The Kavery Engineering College

Mecheri, Mettur Tk. Salem Dt – 636 453.

(An Autonomous Institution Approved by AICTE, New Delhi & Affiliated to Anna University)

An ISO 9001:2015 certified Institution and accredited by NAAC with A+ grade.

M.E. POWER SYSTEMS ENGINEERING
CHOICE BASED CREDIT SYSTEM
CURRICULUM FOR SEMESTER I TO IV

(Applicable to the students admitted from the Academic year 2024-2025 onwards)

VISION

To render services to meet the growing global challenges of Engineering Industries by educating students to become exemplary Professional Electrical and Electronics Engineers of high ethics.

MISSION

- To establish quality learning facilities to produce Quality Electrical Engineers to compete globally.
- To nurture innovative research on cutting edge technologies and inculcate the positive attitude and the spirit of ethical practices.

PROGRAMME EDUCATIONAL OBJECTIVES (PEOs)

Our Graduates will have

- To prepare the students for successful career in electrical power industry, research and teaching institutions.
- To provide strong foundation in Power Engineering, necessary for day-to-day operation and planning of Power System.
- To develop the ability to design various controllers to enhance the stability and power transfer capability of the Power System.
- To provide knowledge in Renewable Energy Systems, Electric Vehicles and Grid Integrations using Power Converters.
- To develop a detailed understanding of various tools applied to the operation, design and investigation of modern electric power systems.

PROGRAMME OUTCOMES (POs)

- Engineering knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.

- Problem analysis: Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
- Design/development of solutions: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
- Conduct Investigations of Complex Problems: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
- Modern Tool Usage: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modelling to complex engineering activities with an understanding of the limitations.
- The engineer and society: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
- Environment and sustainability: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
- Ethics: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
- Individual and team work: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
- Communication: Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
- Project management and finance: Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.
- Life-long learning: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

PROGRAMME SPECIFIC OUTCOMES (PSOs)

- Ability to apply knowledge of electrical power system principles and techniques for power system applications.
- Ability to develop steady-state and dynamic models of various power system components to perform system studies for generation and transmission system expansion planning.
- Ability to design and develop various indigenous controllers for efficient and economic operation of power system.
- Ability to design and develop principles, practices and state-of-art techniques to protect the power system.
- Ability to analyze various electricity market models with distributed energy resources and demand response management.
- Ability to incorporate interdisciplinary knowledge to address the recent problems in the electrical power industry.

THE KAVERY ENGINEERING COLLEGE, MECHERI
REGULATIONS - 2024
CHOICE BASED CREDIT SYSTEM
M.E. POWER SYSTEMS ENGINEERING
CURRICULUM FOR SEMESTER I TO IV
(Applicable to the students admitted from the Academic year 2024-2025 onwards)

SEMESTER – I

Course Code	Course Title	Hours / Week			Credit	Maximum Marks			Category
		L	T	P		CA	ESE	Total	
Theory/Theory with Practical									
PAMPST2411	Applied Mathematics for Power Systems Engineers	3	1	0	4	40	60	100	FC
PRMT2411	Research Methodology and IPR	2	0	0	2	40	60	100	RMC
PPST2411	Computer Aided Power System Analysis	3	1	0	4	40	60	100	PCC
PPST2412	Power System Operation and	3	0	0	3	40	60	100	PCC
PPST 2413	System Theory	3	0	0	3	40	60	100	PCC
PPST2414	Analysis of Power Converters	3	1	0	4	40	60	100	PCC
	Audit Course I*	2	0	0	0				AC
Practical / Employability Enhancement									
PPSL2411	Power System Laboratory - I	0	0	3	1.5	60	40	100	PCC
PPSL2412	Power Converters Laboratory	0	0	3	1.5	60	40	100	PCC
Total Credits to be earned					**24**				

 # For students admitted from 2025 year onwards.

*** Audit Course is optional,**

SEMESTER – II

Course Code	Course Title	Hours / Week			Credit	Maximum Marks			Category
		L	T	P		CA	ESE	Total	
Theory/Theory with Practical									
PPST2421	Advanced Power System Protection	3	0	0	3	40	60	100	PCC
PPST2422	Power System Dynamics	3	0	0	3	40	60	100	PCC
PPST2423	Power System Transients	3	0	0	3	40	60	100	PCC
PPST2424	Restructured Power System	3	0	0	3	40	60	100	PCC
PPSE24XX	Professional Elective I	3	0	0	3	50	50	100	PCC
PPSE24XX	Professional Elective II	3	0	0	3	40	60	100	PCC
	Audit Course II*	2	0	0	0				AC
Practical / Employability Enhancement									
PPSL2421	Power System Laboratory – II	0	0	4	2	60	40	100	PCC
PPSL2422	Technical Seminar / Mini Project	0	0	4	2	60	40	100	EEC
Total Credits to be earned					**22**				

* Audit Course is optional

SEMESTER – III									
Course Code	**Course Title**	**Hours / Week**				**Maximum Marks**			**Category**
		L	**T**	**P**	**Credit**	**CA**	**ESE**	**Total**	
Theory/Theory with Practical									
PPST2431	HVDC and FACTS	3	0	0	3	40	60	100	PCC
PPSE24XX	Professional Elective III	3	0	0	3	40	60	100	PEC
PPSE24XX	Professional Elective IV	3	0	0	3	40	60	100	PEC
	Open Elective	3	0	0	3	40	60	100	OEC
Practical / Employability Enhancement									
PPSL2431	Project Work I	0	0	12	6	60	40	100	EEC
PPSL2432	Internship	0	0	0	1	100	0	100	EEC
Total Credits to be earned					**18**				

SEMESTER – IV									
Course Code	**Course Title**	**Hours / Week**				**Maximum Marks**			**Category**
		L	**T**	**P**	**Credit**	**CA**	**ESE**	**Total**	
Practical / Employability Enhancement									
PPSL2441	Project Work II	0	0	24	12	60	40	100	PCC
Total Credits to be earned					**12**				

AUDIT COURSES

Course Code	**Course Title**	**Hours / Week**			**Contact periods**
		L	**T**	**P**	
Theory/Theory with Practical					
PAXC2401	English for Research Paper Writing	2	0	0	0
PAXC2402	Disaster Management	2	0	0	0
PAXC2403	Constitution of India	2	0	0	0
PAXC2404	நற்றமிழ் இலக்கியம்	2	0	0	0

CREDITS SUMMARY

S.NO	CATEGORY	TOTAL CREDITS				PERCENTAGE	
		I	II	III	IV		
1.	FC	4				4	5
2.	PCC	17	14	3		34	45.3
3.	PEC	-	6	6		12	16
4.	RMC	3				3	2.9
5.	OEC			3		3	4
6.	EEC		2	6	12	20	26.6
7.	Non Credit/Audit Course	0	0			0	
TOTAL		**24**	**22**	**18**	**12**	**76**	**100%**

FC – Foundation Courses

PCC – Professional Core Courses

PEC – Professional Elective Courses

RMC – Research Methodology and IPR Courses

OEC – Open Elective Courses

EEC – Employment Enhancement Course

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Department	EEE	**Programme Code & Name**	411- ME - PSE

Course Code	Course Name	Hours/Week			Credit	Maximum Marks
		L	**T**	**P**	**C**	
PAMPST2411	**APPLIED MATHEMATICS FOR POWER SYSTEMS ENGINEERS**	3	0	0	3	**100**
Course Objectives	• To develop the ability to apply the concepts of matrix theory in Electrical Engineering problems • To familiarize the students in the field of differential equations to solve boundary value problems associated with engineering applications. • To develop the ability among the students to solve problems using Fourier series associated with engineering applications. • To impart deep knowledge and concepts to solve complicated problems using linear programming. • To develop the capability of solving problems using non - linear programming techniques					

Unit-I	**MATRIX THEORY**	**(9)**
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 EQUATION**	**(9)**
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**	**(9)**
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 –Liouvillesystems - Generalized Fourier series.		
Unit-IV	**LINEAR PROGRAMMING PROBLEMS**	**(9)**
Formulation - Graphical solution - Simplex method - Big M method - Two phase method – Transportation and Assignment models.		
Unit-V	**NON – LINEAR PROGRAMMING PROBLEMS**	**(9)**
Lagrange multipliers – Equality constraints – Inequality constraints – Kuhn – Tucker Conditions – Quadratic programming.		
Total No of Periods to be Taught	**45 periods**	

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TEXT BOOK:	
1	Richard Bronson , MATRIX OPERATION , Schaum's outline series, Second Edition, McGraw Hill, New Delhi , 2011.
2	SankaraRao . K, INTRODUCTION TO PARTIAL DIFFERENTIAL EQUATIONS , Prentice Hall of India Pvt . Ltd, New Delhi , 1997
REFERENCES:	
1	Andrews .L.C, and Phillips. R.L, MATHEMATICAL TECHNIQUES FOR ENGINEERS AND SCIENTISTS , Prentice Hall , New Delhi , 2005.
2	Taha .H.A , OPERATIONS RESEARCH - AN INTRODUCTION , Tenth Edition, Pearson Education, New Delhi , 2010.
3	Richard Bronson , MATRIX OPERATION , Schaum's outline series, Second Edition, McGraw Hill, New Delhi , 2011.

COURSE OUTCOMES:	
On completion of the course, the students will be able to	
CO1:	Student can able to apply the concepts of matrix theory in Electrical Engineeringproblems.
CO2:	Students can be easily understood to solve boundary value problems associatedwith engineering applications.
CO3:	Able to solve problems using Fourier series associated with engineering applications.
CO4:	Able to understood the basic concepts and also to solve complicated problems using linear programming.
CO5:	Student have capability of solving problems using non - linear programming techniques.

Mapping of COs with POs and PSOs

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO 2	PSO 3
CO1	3	2	2	1	3	1								
CO2	3	2	2	1	3	1								
CO3	3	2	2	1	3	1								
CO4	3	2	2	1	3	1								
CO5	3	2	2	1	3	1								
Avg.	3	2	2	1	3	1								

1 – Slight, 2 – Moderate, 3 –Substantial , BT – Bloom's Taxonomy

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Department	EEE	**Programme Code & Name**	411- ME - PSE

Course Code	Course Name	Hours/Week			Credit	Maximum Marks
		L	T	P	C	
PRMT2411	**RESEARCH METHODOLOGY AND IPR**	**2**	**0**	**0**	**2**	100

Course Objectives	• To develop the ability to apply the concepts of matrix theory in Electrical Engineering problems • To familiarize the students in the field of differential equations to solve boundary value problems associated with engineering applications. • To develop the ability among the students to solve problems using Fourier series associated with engineering applications. • To impart deep knowledge and concepts to solve complicated problems using linear programming. • To develop the capability of solving problems using non - linear programming techniques.

Unit-I	**RESEARCH DESIGN**	**(6)**

Overview of research process and design, Use of Secondary and exploratory data to answer the research question, Qualitative research, Observation studies, Experiments and Surveys.

