologies.	3	K3
CO4	Analyze the system performance with proper remedial strategies.	4	K4
CO5	Enrich the capability of analyzing reliability design alternatives in engineering systems.	5	K4

24PS3A2	EHV AC TRANSMISSION	L	T	P	C
		3	0	0	3

OBJECTIVES:

- To understand power system structure and line configurations
- To compute line parameters and understand effect of ground return
- To analyze voltage gradients of transmission line conductors.
- To compute electrostatic field and design of EHVAC
- To design and know basic concepts of HVDC lines.

UNIT - I INTRODUCTION 9

Standard transmission voltages-AC and DC – different line configurations– average values of line parameters – power handling capacity and line loss – costs of transmission lines and equipment – mechanical considerations in line performance

UNIT - II CALCULATION OF LINE PARAMETERS 9

Calculation of resistance, inductance and capacitance for multi-conductor lines — calculation of sequence inductances and capacitances–line parameters for different modes of propagation –effect of ground return

UNIT - III VOLTAGE GRADIENTS OF CONDUCTORS 9

Charge-potential relations for multi-conductor lines — surface voltage gradient on conductors — gradient factors and their use — distribution of voltage gradient on sub conductors of bundle - voltage gradients on conductors in the presence of ground wires on towers-I^2R loss and corona loss-RIV

UNIT - IV ELECTROSTATIC FIELD AND DESIGN OF EHV LINES 9

Effect of EHV line on heavy vehicles - calculation of electrostatic field of AC lines- effect of high field on humans, animals, and plants - measurement of electrostatic fields - electrostatic Induction in unenergised circuit of a D/C line - induced voltages in insulated ground wires - electromagnetic interference, Design of EHV lines

UNIT - V HVDC LINES 9

Introduction- Reliability and failure issues-Design-tower, ROW, clearances, insulators, electrical and mechanical protection-Maintenance-Control and protection-D.C Electric field and Magnetic field -Regulations and guide lines-underground line design.

TOTAL: 45 PERIODS

TEXT BOOKS:

1. Rakosh Das Begamudre, “Extra High Voltage AC Transmission Engineering”, Second Edition, New Age International Pvt. Ltd.,2006.
2. Pritindra Chowdhari, “Electromagnetic transients in Power System”, John Wiley and SonsInc.,2009

REFERENCES:

1. Andrew R. Hileman, “Insulation Coordination for Power Systems”, CRC press, Taylor &Francis Group, New York,1999.
2. Sunil S.Rao, “EHV-AC, HVDC Transmission & Distribution Engineering”, Third Edition, Khanna Publishers,2008

OUTCOMES:
AT THE END OF THE COURSE, LEARNERS WILL BE ABLE TO:

Course Code & Name : 24PS3A2 - EHV AC TRANSMISSION			
CO	**Course Outcomes**	**Unit**	**K –CO**
CO1	Analyze the identify voltage level and line configurations	1	K4
CO2	Model EHV AC and HVDC lines	2	K3
CO3	Compute voltage gradients of transmission line conductors	3	K3
CO4	Analyze the effects of electrostatic field on living and nonliving organisms	4	K4
CO5	Analyze the design, control and protection aspects of HVDC lines.	5	K4

24PS3A3	**ELECTROMAGNETIC INTERFERENCE AND COMPATIBILITY IN SYSTEM DESIGN**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**

OBJECTIVES:

1. To provide fundamental knowledge on electromagnetic interference and electromagnetic compatibility.
2. To know about the importance of Grounding and shielding.
3. To study the important techniques to control EMI and EMC.
4. To expose the knowledge on testing techniques as per Indian and international standards in EMI measurement.

UNIT - I INTRODUCTION 9

Definitions of EMI/EMC –Sources of EMI- Inter systems and Intra system- Conducted and radiated interference- Characteristics – Designing for electromagnetic compatibility (EMC)- EMC regulation typical noise path- EMI predictions and 67odeling, Methods of eliminating interferences and noise mitigation

UNIT - II GROUNDING AND CABLING 9

Cabling- types of cables, mechanism of EMI emission / coupling in cables –capacitive coupling, inductive coupling- shielding to prevent magnetic radiation- shield transfer impedance, Grounding – safety grounds – signal grounds- single point and multipoint ground systems –hybrid grounds- functional ground layout –grounding of cable shields- -guard shields- isolation, neutralizing transformers, shield grounding at high frequencies, digital grounding- Earth measurement Methods

UNIT - III BALANCING, FILTERING AND SHIELDING 9

Power supply decoupling- decoupling filters-amplifier filtering –high frequency filtering- EMI filters characteristics of LPF, HPF, BPF, BEF and power line filter design –Choice of capacitors, inductors, transformers and resistors, EMC design components –shielding – near and far fields shielding effectiveness- absorption and reflection loss- magnetic materials as a shield, shield discontinuities, slots and holes, seams and joints, conductive gaskets-windows and coatings – grounding of shields

UNIT - IV EMI IN ELEMENTS AND CIRCUITS 9

Electromagnetic emissions, noise from relays and switches, non-linearities in circuits, passive inter modulation, transients in power supply lines, EMI from power electronic equipment, EMI as combination of radiation and conduction

UNIT - V ELECTROSTATIC DISCHARGE, STANDARDS AND TESTING TECHNIQUES 9

Static Generation- human body model- static discharges- ESD versus EMC, ESD protection in equipment- standards – FCC requirements – EMI measurements – Open area test site measurements and precautions- Radiated and conducted interference measurements, Control requirements and testing methods

TOTAL: 45 PERIODS

TEXT BOOKS:

1. V.P. Kodali, "Engineering Electromagnetic Compatibility", S. Chand,1996.
2. Bernhard Keiser, "Principles of Electro-magnetic Compatibility", Artech House, Inc. (685canton street, Norwood, MA 020062 USA)1987.

REFERENCES:

1. Bridges, J.E Milleta J. and Ricketts.L.W., "EMP Radiation and Protective techniques", John Wiley and sons, USA1976.
2. William Duff G., & Donald White R. J, "Series on Electromagnetic Interference and Compatibility", Vol. 6. Weston David A., "Electromagnetic Compatibility, Principles and Applications",1991

OUTCOMES:
AT THE END OF THE COURSE, LEARNERS WILL BE ABLE TO:

Course Code & Name : 24PS3A3 - ELECTROMAGNETIC INTERFERENCE AND COMPATIBILITY IN SYSTEM DESIGN			
CO	**Course Outcomes**	**Unit**	**K –CO**
CO1	Understand the types and sources of EMI.	1	K2
CO2	Understand the needs of rounding and cabling.	2	K2
CO3	Understand the design concept of filtering and shielding.	3	K2
CO4	Study the effect of EMI in elements and circuits.	4	K3
CO5	Know about the effects of electrostatic discharge and testing techniques.	5	K3

24PS3A4 INDUSTRIAL POWER SYSTEM ANALYSIS AND DESIGN

L	T	P	C
3	0	0	3

OBJECTIVES:

- To impart knowledge on Motor Starting Studies.
- To understand the need for power factor correction and analyze the various methods that are used in the Power Factor Correction studies.
- To learn about the sources of harmonics, evaluate the harmonics present in the power system and mitigate them by filters.
- To analyze the sources that can cause the voltage flicker and find solutions to minimize the flicker.
- To impart knowledge on the ground grid analysis.

UNIT - I MOTOR STARTING STUDIES 9

Introduction-Evaluation Criteria-Starting Methods-System Data-Voltage Drop Calculations-Calculation of Acceleration time - Motor Starting with Limited-Capacity Generators-Computer-Aided Analysis- Conclusions.

UNIT - II POWER FACTOR CORRECTION STUDIES 9

Introduction-System Description and Modeling-Acceptance Criteria-Frequency Scan Analysis- Voltage Magnification Analysis-Sustained Overvoltage's-Switching Surge Analysis-Back-to-Back Switching-Summary and Conclusions.

UNIT - III HARMONIC ANALYSIS 9

Harmonic Sources-System Response to Harmonics-System Model for Computer-Aided Analysis- Acceptance Criteria-Harmonic Filters-Harmonic Evaluation-Case Study-Summary and Conclusions.

UNIT - IV FLICKER ANALYSIS 9

Sources of Flicker-Flicker Analysis-Flicker Criteria-Data for Flicker analysis- Case Study-Arc Furnace Load-Minimizing the Flicker Effects-Summary.

UNIT - V GROUND GRID ANALYSIS 9

Introduction-Acceptance Criteria-Ground Grid Calculations-Computer-Aided Analysis - Improving the Performance of the Grounding Grids-Conclusions.

TOTAL: 45 PERIODS

TEXT BOOKS:

1. Ramasamy Natarajan," Computer-Aided Power System Analysis", Marcel Dekker Inc.,2002.

OUTCOMES:
AT THE END OF THE COURSE, LEARNERS WILL BE ABLE TO:

Course Code & Name : 24PS3A4 - INDUSTRIAL POWER SYSTEM ANALYSIS AND DESIGN			
CO	**Course Outcomes**	**Unit**	**K –CO**
CO1	Perform motor starting studies.	1	K2
CO2	To model and carry out power factor correction studies.	2	K2
CO3	Perform harmonic analysis and reduce the harmonics by using filters.	3	K2
CO4	Carry out the flicker analysis by proper modeling of the load and its minimization.	4	K3
CO5	Design the appropriate ground grid for electrical safety.	5	K3

24PS3A5	ADVANCED POWER SYSTEM DYNAMICS	L	T	P	C
		3	0	0	3

OBJECTIVES:

- To perform transient stability analysis using unified algorithm.
- To impart knowledge on sub-synchronous resonance and oscillations.
- To analyze voltage stability problem in power system.
- To familiarize the methods of transient stability enhancement.

UNIT - I SUB SYSNCHRONOUS RESONANCE(SSR) AND OSCILLATIONS 9

Sub synchronous Resonance (SSR) — Types of SSR - Characteristics of series – Compensated transmission systems –Modelling of turbine-generator-transmission network-Self-excitation due to induction generator effect – Torsional interaction resulting in SSR – Methods of analyzing SSR – Numerical examples illustrating instability of sub synchronous oscillations –time-domain simulation of sub synchronous resonance — EMTP with detailed synchronous machine model- Turbine Generator Torsional Characteristics: Shaft system model – Examples of torsional characteristics – Torsional Interaction with Power System Controls: Interaction with generator excitation controls – Interaction with speed governors – Interaction with nearby DC converters.

UNIT - II TRANSMISSION, GENERATION AND LOAD ASPECTS OF VOLTAGE STABILITY ANALYSIS 9

Review of transmission aspects – Generation Aspects: Review of synchronous machine theory – Voltage and frequency controllers – Limiting devices affecting voltage stability – Voltage reactive power characteristics of synchronous generators – Capability curves – Effect of machine limitation on deliverable power – Load Aspects – Voltage dependence of loads – Load restoration dynamics – Induction motors – Load tap changers – Thermostatic load recovery – General aggregate load models.

UNIT - III SMALL SIGNAL STABILITY ANALYSIS AND ENHANCEMENT 9

Multi machine small signal stability analysis - Effects of Excitation System - Power System Stabilizer: Block diagram with AVR and PSS, Illustration of principle of PSS application with numerical example, Block diagram of PSS with description, system state matrix including PSS, analysis of stability with numerical example. Multi-Machine Configuration: Equations in a common reference frame, equations in individual machine rotor coordinates, illustration of formation of system state matrix with classical model and variable voltage behind transient reactant model of synchronous machines, illustration of stability analysis using a numerical example. Principle behind small-signal stability improvement methods: delta-omega and delta P-omega stabilizers.

UNIT - IV UNIFIED ALGORITHM FOR DYNAMIC ANALYSIS OF POWER SYSTEMS 9

Need for unified algorithm- numerical integration algorithmic steps-truncation error- variable step size — handling the discontinuities- numerical stability- application of the algorithm for transient. Mid-term and long-term stability simulations.

UNIT - V INSTABILITY MECHANISM AND COUNTER MEASURES 9

Types of Counter measures – Classification of Instability Mechanisms – Examples of Short term Voltage Instability- Counter measures to Short – term Instability – Case studies of Long Term voltage Instability – Corrective Actions against Long-term Instability.

TOTAL: 45 PERIODS

TEXT BOOKS:

1. R.Ramanujam,” Power System Dynamics Analysis and Simulation, PHI Learning Private Limited, NewDelhi,2009
2. T.V. Cutsem and C.Vournas, “Voltage Stability of Electric Power Systems”, Kluwer publishers,1998.

REFERENCES:

1. P. Kundur, Power System Stability and Control, McGraw-Hill,1993.
2. H.W. Dommel and N.Sato, "Fast Transient Stability Solutions," IEEE Trans., Vol. PAS- 91, pp, 1643-1650,July/August1972.

OUTCOMES:
AT THE END OF THE COURSE, LEARNERS WILL BE ABLE TO:

Course Code & Name : 24PS3A5 - ADVANCED POWER SYSTEM DYNAMICS			
CO	**Course Outcomes**	**Unit**	**K –CO**
CO1	Understand the concepts behind sub-synchronous resonance and detect the SSR by suitable modeling.	1	K2
CO2	Analyze the effect of generation and transmission and load dynamics on voltage stability .	2	K4
CO3	Analyze and enhance small signal stability of the power system.	3	K4
CO4	Analyze the short-term and long-term stability of the power system using unified stability algorithm.	4	K4
CO5	Study and analyze the various instability mechanisms of voltage stability.	5	K4

24PS3A6 PYTHON PROGRAMMING FOR MACHINE LEARNING

L	T	P	C
3	0	0	3

OBJECTIVES:

1. Students will understand and be able to use the basic programming principles such as data types, variable, conditionals, loops, recursion and function calls.
2. Students will learn how to use basic data structures such as List, Dictionary and be able to manipulate text files and images.
3. To make the students familiar with machine learning concepts &techniques.
4. Students will understand the process and will acquire skills necessary to effectively attempt a machine learning problem and implement it using Python.
5. To involve Discussions/ Practice/Exercise onto revising & familiarizing the concepts acquired over the 5 Units of the subject for improved research/employability skills

UNIT - I INTRODUCTION TO MACHINE LEARNING AND PYTHON 9

Introduction to Machine Learning: Significance, Advantage and Applications – Categories of Machine Learning – Basic Steps in Machine Learning: Raw Data Collection, Pre-processing, Training a Model, Evaluation of Model, Performance Improvement Introduction to Python and its significance – Difference between C, C++ and Python Languages; Compiler and Interpreters – Python3 Installation & Running – Basics of Python Programming Syntax: Variable Types, Basic Operators, Reading Input from User – Arrays/List, Dictionary and Set – Conditional Statements – Control Flow and loop control statements