Unit-II	**DATA COLLECTION AND SOURCES**	**(6)**

Measurements, Measurement Scales, Questionnaires and Instruments, Sampling and methods. Data - Preparing, Exploring, examining and displaying

Unit-III	**DATA ANALYSIS AND REPORTING**	**(6)**

Overview of Multivariate analysis, Hypotheses testing and Measures of Association.Presenting Insights and findings using written reports and oral presentation.

Unit-IV	**INTELLECTUAL PROPERTY RIGHTS**	**(6)**

Intellectual Property – The concept of IPR, Evolution and development of concept of IPR, IPR development process, Trade secrets, utility Models, IPR & Bio diversity, Role of WIPO and WTO in IPR establishments, Right of Property, Common rules of IPR practices, Types and Features of IPR Agreement, Trademark, Functions of UNESCO in IPR maintenance.

Unit-V	**PATENTS**	**(6)**

Patents – objectives and benefits of patent, Concept, features of patent, Inventive step, Specification, Types of patent application, process E-filling, Examination of patent, Grant of patent, Revocation, Equitable Assignments, Licences, Licensing of related patents, patent agents, Registration of patent agents.

Total No of Periods to be Taught	**30 periods**

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2	SankaraRao . K, INTRODUCTION TO PARTIAL DIFFERENTIAL EQUATIONS , Prentice Hall of India Pvt . Ltd, New Delhi , 1997

REFERENCES:	
1	Cooper Donald R, Schindler Pamela S and Sharma JK, "Business Research Methods", Tata McGraw Hill Education, 11e (2012)
2	Catherine J. Holland, "Intellectual property: Patents, Trademarks, Copyrights, Trade Secrets", Entrepreneur Press, 2007.
3	David Hunt, Long Nguyen, Matthew Rodgers, "Patent searching: tools & techniques", Wiley, 2007.

COURSE OUTCOMES: On completion of the course, the students will be able to	
CO1:	Student can able to apply the concepts of matrix theory in Electrical Engineering problems.
CO2:	Students can be easily understood to solve boundary value problems associated with engineering applications.
CO3:	Able to solve problems using Fourier series associated with engineering applications.
CO4:	Able to understood the basic concepts and also to solve complicated problems using linear programming.
CO5:	Student have capability of solving problems using non - linear programming techniques.

Mapping of COs with POs and PSOs

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO 1	PSO2	PSO 3
CO1	3	2	2	1	3	1								
CO2	3	2	2	1	3	1								
CO3	3	2	2	1	3	1								
CO4	3	2	2	1	3	1								
CO5	3	2	2	1	3	1								
Avg.	3	2	2	1	3	1								

1 – Slight, 2 – Moderate, 3 –Substantial , BT – Bloom's Taxonomy

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Department	EEE	**Programme Code & Name**	411- ME - PSE

Course Code	Course Name	Hours/Week			Credit	Maximum Marks
		L	T	P	C	
PPST2411	**COMPUTER AIDED POWER SYSTEM ANALYSIS**	3	1	0	4	100
Course 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)**
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 Bifactorization and Gauss elimination methods - Repeat solution using Left and Right factors and L and U matrices.		
Unit-II	**POWER FLOW ANALYSIS**	**(9)**
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)**
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)**
Formation of bus impedance matrix with mutual coupling (single phase basis and three phase basis) - Computer method for fault analysis using ZBUS 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)**
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 No of Periods to be Taught		**45 periods**

TEXT BOOK:	
1	Richard Bronson , MATRIX OPERATION , Schaum's outline series, Second Edition, McGraw Hill, New Delhi , 2011.
2	SankaraRao . K, INTRODUCTION TO PARTIAL DIFFERENTIAL EQUATIONS , Prentice Hall of India Pvt . Ltd, New Delhi , 1997

REFERENCES:	
1	A. J. Wood and B. F. Wollenberg, “Power Generation Operation and Control”, John Wiley and sons, New York, 2016.

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2	M. A. Pai," Computer Techniques in Power System Analysis",Tata McGraw Hill Publishing Company Limited, New Delhi, 2006
3	G W Stagg, A.H El. Abiad, "Computer Methods in Power System Analysis", McGraw Hill,1968
4	P. Kundur, "Power System Stability and Control", McGraw Hill, 1994
5	D. P. Kothari and I. J. Nagrath, 'Modern Power System Analysis', Fourth Edition, Tata McGraw Hill Publishing Company Limited, New Delhi, 2011.
6	K. Zollenkopf, "Bi-Factorization: Basic Computational Algorithm and Programming Techniques ; pp:75-96 ; Book on "Large Sparse Set of Linear Systems" Editor:J.K.Rerd, Academic Press, 1971.

COURSE OUTCOMES:

On completion of the course, the students will be able to

CO1:	Ability to solve large scale simultaneous linear equations and the ordering schemes for preserving sparsity.
CO2:	Students can be easily understood to solve boundary value problems associated with engineering applications.
CO3:	Able to solve problems using Fourier series associated with engineering applications.
CO4:	Able to understand the basic concepts and also to solve complicated problems using linear programming.
CO5:	Students have capability of solving problems using non - linear programming techniques.

Mapping of COs with POs and PSOs

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	2	2	1	3	1								
CO2	3	2	2	1	3	1								
CO3	3	2	2	1	3	1								
CO4	3	2	2	1	3	1								
CO5	3	2	2	1	3	1								
Avg.	3	2	2	1	3	1								

1 – Slight, 2 – Moderate, 3 –Substantial , BT – Bloom's Taxonomy

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Department	EEE	**Programme Code & Name**	411- ME - PSE

Course Code	Course Name	Hours/Week			Credit	Maximum Marks
		L	T	P	C	
PPST2412	**POWER SYSTEM OPERATION AND CONTROL**	**3**	**0**	**0**	**3**	100
Course Objectives	• To understand the fundamentals of speed governing system and the concept of control areas. • To get the insight of load frequency control and itsmodelling. • 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, loadduration curve, load factor, diversity factor. Reserve requirements: Installed reserves, spinning reserves, cold reserves, hot reserves. Overview of system operation and Control: Load forecasting, techniques of forecasting, Indian power sector – Past and present status: Recent growth of power sector in India – An overview, A time line of the Indian power sector, Players in the Indian power sector, basics of power system operation and control.

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, thermalunit constraints, hydro constraints, fuel constraints and other constraints; UC solution methods: Priority-list methods, forward dynamic programming approach, numerical problems. Incremental cost curve, coordination 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-Interior point algorithm-Bus incremental costs.

Total No of Periods to be Taught	**45 periods**

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REFERENCES:	
1	Robert H. Miller, James H. Malinowski, 'Power system operation', Tata McGraw-Hill, 2009
2	Allen J. Wood, Bruce F. Wollenberg, 'Power Generation, Operation and Control', Wiley India Edition, 2nd Edition,
3	Olle. I. Elgerd, "Electric Energy Systems Theory – An Introduction", Tata McGraw Hill Publishing Company Ltd, New
4	D.P. Kothari and I.J. Nagrath, "Modern Power System Analysis", Third Edition, Tata McGraw Hill Publishing
5	L.L. Grigsby, "The Electric Power Engineering, Hand Book", CRC Press & IEEE Press, 2001.
6	Allen.J.Wood and Bruce F.Wollenberg, "Power Generation, Operation and Control", John Wiley & Sons, Inc., 2003.
7	http://nptel.ac.in/courses/108101040/ (PSOC webcourse)

COURSE OUTCOMES:
On completion of the course, the students will be able to

CO1:	Explain about the operation and control of power system and List the past and present status of Indian power sector..
CO2:	Develop the static and dynamic model of Load Frequency Control in single and two area system.
CO3:	Analyse the problems associated with hydro thermal Scheduling and to construct the algorithm for feasible load management.
CO4:	Distinguish between various methods involved in unit commitment and economic dispatch problems.
CO5:	Define about the power system security

Mapping of COs with POs and PSOs

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO 2	PSO 3
CO1	-	3	-	2	2	-								
CO2	-	-	-	-	3	2								
CO3	1	2	-	1	2	3								
CO4	2	1	-	2	2	3								
CO5	1	2	-	-	2	3								
Avg.	1.34	2	-	1.67	2.2	2.75								

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Department	EEE	**Programme Code & Name**	411- ME - PSE

Course Code	Course Name	Hours/Week			Credit	Maximum Marks
		L	T	P	C	
PPST 2413	**SYSTEM THEORY**	**3**	**0**	**0**	**3**	100
Course Objectives	• To educate on modeling and representing systems in state variable form. • To train on solving linear and non-linear state equations. • To illustrate the properties of control system. • To classify non–linearities and examine stability of systems in the sense of Lyapunov's theory. • 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-Types of nonlinearity – Phase plane analysis – Singular points – Limit cycles – Construction of phase trajectories – Describing function method – Derivation of describing functions. 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 No of Periods to be Taught		**45 periods**

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TEXT BOOK:	
1	Richard Bronson , MATRIX OPERATION , Schaum's outline series, Second Edition, McGraw Hill, New Delhi , 2011.
2	SankaraRao . K, INTRODUCTION TO PARTIAL DIFFERENTIAL EQUATIONS , Prentice Hall of India Pvt . Ltd, New Delhi , 1997

REFERENCES:	
1	M. Gopal, "Modern Control System Theory", New Age International, 2005.
2	Z. Bubnicki, "Modern Control Theory", Springer, 2005
3	K. Ogatta, "Modern Control Engineering", PHI, 2002
4	John S. Bay, "Fundamentals of Linear State Space Systems", McGraw-Hill, 1999
5	D. Roy Choudhury, "Modern Control Systems", New Age International, 2005
6	John J. D'Azzo, C. H. Houpis and S. N. Sheldon, "Linear Control System Analysis and Design with MATLAB", Taylor Francis, 2003
7	M. Vidyasagar, "Nonlinear Systems Analysis', 2nd edition, Prentice Hall, Englewood Cliffs, New Jersey, 2002

COURSE OUTCOMES: On completion of the course, the students will be able to	
CO1:	M. Gopal, "Modern Control System Theory", New Age International, 2005.
CO2:	Explain the solution techniques of state equations
CO3:	Realize the properties of control systems in state space form
CO4:	Identify non-linearities and evaluate the stability of the system using Lyapnov notion
CO5:	Perform Modal analysis and design controller and observer in state space form

Mapping of COs with POs and PSOs

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO 2	PSO 3
CO1	3	-	2	2	3	-								
CO2	2	2	3	-	2	3								
CO3	3	-	3	-	-	-								
CO4	3	-	2	2	-	-								
CO5	3	-	3	2	3	2								
Avg.	2.8	2	2.8	3	2.5	2.5								

1 – Slight, 2 – Moderate, 3 –Substantial , BT – Bloom's Taxonomy

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Department	EEE	**Programme Code & Name**	411- ME - PSE

Course Code	Course Name	Hours/Week			Credit	Maximum Marks
		L	T	P	C	
PPST2414	**ANALYSIS OF POWER CONVERTERS**	**3**	**1**	**0**	**4**	100
Course 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**	**(12)**
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**	**(12)**
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**	**(12)**
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 various PWM techniques – various harmonic elimination techniques – Design of UPS - VSR operation		
Unit-IV	**THREE PHASE INVERTERS**	**(12)**
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**	**(12)**
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 No of Periods to be Taught		**45 periods**

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REFERENCES:	
1	Rashid M.H., “Power Electronics Circuits, Devices and Applications ", Pearson, fourth Edition, 10th Impression 2021.
2	Jai P. Agrawal, “Power Electronics System Theory and Design”, Pearson Education, First Edition, 2015
3	Bimal.K.Bose “Modern Power Electronics and AC Drives”, Pearson Education, Second Edition, 2003
4	Ned Mohan, T.M.Undeland and W.P.Robbins, “Power Electronics: converters, Application and design”, 3rd edition Wiley, 2007.
5	Philip T. Krein, “Elements of Power Electronics” Indian edition Oxford University Press-2017
6	P.C.Sen, “Modern Power Electronics”, S.Chand Publishing 2005.
7	P.S.Bimbra, “Power Electronics”, Khanna Publishers, Eleventh Edition, 2003
8	Bin Wu, Mehdi Narimani, "High-Power Converters and AC Drives", Wiley, 2nd Edition, 2017.