UNIT - II PYTHON FUNCTIONS AND PACKAGES 9

File Handling: Reading and Writing Data – Errors and Exceptions Handling – Functions & Modules – Package Handling in Python – Pip Installation & Exploring Functions in python package – Installing the Numpy Library and exploring various operations on Arrays: Indexing, Slicing, Multi-Dimensional Arrays, Joining Numpy Arrays, Array intersection and Difference, Saving and Loading Numpy Arrays – Introduction to SciPy Package & its functions - Introduction to Object Oriented Programming with Python

UNIT - III IMPLEMENTATION OF MACHINE LEARNING USING PYTHON 9

Description of Standard Datasets: Coco, ImageNet, MNIST (Handwritten Digits) Dataset, Boston Housing Dataset – Introducing the concepts of Regression – Linear, Polynomial & Logistic Regression with analytical understanding - Introduction to SciPy Package & its functions – Python Application of Linear Regression and Polynomial Regression using SciPy – Interpolation, Overfitting and Underfitting concepts & examples using SciPy

UNIT - IV CLASSIFICATION AND CLUSTERING CONCEPTS OF ML 9

Introduction to ML Concepts of Clustering and Classification — Types of Classification Algorithms — Support Vector Machines (SVM) - Decision Tree - Random Forest — Introduction to ML using scikit- learn — Using scikit-learn, Loading a sample dataset, Learning & prediction, interpolation & fitting, Multiclass fitting - Implementation of SVM using Blood Cancer Dataset, Decision Tree using data from csv. Types of Clustering Algorithms & Techniques — K-means Algorithm, Mean Shift Algorithm & Hierarchical Clustering Algorithm — Introduction to Python Visualization using Matplotlib: Plotting 2-dimensional, 3-dimensional graphs; formatting axis values; plotting multiple rows of data in same graph – Implementation of K-means Algorithm and Mean Shift Algorithm using Python

UNIT - V INTRODUCTION TO NEURAL NETWORKS AND EMBEDDED MACHINE LEARNING 9

Introduction to Neural Networks & Significance – Neural Network Architecture – Single Layer Perceptron & Multi-Layer Perceptron (MLP) – Commonly Used Activation Functions - Forward Propagation, Back Propagation, and Epochs – Gradient Descent – Introduction to Tensorflow and Keras ML Python packages – Implementation of MLP Neural Network on Iris Dataset – Introduction to Convolution Neural Networks – Implementation of Digit Classification using MNIST Dataset ML for Embedded Systems: Comparison with conventional ML – Challenges & Methods for Overcoming – TinyML and Tensorflow Lite for Microcontrollers – on-Board AI – ML Edge Devices: Arduino Nano BLE Sense, Google Edge TPU and Intel Movidius

TOTAL: 45 PERIODS

TEXT BOOKS:

1. Andreas C. Müller, Sarah Guido, “Introduction to Machine Learning with Python”,O'Reilly,2
2. Sebastian Raschka , Vahid Mirjalili, “Python Machine Learning - Third Edition”, Packt, December2019

REFERENCES:

1. Mark Lutz,”Learning Python, Powerful OOPs,O’reilly,2011
2. Zelle, John “M. Python Programming: An Introduction to Computer Science.”, Franklin Beedle & Associates, 2003

OUTCOMES:

AT THE END OF THE COURSE, LEARNERS WILL BE ABLE TO:

Course Code & Name : **24PS3A6 - PYTHON PROGRAMMING FOR MACHINE LEARNING**			
CO	**Course Outcomes**	**Unit**	**K –CO**
CO1	Develop skill in system administration and network programming by learning Python.	1	K3
CO2	Demonstrating understanding in concepts of Machine Learning and its implementation using Python.	2	K3
CO3	Relate to use Python’s highly powerful processing capabilities for primitives, modelling etc	3	K3
CO4	Improved Employability and entrepreneurship capacity due to knowledge up gradation on recent trends in embedded systems design.	4	K3
CO5	Apply the concepts acquired over the advanced research/employability skills	5	K3

		L	T	P	C
24PS3B1	**COMPUTER RELAYING AND WIDE AREA MEASUREMENT SYSTEMS**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**

OBJECTIVES:

The goal of this course is

1. To discriminate conventional relays and computer relays
2. To comprehend the operating values of a computer relays
3. To provide exposure to wide area measurement systems through the computer hierarchy in the substation, system relaying and control
4. To inculcate knowledge on phasor measurement unit and its application to power system
5. To enhance the conventional power system studies with wide area measurement techniques

UNIT - I INTRODUCTION 9

Historical background - Expected benefits - Computer relay architecture - Analog to digital converters - Anti-aliasing filters - Substation computer hierarchy - Fourier series Exponential fourier series - Sine and cosine fourier series — Phasor.

UNIT - II FILTERS IN COMPUTER RELAYING 9

Walsh functions - Fourier transforms - Discrete fourier transform - Random processes - Filtering of random processes - Kalman filtering - Digital filters - Windows and windowing - Linear phase Approximation - Filter synthesis – Wavelets - Elements of artificial intelligence.

UNIT - III COMPUTATION OF PHASORS 9

Introduction - Phasor representation of sinusoids - Fourier series and Fourier transform and DFT Phasor representation - Phasor Estimation of Nominal Frequency Signals - Formulas for updating phasors — non-recursive updates - Recursive updates - Frequency Estimation.

UNIT - IV PHASOR MEASUREMENT UNITS 9

A generic PMU - The global positioning system - Hierarchy for phasor measurement systems - Functional requirements of PMUs and PDCs - Transient Response of: Phasor Measurement Units, of instrument transformers, filters. Transient response during electromagnetic transients and power swings.

UNIT - V PHASOR MEASUREMENT APPLICATIONS 9

State Estimation - History, Operator’s load flow - Weighted least square: least square, Linear weighted least squares, Nonlinear weighted least squares - Static state estimation - State estimation with Phasors measurements - Linear state estimation — Protection system with phasor inputs: Differential and distance protection of transmission lines - Adaptive protection - Adaptive out-of-step protection.

TOTAL: 45 PERIODS

TEXT BOOKS:

1. A.G. Phadke, J.S. Thorp, “Computer Relaying for Power Systems”, John Wiley and Sons Ltd., Research Studies Press Limited, 2nd Edition, 2009.
2. A.G. Phadke, J.S. Thorp, “Synchronized Phasor Measurements and Their Applications”,Springer,2008

REFERENCES:

1. Antonello Monti, Carlo Muscas, Ferdinanda Ponci, “Phasor Measurement Units and Wide Area Monitoring Systems” Academic Press,09-Jun-2016
2. Stanley H. Horowitz, Arun G. Phadke, “Power System Relaying”, John Wiley & Sons, 25-Oct- 2013.

OUTCOMES:
AT THE END OF THE COURSE, LEARNERS WILL BE ABLE TO:

Course Name : 24PS3B1 - COMPUTER RELAYING AND WIDE AREA MEASUREMENT SYSTEMS			
CO	**Course Outcomes**	**Unit**	**K –CO**
CO1	Demonstrate knowledge of fundamental theories, principles and practice of computer relaying, Wide area measurement system	1	K3
CO2	Analyze the power system with computer relaying and Wide area measurement system	2	K4
CO3	Validate the recent relaying technologies which work towards smart grid	3	K4
CO4	Design wide area measurement systems for Smart grid.	4	K4
CO5	Compare the performance of modern relaying schemes and measurement techniques with the conventional one.	5	K3

24PS3B2	APPLICATION OF DSP TO POWER SYSTEM PROTECTION	L	T	P	C
		3	0	0	3

OBJECTIVES:

- To expose the students to learn about DFT and Wavelet transforms.
- To provide an in-depth knowledge on the components used for the implementation of digital protection.
- To impart knowledge on different algorithms for digital protection of power system components.
- To implement digital protection for transformer.
- To understand different decision making methodologies in protective relays.

UNIT - I DIGITAL SIGNAL PROCESSING TECHNIQUES 9

Sampling-Principle of scaling- aliasing- Decimation, Interpolation. Fourier and discrete Fourier transforms - Fast Fourier Transforms.-Wavelet transform -Numerical Algorithms

UNIT - II DIGITAL PROTECTION 9

Digital Protection -performance and operational characteristics of digital protection. Basic components of digital relays -Signal conditioning systems -Conversion subsystem -digital relay subsystem- Numerical relay for generator, transformer, feeder, busbar protection

UNIT - III ALGORITHMIC TECHNIQUES 9

Finite difference techniques- Interpolation- Numerical differentiation- curve fitting and smoothing. Sinusoidal wave based algorithms -First and second derivative method -two and three sample technique. Walsh function analysis- least squares based methods-differential equation based techniques -Travelling wave protective schemes. FIR based algorithms-Least square curve fitting algorithm.

UNIT - IV DIGITAL PROTECTION TECHNIQUES 9

Transformer protection- -Fourier based algorithm-basic hardware of microprocessor based transformer protection. Digital line differential scheme. Measurement algorithms for digital protection - power-voltage -current -Impedance -phase shift. -short window Wavelet based fault identification techniques-sliding window-FWHT-signal analysis and synthesis-AC/DC cable fault location-intrinsic and extrinsic fault-harmonic filtering in fault analysis

UNIT - V DIGITAL PROTECTIVE RELAYS 9

Decision making in protective relays- Deterministic Decision Making - Statistical Hypotheses Testing - Decision Making with Multiple Criteria - Adaptive Decision Schemes. Elements of Fuzzy Logic in Protective Relays -Fuzzy Sets and Fuzzy Numbers -Boolean Versus Fuzzy Logic -Fuzzy Reasoning - Fuzzy Logic Applications for Protection and Control.

TOTAL: 45 PERIODS

TEXT BOOKS:

1. J.L. Blackburn, Protective Relaying: Principles and Applications, Marcel Dekker, New York, 1987.
2. A.G. Phadke and J.S. Thorp, Computer Relaying for Power Systems, John Wiley & Sons, New York,1988.

REFERENCES:

1. J.G. Proakis and D.G. Manolakis, 'Digital Signal Processing Principles, Algorithms
2. Y.G. Paithankar and S.R Bhide, "Fundamentals of Power System Protection", PHI Learning; 2nd edition edition (July 30,2013)

OUTCOMES:
AT THE END OF THE COURSE, LEARNERS WILL BE ABLE TO:

Course Code & Name : 24PS3B2 - APPLICATION OF DSP TO POWER SYSTEM PROTECTION			
CO	**Course Outcomes**	**Unit**	**K –CO**
CO1	Apply DSP techniques for digital protection.	1	K3
CO2	Decision making algorithm suitable for digital relaying applications.	2	K3
CO3	Employ FIR based algorithms for digital relaying.	3	K3
CO4	Transformer protection using digital techniques.	4	K3
CO5	Perform coordinated operation of relays for specific purposes.	5	K3

24PS3B3 POWER SYSTEM INSTRUMENTATION

L	T	P	C
3	0	0	3

OBJECTIVES:

- To use the processors in the process and their relative merits to be brought out.
- To explain the algorithms used in the investigation procedure and error analysis.
- To offer an opportunity to innovate newer procedures and better methods for effective design of instrumentation systems for power networks.
- To provide the knowledge on various controls and measurements involved in power plant
- To import knowledge on distribution automation and substation controls

UNIT - I MEASUREMENTS AND SCADA SYSTEMS 9

Measurement and error analysis. Object and philosophy of power system instrumentation to measure large currents, high voltages, Torque and Speed - Standard specifications - Data acquisition systems for Power System applications - Data Transmission and Telemetry - PLC equipment - computer control of power system - Man Machine Interface.

UNIT - II POWER PLANT INSTRUMENTATION 9

Piping and Instrumentation diagram of thermal and nuclear power plants - Fuel measurement – gas analysis meters - smoke measurement - Monitoring systems – measurement and control of furnace draft – measurement and control of combustion – Turbine monitoring and control: speed, vibration, shell temperature monitoring – radiation detection instruments – process sensors for nuclear power plants – spectrum analyzers – nuclear reactor control systems and allied instrumentation.

UNIT - III DISTRIBUTION AUTOMATION 9

Definitions – automation switching control – management information systems (MIS) – remote terminal units – communication method for data transfer – consumer information service (CIS) – graphical information systems (GIS) - automatic meter reading (AMR) – Remote control load management.

UNIT - IV SUBSTATION INSTRUMENTATION 9

Sub-station automation – requirements – control aspects in substations – feeder automation – consumer side automation – reliability - GPIB programmable test instruments - microprocessor / microcontroller based GPIB controllers

UNIT - V ENERGY MANAGEMENT TECHNIQUES AND INSTRUMENTS 9

Demand side management (DSM)– DSM planning – DSM Techniques – Load management as a DSM strategy – energy conservation – tariff options for DSM - Energy audit – instruments for energy audit – Energy audit for generation, distribution and utilization systems – economic analysis.

TOTAL: 45 PERIODS

TEXT BOOKS:

1. Liptak B.G, Instrumentation in Process Industries, Vol I and II, Chilton Book Co.,1973.
2. Sherry A., Modern Power Station Practice, Vol.6 (Instrumentation, controls and Testing), Pergamon Press,1971.

REFERENCES:

1. Pabla. A.S “Electric power distribution “- Tata McGraw Hill; New Delhi2004
2. MahalanaBis A K, Kothari D P and Ahson S I “Computer aided Power System analysis and control” - Tata McGraw Hill; New Delhi1988.

OUTCOMES:
AT THE END OF THE COURSE, LEARNERS WILL BE ABLE TO:

Course Code & Name : 24PS3B3 - POWER SYSTEM INSTRUMENTATION			
CO	**Course Outcomes**	**Unit**	**K –CO**
CO1	Understand the basics of instrumentation and SCADA system implementation in PS	1	K2
CO2	Understand and implement the controls involved in power plant instrumentation	2	K2
CO3	Understand the functioning of distribution automation in power system network	3	K2
CO4	Understand concepts of substation automation and to implement the controls	4	K2
CO5	Analyse the energy management techniques and energy audit	5	K4

24PS3B4	HIGH VOLTAGE TECHNOLOGY	L	T	P	C
		3	0	0	3

OBJECTIVES:

- To provide strong knowledge on different types of electrical stresses on power system and equipment
- To impart knowledge on generation of high AC and DC voltages
- To provide adequate knowledge to simulate and generate impulse voltages and impulse currents.
- To expose the different techniques of measuring High voltages and high currents
- To provide awareness on electro-static hazards and safety measures

UNIT - I GENERATION OF DIRECT VOLTAGES 9

Requirements of HV generation in Laboratory, voltage stress, testing voltages, generation of direct voltages – AC to DC conversion – single phase rectifier circuits – cascade circuits –Voltage multiplier circuits – Cockcroft-Walton circuit – voltage regulation –ripple-factor – Electrostatic generators.

UNIT - II GENERATION OF ALTERNATING VOLTAGE 9

Testing transformer – single unit testing transformer, cascaded transformer – equivalent circuit of cascaded transformer –resonant circuits – resonant transformer – voltage regulation.