COURSE OUTCOMES: On completion of the course, the students will be able to	
CO1:	Acquire and apply knowledge of mathematics in power converter analysis
CO2:	Model, analyze and understand power electronic systems and equipments
CO3:	Formulate, design and simulate phase controlled rectifiers for generic load and for machine loads
CO4:	Design and simulate switched mode inverters for generic load and for machine loads
CO5:	Select device and calculate performance parameters of power converters under various operating modes

Mapping of COs with POs and PSOs

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	-	3	3	2	2								
CO2	3	-	3	3	2	2								
CO3	3	-	3	3	2	2								
CO4	3	-	3	3	2	2								
CO5	3	-	3	3	2	2								
Avg.	3	-	3	3	2	2								
1 – Slight, 2 – Moderate, 3 – Substantial , BT – Bloom’s Taxonomy														

Department	EEE	**Programme Code & Name**	411- ME - PSE

Course Code	Course Name	Hours/Week			Credit	Maximum Marks
		L	T	P	C	
PPSL2411	**POWER SYSTEM LABORATORY- I**	**0**	**0**	**3**	**1.5**	100
Course Objectives	• Illustrate the power system issues under normal and abnormal conditions • Analyze the performance of power system under normal and abnormal conditions using simulation software • Evaluate the existing system and system under smart environment					

List of Exercises/Experiments
1. Power flow analysis by Newton-Raphson/ Fast decoupled method
2. Transient stability analysis of single machine-infinite bus system using classical machine model
3. Economic load dispatch using lambda-iteration method
4. Unit commitment: Priority-list scheme and dynamic programming
5. Contingency analysis: Generator shift factors and line outage distribution factors
6. Load flow analysis of two-bus system with STATCOM
7. Available Transfer Capability(ATC) calculation using an existing load flow program in deregulated environment.
8. Harmonic Analysis of Power system with nonlinear load
9. Study of protective relaying schemes of Power Apparatus
10. Demand Side Management in Smart Power Grid environment
11. Determination of Sequence Impedances of Power Network.
Total:45 Periods

COURSE OUTCOMES: On completion of the course, the students will be able to	
CO1:	Acquire expertise in usage of simulation software as applied to power system
CO2:	Apply tools to simulate the mathematical model of power network for power system Analysis
CO3:	Analyze the power system through various numerical methods under normal and Abnormal conditions

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REFERENCES / MANUALS / SOFTWARES:	
1.	Laboratory manual
2.	Mat lab 2013 version

LIST OF EQUIPMENT FOR A BATCH OF 30 STUDENTS		
S.NO	**DESCRIPTION OF EQUIPMENT**	**REQUIRED NUMBERS**
1	Personal Desktop Computers (Intel Core i3, 500 GB, 4 - 8 GB RAM)	25 Nos
2	Server (Intel Core i3, 8 GB RAM) (High Speed Processor)	1 No
3	Printer	1 No
4	Software: EMTP / ETAP / MIPOWER / Matlab/ any Power system simulation software	5 User Licence
5	Compilers: C / C++	Original or Student Version

Mapping of COs with POs and PSOs

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO 3
CO1	3	-	3	-	-	3								
CO2	3	2	3	-	3	2								
CO3	3	-	3	3	3	-								
1 – Slight, 2 – Moderate, 3 – Substantial , BT – Bloom's Taxonomy														

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Department	EEE	**Programme Code & Name**	411- ME - PSE

Course Code	Course Name	Hours/Week			Credit	Maximum Marks
		L	T	P	C	
PPSL2412	**POWER CONVERTERS LABORATORY**	**0**	**0**	**3**	**1.5**	100

Course 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/Experiments

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 and study of spectrum analysis for various modulation indices.
6. Simulation of Four quadrant operation of DC Chopper.
7. Generation of Gating pulse using Arduino/Micro Controller/PIC microcontroller for a DCDC converter and single-phase voltage source i
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.
11. Simulation of a Flyback DC-DC converter

Total: 45 periods

COURSE OUTCOMES:
On completion of the course, the students will be able to

CO1:	Comprehensive understanding on the switching behaviour of Power Electronic Switches
CO2:	Comprehensive understanding on mathematical modeling of power electronic system and ability to implement the same using simulation tools
CO3:	Ability of the student to use arduino/microcontroller for power electronic applications

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CO4:	Ability of the student to design and simulate various topologies of inverters and analyze their harmonic spectrum
CO5:	Ability to design and fabricate the gate drive power converter circuits. Analyze the threephase controlled rectifiers and isolated DC-DC converters for designing the power supplies

REFERENCES / MANUALS / SOFTWARES:	
1.	Laboratory manual
2.	Mat lab 2013 version

LIST OF EQUIPMENT FOR A BATCH OF 30 STUDENTS

S.NO	DESCRIPTION OF EQUIPMENT	REQUIRED NUMBERS
1	Arduino or Micro Controller or PIC microcontroller along with interfacing cable	5 Nos
2	CRO	5 Nos
3	Regulated Power Supply (0-30V, 2A)	5 Nos
4	Digital Multimeter	5 Nos
5	Personal Computers	25 Nos
6	Software (Any software related to Power Electronics & Drives)	5 License users
7	Printer	1 No.

Mapping of COs with POs and PSOs

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	2	1	3	1	2	2	-							
CO2	2	-	3	1	2	2	3							
CO3	2	-	3			-								
CO4	2	-	3			2								
CO5	2	-	3		2		3							
1 – Slight, 2 – Moderate, 3 – Substantial , BT – Bloom's Taxonomy														

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Department	EEE	**Programme Code & Name**	411- ME - PSE

Course Code	Course Name	Hours/Week			Credit	Maximum Marks
		L	T	P	C	
PPST2421	**ADVANCED POWER SYSTEM PROTECTION**	**3**	**0**	**0**	**3**	100
Course Objectives	• To demonstrate the basic concepts and recent trends in power system protection • To design and work with the concepts of digital and numerical relaying of various power apparatuses • To train up with the relay coordination for the transmission line protection schemes • To expose PC applications for designing protective relaying schemes • To compare different protection schemes of a power apparatus through performance analysis.					

Unit-I	**NUMERICAL PROTECTION**	**(9)**
Introduction - Block diagram of numerical relay - Sampling theorem - Correlation with a reference wave - Least Error Squared (LES) technique - Digital filtering and numerical over- Current protection.		
Unit-II	**DIGITAL PROTECTION OF TRANSMISSION LINE**	**(9)**
Introduction - Protection scheme of transmission line – Distance relays - Traveling wave relays - Digital protection scheme based upon fundamental signal - Hardware design - Software design - Digital protection of EHV/UHV transmission line based upon traveling wave phenomenon - New relaying scheme using amplitude comparison		
Unit-III	**DIGITAL PROTECTION OF SYNCHRONOUS GENERATOR & TRANSFORMER**	**(9)**
Introduction - Faults in synchronous generator - Protection schemes for Synchronous Generator - Digital protection of Synchronous Generator - Faults in a Transformer - Schemes used for Transformer Protection - Digital Protection of Transformer.		
Unit-IV	**DISTANCE AND OVERCURRENT RELAY SETTING AND CO-ORDINATION**	**(9)**
Directional instantaneous IDMT over current relay - Directional multi-Zone distance relay - Distance relay setting - Co-ordination of distance relays - Co-ordination of over current relays - Computer graphics display - Man-machine interface subsystem - Integrated operation of national power system - Application of computer graphics.		
Unit-V	**PC APPLICATIONS FOR DESIGNING PROTECTIVE RELAYING SCHEME**	**(9)**
Types of faults – Assumptions - Development of algorithm for SC studies - PC based integrated software for SC studies - Transformation to component quantities - SC studies of multiphase systems - Ultra high speed protective relays for high voltage long transmission line.		
Total No of Periods to be Taught		**45 periods**

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REFERENCES:	
1	L. P. Singh, "Digital Protection - Protective Relaying from Electromechanical to Microprocessor", New Age International Ltd., New Delhi, Second Edition, 2006
2	S. R. Bhide, “Digital Power System Protection”, Prentice Hall of India Pvt. Ltd., New Delhi, 2014
3	Paithankar and Bhide, “Fundamentals of Power System Protection”, Prentice Hall of India Pvt. Ltd., New Delhi, second edition, 2010.
4	Paithankar, “Transmission Network Protection”, Marcel & Dekker, New York, 1998.
5	Stanley Horowitz, “Protective Relaying for Power System II”, John Wiley & Sons, 2008.
6	T. S. M. Rao, “Digital / Numerical relays”, Tata McGraw Hill, New Delhi, 2005.

COURSE OUTCOMES:	
CO1:	Familiarize the underlying principle of digital techniques for power system protection
CO2:	Design the relaying scheme for protection of power apparatus using digital techniques
CO3:	Evaluate and interpret relay coordination
CO4:	Develop PC based algorithm for short circuit studies
CO5:	Compare the performance of modern protection schemes with the conventional schemes

Mapping of COs with POs and PSOs

COs/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO1	PO11	PSO1	PSO2	PSO
CO1	2	-	3	-	3	-	2	-	3	-				
CO2	3	-	3	-	3	3	3	-	3	-				
CO3	3	1	3	2	2	2	3	1	3	2				
CO4	3	-	3	-	-	3	3	-	3	-				
CO5	3	1	3	3	3	2	3	1	3	3				
Avg.	2.8	1	3	2.5	2.75	2.5	2.8	1	3	2.5				
1 – Slight, 2 – Moderate, 3 – Substantial , BT – Bloom’s Taxonomy														

Department	EEE	**Programme Code & Name**	411- ME - PSE

Course Code	Course Name	Hours/Week			Credit	Maximum Marks
		L	T	P	C	
PPST2422	**POWER SYSTEM DYNAMICS**	**3**	**0**	**0**	**3**	100
Course 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 speedgoverning 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 PSSIllustration of principle of PSS application with

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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 SMALL SIGNAL 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 No of Periods to be Taught	**45 periods**	

REFERENCES:

1	PrabhaKundur, "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
3	J.Machowski, Bialek, Bumby, "Power System Dynamics and Stability", John wiley and sons, 3rd edition, 2020.
4	Vijay Vittal, James D. McCalley, Paul, P.M Anderson and A.A Fouad, "Power System Control and Stability", Iowa State University Press, Ames, Iowa, 3rd edition, 2019
5	P. W. Sauer and M. A. Pai," Power System Dynamics and Stability", Stipes Publishing Co, 2007.

COURSE OUTCOMES:
On completion of the course, the students will be able to

CO1:	Analyze the mathematical modeling and inductance calculations in a synchronous machine.
CO2:	Develop the transfer function model for excitation, speed governing and turbine systems.
CO3:	Analyze the small signal stability of SMIB power systems.
CO4:	Analyze the small signal stability of SMIB and Multi-machine power systems with damping controllers.
CO5:	Describe feedback controllers for small signal stability enhancement in power systems.

Mapping of COs with POs and PSOs

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	-	3	-	2	-								
CO2	3	-	3	1	2	-								
CO3	3	1	3	-	1	2								
CO4	3	-	2	2	2	3								
CO5	2	2	3	2	-	3								
Avg.	2.8	1.5	2.2	1.7	1.75	2.7								
1 – Slight, 2 – Moderate, 3 – Substantial , BT – Bloom's Taxonomy														

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Department	EEE	**Programme Code & Name**	411- ME - PSE

Course Code	Course Name	Hours/Week			Credit	Maximum Marks
		L	T	P	C	
PPST2423	**POWER SYSTEM TRANSIENTS**	**3**	**0**	**0**	**3**	100
Course Objectives	• To compute transient over voltages using Electromagnetic Transient Program (EMTP). • To gain knowledge in sources of transients like lightning, switching and temporary • To model power system components and estimate the over voltages in power system over voltages • To analyze travelling wave phenomena against different over voltages • 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 TRANSMISSION LINE**	**(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 selectionEvaluation 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 No of Periods to be Taught	**45 periods**	

REFERENCES:	
1	Pritindra Chowdhari, "Electromagnetic transients in Power System", John Wiley and Sons Inc., Second Edition, 2009..
2	Allan Greenwood, "Electrical Transients in Power System", Wiley & Sons Inc. New York, 2012.
3	Andrew R. Hileman, "Insulation Coordination for Power Systems", CRC press, Taylor & Francis Group, New York, 1999.
4	Klaus Ragaller, "Surges in High Voltage Networks", Plenum Press, New York, 1980.
5	Naidu M S and Kamaraju V, "High Voltage Engineering", Tata McGraw-Hill Publishing Company Ltd., New Delhi, 2004

COURSE OUTCOMES: On completion of the course, the students will be able to	
CO1:	Ability to analyse various sources of transients.
CO2:	Ability to compute possible overvoltages in power systems.
CO3:	Ability to predict overvoltages in power system using travelling wave theory
CO4:	Ability to compute overvoltages using EMTP with multiple sources
CO5:	Ability to coordinate the insulation level of the power system

Mapping of COs with POs and PSOs

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	3	1	-	-	-								
CO2	3	3	-	-	3	-								
CO3	3	3	2	3	3									
CO4	3	3	2	3	3									
CO5	3	3	3	3	3		5							
Avg.	3	3	1.6	1.8	2.4		2.4							
1 – Slight, 2 – Moderate, 3 – Substantial , BT – Bloom's Taxonomy														

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Department	EEE	**Programme Code & Name**	411- ME - PSE

Course Code	Course Name	Hours/Week			Credit	Maximum Marks
		L	T	P	C	
PPST2424	**RESTRUCTURED POWER SYSTEM**	**3**	**0**	**0**	**3**	100
Course 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 of financial 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	**NCILLARY 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 No of Periods to be Taught		**45 periods**

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REFERENCES:	
1	Mohammad Shahidehpour, MuwaffaqAlomoush, “Restructured electrical power systems: operation, trading and volatility” Marcel Dekker Pub.,2001.
2	Kankar Bhattacharya, Math H.J.Boolen, and JaapE. Daadler, "Operationofrestructured power systems”, Kluwer AcademicPub.,2001.
3	Paranjothi, S.R., “Modern Power Systems The Economics of Restructuring”, New Age International Publishers, First Edition: 2017.
4	Sally Hunt, "MakingcompetitionworkInelectricity”,JohnWilleyandSonsInc.2002.
5	Steven Stoft," Power System Economics: Designing Markets for Electricity”,Wiley-IEEE Press, 2002.
6	A. Khaparde, A. R. Abhyankar, "Restructured Power Systems", NPTEL Course, https://nptel.ac.in/courses/108101005/.

COURSE OUTCOMES: On completion of the course, the students will be able to	
CO1:	Describe the requirement for deregulation of the electricity market and the principles of market models in
CO2:	Analyze the methods of congestion management in deregulated power system
CO3:	Analyze the locational marginal pricing and financial transmission rights
CO4:	Analyze the ancillary services management
CO5:	Differentiate the framework of US and Indian power sectors

Mapping of COs with POs and PSOs

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	-		3		2								
CO2	2	3	2	-	-	3								
CO3	2	2	2	-	-	3								
CO4	2	2	3	-	-	2								
CO5	3	-	-	2	2	1								
Avg.	2.4	2.33	2.33	2.5	2	2.2								
1 – Slight, 2 – Moderate, 3 – Substantial , BT – Bloom’s Taxonomy														

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Department	EEE	**Programme Code & Name**	411- ME - PSE

Course Code	Course Name	Hours/Week			Credit	Maximum Marks
		L	T	P	C	
PPSL2421	**POWER SYSTEM LABORATORY - II**	**0**	**0**	**4**	**2**	100
Course Objectives	• Solve the power system problems using computational intelligent techniques • Analyze the solution obtained for power system under normal and abnormal conditions using simulation software • 3Expose with real time monitoring of power system • Evaluate the new techniques used for power system problems with the conventional • Educate to integrate renewable energy sources					

List of Exercises/Experiments
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
Total: 60 periods

COURSE OUTCOMES: On completion of the course, the students will be able to	
CO1:	Apply advanced tools to simulate the model of power network for power system problems
CO2:	Acquire expertise in usage of modern techniques for Power System Issues
CO3:	Apply soft computing techniques to Power System problems and evaluate the solution
CO4:	Analyze the solution obtained through soft computing techniques
CO5:	Suggest suitable technique as applicable to power system problem

REFERENCES / MANUALS / SOFTWARES:	
1.	Laboratory manual
2.	Mat lab 2013 version

LIST OF EQUIPMENT FOR A BATCH OF 30 STUDENTS		
S.NO	**DESCRIPTION OF EQUIPMENT**	**REQUIRED NUMBERS**
1	Personal Computers (Intel Core i5 or i7, 500 GB, 8 GB RAM)	25
2	Printer	1
3	Server (Intel Core i7, 2 TB, 8 GB RAM or higher) (High Speed Processor)	1
4	Software: EMTP / ETAP / CYME / MIPOWER / any Power system simulation software	5
5	Compilers: C / C++ / Matlab	25

Mapping of COs with POs and PSOs

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	-	3	-	3	3								
CO2	3	2	3	2	2	3								
CO3	3	-	3		3	3								
CO4	3	-	3		2	1								
CO5	3	-	3	2	2	3								
1 – Slight, 2 – Moderate, 3 – Substantial , BT – Bloom's Taxonomy														

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Department	EEE	**Programme Code & Name**	411- ME - PSE

Course Code	Course Name	Hours/Week			Credit	Maximum Marks
		L	T	P	C	
PPST2431	**HVDC AND FACTS**	**3**	**0**	**0**	**3**	100
Course 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)**
Review of basics of power transmission networks-control of power flow in AC transmission line- Analysis of uncompensated AC Transmission line- Passive reactive power compensation: Effect of series and shunt compensation at the mid-point of the line on power transfer- Need for FACTS controllers- types of FACTS controllers- Need for HVDC system-MTDC systemReview 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 analysisStability 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 SSSCModelling 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 controlles		
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 Submodule 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 No of Periods to be Taught	**45 periods**

REFERENCES:

1	Mohan Mathur, R., Rajiv. K. Varma, "Thyristor – Based Facts Controllers forElectrical Transmission Systems", IEEE press and John Wiley & Sons, Inc.
2	K.R.Padiyar, "FACTS Controllers in Power Transmission and Distribution", New AgeInternational(P) Ltd., Publishers, New Delhi, Reprint 2008.
3	K.R.Padiyar, "HVDC Power Transmission Systems", New Age International (P) Ltd., New Delhi, 2002.
4	J.Arrillaga, "High Voltage Direct Current Transmission", Peter Pregrinus, London,1983
5	V.K.Sood, "HVDC and FACTS controllers- Applications of Static Converters in Power System", Kluwer Academic Publishers 2004.

COURSE OUTCOMES:
On completion of the course, the students will be able to

CO1:	Learners will be able to refresh on basics of power transmission networks and need for FACTS controllers
CO2:	Ability to design series and shunt compensating devices for power transfer enhancement
CO3:	Learners will understand the significance about different voltage source converter based FACTS controllers
CO4:	Learners will attain knowledge on AC/DC system coordinated control with FACTS and HVDC link
CO5:	Learners will be capable to explore the MMC converter applications FACTS and MTDC system

Mapping of COs with POs and PSOs

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO 3
CO1	3	2	1	-	1	-								
CO2	1	1	2	-	3	-								
CO3	2	-	3	1	1	2								
CO4	3	3	1	2	-	1								
CO5	2	2	2	-	3	-								
Avg.	2.2	2	1.8	1.5	2.33	1.5								
1 – Slight, 2 – Moderate, 3 – Substantial , BT – Bloom's Taxonomy														

Department	EEE	**Programme Code & Name**	411- ME - PSE

Course Code	Course Name	Hours/Week			Credit	Maximum Marks
		L	T	P	C	
PPSE2401	**POWER SYSTEM STATE ESTIMATION AND SECURITY ASSESSMENT**	**3**	**0**	**0**	**3**	100
Course 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 and State 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 IDENTIFICATION**	**(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 SecurityIndices-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 No of Periods to be Taught	**45 periods**	

REFERENCES:	
1	Ali Abur and Antonio Gomez Exposito ,"Power System State Estimation Theory and Implementation", Marcel Dekker, Inc., New York . Basel, 2004.
2	J J Grainger and W D Stevension, " Power System Analysis", McGraw-Hill, Inc., 1994.
3	A Monticelli, "State Estimation in Electric Power Systems", Kluwer Academic Publishers,1999.
4	Mukhtar Ahmad, "Power System State Estimation", Lap Lambert Acad Publishers,2013.
5	Felix L. Chernousko, " State Estimation for Dynamic Systems", CRC Press, 1993
6	Naim Logic, "Power System State Estimation" , LAP Lambert Acad. Publ., 2010.
7	Power System Security Assessment and Enhancement: A Bibliographical Survey.