UNIT - III GENERATION OF IMPULSE VOLTAGES AND CURRENTS 9

Impulse voltage, general shape and definition of lightning impulses, generator circuit – Marx generator–analysis of various impulse voltage generator circuits, controlled switching — multistage impulse generator circuits – Switching impulse generator circuits – Generation of impulse currents, generation of non- standard impulse voltages and very fast transient voltage (VFTO)- Relevant IS and IEC Standards

UNIT - IV MEASURMENT OF HIGH VOLTAGES 9

Measurement of high AC, DC Impulse voltages - Peak voltage measurements by sphere gaps – Electrostatic voltmeter – generating voltmeters and field sensors – Chubb-Fortescue method –voltage dividers, types, dynamic response and impulse voltage measurements- Relevant IS and IEC Standards, measurement of high DC, AC and impulse currents — shunts, measurement using magnetic potentiometers and magnetic coupling - Fast digital transient recorders for impulse measurements

UNIT - V SAFETY AND ELECTROSTATIC HAZARDS 9

Introduction – Nature of static electricity – Triboelectric series – Basic laws of Electrostatic electricity– materials and static electricity – Electrostatic discharges (ESD) – Static electricity problems – Hazards of Electrostatic electricity in industry – Hazards from electrical equipment and installations – Static eliminators and charge neutralizers – Lightning protection- safety measures and standards

TOTAL: 45 PERIODS

TEXT BOOKS:

1. Naidu M S and Kamaraju V, “High Voltage Engineering”, Tata McGraw-hill Publishing Company Ltd., Fifth edition., New Delhi,2017.
2. Kuffel, E., Zaengl, W.S. and Kuffel J., “High Voltage Engineering Fundamentals”, Elsvier India Pvt. Ltd, Second edition,2008

REFERENCES:

1. R.Mazen Abdel-Salam, Hussein Anis, Ahdab El-Morshedy, Roshdy Radwan, “High Voltage Engineering Theory and Practice” Second Edition, Revised and Expanded, Marcel Dekker,Inc., New York, 2000.
2. Adolf J. Schwab, “High Voltage Measurement Techniques”, M.I.T Press, 1972.

OUTCOMES:
AT THE END OF THE COURSE, LEARNERS WILL BE ABLE TO:

Course Code & Name : 24PS3B4 - HIGH VOLTAGE TECHNOLOGY			
CO	**Course Outcomes**	**Unit**	**K –CO**
CO1	Design, simulate and generate HVDC	1	K4
CO2	Design, simulate and generate HVAC	2	K4
CO3	Design, simulate and generate impulse voltage and current	3	K4
CO4	Design and analyze the suitable measuring circuits for HV	4	K4
CO5	Provide safety measures against electrostatic hazards	5	K3

24PS3B5 ELECTRIC VEHICLES AND POWER MANAGEMENT

L	T	P	C
3	0	0	3

OBJECTIVES:

- To understand the concept of electric vehicles and its operations
- To present an overview of Electric Vehicle (EV), Hybrid Electric vehicle (HEV) and their architecture
- To understand the need for energy storage in hybrid vehicles
- To provide knowledge about various possible energy storage technologies that can be used in electric vehicles

UNIT - I ELECTRIC VEHICLES AND VEHICLE MECHANICS 9

Electric Vehicles (EV), Hybrid Electric Vehicles (HEV), Engine ratings- Comparisons of EV with internal combustion Engine vehicles- Fundamentals of vehicle mechanics.

UNIT - II ARCHITECTURE OF EV's AND POWERTRAIN COMPONENTS 9

Architecture of EV's and HEV's – Plug-in Hybrid Electric Vehicles (PHEV)- Power train components and sizing, Gears, Clutches, Transmission and Brakes.

UNIT - III POWER ELECTRONICS AND MOTOR DRIVES 9

Electric drive components – Power electronic switches- four quadrant operation of DC drives – Induction motor and permanent magnet synchronous motor-based vector control operation – Switched reluctance motor (SRM) drives- EV motor sizing.

UNIT - IV BATTERY ENERGY STORAGE SYSTEM 9

Battery Basics- Different types- Battery Parameters-Battery life & safety impacts -Battery modeling- Design of battery for large vehicles.

UNIT - V ALTERNATIVE ENERGY STORAGE SYSTEMS 9

Introduction to fuel cell – Types, Operation and characteristics- proton exchange membrane (PEM) fuel cell for E-mobility– hydrogen storage systems –Super capacitors for transportation applications.

TOTAL: 45 PERIODS

TEXT BOOKS:

1. Iqbal Hussain, "Electric and Hybrid Vehicles: Design Fundamentals, Second Edition" CRC Press, Taylor & Francis Group, Second Edition (2011).
2. Ali Emadi, Mehrdad Ehsani, John M.Miller, "Vehicular Electric Power Systems", Special Indian Edition, Marcel dekker, Inc2010.

REFERENCES:

1. Mehrdad Ehsani, YiminGao, Sebastian E. Gay, Ali Emadi, 'Modern Electric, Hybrid Electric and Fuel Cell Vehicles: Fundamentals, Theory and Design', CRC Press,2004.
2. C.C. Chan and K.T. Chau, 'Modern Electric Vehicle Technology', OXFORD University Press, 2001.

OUTCOMES:
AT THE END OF THE COURSE, LEARNERS WILL BE ABLE TO:

Course Code & Name : **24PS3B5 - ELECTRIC VEHICLES AND POWER MANAGEMENT**			
CO	**Course Outcomes**	**Unit**	**K –CO**
CO1	Understand the concept of electric vehicle and energy storage systems.	1	K2
CO2	Describe the working and components of Electric Vehicle and Hybrid Electric Vehicle	2	K3
CO3	Know the principles of power converters and electrical drives	3	K3
CO4	Illustrate the operation of storage systems such as battery and super capacitors	4	K3
CO5	Analyze the various energy storage systems based on fuel cells and hydrogen storage	5	K4

24PS3B6	ENERGY MANAGEMENT AND AUDITING	L	T	P	C
		3	0	0	3

OBJECTIVES:

- To study the concepts behind economic analysis and load management
- To emphasize the energy management of various electrical equipment and metering
- To illustrate the concept of energy management technologies

UNIT - I ENERGY SCENARIO **9**

Basics of Energy and its various forms - Conventional and non-conventional sources - Energy policy - Energy conservation act 2001, Amendments (India) in 2010 - Need for energy management- Designing and starting an energy management program - Energy managers and energy auditors - Roles and responsibilities of energy managers - Energy labelling and energy standards.

UNIT - II ENERGY COST AND LOAD MANAGEMENT **9**

Important concepts in an economic analysis - Economic models-Time value of money-Utility rate structures- Cost of electricity-Loss evaluation- Load management: Demand control techniques-Utility monitoring and control system-HVAC and energy management-Economic justification.

UNIT - III ENERGY MANAGEMENT **9**

Demand side management (DSM)– DSM planning – DSM techniques – Load management as a DSM strategy – Energy conservation – Tariff options for DSM.

UNIT - IV ENERGY AUDITING **9**

Definition – Energy audit methodology: audit preparation, execution and reporting – Financial analysis — Sensitivity analysis – Project financing options - Instruments for energy audit – Energy audit for generation, distribution and utilization systems – Economic analysis.

UNIT - V ENERGY EFFICIENT TECHNOLOGIES **9**

Energy saving opportunities in electric motors - Power factor improvement benefit and techniques- Shunt capacitor, Synchronous Condenser and Phase Advancer - Energy conservation in industrial drives, electric furnaces, ovens and boilers - Lighting techniques: Natural, CFL, LED lighting sources and fittings.

TOTAL: 45 PERIODS

TEXT BOOKS:

1. IEEE Recommended Practice for Energy Management in Industrial and Commercial Facilities, IEEE,1996.
2. Anil Kumar, Om Prakash, Prashant Singh Chauhan “Energy Management: Conservatior and Audits, CRC Press,2020.