COURSE OUTCOMES:

On completion of the course, the students will be able to

CO1:	Define various concepts implied in State estimation and its need in DC networks.
CO2:	Apply State estimation algorithms in modelling of transmission lines.
CO3:	Compare the different types of formulation techniques of State estimation.
CO4:	Analyse network observability and identify the bad data detection using different methods.
CO5:	List the different types of assessing power system security and solve the issues.

Mapping of COs with POs and PSOs

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	2	3	-	-	2	-								
CO2	2	2	-	-	3	-								
CO3	2	3	-	-	-	-								
CO4	1	3	2	-	2	-								
CO5	3	2	-	-	-	3								
Avg.	2	2.6	2	-	2.3	3								
1 – Slight, 2 – Moderate, 3 – Substantial , BT – Bloom's Taxonomy														

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Department	EEE	**Programme Code & Name**	411- ME - PSE

Course Code	Course Name	Hours/Week			Credit	Maximum Marks
		L	T	P	C	
PPSE2402	**OPTIMIZATION TECHNIQUES TO POWER SYSTEM ENGINEERING**	**3**	**0**	**0**	**3**	100
Course 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 near global 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 - memeplexupdation - BA and SFLA algorithms for solving ELD and optimal placement and sizing of the DG problem.		
Unit-V	**MULTI OBJECTIVE 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 No of Periods to be Taught	**45 periods**	

REFERENCES:	
1	Xin-She Yang, "Recent Advances in Swarm Intelligence and Evolutionary Computation", Springer International Publishing, Switzerland, 2015.
2	Kalyanmoy Deb, "Multi-Objective Optimization using Evolutionary Algorithms", John Wiley & Sons, 2001
3	James Kennedy and Russel E Eberheart, "Swarm Intelligence", The Morgan Kaufmann Series in Evolutionary Computation, 2001.
4	Eric Bonabeau, Marco Dorigo and Guy Theraulaz, "Swarm Intelligence-From natural to Artificial Systems", Oxford university Press, 1999.
5	David Goldberg, "Genetic Algorithms in Search, Optimization and Machine Learning", Pearson Education, 2007.
6	Konstantinos E. Parsopoulos and Michael N. Vrahatis, "Particle Swarm Optimization and Intelligence: Advances and Applications", Information science reference, IGI Global, 2010
7	N P Padhy, "Artificial Intelligence and Intelligent Systems", Oxford University Press, 2005.
8	D.P. Kothari, J.S. Dhillon, "Power System Optimization", PHI, 2nd edition, 30 December 2010.

COURSE OUTCOMES:	
CO1:	understand the capabilities of bio-inspired system and conventional methods in solving optimization problems
CO2:	implement the genetic algorithm and particle swarm optimization technique to solve the ED problems
CO3:	understand and implement the ant colony algorithm and artificial bee colony algorithms to PS problems
CO4:	implement the shuffled frog-leaping algorithm and bat optimization algorithm for solving ELD and optimal placement and sizing of the DG problem
CO5:	understand and implement the multi-objective optimization techniques to implement in power system problems

Mapping of COs with POs and PSOs

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	2	2	3	-	2	2								
CO2	3	3	2	-	2	3								
CO3	3	3	3	-	2	3								
CO4	3	3	2	-	2	3								
CO5	3	3	2	-	2	3								
Avg.	2.8	2.8	2.4	-	2	2.8								
1 – Slight, 2 – Moderate, 3 – Substantial , BT – Bloom's Taxonomy														

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Department	EEE	**Programme Code & Name**	411- ME - PSE

Course Code	Course Name	Hours/Week			Credit	Maximum Marks
		L	T	P	C	
PPSE2403	**COMPUTATIONAL INTELLIGENCE TECHNIQUES TO POWER SYSTEMS**	**3**	**0**	**0**	**3**	100

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 feed back 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 ANDNUMERICAL 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 digonesis 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 estimationLeast 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 No of Periods to be Taught	**45 periods**	

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REFERENCES:	
1	Ajith Abrahamand SwagathamDas.,"ComputaionalIntelligence in Power Engineering", 2010 Springer Verlag.
2	YongHuaSong,JohnsAllen,AggarwalRaj,'ComputationalIntelligenceApplicationtoPower System',SpringerNetherlands.,1997.

COURSE OUTCOMES: On completion of the course, the students will be able to	
CO1:	Understand the concept of Optim Optimization Techique for power system
CO2:	Identify, Formulate and measure the performance of Optimal Controllers for power system.
CO3:	Understand the Linear Quadratic Tracking Problems and implement dynamic programming application for discrete and continuous systems.
CO4:	Apply Filtering and Estimation techniques for power system applications.
CO5:	Design Kalman filter for power system protection application

Mapping of COs with POs and PSOs

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	1	2	1	-	1	-								
CO2	2	3	3	-	2	-								
CO3	2	-	3	1	3	2								
CO4	3	2	1	2	-	1								
CO5	2	2	2	-	3	-								
Avg.	2	2.25	2	1.5	2.66	1.5								
1 – Slight, 2 – Moderate, 3 – Substantial , BT – Bloom's Taxonomy														

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Department	EEE	**Programme Code & Name**	411- ME - PSE

Course Code	Course Name	Hours/Week			Credit	Maximum Marks
		L	T	P	C	
PPSE2404	**IoT FOR SMART SYSTEMS**	**3**	**0**	**0**	**3**	100
Course Objectives	• To study about Internet of Things technologies and its role in real time applications • To introduce the infrastructure required for IoT • To familiarize the accessories and communication techniques for IoT. • To provide insight about the embedded processor and sensors required for IoT • To familiarize the different platforms and Attributes for IoT					

Unit-I	**INTRODUCTION TO INTERNET OF THINGS**	**(9)**
Overview, Hardware and software requirements for IOT, Sensor and actuators, Technology drivers, Business drivers, Typical IoT applications, Trends and implications		
Unit-II	**IOT ARCHITECTURE**	**(9)**
IoT reference model and architecture -Node Structure - Sensing, Processing, Communication, Powering, Networking - Topologies, Layer/Stack architecture, IoT standards, Cloud computing for IoT, Bluetooth, Bluetooth Low Energy beacons.		
Unit-III	**PROTOCOLS AND WIRELESS TECHNOLOGIES FOR IOT PROTOCOLS**	**(9)**
NFC, SCADA and RFID, Zigbee MIPI, M-PHY, UniPro, SPMI, SPI, M-PCIe GSM, CDMA, LTE, GPRS, small cell. Wireless technologies for IoT: WiFi (IEEE 802.11), Bluetooth/Bluetooth Smart, ZigBee/ZigBee Smart, UWB (IEEE 802.15.4), 6LoWPAN, Proprietary systems-Recent trends		
Unit-IV	**IOT PROCESSORS**	**(9)**
Services/Attributes: Big-Data Analytics for IOT, Dependability,Interoperability, Security, Maintainability. Embedded processors for IOT :Introduction to Python programming -Building IOT with RASPERRY PI and Arduino		
Unit-V	**CASE STUDIES**	**(9)**
Industrial IoT, Home Automation, smart cities, Smart Grid, connected vehicles, electric vehicle charging, Environment, Agriculture, Productivity Applications, IOT Defense		
Total No of Periods to be Taught	**45 periods**	

REFERENCES:

1	ArshdeepBahga and VijaiMadisetti : A Hands-on Approach “Internet of Things”,Universities Press 2015.
2	Yong Hua Song, Johns Allen, Aggarwal Raj, ‘Computational Intelligence Application to Power System’, Springer Netherlands., 1997.
3	Samuel Greengard, “ The Internet of Things”, The MIT press, 2015.

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4	Adrian McEwen and Hakim Cassimally"Designing the Internet of Things "Wiley,2014.
5	Jean- Philippe Vasseur, Adam Dunkels, "Interconnecting Smart Objects with IP: The Next Internet" Morgan Kuffmann Publishers, 2010.
6	Adrian McEwen and Hakim Cassimally, "Designing the Internet of Things", John Wiley and sons, 2014.

COURSE OUTCOMES: On completion of the course, the students will be able to	
CO1:	Analyze the concepts of IoT and its present developments.
CO2:	Compare and contrast different platforms and infrastructures available for IoT
CO3:	Explain different protocols and communication technologies used in IoT
CO4:	Analyze the big data analytic and programming of IoT
CO5:	Implement IoT solutions for smart applications

Mapping of COs with POs and PSOs

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	1	2	1	-	-	-								
CO2	-	2	-	-	-	-								
CO3	1	2	-	1	3	-								
CO4	2	-	3	3	3	3								
CO5	3	2	3	3	3	3								
Avg.	1.75	2	2.33	2.33	3	2								
1 – Slight, 2 – Moderate, 3 – Substantial , BT – Bloom's Taxonomy														

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Department	EEE	**Programme Code & Name**	411- ME - PSE

Course Code	Course Name	Hours/Week			Credit	Maximum Marks
		L	T	P	C	
PPSE2405	**RENEWABLE ENERGY AND GRID INTEGRATION**	**3**	**0**	**0**	**3**	100
Course 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 AND WIND 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 No of Periods to be Taught	**45 periods**	

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COURSE OUTCOMES: On completion of the course, the students will be able to	
CO1:	Relate the power generation of different renewable energy sources to grid impact and grid codes
CO2:	Explain the design principles of solar energy management systems
CO3:	Understand the power conversion system of wind generators
CO4:	Analyze the different Maximum Power Point tracking Techniques
CO5:	Build grid connected and stand alone renewable energy management system

Mapping of COs with POs and PSOs

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	1	2	1	-	1	-								
CO2	1	2	2	-	1	-								
CO3	2	-	1	1	1	2								
CO4	1	2	1	2	-	2								
CO5	3	3	2	-	2	-								
Avg.	1.6		1.4	1.5	1.25	2								
1 – Slight, 2 – Moderate, 3 – Substantial , BT – Bloom's Taxonomy														

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Department	EEE	**Programme Code & Name**	411- ME - PSE

Course Code	Course Name	Hours/Week			Credit	Maximum Marks
		L	T	P	C	
PPSE2406	**SMART GRID**	**3**	**0**	**0**	**3**	100
Course 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 No of Periods to be Taught	**45 periods**	

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REFERENCES:	
1	JanakaEkanayake, Nick Jenkins, KithsiriLiyanage, Jianzhong Wu, Akihiko Yokoyama, 'Smart Grid: Technology and Applications', Wiley, 2012.
2	Stuart Borlase 'Smart Grid: Infrastructure, Technology and Solutions', CRC Press 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.

Mapping of COs with POs and PSOs

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	2	-	2	2	2								
CO2	3	-	2	2	-	2								
CO3	2	-	1	-	-	-								
CO4	1	-	-	3	3	1								
CO5	3	2	2	2	2	3								
Avg.	2.25	2	1.66	2.25	2.3	2								
1 – Slight, 2 – Moderate, 3 – Substantial , BT – Bloom's Taxonomy														

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Department	EEE	**Programme Code & Name**	411- ME - PSE

Course Code	Course Name	Hours/Week			Credit	Maximum Marks
		L	T	P	C	
PPSE2407	**ELECTRICAL POWER DISTRIBUTION SYSTEM**	**3**	**0**	**0**	**3**	100
Course 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					

(9)

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 no of periods to be taught	**45 periods**	

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COURSE OUTCOMES: On completion of the course, the students will be able to	
CO1:	Obtain fundamental knowledge in electric power distribution system.
CO2:	Be proficient in control and protection schemes for distribution systems.
CO3:	Gain familiarity to evaluate reliability of distribution systems.
CO4:	Demonstrate the methodologies for distribution automation.
CO5:	Able to develop strategies for expanding the existing distribution systems.

Mapping of COs with POs and PSOs

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	1	1	-	-	2	1								
CO2	2	2	2	1	3	2								
CO3	2	2	3	1	2	2								
CO4	2	2	3	1	3	2								
CO5	3	3	2	2	2	2								
Avg.	2	1.8	2	1	2.4	1.8								
1 – Slight, 2 – Moderate, 3 – Substantial , BT – Bloom's Taxonomy														

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Department	EEE	**Programme Code & Name**	411- ME - PSE

Course Code	Course Name	Hours/Week			Credit	Maximum Marks
		L	T	P	C	
PPSE2408	WIND AND SOLAR ENERGY SYSTEMS	**3**	**0**	**0**	**3**	100
Course 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)**
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	**PHOTO VOLTAIC 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 No of periods to be taught	**45 periods**	

REFERENCES:

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

COURSE OUTCOMES:
On completion of the course, the students will be able to

CO1:	Understand the basics of wind energy conversion systems & solar energy conversion systems
CO2:	Implement the appropriate power extraction techniques.
CO3:	Apply power electronics to the renewable energy systems.
CO4:	Understand the grid integration techniques, and power quality issues.
CO5:	Apply the technology & techniques in variety of applications.

Mapping of COs with POs and PSOs

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO 1	PSO2	PSO3
CO1	1	1	-	-	2	-								
CO2	3	1	3	-	3	3								
CO3	3	2	2	2	2	2								
CO4	2	2	2	1	3	2								
CO5	3	2	2	-	2	2								
Avg.	2.4	1.6	2.5	1.5	2.4	2.25								

1 – Slight, 2 – Moderate, 3 – Substantial , BT – Bloom's Taxonomy

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Department	EEE	**Programme Code & Name**	411- ME - PSE

Course Code	Course Name	Hours/Week			Credit	Maximum Marks
		L	T	P	C	
PPSE2409	**DISTRIBUTED GENERATION AND MICRO GRID**	**3**	**0**	**0**	**3**	100
Course Objectives	• To familiarize with the concept of Distributed Generation • To focus on the planning and protection of Distributed Generation • To study the concept of MicroGrid and to analyze the impact of MicroGrid • To understand the major issues on MicroGrid economics • To expose the various distributed energy resources • To expose the various distributed energy resources					

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 RESOURCE**	**(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 generationProtection 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- Microturbine 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 no of periods to be taught	**45 periods**	

REFERENCES:

1	Nick Jenkins, JanakaEkanayake , GoranStrbac , “Distributed Generation”, Institution of Engineering and Technology, London, UK,2010.

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2	S. Chowdhury, S.P. Chowdhury and P. Crossley, "Microgrids and Active Distribution Networks", The Institution of Engineering and Technology, London, United Kingdom, 2009.
3	Math H. Bollen , Fainan Hassan, "Integration of Distributed Generation in the Power System", John Wiley &Sons, New Jersey, 2011.
4	NadarajahMithulananthan, Duong Quoc Hung, Kwang Y. Lee, "Intelligent Network Integration of Distributed Renewable Generation", Springer International Publishing, Switzerland, 2017.
5	Ali K., M.N. Marwali, Min Dai, "Integration of Green and Renewable Energy in Electric Power Systems", Wiley and sons, New Jersey, 2010.

COURSE OUTCOMES:

On completion of the course, the students will be able to

CO1:	Understand the concepts of Distributed Generation and Microgrids.
CO2:	Gain Knowledge about the various DG resources.
CO3:	Learn the concept of Microgrid and its mode of operation.
CO4:	Familiarize with the planning and protection schemes of Distributed Generation
CO5:	Acquire knowledge on the impacts of Microgrid

Mapping of COs with POs and PSOs

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	1	1	2	1	2	1								
CO2	2	2	2	1	3	2								
CO3	2	2	2	1	3	2								
CO4	1	1	2	1	2	1								
CO5	2	2	2	2	3	2								
1 – Slight, 2 – Moderate, 3 – Substantial , BT – Bloom's Taxonomy														

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Department	EEE	**Programme Code & Name**	411- ME - PSE

Course Code	Course Name	Hours/Week			Credit	Maximum Marks
		L	T	P	C	
PPSE2410	**ENERGY STORAGE TECHNOLOGIES**	**3**	**0**	**0**	**3**	100

Course Objectives	• To familiarize with the concept of Distributed Generation • To focus on the planning and protection of Distributed Generation • To study the concept of MicroGrid and to analyze the impact of MicroGrid • To understand the major issues on MicroGrid economics • To expose the various distributed energy resourcesTo expose the various distributed energy resources

Unit-I	**INTRODUCTION**	**(9)**
Necessity of energy storage – types of energy storage –energy storage technologies – Applications.		
Unit-II	**THERMAL STORAGE SYSTEM**	**(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	**ELECTRICAL ENERGY STORAG**	**(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, NickelCadmium, 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 No of periods to be taught	**45 periods**	

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REFERENCES:	
1	James Larminie and Andrew Dicks, 'Fuel cell systems Explained', Wiley publications, 2003.
2	LunardiniV.J, "Heat Transfer in Cold Climates", John Wiley and Sons 1981.
3	Jiujun Zhang (Editor), Lei Zhang (Editor), Hansan Liu (Editor), Andy Sun (Editor), Ru-Shi Liu (Editor), "Electrochemical technologies for energy storage and conversion", Two Volume Set, Wiley publications, 2012
4	Schmidt.F.W. and Willmott.A.J., "Thermal Storage and Regeneration", Hemisphere Publishing Corporation, 1981
5	Luisa F. Cabeza (Editor), "Advances in Thermal Energy Storage Systems: Methods and Applications", Woodhead Publishers, 2020.

Mapping of COs with POs and PSOs

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	-	1	-	-	2	-								
CO2	2	1	2	-	3	-								
CO3	2	2	2	-	3	-								
CO4	3	2	3	-	3	3								
CO5	2	2	2	2	3	3								
Avg.	2.25	1.6	2.25	1	2.6	3								
1 – Slight, 2 – Moderate, 3 – Substantial , BT – Bloom's Taxonomy														

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Department	EEE	**Programme Code & Name**	411- ME - PSE

Course Code	Course Name	Hours/Week			Credit	Maximum Marks
		L	**T**	**P**	**C**	
PPSE2411	**POWER QUALITY**	3	0	0	3	**100**
Course 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 No of Periods to be Taught		**45 periods**

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REFERENCES:	
1	R.C.Duggan "Electric Power Systems Quality", Tata MC Graw Hill Publishers, Third Edition,2012Nick Jenkins, JanakaEkanayake , GoranStrbac , "Distributed Generation", Institution of Engineering and Technology, London,UK,2010.
2	Arrillga "Power System Harmonics", John Wiely and Sons,2003
3	Derek A.Paice "Power Electronic Converter Harmonics" IEEE Press, 1995
4	Arindam Ghosh and Gerad Ledwich "Power Quality Enhancement Using Custom Power Devices",Kluwer Academic Publishers, First Edition,2002
5	G.T.Heydt, "Electric Power Quality", Stars in a Circle Publications, Second Edition, 1994

COURSE OUTCOMES: On completion of the course, the students will be able to	
CO1:	Comprehend the consequences of Power Quality issues.
CO2:	Conduct harmonic analysis of single phase and three phase systems supplying non-linear loads.
CO3:	Design passive filter for load compensation.
CO4:	Understand the mitigation techniques using custom power devices such as distribution static compensator (DSTATCOM), dynamic voltage restorer (DVR) & UPQC.
CO5:	Design active filters for load compensation.

Mapping of COs with POs and PSOs

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO 3
CO1	3	-	3	3	3	2								
CO2	3	-	3	3	3	2								
CO3	3	-	3	3	3	2								
CO4	3	-	3	3	3	2								
CO5	3	-	3	3	3	2								
Avg.	3	-	3	3	3	2								

1 – Slight, 2 – Moderate, 3 – Substantial , BT – Bloom's Taxonomy

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Department	EEE	**Programme Code & Name**	411- ME - PSE

Course Code	Course Name	Hours/Week			Credit	Maximum Marks
		L	**T**	**P**	**C**	
PPSE2412	**MACHINE LEARNING AND DEEP LEARNING**	3	0	0	3	**100**
Course 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	**LEARNING PROBLEMS AND ALGORITHMS**	**(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	**NEURAL NETWORK**	**(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, overfitting, 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, 65 Autoencoders: Convolutional Autoencoders, Denoising autoencoders, Variational autoencoders, GANs: The discriminator, generator, DCGANs		
Total No of Periods to be Taught	**45 periods**	

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REFERENCES:	
1	Pattern Recognition and Machine Learning. Christopher Bishop. Springer. 2006.
2	Understanding Machine Learning. Shai Shalev-Shwartz and Shai Ben-David. Cambridge University Press. 2017.
3	The Elements of Statistical Learning. Trevor Hastie, Robert Tibshirani and Jerome Friedman. Second Edition. 2009.
4	Deep Learning, Ian Good fellow, Yoshua Bengio and Aaron Courville, MIT Press, ISBN: 9780262035613, 2016.