REFERENCES:

1. Barney L. Capehart, Wayne C. Turner, William J. Kennedy, “Guide to Energy Management”, CRC press, Taylor & Francis group, Eighth Edition,2016.
2. Eastop T.D and Croft D.R, “Energy Efficiency for Engineers and Technologists”, LogmanScientific & Technical,1990.

OUTCOMES:
AT THE END OF THE COURSE, LEARNERS WILL BE ABLE TO:

Course Code & Name : 24PS3B6 - ENERGY MANAGEMENT AND AUDITING			
CO	**Course Outcomes**	**Unit**	**K –CO**
CO1	Understand the present energy scenario and role of energy managers.	1	K2
CO2	Comprehend the Economic Models for cost and load management.	2	K3
CO3	Configure the Demand side energy management through its control techniques, strategy and planning.	3	K3
CO4	Understand the process of energy auditing.	4	K2
CO5	Implement energy conservation aspects in industries.	5	K4

24AC101	ENGLISH FOR RESEARCH PAPER WRITING	L	T	P	C
		2	0	0	0

OBJECTIVES:

- Teach how to improve writing skills and level of readability
- Tell about what to write in each section
- Summarize the skills needed when writing a Title
- Infer the skills needed when writing the Conclusion
- Ensure the quality of paper at very first-time submission

UNIT - I INTRODUCTION TO RESEARCH PAPER WRITING 6

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 6

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

UNIT - III TITLEWRITING SKILLS 6

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, Methods, Results, Discussion, Conclusions, The Final Check

UNIT - IV RESULT WRITING SKILLS 6

Skills are needed when writing the Methods, skills needed when writing the Results, skills are needed when writing the Discussion, skills are needed when writing the Conclusions

UNIT - V VERIFICATION SKILLS 6

Useful phrases, checking Plagiarism, how to ensure paper is as good as it could possibly be the first- time submission

TOTAL: 30 PERIODS

TEXT BOOKS:

1. Adrian Wallwork , English for Writing Research Papers, Springer New York Dordrecht Heidelberg London,2011
2. Day R How to Write and Publish a Scientific Paper, Cambridge University Press2006

REFERENCES:

1. Goldbort R Writing for Science, Yale University Press (available on Google Books)2006
2. Highman N, Handbook of Writing for the Mathematical Sciences, SIAM. Highman’s book1998.

OUTCOMES:
AT THE END OF THE COURSE, LEARNERS WILL BE ABLE TO:

Course Code & Name : 24AC101 - ENGLISH FOR RESEARCH PAPER WRITING			
CO	**Course Outcomes**	**Unit**	**K –CO**
CO1	Understand that how to improve your writing skills and level of readability	1	K2
CO2	Learn about what to write in each section	2	K3
CO3	Understand the skills needed when writing a Title	3	K2
CO4	Understand the skills needed when writing the Conclusion	4	K2
CO5	Ensure the good quality of paper at very first-time submission	5	K3

24AC105	DISASTER MANAGEMENT	L	T	P	C
		2	0	0	0

OBJECTIVES:

- Summarize basics of disaster
- Explain a critical understanding of key concepts in disaster risk reduction and humanitarian response.
- Illustrate disaster risk reduction and humanitarian response policy and practice from multiple perspectives.
- Describe an understanding of standards of humanitarian response and practical relevance in specific types of disasters and conflict situations.
- Develop the strengths and weaknesses of disaster management approaches

UNIT - I INTRODUCTION 6

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

UNIT - II REPERCUSSIONS OF DISASTERS AND HAZARDS 6

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

UNIT - III DISASTER PRONE AREAS IN INDIA 6

Study of Seismic Zones; Areas Prone to Floods and Droughts, Landslides and Avalanches; Areas Prone to Cyclonic and Coastal Hazards with Special Reference to Tsunami; Post-Disaster Diseases and Epidemics

UNIT - IV DISASTER PREPAREDNESS AND MANAGEMENT 6

Preparedness: Monitoring of Phenomena Triggering a Disaster or Hazard; Evaluation of Risk: Application of Remote Sensing, Data from Meteorological and Other Agencies, Media Reports: Governmental and Community Preparedness.

UNIT - V RISK ASSESSMENT 6

Disaster Risk: Concept and Elements, Disaster Risk Reduction, Global and National Disaster Risk Situation. Techniques of Risk Assessment, Global Co-Operation in Risk Assessment and Warning, People’s Participation in Risk Assessment. Strategies for Survival

TOTAL: 30 PERIODS

TEXT BOOKS:

1. Goel S. L., Disaster Administration and Management Text and Case Studies”, Deep & Deep Publication Pvt. Ltd., NewDelhi, 2009.
2. Nishitha Rai, Singh AK, “Disaster Management in India: Perspectives, issues and strategies “’New Royal book Company, 2007.

REFERENCES:

1. Sahni, PardeepEt.Al.,” Disaster Mitigation Experiences and Reflections”, Prentice Hall of India, NewDelhi,2001.

OUTCOMES:
AT THE END OF THE COURSE, LEARNERS WILL BE ABLE TO:

Course Code & Name : 24AC102 - DISASTER MANAGEMENT			
CO	**Course Outcomes**	**Unit**	**K –CO**
CO1	Summarize basics of disaster	1	K2
CO2	Explain a critical understanding of key concepts in disaster risk reduction and humanitarian response.	2	K2
CO3	Illustrate disaster risk reduction and humanitarian response policy and practice from multiple perspectives.	3	K2
CO4	Describe an understanding of standards of humanitarian response and practical relevance in specific types of disasters and conflict situations.	4	K2
CO5	Develop the strengths and weaknesses of disaster management approaches	5	K2

24AC105	CONSTITUTION OF INDIA	L	T	P	C
		2	0	0	0

OBJECTIVES:

Students will be able to:

- Understand the premises informing the twin themes of liberty and freedom from a civil rights perspective.
- To address the growth of Indian opinion regarding modern Indian intellectuals constitutional
- Role and entitlement to civil and economic rights as well as the emergence nation hood in the early years of Indian nationalism.
- To address the role of socialism in India after the commencement of the Bolshevik Revolutionin1917and its impact on the initial drafting of the Indian Constitution.

UNIT - I HISTORY OF MAKING OF THE INDIAN CONSTITUTION

History, Drafting Committee, (Composition &Working)

UNIT - II PHILOSOPHY OF THE INDIAN CONSTITUTION

Preamble, Salient Features

UNIT - III ORGANS OF GOVERNANCE

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

UNIT - IV CONTOURS OF CONSTITUTIONAL RIGHTS AND DUTIES

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

UNIT - V LOCAL ADMINISTRATION

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

UNIT VI ELECTION COMMISSION

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

TOTAL: 30 PERIODS

TEXT BOOKS:

1. The Constitution of India,1950 (Bare Act), Government Publication.
2. Dr.S.N.Busi, Dr.B.R.Ambedkar framing of Indian Constitution,1st Edition,2015.

SUGGESTED READING

1. M.P. Jain, Indian Constitution Law, 7thEdn., LexisNexis,2014.
2. D.D. Basu, Introduction to the Constitution of India, Lexis Nexis,2015.

OUTCOMES:
AT THE END OF THE COURSE, LEARNERS WILL BE ABLE TO:

Course Code & Name : 24AC105 - CONSTITUTION OF INDIA			
CO	**Course Outcomes**	**Unit**	**K –CO**
CO1	Discuss the growth of the demand for civil rights in India for the bulk of Indians before the arrival of Gandhi in Indian politics.	1	K2
CO2	Discuss the intellectual origins of the framework of argument that informed the conceptualization Of social reforms leading to revolution in India.	2	K2
CO3	Discuss the circumstances surrounding the foundation of the Congress Socialist Party [CSP] under the leadership of Jawaharlal Nehru and the eventual failure of the proposal of direct elections through adult suffrage in the Indian Constitution.	3	K2
CO4	Discuss the passage of the Hindu Code Bill of1956.	4	K2
CO5	Explain the structure and functions of local administration	5	K2

24PSOE1	ENERGY CONSERVATION AND MANAGEMENT IN DOMESTIC SECTORS	L	T	P	C
		3	0	0	3

OBJECTIVES:

- To learn the present energy scenario and the need for energy conservation.
- To understand the different measures for energy conservation in utilities.
- Acquaint students with principle theories, materials, and construction techniques to create energy efficient buildings.
- To identify the energy demand and bridge the gap with suitable technology for sustainable habitat
- To get familiar with the energy technology, current status of research and find the ways to optimize a system as per the user requirement

UNIT - I ENERGY SCENARIO 9

Primary energy resources - Sectorial energy consumption (domestic, industrial and other sectors), Energy pricing, Energy conservation and its importance, Energy Conservation Act-2001 and its features – Energy star rating.

UNIT - II HEATING, VENTILLATION & AIR CONDITIONING 9

Basics of Refrigeration and Air Conditioning – COP / EER / SEC Evaluation – SPV system design & optimization for Solar Refrigeration

UNIT - III LIGHTING, COMPUTER, TV 9

Specification of Luminaries – Types – Efficacy – Selection & Application – Time Sensors – Occupancy Sensors – Energy conservation measures in computer – Television – Electronic devices.

UNIT - IV ENERGY EFFICIENT BUILDINGS 9

Conventional versus Energy efficient buildings – Landscape design – Envelope heat loss and heat gain – Passive cooling and heating – Renewable sources integration.

UNIT - V ENERGY STORAGE TECHNOLOGIES 9

Necessity & types of energy storage – Thermal energy storage – Battery energy storage, charging and discharging– Hydrogen energy storage & Super capacitors – energy density and safety issues – Applications.

TOTAL: 45 PERIODS

REFERENCES:

1. Yogi Goswami, Frank Kreith, Energy Efficiency and Renewable energy Handbook, CRC Press, 2016
2. ASHRAE Handbook 2020 – HVAC Systems & Equipment
3. Paolo Bertoldi, Andrea Ricci, Anibal de Almeida, Energy Efficiency in Household Appliances and Lighting, Conference proceedings, Springer, 2001
4. David A. Bainbridge, Ken Haggard, Kenneth L. Haggard, Passive Solar Architecture: Heating, Cooling, Ventilation, Daylighting, and More Using Natural Flows, Chelsea Green Publishing, 2011.
5. Guide book for National Certification Examination for Energy Managers and Energy Auditors (Could be downloaded from www.energymanagertraining.com)
6. Ibrahim Dincer and Mark A. Rosen, Thermal Energy Storage Systems and Applications, John Wiley & Sons 2002.

7. Robert Huggins, Energy Storage: Fundamentals, Materials and Applications, 2nd edition, Springer, 2015
8. Ru-shiliu, Leizhang, Xueliang sun, Electrochemical technologies for energy storage and conversion, Wiley publications, 2012

OUTCOMES:
AT THE END OF THE COURSE, LEARNERS WILL BE ABLE TO:

Course Code & Name : 24PSOE1 - ENERGY CONSERVATION AND MANAGEMENT IN DOMESTIC SECTORS			
CO	**Course Outcomes**	**Unit**	**K –CO**
CO1	Understand technical aspects of energy conservation scenario.	1	K2
CO2	Energy audit in any type for domestic buildings and suggest the conservation measures.	2	K2
CO3	Perform building load estimates and design the energy efficient landscape system.	3	K3
CO4	Gain knowledge to utilize an appliance/device sustainably.	4	K3
CO5	Understand the status and current technological advancement in energy storage field.	5	K2

24PSOE2	ELECTRIC VEHICLE TECHNOLOGY	L	T	P	C
		3	0	0	3

OBJECTIVES:

- Understand the concept of electric vehicle and energy storage systems
- Describe the working and components of Electric Vehicle and Hybrid Electric Vehicle
- Illustrate the operation of storage systems such as battery and Fuel cell
- Know the principles of electrical drives and control
- Analyze the design of electric vehicles

UNIT - I NEED FOR ELECTRIC VEHICLES 9

History and need for electric and hybrid vehicles, social and environmental importance of hybrid and electric vehicles, impact of modern drive-trains on energy supplies, comparison of diesel, petrol, electric and hybrid vehicles, limitations, technical challenges

UNIT - II ELECTRIC VEHICLE ARCHITECHTURE 9

Electric vehicle types, layout and power delivery, performance – traction motor characteristics, tractive effort, transmission requirements, vehicle performance, energy consumption, Concepts of hybrid electric drive train, architecture of series and parallel hybrid electric drive train, merits and demerits, mild and full hybrids, plug-in hybrid electric vehicles and range extended hybrid electric vehicles, Fuel cell vehicles.

UNIT - III ENERGY STORAGE 9

Batteries – types – lead acid batteries, nickel based batteries, and lithium based batteries, electrochemical reactions, thermodynamic voltage, specific energy, specific power, energy efficiency, Battery modeling and equivalent circuit, battery charging and types, battery cooling, Ultra-capacitors, Flywheel technology, Hydrogen fuel cell, Thermal Management of the PEM fuel cell

UNIT - IV ELECTRIC DRIVES AND CONTROL 9

Types of electric motors – working principle of AC and DC motors, advantages and limitations, DC motor drives and control, Induction motor drives and control, PMSM and brushless DC motor -drives and control , AC and Switch reluctance motor drives and control – Drive system efficiency – Inverters – DC and AC motor speed controllers

UNIT - V DESIGN OF ELECTRIC VEHICLES 9

Materials and types of production, Chassis skate board design, motor sizing, power pack sizing, component matching, Ideal gear box – Gear ratio, torque–speed characteristics, Dynamic equation of vehicle motion, Maximum tractive effort – Power train tractive effort Acceleration performance, rated vehicle velocity – maximum grad ability, Brake performance, Electronic control system, safety and challenges in electric vehicles. Case study of Nissan leaf, Toyota Prius, tesla model 3, and Renault Zoe cars.