COURSE OUTCOMES: On completion of the course, the students will be able to	
CO1:	Illustrate the categorization of machine learning algorithms
CO2:	Compare and contrast the types of neural network architectures, activation functions
CO3:	Elaborate various terminologies related with pattern recognition and architectures of convolutional neural networks
CO4:	Acquaint with the pattern association using neural networks
CO5:	Construct different feature selection and classification techniques and advanced neural network architectures such as RNN, Autoencoders, and GANs

Mapping of COs with POs and PSOs

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO 3
CO1	1	3	1	-	-	-								
CO2	2	3	2	-	-	-								
CO3	3	-	3	-	3	-								
CO4	2	3	3	-	-	-								
CO5	3	3	3	-	3	-								
Avg.	3	3	3	-	3	-								

1 – Slight, 2 – Moderate, 3 – Substantial , BT – Bloom's Taxonomy

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Department	EEE	**Programme Code & Name**	411- ME - PSE

Course Code	Course Name	Hours/Week			Credit	Maximum Marks
		L	**T**	**P**	**C**	
PPSE2413	**POWER SYSTEM RELIABILITY**	3	0	0	3	**100**
Course 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 GEWNERATION 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 No of Periods to be Taught	**45 periods**	

REFERENCES:

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
3	Cepin, Marko, “Assessment of Power System Reliability”, Springer, 2011.
4	Roy Billinton, R.N. Allan, “Reliability Evaluation of Power Systems”, Springer, 1996.
5	M.V.F. Pereira, N.J. Balu, “Composite generation/transmission reliability evaluation”, Proceedings of the IEEE, Vol. 80, No. 4, pp. 470-491, 1992.

COURSE OUTCOMES: On completion of the course, the students will be able to	
CO1:	Acquire design knowledge of system components in reliability point of view.
CO2:	Understand the importance of customer oriented and system oriented indices
CO3:	Familiarize with reliability evaluation methodologies.
CO4:	Analyse the system performance with proper remedial strategies.
CO5:	Enrich the capability of analysing reliability design alternatives in engineering systems.

Mapping of COs with POs and PSOs

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	2	1	2	-	3	2								
CO2	1	1	2	1	2	2								
CO3	3	2	2	-	2	3								
CO4	3	2	3	-	3	2								
CO5	3	2	3	-	3	2								
Avg.	2.4	1.6	2.4	0.4	2.6	2.2								

1 – Slight, 2 – Moderate, 3 – Substantial , BT – Bloom's Taxonomy

Department	EEE	**Programme Code & Name**	411- ME - PSE

Course Code	Course Name	Hours/Week			Credit	Maximum Marks
		L	**T**	**P**	**C**	
PPSE2414	**EHV AC TRANSMISSION**	3	0	0	3	**100**
Course Objectives	• To understand power system structure and line configurations • To compute line parameters and understand effect of ground return • To compute electrostatic field and design of EHV AC • To analyse voltage gradients of transmission line conductors. • 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-I2R 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 un energised 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-under ground line design.		
Total No of Periods to be Taught	**45 periods**	

REFERENCES:	
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 Sons Inc., 2009
3	Andrew R. Hileman, “Insulation Coordination for Power Systems”, CRC press, Taylor & Francis Group, New York, 1999.

4	Power Engineer's Handbook, Revised and Enlarged 6th Edition, TNEB Engineers' Association, October 2002.
5	Sunil S.Rao, "EHV-AC, HVDC Transmission & Distribution Engineering", Third Edition, Khanna Publishers, 2008
6	Gas Insulated Transmission Lines (GIL) – by Hermann Koch, Oct 2011, John Wiley & Sons
7	William H. Bailey, Deborah E. Weil and James R. Stewart . "A Review on ,"HVDC Power Transmission Environmental Issues", Oak Ridge National Laboratory.

COURSE OUTCOMES:
On completion of the course, the students will be able to

CO1:	Ability to analyse the identify voltage level and line configurations
CO2:	Ability to model EHV AC and HVDC lines
CO3:	Ability to compute voltage gradients of transmission line conductors
CO4:	Ability to analyze the effects of electrostatic field on living and non living organisms.
CO5:	Ability to analyze the design, control and protection aspects of HVDC lines.

Mapping of COs with POs and PSOs

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO 3
CO1	3	3	3	3	-	3	-							
CO2	3	3	3	3	3	-	-							
CO3	3	3	3	3	3	3	-							
CO4	3	3	3	3	-	3	3							
CO5	3	3	3	3	3	3	-							
Avg.	3	3	3	3	1.8	2.4	0.6							

1 – Slight, 2 – Moderate, 3 – Substantial , BT – Bloom's Taxonomy

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Department	EEE	**Programme Code & Name**	411- ME - PSE

Course Code	Course Name	Hours/Week			Credit	Maximum Marks
		L	**T**	**P**	**C**	
PPSE2415	ELECTROMAGNETIC INTERFERENCE AND COMPATIBILITY IN SYSTEM DESIGN	3	0	0	3	**100**
Course Objectives	• To provide fundamental knowledge on electromagnetic interference and electromagnetic compatibility. • To know about the importance of Grounding and shielding. • To study the important techniques to control EMI and EMC. • To expose the knowledge on testing techniques as per Indian and international standards in EMI measurement. design and know basic concepts of HVDC lines.					

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 69odeling, 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 No of Periods to be Taught	**45 periods**	

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REFERENCES:	
1	V.P. Kodali, "Engineering Electromagnetic Compatibility", S. Chand, 1996.
2	Henry W.Ott, " Noise reduction techniques in electronic systems", John Wiley & Sons, 1989.
3	Bernhard Keiser, "Principles of Electro-magnetic Compatibility", Artech House, Inc. (685 canton street, Norwood, MA 020062 USA) 1987.
4	Bridges, J.E Milleta J. and Ricketts.L.W., "EMP Radiation and Protective techniques", John Wiley and sons, USA 1976.
5	William Duff G., & Donald White R. J, "Series on Electromagnetic Interference and Compatibility", Vol. 6. Weston David A., "Electromagnetic Compatibility, Principles and Applications", 1991

COURSE OUTCOMES: On completion of the course, the students will be able to	
CO1:	Ability to understand the types and sources of EMI
CO2:	Ability to understand the needs of rounding and cabling.
CO3:	Ability to understand the design concept of filtering and shielding.
CO4:	Ability to study the effect of EMI in elements and circuits.
CO5:	Ability to know about the effects of electrostatic discharge and testing techniques.

Mapping of COs with POs and PSOs

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO 3
CO1	3	3	3	3	3	1	-							
CO2	3	3	3	3	3	-	-							
CO3	3	3	3	3	3	1	2							
CO4	3	3	3	3	3	1	2							
CO5	3	3	3	3	3	1	2							
Avg.	3	3	3	3	3	0.8	1.2							

1 – Slight, 2 – Moderate, 3 – Substantial , BT – Bloom's Taxonomy

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Department	EEE	**Programme Code & Name**	411- ME - PSE

Course Code	Course Name	Hours/Week			Credit	Maximum Marks
		L	**T**	**P**	**C**	
PPSE2416	INDUSTRIAL POWER SYSTEM ANALYSIS AND DESIGN	3	0	0	3	**100**

Course Objectives

- To impart knowledge on Motor Starting Studies.
- To understand the need for power factor correction and analyse 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 analyse 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 No of Periods to be Taught	**45 periods**	

REFERENCES:

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

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COURSE OUTCOMES: On completion of the course, the students will be able to	
CO1:	perform motor starting studies.
CO2:	To model and carry out power factor correction studies.
CO3:	Perform harmonic analysis and reduce the harmonics by using filters.
CO4:	Carry out the flicker analysis by proper modeling of the load and its minimization
CO5:	Design the appropriate ground grid for electrical safety.

Mapping of COs with POs and PSOs

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO 3
CO1	3	3	3	3	3	1	-							
CO2	3	3	3	3	3	1	-							
CO3	3	3	3	3	3	1	-							
CO4	3	3	3	3	3	1	-							
CO5	3	3	3	3	3	1	2							
Avg.	3	3	3	3	3	1	0.4							

1 – Slight, 2 – Moderate, 3 – Substantial , BT – Bloom's Taxonomy

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Department	EEE	**Programme Code & Name**	411- ME - PSE

Course Code	Course Name	Hours/Week			Credit	Maximum Marks
		L	**T**	**P**	**C**	
PPSE2417	ADVANCED POWER SYSTEM DYNAMICS	3	0	0	3	**100**
Course 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	**SUBSYSNCHRONOUS RESONANCE (SSR) AND OSCILLATIONS**	**(9)**
Subsysnchronous 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 POWERSYSTEMS**	**(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 No of Periods to be Taught		**45 periods**

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REFERENCES:	
1	R.Ramanujam," Power System Dynamics Analysis and Simulation, PHI Learning Private Limited, New Delhi,2009
2	T.V. Cutsem and C.Vournas, "Voltage Stability of Electric Power Systems", Kluwer publishers,1998.
3	P. Kundur, Power System Stability and Control, McGraw-Hill,1993.
4	H.W. Dommel and N.Sato, "Fast Transient Stability Solutions," IEEE Trans., Vol. PAS- 91, pp, 1643-1650, July/August1972.
5	Roderick J.Frowd and J. C. Giri, "Transient stability and Long term dynamics unified", IEEE Trans., Vol 101, No. 10, October1982.
6	M.Stubbe, A.Bihain,J.Deuse, J.C.Baader, "A New Unified software program for the study of the dynamic behaviour of electrical power system," IEEE Transaction, Power Systems, Vol.4.No.1,Feb:1989,Pg.129 to 138.

COURSE OUTCOMES: On completion of the course, the students will be able to	
CO1:	Understand the concepts behind sub-synchronous resonance and detect the SSR by suitable modelling.
CO2:	Analyze the effect of generation and transmission and load dynamics on voltage stability.
CO3:	Analyze the effect of load dynamics on power system voltage stability and analyze and enhance small signal stability of the power system
CO4:	Analyze the short-term and long-term stability of the power system using unified stability algorithm.
CO5:	Study and analyze the various instability mechanisms of voltage stability.

Mapping of COs with POs and PSOs

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO 3
CO1	3	3	3	3	3	1	3							
CO2	3	3	3	3	3	1	3							
CO3	3	3	3	3	3	1	3							
CO4	3	3	3	3	3	1	3							
CO5	3	3	3	3	3	1	3							
Avg.	3	3	3	3	3	1	3							

1 – Slight, 2 – Moderate, 3 – Substantial , BT – Bloom's Taxonomy

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Department	EEE	**Programme Code & Name**	411- ME - PSE

Course Code	Course Name	Hours/Week			Credit	Maximum Marks
		L	**T**	**P**	**C**	
PPSE2418	PYTHON PROGRAMMING FOR MACHINE LEARNING	3	0	0	3	**100**
Course Objectives	• Students will understand and be able to use the basic programming principles such as data types, variable, conditionals, loops, recursion and function calls. • Students will learn how to use basic data structures such as List, Dictionary and be able to manipulate text files and images. • To make the students familiar with machine learning concepts & techniques. • Students will understand the process and will acquire skills necessary to effectively attempt a machine learning problem and implement it using Python. • 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	**PYTHON FUNCTIONS AND PACKAGES**	**(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 –		

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Gradient Descent – Introduction to Tensor flow 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 Tensor flow Lite for Microcontrollers – on-Board AI – ML Edge Devices: Arduino Nano BLE Sense, Google Edge TPU and Intel Movidius	
Total No of Periods to be Taught	**45 periods**

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
3	Andreas C. Müller, Sarah Guido, "Introduction to Machine Learning with Python", O'Reilly,2016
	Sebastian Raschka , VahidMirjalili, "Python Machine Learning - Third Edition", Packt, December 2019

COURSE OUTCOMES:

On completion of the course, the students will be able to

CO1:	Develop skill in system administration and network programming by learning Python
CO2:	Demonstrating understanding in concepts of Machine Learning and its implementation using Python
CO3:	Relate to use Python's highly powerful processing capabilities for primitives, modelling etc
CO4:	Improved Employability and entrepreneurship capacity due to knowledge up gradation on recent trends in embedded systems design.
CO5:	Apply the concepts acquired over the advanced research/employability skills

Mapping of COs with POs and PSOs

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO 3
CO1	-	-	2	3	3	-								
CO2	3	1	3	-	3	1								
CO3	2	1	2	-	3	3								
CO4	3	2	3	3	3	3								
CO5	-	-	-	-	3	-								
Avg.	2.66	1.33	2.5	3	3	2.33								

1 – Slight, 2 – Moderate, 3 – Substantial , BT – Bloom's Taxonomy

Department	EEE	**Programme Code & Name**	411- ME - PSE

Course Code	Course Name	Hours/Week			Credit	Maximum Marks
		L	**T**	**P**	**C**	
PPSE2419	COMPUTER RELAYING AND WIDE AREA MEASUREMENT SYSTEMS	3	0	0	3	**100**
Course Objectives	• To discriminate conventional relays and computer relays • To comprehend the operating values of a computer relays • To provide exposure to wide area measurement systems through the computer hierarchy in the substation, system relaying and control • To inculcate knowledge on phasor measurement unit and its application to power system • 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)**
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	**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 No of Periods to be Taught	**45 periods**	

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

COURSE OUTCOMES: On completion of the course, the students will be able to	
CO1:	Demonstrate knowledge of fundamental theories, principles and practice of computer relaying, Wide area measurement system
CO2:	Analyze the power system with computer relaying and Wide area measurement system.
CO3:	Validate the recent relaying technologies which work towards smart grid
CO4:	Design wide area measurement systems for Smart grid
CO5:	Compare the performance of modern relaying schemes and measurement techniques with the conventional one.

Mapping of COs with POs and PSOs

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO 3
CO1	3	-	3	-	3	-								
CO2	3	-	3	-	3	3								
CO3	3	-	3	-	-	3								
CO4	3	-	3	-	-	3								
CO5	3	-	3	-	-	3								
Avg.	3	-	3	-	3	3								

1 – Slight, 2 – Moderate, 3 – Substantial , BT – Bloom's Taxonomy

Department	EEE	**Programme Code & Name**	411- ME - PSE

Course Code	Course Name	Hours/Week			Credit	Maximum Marks
		L	**T**	**P**	**C**	
PPSE2420	APPLICATION OF DSP TO POWER SYSTEM PROTECTION	3	0	0	3	**100**
Course 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 decisionmaking 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 No of Periods to be Taught	**45 periods**	

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

COURSE OUTCOMES: On completion of the course, the students will be able to	
CO1:	The students will be able to apply DSP techniques for digital protection.
CO2:	The students will be capable of decisionmaking algorithm suitable for digital relaying applications.
CO3:	The students will be able to employ FIR based algorithms for digital relaying.
CO4:	The students will be able to do transformer protection using digital techniques.
CO5:	The students will be able to perform coordinated operation of relays for specific purposes.

Mapping of COs with POs and PSOs

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO 3
CO1	1	2	1	-	1	-								
CO2	1	1	2	-	3	1								
CO3	2	-	3	1	1	1								
CO4	1	2	1	2	-	1								
CO5	2	2	2	-	3	1								
Avg.	1.4	1.75	1.8	1.5	2.33	1								

1 – Slight, 2 – Moderate, 3 – Substantial , BT – Bloom's Taxonomy

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Department	EEE	**Programme Code & Name**	411- ME - PSE

Course Code	Course Name	Hours/Week			Credit	Maximum Marks
		L	**T**	**P**	**C**	
PPSE2421	POWER SYSTEM INSTRUMENTATION	3	0	0	3	**100**
Course 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 No of Periods to be Taught	**45 periods**	

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REFERENCES:	
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.
3	Pabla. A.S "Electric power distribution "- Tata McGraw Hill; New Delhi 2004
4	Mahalana Bis A K, Kothari D P and Ahson S I " Computer aided Power System analysis and control" - Tata McGraw Hill; New Delhi 1988.
5	Murphy. W.R and McKay G "Energy Management" Butterworths Publications, London 1982
6	Wayne C Tuner "Energy Management Hand Book" John Wiley and Sons, 1982

COURSE OUTCOMES: On completion of the course, the students will be able to	
CO1:	Understand the basics of instrumentation and SCADA system implementation in PS.
CO2:	Understand and implement the controls involved in power plant instrumentation
CO3:	Understand the functioning of distribution automation in power system network
CO4:	Understand concepts of substation automation and to implement the controls
CO5:	Analyse the energy management techniques and energy audit.

Mapping of COs with POs and PSOs

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO 3
CO1	2	1	1	-	1	2								
CO2	3	2	2	-	2	2								
CO3	2	2	1	-	2	2								
CO4	3	2	1	-	2	2								
CO5	3	2	1	2	2	2								
Avg.	2.4	1.8	1.2	0.4	1.8	2								

1 – Slight, 2 – Moderate, 3 – Substantial , BT – Bloom's Taxonomy

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Department	EEE	**Programme Code & Name**	411- ME - PSE

Course Code	Course Name	Hours/Week			Credit	Maximum Marks
		L	**T**	**P**	**C**	
PPSE2422	HIGH VOLTAGE TECHNOLOGY	3	0	0	3	**100**
Course 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 82 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 No of Periods to be Taught	**45 periods**	

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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.
3	Pabla. A.S "Electric power distribution "- Tata McGraw Hill; New Delhi 2004
4	Mahalana Bis A K, Kothari D P and Ahson S I "Computer aided Power System analysis and control" - Tata McGraw Hill; New Delhi 1988.
5	Murphy. W.R and McKay G "Energy Management" Butterworths Publications, London 1982
6	Wayne C Tuner "Energy Management Hand Book" John Wiley and Sons, 1982

COURSE OUTCOMES: On completion of the course, the students will be able to	
CO1:	Ability to design, simulate and generate HVDC
CO2:	Ability to design, simulate and generate HVAC
CO3:	Ability to design, simulate and generate impulse voltage and current
CO4:	Ability to design and analyze the suitable measuring circuits for HV
CO5:	Ability to provide safety measures against electrostatic hazards

Mapping of COs with POs and PSOs

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO 3
CO1	3	3	3	3	-	3								
CO2	3	3	3	2	-	3								
CO3	3	3	3	2	-	3								
CO4	3	3	-	1	-	-								
CO5	-	-	-	-	-	-								
Avg.	2.4	2.4	2.4	1.6	-	1.8								

1 – Slight, 2 – Moderate, 3 – Substantial , BT – Bloom's Taxonomy

Department	EEE	**Programme Code & Name**	411- ME - PSE

Course Code	Course Name	Hours/Week			Credit	Maximum Marks
		L	**T**	**P**	**C**	
PPSE2423	ELECTRIC VEHICLES AND POWER MANAGEMENT	3	0	0	3	**100**
Course 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 POWER TRAIN COMPONENTS**	**(9)**
Architecture of EV's and HEV's – Plug-n 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 No of Periods to be Taught	**45 periods**	

REFERENCES:	
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, Inc 2010

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3	Mehrdad Ehsani, YiminGao, Sebastian E. Gay, Ali Emadi, 'Modern Electric, Hybrid Electric and Fuel Cell Vehicles: Fundamentals, Theory and Design', CRC Press, 2004.
4	C.C. Chan and K.T. Chau, 'Modern Electric Vehicle Technology', OXFORD University Press, 2001.
5	Wie Liu, “Hybrid Electric Vehicle System Modeling and Control”,Second Edition, John Wiley & Sons, 2017.

COURSE OUTCOMES:

On completion of the course, the students will be able to

CO1:	Understand the concept of electric vehicle and energy storage systems.
CO2:	Describe the working and components of Electric Vehicle and Hybrid Electric Vehicle
CO3:	Know the principles of power converters and electrical drives
CO4:	Illustrate the operation of storage systems such as battery and super capacitors
CO5:	Analyze the various energy storage systems based on fuel cells and hydrogen storage

Mapping of COs with POs and PSOs

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO 3
CO1	3	3	3	3	-	3								
CO2	3	3	3	2	-	3								
CO3	3	3	3	2	-	3								
CO4	3	3	-	1	-	-								
CO5	-	-	-	-	-	-								
Avg.	2.4	2.4	2.4	1.6	-	1.8								

1 – Slight, 2 – Moderate, 3 – Substantial , BT – Bloom’s Taxonomy

Department	EEE	**Programme Code & Name**	411- ME - PSE

Course Code	Course Name	Hours/Week			Credit	Maximum Marks
		L	**T**	**P**	**C**	
PPSE2424	ENERGY MANAGEMENT AND AUDITING	3	0	0	3	**100**
Course 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, Amedments (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 techniquesShunt capacitor, Synchronous Condenserand Phase Advancer - Energy conservation in industrial drives, electric furnaces, ovens and boilers - Lighting techniques: Natural,CFL, LED lighting sources and fittings.		
Total No of Periods to be Taught	**45 periods**	

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”, Logman Scientific & Technical, 1990.

3	IEEE Recommended Practice for Energy Management in Industrial and Commercial Facilities, IEEE, 1996
4	Amit K. Tyagi, "Handbook on Energy Audits and Management", TERI, 2003.
5	Anil Kumar, ,Om Prakash ,Chauhan Prashant Singh"Energy Management: Conservation and Audits, CRC Press, 2020.

COURSE OUTCOMES:
On completion of the course, the students will be able to

CO1:	Understand the present energy scenario and role of energy managers.
CO2:	Comprehend the Economic Models for cost and load management
CO3:	Configure the Demand side energy management through its control techniques, strategy and planning.
CO4:	Understand the process of energy auditing.
CO5:	Implement energy conservation aspects in industries

Mapping of COs with POs and PSOs

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO 3
CO1	2	2	2	-	2	-								
CO2	2	3	2	1	2	1								
CO3	2	2	2	1	2	2								
CO4	1	2	2	3	-	-								
CO5	3	3	2	3	3	3								
Avg.	2	2.4	2	2	2.25	2								

1 – Slight, 2 – Moderate, 3 – Substantial , BT – Bloom's Taxonomy

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