TOTAL: 45 PERIODS

REFERENCES:

1. Iqbal Hussein, Electric and Hybrid Vehicles: Design Fundamentals, 2nd edition CRC Press, 2011.
2. Mehrdad Ehsani, Yimi Gao, Sebastian E. Gay, Ali Emadi, Modern Electric, Hybrid Electric and Fuel Cell Vehicles: Fundamentals, Theory and Design, CRC

Press, 2004.
3. James Larminie, John Lowry, Electric Vehicle Technology Explained - Wiley, 2003.
4. Ehsani, M, “Modern Electric, Hybrid Electric and Fuel Cell Vehicles: Fundamentals, Theory and Design”, CRC Press, 2005

OUTCOMES:
AT THE END OF THE COURSE, LEARNERS WILL BE ABLE TO:

Course Code & Name : 24PSOE2- ELECTRIC VEHICLE TECHNOLOGY			
CO	**Course Outcomes**	**Unit**	**K –CO**
CO1	Understand the concept of electric vehicle and energy storage systems.	1	K2
CO2	Describe the working and components of Electric Vehicle and Hybrid Electric Vehicle	2	K2
CO3	Illustrate the operation of storage systems such as battery and Fuel cell	3	K3
CO4	Know the principles of electrical drives and control	4	K3
CO5	Analyze the design of electric vehicles	5	K4

24PSOE3	SMART GRID	L	T	P	C
		3	0	0	3

OBJECTIVES:

- To Study about Smart Grid technologies, different smart meters and advanced metering infrastructure.
- To know about the function of smart grid.
- To familiarize the power quality management issues in Smart Grid.
- To familiarize the high performance computing for Smart Grid applications
- To get familiarized with the communication networks for Smart Grid applications

UNIT - I INTRODUCTION TO SMART GRID 9

Evolution of Electric Grid, Concept, Definitions and Need for Smart Grid, Smart grid drivers, functions, opportunities, challenges and benefits, Difference between conventional & Smart Grid, Comparison of Micro grid and Smart grid, Present development & International policies in Smart Grid, Smart Grid Initiative for Power Distribution Utility in India – Case Study

UNIT - II SMART GRID TECHNOLOGIES 9

Technology Drivers, Smart Integration of energy resources, Smart substations, Substation Automation, Feeder Automation ,Transmission systems: EMS, FACTS and HVDC, Wide area monitoring, Protection and control, Distribution systems: DMS, Volt/Var control, Fault Detection, Isolation and service restoration, Outage management, High-Efficiency Distribution Transformers, Phase Shifting Transformers, Plug in Hybrid Electric Vehicles (PHEV) – Grid to Vehicle and Vehicle to Grid charging concepts.

UNIT - III SMART METERS AND ADVANCED METERING INFRASTRUCTURE 9

Introduction to Smart Meters, Advanced Metering infrastructure (AMI) drivers and benefits, AMI protocols, standards and initiatives, AMI needs in the smart grid, Phasor Measurement Unit(PMU) & their application for monitoring & protection. Demand side management and demand response programs, Demand pricing and Time of Use, Real Time Pricing, Peak Time Pricing.

UNIT - IV POWER QUALITY MANAGEMENT IN SMART GRID 9

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 HIGH PERFORMANCE COMPUTING FOR SMART GRID APPLICATIONS 9

Architecture and Standards -Local Area Network (LAN), House Area Network (HAN), Wide Area Network (WAN), Broadband over Power line (BPL), PLC, Zigbee, GSM, IP based Protocols, Basics of Web Service and CLOUD Computing, Cyber Security for Smart Grid.

TOTAL: 45 PERIODS

REFERENCES:

1. Stuart Borlase ‘Smart Grid: Infrastructure, Technology and Solutions’, CRC Press 2012.
2. JanakaEkanayake, Nick Jenkins, KithsiriLiyanage, Jianzhong Wu, Akihiko Yokoyama, ‘Smart Grid: Technology and Applications’, Wiley, 2012.
3. Mini S. Thomas, John D McDonald, ‘Power System SCADA and Smart Grids’, CRC Press, 2015

4. Kenneth C.Budka, Jayant G. Deshpande, Marina Thottan, ‘Communication Networks for Smart Grids’, Springer, 2014
5. SMART GRID Fundamentals of Design and Analysis, James Momoh, IEEE press, A John Wiley & Sons, Inc., Publication.

OUTCOMES:
AT THE END OF THE COURSE, LEARNERS WILL BE ABLE TO:

Course Code & Name : 24PSOE3- SMART GRID			
CO	**Course Outcomes**	**Unit**	**K –CO**
CO1	Relate with the smart resources, smart meters and other smart devices.	1	K2
CO2	Explain the function of Smart Grid.	2	K2
CO3	Experiment the issues of Power Quality in Smart Grid.	3	K3
CO4	Analyze the performance of Smart Grid.	4	K4
CO5	Recommend suitable communication networks for smart grid applications	5	K3

24PSOE4	RENEWABLE ENERGY TECHNOLOGY	L	T	P	C
		3	0	0	3

OBJECTIVES:

To impart knowledge on

- Different types of renewable energy technologies
- Standalone operation, grid connected operation of renewable energy systems

UNIT - I INTRODUCTION 9

Classification of energy sources – Co2 Emission - Features of Renewable energy - Renewable energy scenario in India -Environmental aspects of electric energy conversion: impacts of renewable energy generation on environment Per Capital Consumption - CO2 Emission - importance of renewable energy sources, Potentials – Achievements– Applications.

UNIT - II SOLAR PHOTOVOLTAICS 9

Solar Energy: Sun and Earth-Basic Characteristics of solar radiation- angle of sunrays on solar collector- Estimating Solar Radiation Empirically - Equivalent circuit of PV Cell- Photovoltaic cell- characteristics: P- V and I-V curve of cell-Impact of Temperature and Insolation on I-V characteristics- Shading Impacts on I- V characteristics-Bypass diode - Blocking diode.

UNIT - III PHOTOVOLTAIC SYSTEM DESIGN 9

Block diagram of solar photo voltaic system : Line commutated converters (inversion mode) - Boost and buck-boost converters - selection of inverter, battery sizing, array sizing - PV systems classification- standalone PV systems - Grid tied and grid interactive inverters- grid connection issues.

UNIT - IV WIND ENERGY CONVERSION SYSTEMS 9

Origin of Winds: Global and Local Winds- Aerodynamics of Wind turbine-Derivation of Betz's limit- Power available in wind-Classification of wind turbine: Horizontal Axis wind turbine and Vertical axis wind turbine- Aerodynamic Efficiency-Tip Speed-Tip Speed Ratio-Solidity- Blade Count-Power curve of wind turbine - Configurations of wind energy conversion systems: Type A, Type B, Type C and Type D Configurations- Grid connection Issues - Grid integrated SCIG and PMSG based WECS.

UNIT - V OTHER RENEWABLE ENERGY SOURCES 9

Qualitative study of different renewable energy resources: ocean, Biomass, Hydrogen energy systems, Fuel cells, Ocean Thermal Energy Conversion (OTEC), Tidal and wave energy, Geothermal Energy Resources.

TOTAL: 45 PERIODS

REFERENCES:

1. S.N.Bhadra, D. Kastha, & S. Banerjee "Wind Electrical Systems", Oxford University Press, 2009.
2. Rai. G.D, "Non conventional energy sources", Khanna publishes, 1993.
3. Rai. G.D," Solar energy utilization", Khanna publishes, 1993.
4. Chetan Singh Solanki, "Solar Photovoltaics: Fundamentals, Technologies and Applications", PHI Learning Private Limited, 2012.
5. John Twideu and Tony Weir, "Renewal Energy Resources" BSP Publications,
6. Gray, L. Johnson, "Wind energy system", prentice hall of India, 1995.
7. B.H.Khan, " Non-conventional Energy sources", , McGraw-hill, 2nd Edition, 2009.
8. Fang Lin Luo Hong Ye, " Renewable Energy systems", Taylor & Francis Group,2013.

OUTCOMES:
AT THE END OF THE COURSE, LEARNERS WILL BE ABLE TO:

Course Code & Name : 24PSOE4- RENEWABLE ENERGY TECHNOLOGY			
CO	**Course Outcomes**	**Unit**	**K –CO**
CO1	Demonstrate the need for renewable energy sources.	1	K3
CO2	Develop a stand-alone photo voltaic system and implement a maximum power point tracking in the PV system.	2	K3
CO3	Design a stand-alone and Grid connected PV system.	3	K4
CO4	Analyze the different configurations of the wind energy conversion systems.	4	K4
CO5	Realize the basic of various available renewable energy sources	5	K3